Total Maximum Daily Loads Report for Nitrogen Compounds and Orthophosphate

in

Streams of the Pajaro River Basin

Santa Cruz, Santa Clara, San Benito, and Monterey Counties, California

Pajaro River
@ Thurwatcher Bridge

TMDL Report

Prepared May 2015
for the July 30-31, 2015
Central Coast Water Board Meeting

This document is identified as a TMDL for streams of the Pajaro River Basin and is officially submitted to the U.S. Environmental Protection Agency to act upon and approve as a TMDL

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Item 13 Attachment 2
July 30-31
TMDL Report

TOTAL MAXIMUM DAILY LOADS REPORT FOR NITROGEN COMPOUNDS AND ORTHOPHOSPHATE IN STREAMS OF THE PAJARO RIVER BASIN

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Central Coast Regional Water Quality Control Board

Total Maximum Daily Loads
for Nitrogen Compounds and Orthophosphate
in Streams of the Pajaro River Basin

APPROVALS

Adopted by the
Central Coast Regional Water Quality Control Board
Resolution No. R3-20XX-XXXX
on _______________, 201X

Approved by the
State Water Resources Control Board
Resolution No. 20XX-XXXX
on _______________, 201X

Approved by the
California Office of Administrative Law
OAL File No. 20XX-XXXX-XXX
on _______________, 201X

Approved by the
U.S. Environmental Protection Agency, Region IX
on _______________, 201X

These TMDLs constitute an update and revision of the 2005 Pajaro River Nitrate TMDL.
Upon approval by the California Office of Administrative Law, these TMDLs supersede and replace the TDML entitled *“Pajaro River and Llagas Creek Total Maximum Daily Load for Nitrate”* which was approved by Resolution No. R3-2005-0131 on December 2, 2005 by California Regional Water Quality Control Board Central Coast Region, and subsequently approved by the U.S. Environmental Protection Agency on October 13, 2006.

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The TMDL project documents are also available online at:
http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/pajaro/nutrients/index.shtml

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Central Coast Regional Water Quality Control Board

Reference Table for Recurring Acronyms & Recurring Terms Used in this TMDL Report

(the hyperlinks will take you to a webpage with more information about the acronym or the term)

AGR	Agricultural Supply – Uses of water for farming, horticulture, or ranching including but not limited to irrigation, stock watering, or support of vegetation for range grazing.
anti-degradation	Provisions of federal and state law that require that wherever the existing quality of water is better than the quality of water established by water quality objectives, such existing water quality shall be maintained unless otherwise provided by the provisions of the state anti-degradation policy (see Basin Plan section II.A.)
Basin Plan	Water Quality Control Plan for the Central Coastal Basin.
biostimulation	As used herein, “biostimulation” refers to a state of excess growth of algae due to anthropogenic nutrient inputs into an aquatic system. Biostimulation is characterized by a number of other factors in addition to nitrogen and phosphorus inputs; for example, dissolved oxygen levels, chlorophyll *a*, sunlight availability, and pH[A,B].
beneficial uses	Legally designated uses of waters of the state that may be protected against water quality degradation including, but not limited to, drinking water supply, agricultural supply, aquatic habitat.
CDFW	California Department of Fish and Wildlife
COLD	Cold Freshwater Habitat – Uses of surface waters that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife including invertebrates.
GWR	Groundwater Recharge –Uses of surface waters for natural or artificial recharge of groundwater for purposes of future extraction and maintenance of water quality.
HUC	Hydrologic unit code
MS4	Municipal separate storm sewer systems
MUN	Municipal and Domestic Supply – Uses of water for community, military, or individual water supply systems, including but not limited to drinking water supply.
NHDplus	National hydrography dataset plus
NO_3 or NO_3-N	nitrate or nitrate as nitrogen
NPDES	National pollutant discharge elimination system
OWTS	Onsite wastewater treatment systems
STEPL	Spreadsheet tool for estimating pollutant load
TMDL	Total maximum daily load
USEPA	United States Environmental Protection Agency
WARM	Warm Freshwater Habitat – Uses of surface waters that support water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife including invertebrates.
WBD	Watershed boundary dataset

[A] See: U.S. Fish and Wildlife Service, 2011. 5-Year Review, Summary and Evaluation: *Rorippa gambellii* [*Nasturtieum gambelli*] (Gambel’s watercress). September 2011, Ventura Fish and Wildlife Office.

[B] The term “eutrophication” has often been considered to be synonymous or interchangeable with the term “biostimulation”. California central coast researchers have noted that the word “eutrophication” is problematic because it lacks scientific specificity. These researchers recommend that the regional water quality control boards not use the word (see Rollins, Los Huertos, Krone-Davis, and Ritz, 2012, Algae Biomonitoring and Assessment for Streams and Rivers of California’s Central Coast)

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1 TMDL REPORT SUMMARY

A number of streams in the Pajaro River basin are impaired due to exceedances of water quality criteria for nitrate, unionized ammonia, and associated nutrient-related problems such as excessive orthophosphate, dissolved oxygen imbalances, toxicity, and excess algal biomass. As a result, a wide range of legally designated beneficial uses – including aquatic habitat, drinking water supply, groundwater recharge, and agricultural supply - are not being supported in these waterbodies, and therefore these impairments constitute serious water quality problems.

TMDLs are strategies or plans to address and rectify impaired waters identified on 303(d) list. The California Water Plan characterizes TMDLs as *"action plans…to improve water quality."* This TMDL report addresses surface water quality impairments in the Pajaro River basin which are caused by exceedances of water quality criteria for nitrate, unionized ammonia, and associated nutrient-related problems such as excessive orthophosphate, dissolved oxygen imbalances, toxicity, and excess algal biomass. These impairments are adversely impacting a range of current or potential designated beneficial uses of surface waters – including aquatic habitat, drinking water supply, groundwater recharge, and agricultural supply. This TMDL report identifies the water quality impairments and outlines a strategy for the attainment of water quality objectives and the restoration of designated beneficial uses of surface waters.

A condensed tabular summary of this TMDL Report is presented in Table 1-1 below.

Table 1-1. Total maximum daily loads summary.

TMDLs for Nitrogen Compounds and Orthophosphate in Streams of the Pajaro River Basin **Central Coast Regional Water Quality Control Board**	
TMDL Pollutants	Nitrogen compounds (nitrate, total nitrogen, un-ionized ammonia), orthophosphate
Other Pollutants Addressed	Biological response indicators – dissolved oxygen, oxygen saturation, chlorophyll *a*, microcystins
TMDL Goals	Reduce nutrient pollution and un-ionized ammonia toxicity in streams to restore and enhance viable freshwater habitat for fish, wildlife, invertebrates; restore domestic and municipal supply beneficial uses of impaired streams\ and restore groundwater recharge beneficial uses of impaired streams, with the goal of enhanced drinking water source protection. Protect existing high quality waters and prevent any further nutrient water quality degradation in streams not currently impaired by nutrient-related pollution.
Location & Watershed	Parts of Santa Cruz, Santa Clara, San Benito, and Monterey counties Pajaro River basin (federal hydrologic cataloging unit # 18060002)
Sources of Nutrients to Streams of the River Basin	Fertilizer application on irrigated cropland Shallow groundwater inputs to streams Urban runoff – stormwater sewer system discharges Natural sources (ambient background loading) Livestock and domestic animal manure NPDES-permitted municipal wastewater treatment facilities NPDES-permitted industrial and construction stormwater discharges Fertilizer application on golf courses Direct atmospheric deposition to streams (negligible source) Onsite wastewater treatment systems (negligible source) *This table is continued on the next page*

<table>
<tr><th colspan="3">TMDLs for Nitrogen Compounds and Orthophosphate in Streams of the Pajaro River Basin
Central Coast Regional Water Quality Control Board</th></tr>
<tr><td rowspan="23">Impaired Streams
<i>On the basis of nutrient water quality criteria and biostimulation indicators</i></td><td>Stream</td><td>Waterbody Identification (WBID, unless otherwise noted)</td></tr>
<tr><td>Pajaro River</td><td>WBID: CAR3051003019980826115152</td></tr>
<tr><td>Pajaro River Estuary</td><td>NHDplus reach code 18060002001843</td></tr>
<tr><td>Watsonville Slough</td><td>WBID: CAR3051003019981209150043</td></tr>
<tr><td>Harkins Slough</td><td>WBID: CAR3051001320080603122917</td></tr>
<tr><td>Struve Slough</td><td>WBID: CAR3051003020080603125227</td></tr>
<tr><td>Struve Slough</td><td>WBID: CAR3051003020080603125227</td></tr>
<tr><td>Corralitos Creek</td><td>WBID: CAR3051001019990225102704</td></tr>
<tr><td>Tributary to Corralitos Creek</td><td>NHDplus reach code 18060002001662</td></tr>
<tr><td>Salsipuedes Creek</td><td>WBID: CAR3051003020080603123522</td></tr>
<tr><td>Casserly Creek</td><td>NHDplus reach code 18060002001643</td></tr>
<tr><td>Pinto Lake outflow ditch</td><td>NHDplus reach code 18060002001656</td></tr>
<tr><td>Beach Road Ditch</td><td>WBID: CAR3051003020080603123839</td></tr>
<tr><td>McGowan Ditch</td><td>WBID: CAR3051003020100620223644</td></tr>
<tr><td>Coward Creek</td><td>NHDplus reach code 18060002000394</td></tr>
<tr><td>Tributary to Green Valley Creek</td><td>NHDplus reach code 18060002001638</td></tr>
<tr><td>Carnadero Creek</td><td>WBID: CAR3053002019990223155037</td></tr>
<tr><td>San Juan Creek</td><td>WBID: CAR3052005020090204001958</td></tr>
<tr><td>West Branch San Juan Creek</td><td>NHDplus reach code 18060002000611</td></tr>
<tr><td>Millers Canal</td><td>WBID: CAR3053002020080603171000</td></tr>
<tr><td>Llagas Creek</td><td>WBID: CAR3053002020020319075726</td></tr>
<tr><td>Furlong Creek</td><td>WBID: CAR3053002019990222111932</td></tr>
<tr><td>Tequisquita Slough</td><td>WBID: CAR3053002020011121091332</td></tr>
<tr><td>High Quality Waters^{B} and Waters Not Currently Showing Nutrient-Related Impairments</td><td colspan="2">For waterbodies assessed as high quality waters and those not currently identified as impaired, anti-degradation requirements apply. The goal of anti-degradation in the context of nutrient pollution is to protect and maintain existing high quality waters, prevent any further degradation, and provide protection for downstream waters.</td></tr>
<tr><td>Beneficial Uses Impaired and Water Quality Standards Violations</td><td colspan="2">Widespread impairments in streams designated for domestic and municipal water supply (MUN)
Widespread impairments in streams designated for aquatic habitat beneficial uses (WARM, COLD, SPWN) on the basis of violations of the biostimulatory substances water quality objective.
Localized violations of the general toxicity objective for surface waters, on the basis of exceedances of the un- ionized ammonia numeric water quality objective.
Localized impairments in streams designated for groundwater recharge beneficial use (GWR).
Localized impairment in Llagas Creek for designated agricultural supply beneficial use (AGR).</td></tr>
<tr><td>Loading Capacity (TMDL)</td><td colspan="2">-Dry Season (May 1 – Oct. 31) nitrate as N range not to exceed 1.8 to 3.9 mg/L in impaired receiving waters, depending on specific stream reach.
-Dry Season (May 1 – Oct. 31) total nitrogen (N) range not to exceed 1.1 mg/L in Millers Canal and not to exceed 2.1 mg/L in the sloughs of the Watsonville Slough subwatershed.
-Wet Season (Nov. 1 – Apr. 30) nitrate as N not to exceed 8 mg/L in impaired receiving waters.
-Dry Season (May 1 – Oct. 31) orthophosphate as P range not to exceed 0.4 to 0.14 mg/L in impaired receiving waters, depending on specific stream reach.
-Wet Season (Nov. 1 – Apr. 30) orthophosphate as P not to exceed 0.3 mg/L in impaired receiving waters
-Year Round, nitrate as N not to exceed 10 mg/L in all receiving waters designated for MUN.
-Year Round, un-ionized ammonia as N not to exceed 0.025 mg/L in all receiving waters.</td></tr>
<tr><td>TMDL Milestones</td><td colspan="2">10 and 15 year interim milestones established with interim water quality goals
Water Board may reconsider TMDL in 10 years, to consider new research, data, & information.
TMDL achievement of final water quality goals in receiving waters anticipated in 25 years.
<i>This table is continued on the next page</i></td></tr>
</table>

TMDLs for Nitrogen Compounds and Orthophosphate in Streams of the Pajaro River Basin **Central Coast Regional Water Quality Control Board**	
Implementation Strategy: **Proposed Actions To Correct the 303(d)-Listed Impairments**	*Owners/operators of irrigated lands:* Implement and comply with the Central Coast Water Board's Agricultural Order to minimize nutrient loading to receiving waters from fertilizers and irrigation, and to make incremental progress towards attaining load allocations. *Municipal separate storm sewer system (MS4) entities:* Waste load allocations for this source category will be implemented through existing NPDES permits. Nutrient pollution discharged from MS4s will be addressed by regulating the MS4 entities under the provisions State Water Resources Control Board's General Permit for the Discharges of Storm Water from Small MS4s (General Permit). *NPDES–permitted industrial and construction stormwater discharges:* Maintain existing water quality and prevent any further water quality degradation by implementing and complying with the requirements of the statewide Industrial General and the statewide Construction General Permit, or their revisions and renewals. *NPDES–permitted municipal wastewater discharges:* Waste load allocations for this source category will be implemented by existing NPDES wastewater permitting authorities. Where warranted, waste load allocations identified in the TMDL will be implemented by existing, new, or revised effluent limits in the NPDES permits. *Owners/operators of livestock and domestic animals:* Maintain existing water quality and prevent further water quality degradation by beginning or continuing to self-monitor and self-asses consistent with technical guidance from existing rangeland water quality management plans. *Owners/operators of golf courses:* Continue to implement turf management practices which help protect and maintain existing water quality and to prevent any further surface water quality degradation.

[A] Anti-degradation policy is a component and expectation of all water quality standards, Also noteworthy, U.S. Environmental Protection Agency guidance indicates that while TMDLs, are typically written for restoring impaired waterbodies, states can also prepare TMDLs geared towards maintaining a "better than water quality standard" conditions for a given waterbody–pollutant combination (see: USEPA, 2014a. *Opportunities to Protect Drinking Water Sources and Advance Watershed Goals Through the Clean Water Act: A Toolkit for State, Interstate, Tribal and Federal Water Program Managers*. November 2014).

[B] For purposes of anti-degradation policy, "high quality waters" are defined on a constituent-by-constituent basis. The State Water Resources Control Board and appellate court decisions indicate that water can be considered high quality for purposes of the anti-degradation policy on a constituent by constituent basis. Therefore, water can be of high quality under the anti-degradation policy for some constituents or beneficial uses, but not for others (see Court of Appeal of the State of California, Third Appellate District, Appeal Case C066410, Acociacion de Gente Unida, etc. et al. v. Central Valley Regional Water Quality Control Board).

2 INTRODUCTION

2.1 Clean Water Act Section 303(d)

Section 303(d) of the federal Clean Water Act requires every state to evaluate its waterbodies, and maintain a list of waters that are considered "impaired" either because the water exceeds water quality standards or does not achieve its designated use. For each impaired water on the Central Coast's Clean Water Act Section 303(d) List, the Central Coast Water Board must develop and implement a plan to reduce pollutants so that the waterbody is no longer impaired and can be de-listed. Section 303(d) of the Clean Water Act states:

> *"Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 1314(a)(2) of this title as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality."*

The State complies with this requirement by periodically assessing the conditions of the rivers, lakes and bays and identifying them as "impaired" if they do not meet water quality standards. These waters, and the pollutant or condition causing the impairment, are placed on the 303(d) List of Impaired Waters, referred to hereafter as the "303(d) List". In addition to creating a list of waterbodies not meeting water quality standards, the Clean Water Act mandates each state to develop TMDLs for each waterbody listed. Simply put, TMDLs are strategies or plans to address and rectify impaired waters identified on 303(d) list. The California Water Plan characterizes TMDLs as *"action plans…to improve water quality."* The Central Coast Water Board is the agency responsible for developing TMDLs and programs of implementation for waterbodies identified as not meeting water quality objectives pursuant to Clean Water Act Section 303(d) and in accordance with the Porter-Cologne Water Quality Control Act §13242.

2.2 Pollutants Addressed & Their Environmental Impacts

The pollutants addressed in this TMDL are nitrate, low dissolved oxygen, un-ionized ammonia, and chlorophyll *a*. In addition, to protect waters from excess biostimulatory substances, orthophosphate is included as a pollutant. Nitrate pollution of both surface waters and groundwater has long been recognized as a problem in parts of the Pajaro River Basin. Elevated levels of nitrate or un-ionized ammonia can degrade municipal and domestic water supply, groundwater, and also can impair freshwater aquatic habitat. While nitrogen fertilizer inputs are essential for maintaining the economic viability of agriculture worldwide, elevated levels of nitrate can degrade municipal and domestic water supply, groundwater, and also can impair freshwater aquatic habitat. It is widely recognized by scientists and resource professionals that there is a critical need to continue to improve best management practices to reduce nitrogen releases to the environment from human activities, while maintaining the economic viability of farming operations (for example, see Shaffer and Delgado, 2002). Some streams in the Pajaro River Basin frequently have exceeded the water quality objective for nitrate in drinking water. The streams therefore do not support designated drinking water supply (MUN) beneficial uses and may be impaired for designated groundwater recharge (GWR) beneficial uses[1]. The Water Quality Control Plan for the Central Coastal Region – 2011 version (Basin Plan) explicitly requires that the designated GWR beneficial use of streams be maintained, in part, to protect the water quality of the underlying groundwater resources[2].

Regarding nitrate-related health concerns, it has been well-established that infants less than six months old who are fed formula made with water containing nitrate in excess of the U.S. Environmental Protection Agency (USEPA) safe drinking water standard (i.e., 10 milligrams of nitrate as nitrogen per liter) are at risk of becoming seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome, also known as methemoglobinemia[3]. High nitrate levels may also affect the oxygen-carrying ability of the blood of pregnant women[4]. There is some evidence to suggest that exposure to nitrate in drinking water is associated with adverse reproductive outcomes such as intrauterine growth retardations and various birth defects such as anencephaly; however, the evidence is inconsistent (Manassaram et al., 2006). Additionally, some public health concerns have been raised about the linkage between nitrate and cancer. Some peer-reviewed epidemiological studies have suggested elevated nitrate in drinking water may be associated with elevated cancer risk (for example, Ward et al. 2010); however currently there is no strong evidence linking higher risk of cancer in humans to elevated nitrate in drinking water. Further research is recommended by scientists to confirm or refute the linkage between nitrates in drinking water supply and cancer.

Another water quality impairment associated with nutrients and addressed in this TMDL report is biostimulation[5]. While nutrients - specifically nitrogen and phosphorus – are essential for plant growth, and are ubiquitous in the environment, they are considered pollutants when they occur at levels that have adverse impacts on water quality; for example, when they cause toxicity or biostimulation.

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[1] "Beneficial uses" is a regulatory term which refers to the legally-protected current, potential, or future designated uses of the waterbody. The Water Board is required by law to protect all designated beneficial uses.

[2] See Basin Plan, Chapter 2 Beneficial Use Definitions, page II-19

[3] USEPA: http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm

[4] California Department of Public Health www.cdph.ca.gov/certlic/drinkingwater/Pages/Nitrate.aspx

[5] The term "eutrophication" has often been considered to be synonymous with the word "biostimulation". California central coast researchers have noted that the word "eutrophication" is problematic because it is based on simplistic categories that fail to appreciate the diversity of aquatic systems, and lacks scientific specificity. Accordingly, these researchers recommend that the regional water quality control boards not use the word "eutrophication" (see Rollins, et al., 2012).

Biostimulation refers to a state of excess growth of aquatic vegetation resulting from anthrophogenic nutrient inputs into an aquatic system. Biostimulation is also characterized by a number of other environmental factors in addition to nitrogen and phosphorus inputs; for example, dissolved oxygen levels in the waterbody, chlorophyll *a* levels, sunlight availability, and pH. Biostimulation can adversely affect the entire aquatic food web from macroinvertebrates (principally aquatic insect larvae), through fish, reptiles and amphibians, to the mammals and birds at the top of the food web. Additionally, waters in some stream reaches in the Pajaro River basin are locally impaired by elevated levels of un-ionized ammonia. Un-ionized ammonia (a nitrogen compound) is highly toxic to aquatic species. Reducing the amount of nutrients that enters streams in the Pajaro River basin will help to reduce the risks of biostimulation and nitrogen-related toxicity, and will help restore and maintain viable freshwater aquatic habitat.

In addition to adverse impacts to aquatic habitat, algal blooms resulting from biostimulation may also constitute a potential health risk and public nuisance to humans, their pets, and to livestock. The majority of freshwater harmful algal blooms reported in the United States and worldwide is due to one group of algae, cyanobacteria (blue-green algae), although other groups of algae can be harmful (Worcester and Taberski, 2012). Possible health effects of exposure to blue-green algae blooms and their toxins can include rashes, skin and eye irritation, allergic reactions, gastrointestinal upset, and other effects[6]. At high levels, exposure can result serious illness or death. These effects are not theoretical; worldwide animal poisonings and adverse human health effects have been reported by the World Health Organization (WHO, 1999). The California Department of Public Health and various County Health Departments have documented cases of dog die-offs throughout the state and the nation due to blue-green algae. Dogs can die when their owners allow them to swim or wade in waterbodies with algal blooms. Dogs are also attracted to fermenting mats of cyanobacteria near shorelines of waterbodies (Carmichael, 2011). Dogs reportedly die due to ingestion associated with licking algae and associated toxins from their coats.

Additionally, according to recent findings, algal toxins have been implicated in the deaths of central California southern sea otters (Miller et al., 2010). Currently, there reportedly have been no confirmations of human deaths in the U.S. from exposure to algal toxins, however many people have become ill from exposure, and acute human poisoning is a distinct risk (Dr. Wayne Carmichael of the Wright State University-Department of Biological Sciences, as reported in NBC News, 2009).

TMDL development intended to address nitrate pollution risks to human health and address degradation of aquatic habitat is consistent with the Central Coast Water Board's highest identified priorities. The Central Coast Water Board's two highest priority areas[7] (listed in priority order) are presented below:

Central Coast Water Board Top Two Water Quality Priorities

1) "Preventing and Correcting Threats to Human Health"
    - ✓ *Nitrate contamination is by far the most widespread threat to human health in the central coast region*
2) "Preventing and Correcting Degradation of Aquatic Habitat"
    - ✓ *"Including requirements for aquatic habitat protection in Total Maximum Daily Load Orders"*

Also noteworthy, the USEPA recently reported that nitrogen and phosphorus pollution, and the associated degradation of drinking and environmental water quality, has the potential to become one of the costliest and most challenging environmental problems the nation faces[8]. Over half of the nation's streams, including some steams in the Pajaro River Basin, have medium to high levels of nitrogen and phosphorus. According to USEPA, nitrate drinking water standard violations have doubled nationwide in

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[6] California Department of Public Health website, http://www.cdph.ca.gov

[7] See Staff Report (agenda item 3) for the July 11, 2012 Water Board meeting.

[8] USEPA: Memorandum from Acting Assistant Administrator Nancy K. Stoner. March 16, 2011. Subject: "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions".

eight years, and algal blooms, resulting from the biostimulatory effects of nutrients, are steadily on the rise nationwide; related toxins have potentially serious health and ecological effects[9]. Water quality monitoring in the Pajaro River basin demonstrates that streams in the river basin have locally been substantially impacted by nitrate.

Biostimulation of surface waters in the Pajaro River basin are documented in this report; these water quality impairments may also be contributing to localized, episodic adverse downstream nutrient impacts to ecologically sensitive coastal and estuarine areas of the Monterey Bay National Marine Sanctuary (refer to report Section 3.13). Also worth noting, citizens and local agencies have been working to preserve the riparian habitat of the Pajaro River and enhance opportunities for kayaking and canoeing. Kayaking and canoeing are types of water contact recreation available to the public on the Pajaro River, thus highlighting the importance of minimizing nuisance algae blooms and minimizing the current or future risk of algal cyanobacteria toxins (refer to report Section 4.1.5).

2.3 Updating & Replacement of the 2005 Pajaro River Nitrate TMDL

Upon approval by the Office of Administration Law, these TMDLs supersede and replace the TMDL *entitled "Pajaro River and Llagas Creek Total Maximum Daily Load for Nitrate"* which was approved by Resolution No. R3-2005-0131 on December 2, 2005 by the Central Coast Water Control Board , and subsequently approved by the USEPA on October 13, 2006. The 2005 Pajaro River nitrate TMDL addressed only nitrate surface water impairments for the drinking water supply beneficial use (MUN); the current TMDLs will update and supersede the 2005 nitrate TMDL by addressing nutrient-related impairments to all relevant designated beneficial uses of streams[10] in the Pajaro River basin.

2.4 A Note on Spatial Datasets & Scientific Certainty

Central Coast Water Board staff endeavored to use the best available spatial datasets from reputable scientific and public agency sources to render and assess physical, hydrologic, and biologic conditions in the Pajaro River basin. Spatial data of these types are routinely used in TMDL development and watershed studies nationwide. Where appropriate, staff endeavored to clearly label spatial data and literature-derived values as estimates in this project report, and identify source data and any assumptions.

It is important to recognize that the nature of public agency data and digital spatial data provide snapshots of conditions at the time the data was compiled, or are regionally-scaled and are not intended to always faithfully and accurately render all local, real-time, or site-specific conditions. When reviewing TMDLs, the USEPA will recognize these types of datasets as estimates, approximations, and scoping assessments. As appropriate, closer assessments of site specific conditions and higher resolution information about localized pollution problems would be conducted during TMDL implementation.

Also noteworthy is that while science is one cornerstone of the TMDL program, a search for full scientific certainty and a resolution of all uncertainties is not contemplated or required in TMDLs adopted in accordance with the Clean Water Act, and pursuant to U.S. Environmental Agency (USEPA) guidance. Staff endeavored to identify uncertainties in the TMDL, and reduce uncertainties where possible on the basis of available data. It should be recognized that from the water quality risk management perspective, scientific certainty is balanced by decision makers against the necessities of addressing risk management. Conceptually, this issue is highlighted by reporting from the U.S. National Research Council as shown below:

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[9] *Ibid*

[10] In the context of this TMDL project "streams" refer to any body of running water (such as a river, creek, brook, slough, canal, ditch, ephemeral drainage) which flows on the earth's surface within the area shown on Figure 3-2.

> *“**Scientific uncertainty is a reality within all water quality programs, including the TMDL program that cannot be entirely eliminated.** The states and EPA should move forward with decision-making and implementation of the TMDL program in the face of this uncertainty while making substantial efforts to reduce uncertainty. Securing designated uses is limited not only by a focus on administrative rather than water quality outcomes in the TMDL process, but also by unreasonable expectations for predictive certainty among regulators, affected sources, and stakeholders… Although science should be one cornerstone of the program, an unwarranted search for scientific certainty is detrimental to the water quality management needs of the nation. Recognition of uncertainty and creative ways to make decisions under such uncertainty should be built into water quality management policy.”*
>
> *From: National Academy of Sciences – National Research Council (2001)*
>
> *Report issued pursuant to a request from the U.S. Congress to assess the scientific basis of the TMDL program: National Research Council, 2001. “Assessing the TMDL Approach to Water Quality Management – Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction, Water Science and Technology Board”*
>
> *(Emphasis not added – emphasis as published in the original National Research Council report)*

3 RIVER BASIN SETTING

3.1 Informational Background

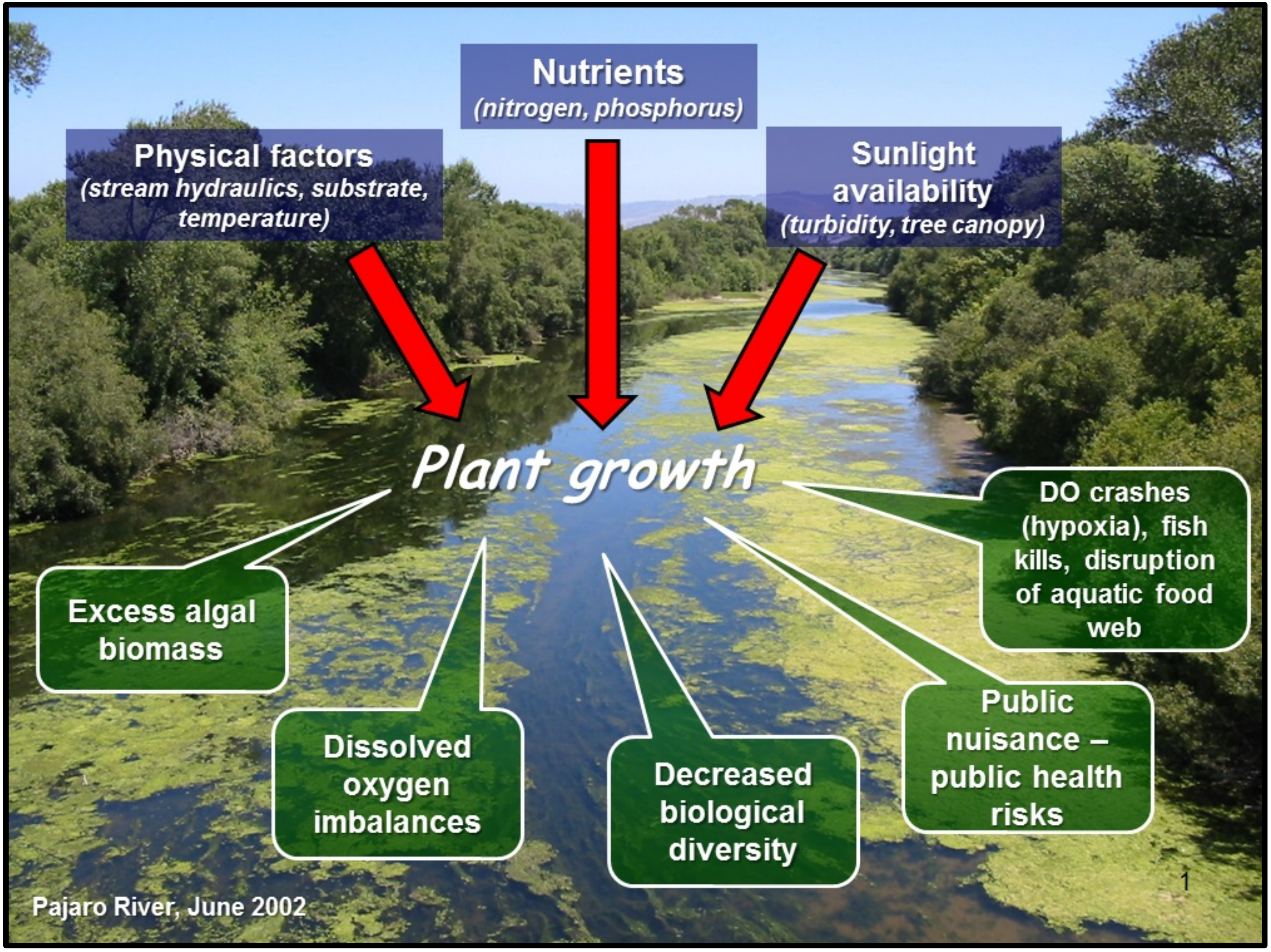
This section of this report presents substantial amounts of information on the river basin setting for this TMDL project. Understanding and assessing variation in river basin characteristics is important to the development of water quality criteria for nutrients. Human activities can result in discharge of nutrients (specifically nitrogen and phosphorus) to waterbodies, but nutrients are also naturally present and ubiquitous in the environment.

It is important to recognize that documenting high nitrogen and phosphorus concentrations is not sufficient in and of itself to demonstrate a risk of eutrophication. Research has demonstrated the shortcomings of using ambient nutrient concentrations within a waterbody alone to predict eutrophication, particularly in streams (Tetra Tech, 2006). Tetra Tech (2006) notes that except in extreme cases, nutrients alone do not impair beneficial uses. Rather, they cause indirect impacts through algal growth, low dissolved oxygen, etc., that impair uses. These impacts are associated with nutrients, but result from a combination of nutrients interacting with other physical and biological factors. Other factors that can combine with nutrient enrichment to contribute to biostimulatory effects include light availability (shading and tree canopy), stream hydraulics, geomorphology, geology, and other physical and biological attributes (see Figure 3-1).

As such, nutrient criteria need to be developed to account for natural variation existing at the regional and/or watershed-scale. To reiterate: nutrient water column concentration data by itself is generally not sufficient to evaluate biostimulatory conditions and develop numeric nutrient criteria. Waterbodies in the Pajaro River basin have substantial variation in stream hydraulics, stream morphology, tree canopy and other factors. Accordingly, this section of the TMDL report presents information on relevant physical and biological watershed characteristics for the Pajaro River basin that can potentially be important to consider in the development of nutrient criteria for streams.

Therefore, staff endeavored to characterize the river basin as fully as possible both to assist in development of defensible nutrient water quality criteria (where needed) and to assess natural inputs of nutrients in the watershed. The information and data on watershed conditions are presented in this section of the project report.

Figure 3-1. Biostimulation (excessive aquatic plant growth) can result from a combination of contributing factors. The consequences of biostimulation may include a cascade of adverse environmental impacts (figure loosely based on an undated powerpoint slide by K. Worcester, Central Coast Water Board).



3.2 TMDL Project Area & Watershed Delineation

The geographic scope of this TMDL project[11] encompasses approximately 1,300 square miles of the Pajaro River basin located in parts of Santa Clara, Santa Cruz, San Benito, and Monterey counties (see Figure 3-2). The Pajaro River mainstem begins just west of San Felipe Lake (also called Upper Soda Lake) approximately 5 miles east-southeast of the city of Gilroy. From there, the Pajaro River flows west for 30 miles through south Santa Clara Valley, through the Chittenden Gap, past the city of Watsonville, and ultimately forming an estuary/lagoon system at the river mouth at the coastal confluence with Monterey Bay. A sand bar forms across the mouth of the Pajaro River in many years, and thus direct discharge into Monterey Bay occurs only episodically when the sand bar is breached. Major tributaries of the Pajaro River include the San Benito River, Pacheco Creek, Llagas Creek, Uvas Creek, Watsonville Slough, and Corralitos Creek.

The human population of the Pajaro River basin is approximately 233,000 people, with an average of 3.22 people per housing unit according to 2010 Census Bureau data. Agriculture, including livestock grazing lands and cultivated cropland, is the current dominant human land use in the river basin. Urbanized land use comprises 4% of the river basin's land area. Undeveloped lands, including grassland, shrubland and forest also comprise substantial parts of the upland reaches of the river basin

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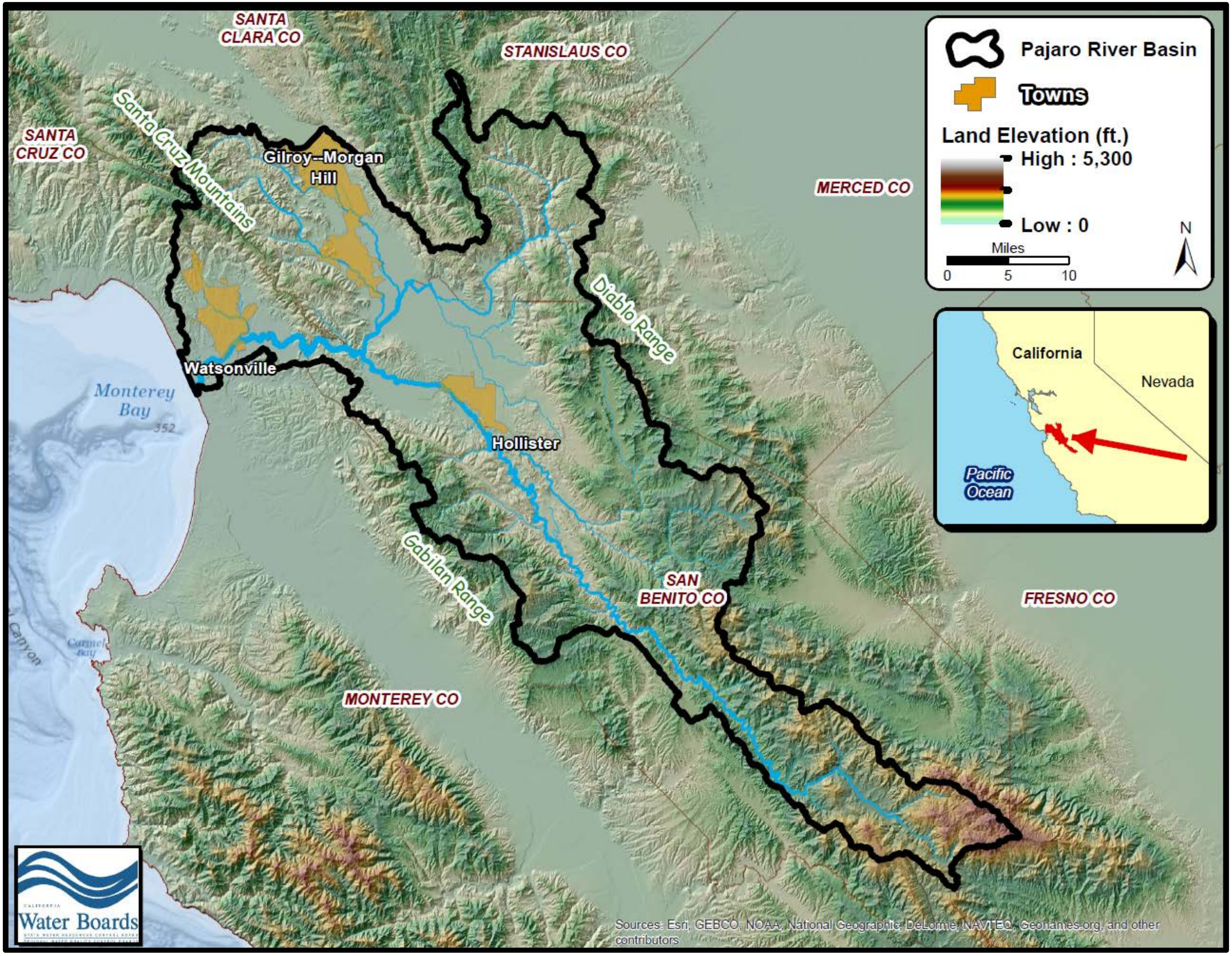
[11] In the context of this report, the terms "TMDL project area" and "Pajaro River Basin" are used interchangeably and refer to the same geographic area.

within an ecosystem characterized locally by oak woodland, annual grasslands, montane hardwood, and coastal scrub (source: National Land Cover Dataset, 2006; Calif. Dept. of Forestry and Fire Protection, 1977).

Figure 3-2. TMDL Project area – the Pajaro River basin.



Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

ESRI™ ArcMap® 10.1 was used to create watershed layers for the Pajaro River basin. Drainage boundaries of the TMDL project area can be delineated on the basis of the Watershed Boundary Dataset[12], which contain digital hydrologic unit boundary layers organized on the basis of Hydrologic Unit Codes. Hydrologic Unit Codes (HUCs) were developed by the United States Geological Survey to identify all the drainage basins of the United States.

Watersheds range in all sizes, depending on how the drainage area of interest is spatially defined, if drainage areas are nested, and on the nature and focus of a particular hydrologic study. Watersheds can be characterized by a hierarchy as presented in Table 3-1.

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[12] The Watershed Boundary Dataset (WBD) is developed by federal agencies and national associations. WBD contains watershed boundaries that define the areal extent of surface water drainage to a downstream outlet. WBD watershed boundaries are determined solely upon science-based principles, not favoring any administrative boundaries.

Table 3-1. Watershed heirachy used in this TMDL project [A].

Hydrologic Unit	Drainage Area mi^2 (approx.)	Example(s)	Spatial Data Reference (USGS Hydrologic Unit Code shapefiles)
basin	$\geq$ 1,000	Pajaro River basin	Watershed Boundary Dataset HUC-8 shapefiles
subbasin	> 250 to < 1,000	San Benito River subbasin	2 or 3 HUC-10s [B] *(spatial dissolve)*
watershed	~ 100 to ~ 250	Llagas Creek watershed	Watershed Boundary Dataset HUC-10 shapefiles
subwatershed	> 10 to < 100	Salsipuedes Creek subwatershed	Watershed Boundary Dataset HUC-12 shapefiles
catchment	~ 1 to < 10	Beach Road Ditch catchment Tar Springs Creek catchment	National Hydrography Dataset catchment shapefiles

[A] Based on adaptation from Jonathan Brant, PhD, and Gerald J. Kauffman, MPA, PE (2011) Water Resources and Environmental Depth Reference Manual for the Civil Professional Engineer Exam.

[B] This is approximately equivalent to "Hydrologic Area" in the CalWater 2.2 watershed convention, and is developed here to allow for distinct drainage areas that are smaller than a river basin, but larger than a United States Geological Survey (USGS) HUC-10 watershed.

The Pajaro River basin is delineated at the HUC-8 hydrologic unit scale (HUC 18060002). Individual watersheds at the HUC-10 hydrologic unit scale that are nested within the Pajaro River basin were delineated by digitally clipping HUC-10 watershed shapefiles using the Pajaro River basin shapefile as a mask. Based on HUC delineations, there are three distinct subbasins nested within the Pajaro River basin: the 1) Pajaro River subbasin[13]; the 2) San Benito River subbasin[14]; and the 3) Pacheco Creek subbasin[15] (see Figure 3-3).

There are eight distinct watersheds, delineated at the HUC-10 scale, located within these three subbasins, as shown in Figure 3-3.

A total of 36 subwatersheds delineated at the HUC-12 scale are nested with the Pajaro River basin (subwatersheds are shown in Figure 3-4).

A summary of the Pajaro River basin's watershed hierarchy is presented in Table 3-2.

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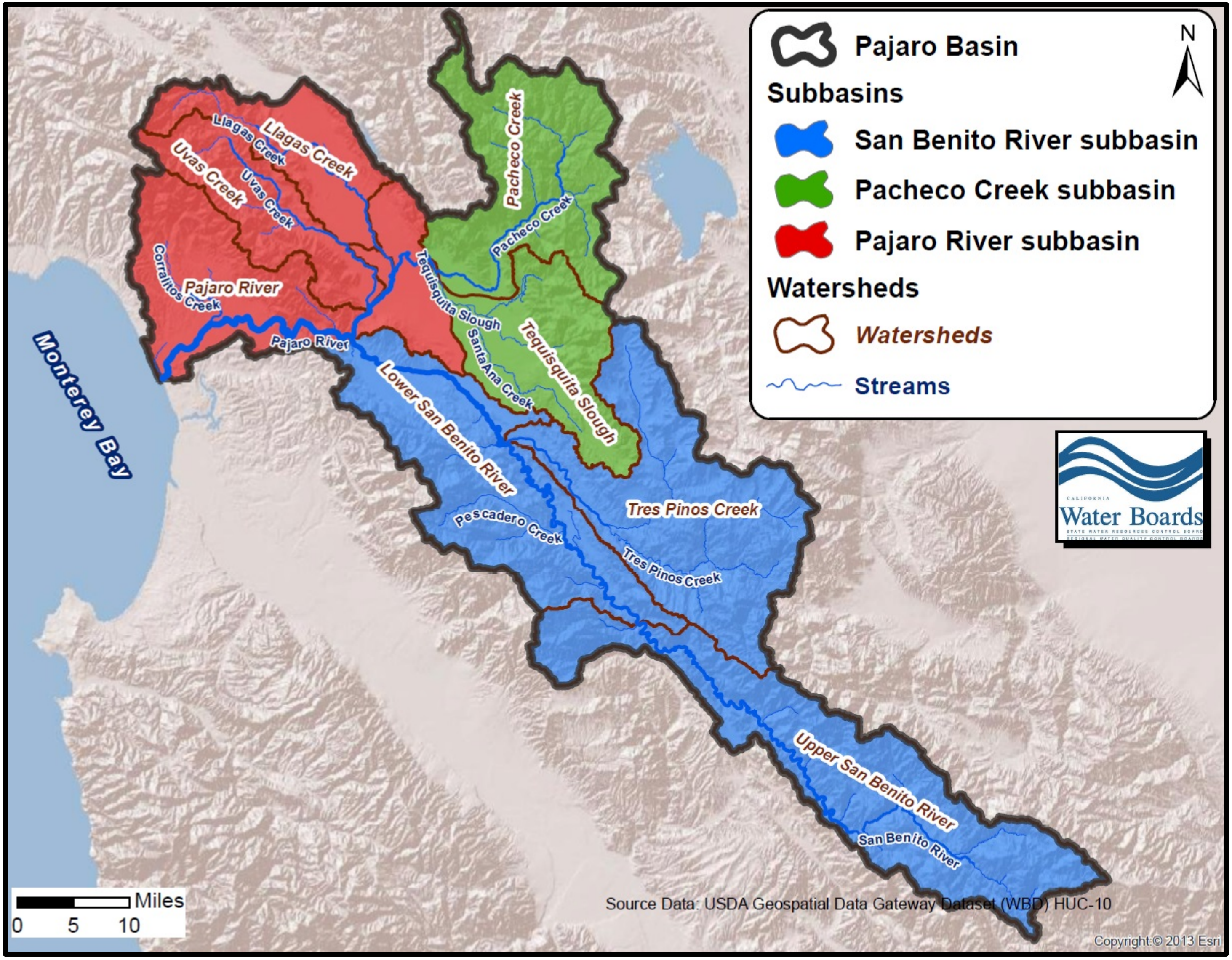
[13] In the CalWater 2.2 watershed convention, this area corresponds approximately to the Watsonville, Santa Cruz Mountains, and South Santa Clara Valley hydrologic areas.

[14] In the CalWater 2.2 watershed convention, this area corresponds to the San Benito River hydrologic area.

[15] In the CalWater 2.2 watershed convention, this area corresponds approximately to the Pacheco-Santa Ana Creek hydrologic area.

Figure 3-3. subbasins and watersheds nested within the Pajaro River basin.



Source Data: USDA Geospatial Data Gateway Dataset (WBD) HUC-10

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Table 3-2. TMDL watershed hierarchy (basins, subbasins, watersheds, and subwatersheds).

Name	**Hydrologic Scale**	**Data Source (HUC)**	**Drainage Area (square miles)**
Pajaro River basin	**basin**	WBD 8-digit Hydrologic Unit Code *HUC # 18060004*	1,300.6
Pajaro River subbasin[A]	**subbasin** *within the Pajaro River basin*	Spatial dissolve on WBD 10-digit Hydrologic Unit Codes *1806000203* *1806000204* *1806000208*	355.6
San Benito River subbasin[B]	**subbasin** *within the Pajaro River basin*	Spatial dissolve on WBD 10-digit Hydrologic Unit Codes *1806000205* *1806000206* *1806000207*	660.8
Pacheco Creek subbasin[C]	**subbasin** *within the Pajaro River basin*	Spatial dissolve on WBD 10-digit Hydrologic Unit Codes *1806000201* *1806000202*	284.2

Name	Hydrologic Scale	Data Source (HUC)	Drainage Area (square miles)
Llagas Creek watershed	**watershed** *within the Pajaro River subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000203*	84.6
Pajaro River watershed	**watershed** *within the Pajaro River subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000208*	184.3
Uvas Creek watershed	**watershed** *within the Pajaro River subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000204*	86.7
Lower San Benito River watershed	**watershed** *within the San Benito River subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000207*	198.2
Upper San Benito River watershed	**watershed** *within the San Benito River subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000205*	243.2
Tres Pinos Creek watershed	**watershed** *within the San Benito River subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000206*	219.4
Pacheco Creek watershed	**watershed** *within the Pacheco Creek subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000202*	167.9
Tequisquita Slough watershed	**watershed** *within the Pacheco Creek subbasin*	WBD 10-digit Hydrologic Unit Code *HUC # 1806000201*	116.3
Subwatersheds of the Pajaro River basin	**subwatersheds**	WBD 12-digit Hydrologic Unit Codes See Figure 3-4 and Table 3-3 for subwatershed information	

[A] *In the CalWater 2.2 watershed convention, this subbasin corresponds approximately to the Watsonville, Santa Cruz Mountains, and South Santa Clara Valley hydrologic areas.*

[B] *In the CalWater 2.2 watershed convention, this subbasin corresponds to the San Benito River hydrologic area.*

[C] *In the CalWater 2.2 watershed convention, this subbasin corresponds to the Pacheco-Santa Ana Creek hydrologic area.*

Within each HUC-10 watershed, higher resolution subwatershed delineation of Pajaro River basin stream reaches and associated drainage areas were delineated on the basis of HUC-12 shapefiles. According to the Watershed Boundary Dataset's HUC-12 delineations, there are 36 distinct subwatersheds within the Pajaro River basin. Figure 3-4 illustrates the individual subwatersheds developed for the Pajaro River basin. Table 3-3 tabulates the names and the areal sizes of the subwatersheds. It should be noted that at high-resolution spatial scales (e.g., individual parcels), site-specific engineering, such as man-made water conveyance structures or grading, can result in parcel-scale drainage that runs counter to topographic elevation direction. Thus, the lower spatial resolution drainage patterns of watersheds and subwatershed delineations may not necessarily represent hydrologic drainage patterns at localized parcel and catchment scales.

Figure 3-4. Map of subwatersheds (HUC-12 delineations) with numeric identifiers located within the Pajaro River basin. The subwatershed names with their associated numeric identifiers are tabulated in Table 3-3.

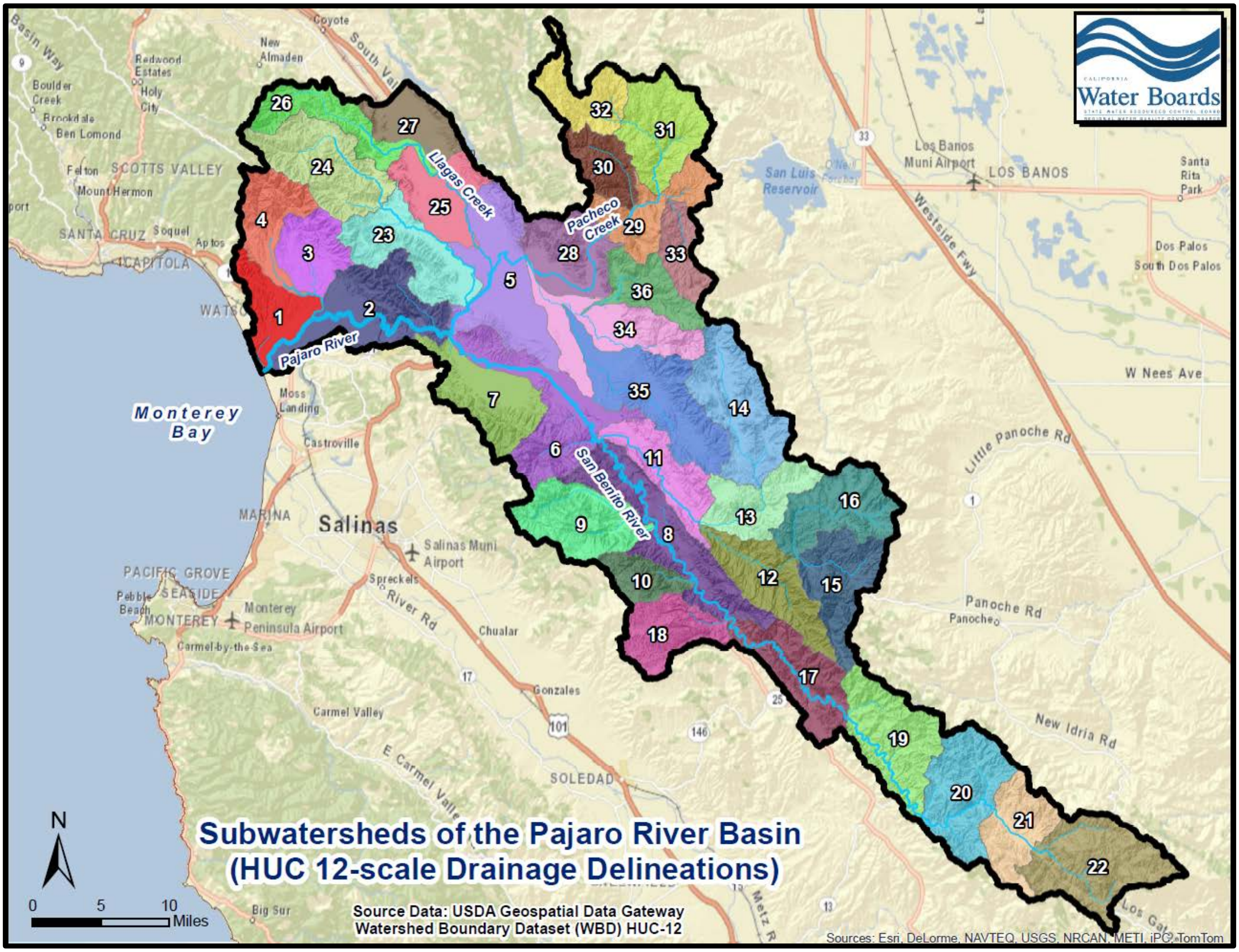

Table 3-3. Tabular summary of Pajaro River basin subwatersheds as shown in Figure 3-4.

Subwatershed Numeric ID	Subwatershed (HUC 12) Name	U.S. Acres	Square Miles	Major Hydrologic Modification(s)[A]	The subwatershed is located within this watershed (HUC 10)
1	Watsonville Slough	15,551	24.3	Levee	Pajaro River Watershed
2	Lower Pajaro River	33,285	52.0	Levee	Pajaro River Watershed
3	Salsipuedes Creek	15,881	24.8	Levee	Pajaro River Watershed
4	Corralitos Creek	17,789	27.8	Levee	Pajaro River Watershed
5	Upper Pajaro River	35,467	55.4	Levee	Pajaro River Watershed
6	Bird Creek-San Benito River	32,742	51.2	No Modifications	Lower San Benito River Watershed
7	San Juan Canyon	24,415	38.1	No Modifications	Lower San Benito River Watershed
8	Paicines Reservoir-San Benito River	33,976	53.1	No Modifications	Lower San Benito River Watershed
9	Pescadero Creek	25,665	40.1	No Modifications	Lower San Benito River Watershed
10	Stone Creek	10,060	15.7	No Modifications	Lower San Benito River Watershed
11	Lower Tres Pinos Creek	17,851	27.9	Pipe Diversion	Tres Pinos Creek Watershed
12	Middle Tres Pinos Creek	22,997	35.9	Pipe Diversion	Tres Pinos Creek Watershed

Subwatershed Numeric ID	Subwatershed (HUC 12) Name	U.S. Acres	Square Miles	Major Hydrologic Modification(s) [A]	The subwatershed is located within this watershed (HUC 10)
13	Los Muertos Creek	18,928	29.6	Pipe Diversion	Tres Pinos Creek Watershed
14	Quien Sabe Creek	32,669	51.0	No Modifications	Tres Pinos Creek Watershed
15	Upper Tres Pinos Creek	23,240	36.3	Pipe Diversion	Tres Pinos Creek Watershed
16	Las Aguilas Creek	24,730	38.6	Pipe Diversion	Tres Pinos Creek Watershed
17	Sulphur Creek-San Benito River	24,174	37.8	No Modifications	Upper San Benito River Watershed
18	Willow Creek	18,585	29.0	No Modifications	Upper San Benito River Watershed
19	Rock Springs Creek-San Benito River	29,781	46.5	No Modifications	Upper San Benito River Watershed
20	James Creek-San Benito River	28,740	44.9	No Modifications	Upper San Benito River Watershed
21	Hernandez Reservoir-San Benito River	19,512	30.5	No Modifications	Upper San Benito River Watershed
22	Clear Creek-San Benito River	34,843	54.4	No Modifications	Upper San Benito River Watershed
23	Lower Uvas Creek	25,690	40.1	No Modifications	Uvas Creek Watershed
24	Upper Uvas Creek	29,823	46.6	No Modifications	Uvas Creek Watershed
25	Lower Llagas Creek	20,007	31.3	Levee	Llagas Creek Watershed
26	Upper Llagas Creek	18,737	29.3	Levee	Llagas Creek Watershed
27	Little Llagas Creek	15,392	24.1	Levee	Llagas Creek Watershed
28	Lower Pacheco Creek	21,986	34.4	Reservoir, General Canal	Pacheco Creek Watershed
29	Upper Pacheco Creek	18,334	28.6	Reservoir, General Canal	Pacheco Creek Watershed
30	Cedar Creek	12,766	19.9	No Modifications	Pacheco Creek Watershed
31	Lower North Fork Pacheco Creek	25,771	40.3	No Modifications	Pacheco Creek Watershed
32	Upper North Fork Pacheco Creek	17,079	26.7	No Modifications	Pacheco Creek Watershed
33	South Fork Pacheco Creek	11,518	18.0	No Modifications	Pacheco Creek Watershed
34	Tequisquita Slough	25,964	40.6	General Canal	Tequisquita Slough Watershed
35	Santa Ana Creek	33,717	52.7	No Modifications	Tequisquita Slough Watershed
36	Arroyo De Las Viboras	14,742	23.0	General Canal	Tequisquita Slough Watershed
Total		832,406	1,300.6		

[A] This column identifies any type of man-made modification(s) to natural overland flow that alters the location of the hydrologic unit boundary for a HUC-12 subwatershed, on the basis of attribute data provided with the Watershed Boundary Dataset.

3.3 Land Use & Land Cover

Land use conditions play an important role in pollutant loading to water resources in any given watershed, thus evaluating land use and land cover is an important part of TMDL development. Historical land cover conditions in parts of the Pajaro River basin (south Santa Clara Valley), prior to Euro-American modification, are available as spatial datasets from the San Francisco Bay Estuary Institute[16] (see Figure 3-5). These datasets provide some insight into what land cover conditions were in historical lowland ecosystems of the Pajaro River basin prior to substantial human modification. The lowlands associated with the Santa Clara Valley in historic times were characterized predominantly by grasslands, oak savannah, oak woodlands, freshwater marshes, wet meadows, and alkali meadows. Also worth noting, 1917-vintage topographic maps of the southern Santa Clara Valley indicate there were still substantial areas of freshwater marshes in the vicinity of Gilroy and the lower Llagas Creek area at that time (U.S. Geological Survey, 1917a and 1917b).

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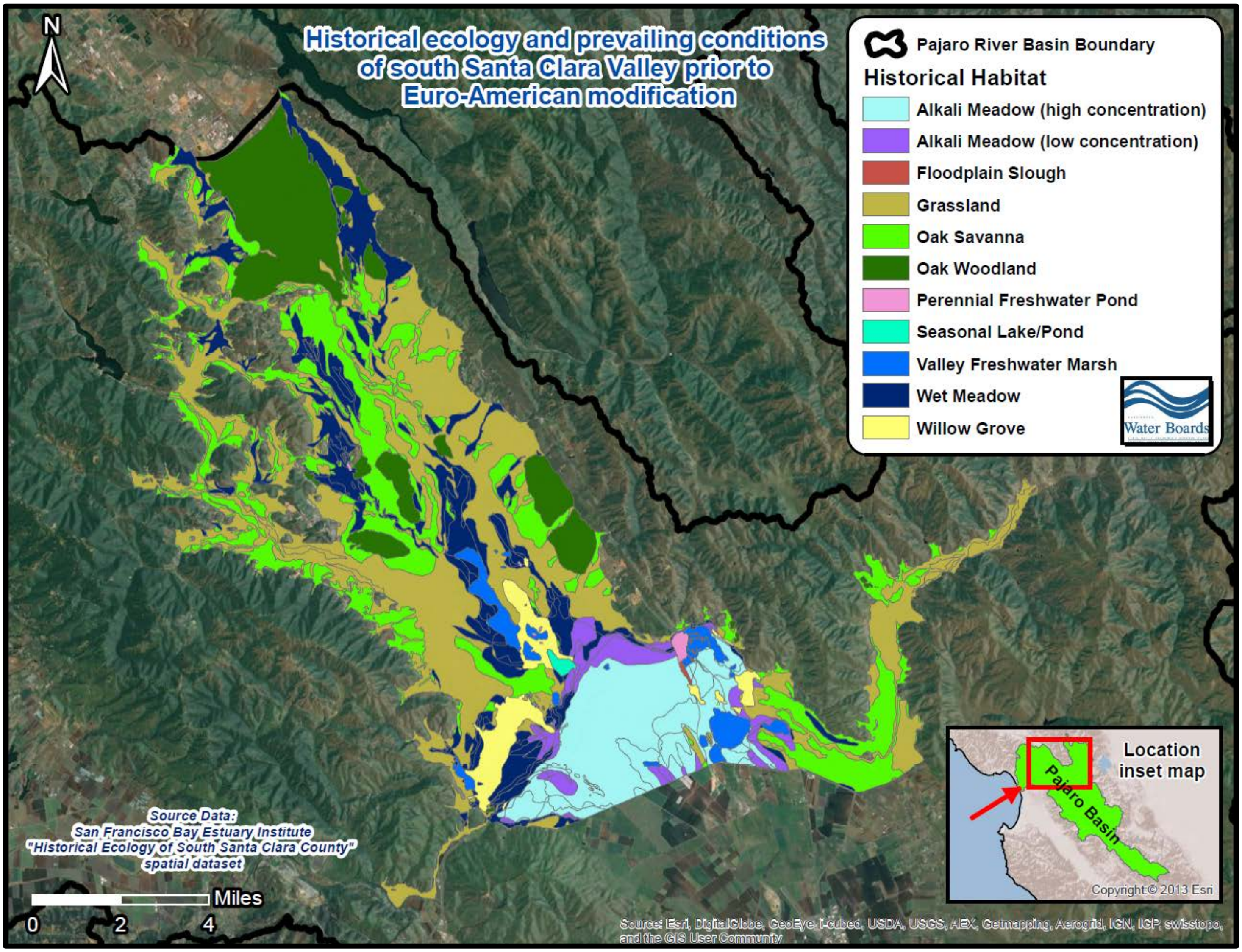
[16] Source data – Robin Grossinger, San Francisco Estuary Institute. Title: *South Santa Clara Valley Historical Landscape*. This database contains several feature classes representing a reconstruction of the historical landscape and prevailing conditions of south Santa Clara Valley prior to Euro-American modification. This dataset integrates many sources of data describing the historical features of south Santa Clara Valley. Extensive supporting information, including bibliographic references and research methods, can be found in the south Santa Clara Valley report. Online linkage: http://gis.sfei.org/geofetch/catalog/search/search.page

Figure 3-5. Historical ecology and landscape conditions of the southern Santa Clara Valley prior to Euro-American modification.



Modern land use and land cover in the Pajaro River basin can be evaluated from digital data provided by the California Department of Conservation Farmland Mapping and Monitoring Program. The Farmland Mapping and Monitoring Program maps are updated every two years with the use of aerial photographs, a computer mapping system, public review, and field reconnaissance. For this TMDL Report, the 2010 Farmland Mapping and Monitoring Program mapping data was used. Table 3-4 presents the Farmland Mapping and Monitoring land use–land cover categories as defined by the Department of Conservation.

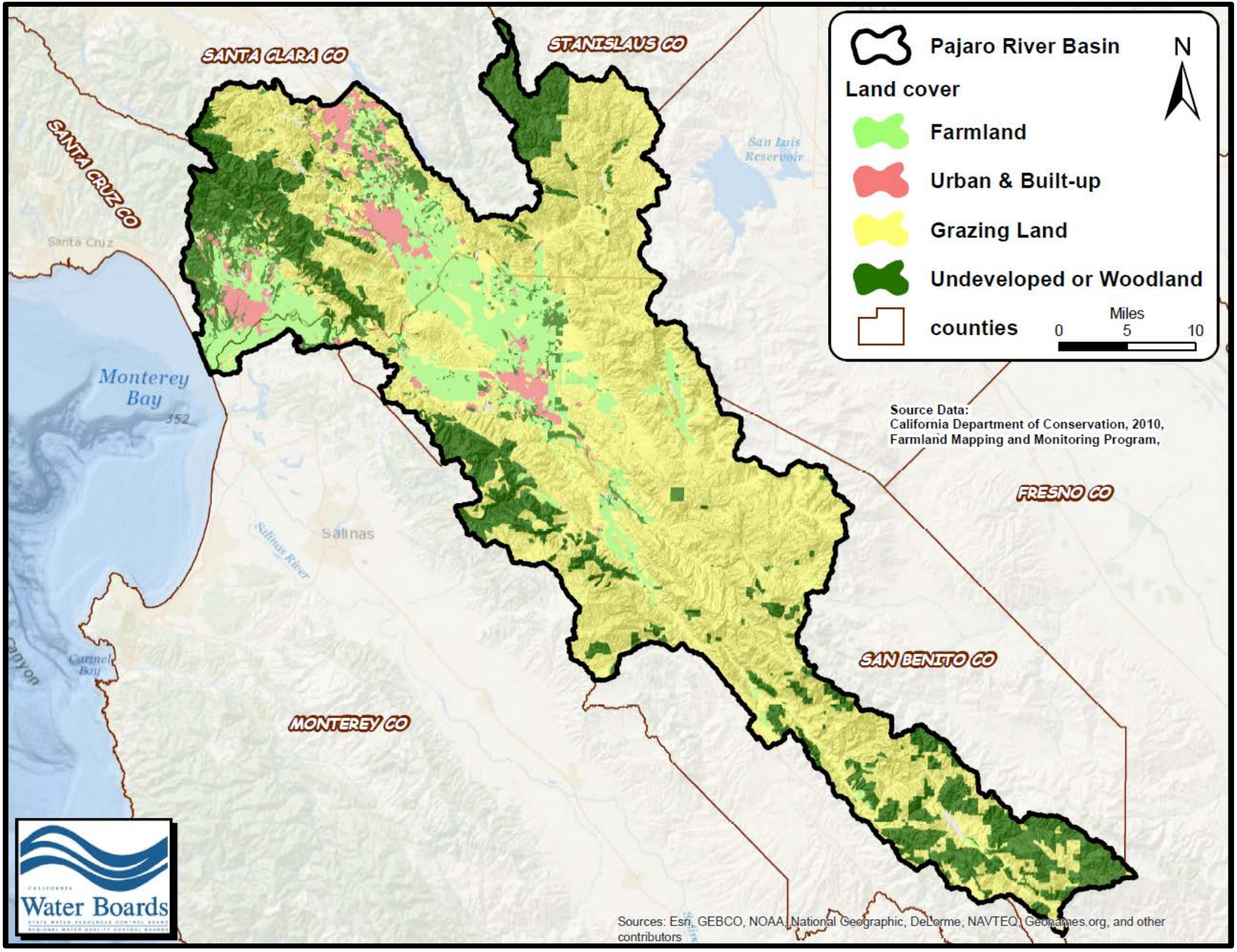
Table 3-4. Land use-land cover categories used in this TMDL report and as defined by the California Department of Conservation's Farmland Mapping and Monitoring Program.

Land Use / Land Cover	**Description** **(with alphabetic code)** **as defined by Farmland Mapping and Monitoring Program** [A]
Farmland	*The aggregate category "Farmland" used in this TMDL report includes several categories defined by the Farmland Mapping and Monitoring Program, as shown below:* Prime Farmland (P): Irrigated land with the best combination of physical and chemical features able to sustain long-term production of agricultural crops. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for production of irrigated crops at some time during the four years prior to the mapping date. Farmland of Statewide Importance (S): Irrigated land similar to Prime Farmland that has a good combination of physical and chemical characteristics for the production of agricultural crops. This land has minor shortcomings, such as greater slopes or less ability to store soil moisture than Prime Farmland. Land must have been used for production of irrigated crops at some time during the four years prior to the mapping date. Unique Farmland (U): Lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated, but may include non-irrigated orchards or vineyards as found in some climatic zones in California. Land must have been cropped at some time during the four years prior to the mapping date. Farmland of Local Importance (L)
Urban and Built-up Land	Urban and Built-Up Land (D)**:** Urban and Built-Up land is occupied by structures with a building density of at least 1 unit to 1.5 acres, or approximately 6 structures to a 10-acre parcel. Common examples include residential, industrial, commercial, institutional facilities, cemeteries, airports, golf courses, sanitary landfills, sewage treatment, and water control structures.
Grazing Land	Grazing Land (G)**:** Land on which the existing vegetation is suited to the grazing of livestock. This category is used only in California and was developed in cooperation with the California Cattlemen's Association, University of California Cooperative Extension, and other groups interested in the extent of grazing activities. The minimum mapping unit for Grazing Land is 40 acres.
Other Land (Woodland, Undeveloped, or Restricted)	Other Land (X)**:** Land which does not meet the criteria of any other category. Typical uses include low-density rural development, heavily forested land, mined land, or government land with restrictions on use**.**
Open Water	Water (W)**:** Water areas with an extent of at least 40 acres.

[A] *Land use-Land cover dataset: California Department of Conservation Farmland Mapping and Monitoring Program (2010)*

Figure 3-6 illustrates land use and land cover in the Pajaro River basin. As one would expect, agricultural lands, and developed or urbanized lands generally comprise the majority of the lowlands areas within the river basin. Upland areas are typically characterized chiefly by grasslands, woodlands, and natural areas.

Figure 3-6. Land use – land cover of the Pajaro River basin (year 2010).



Source Data:
California Department of Conservation, 2010,
Farmland Mapping and Monitoring Program,

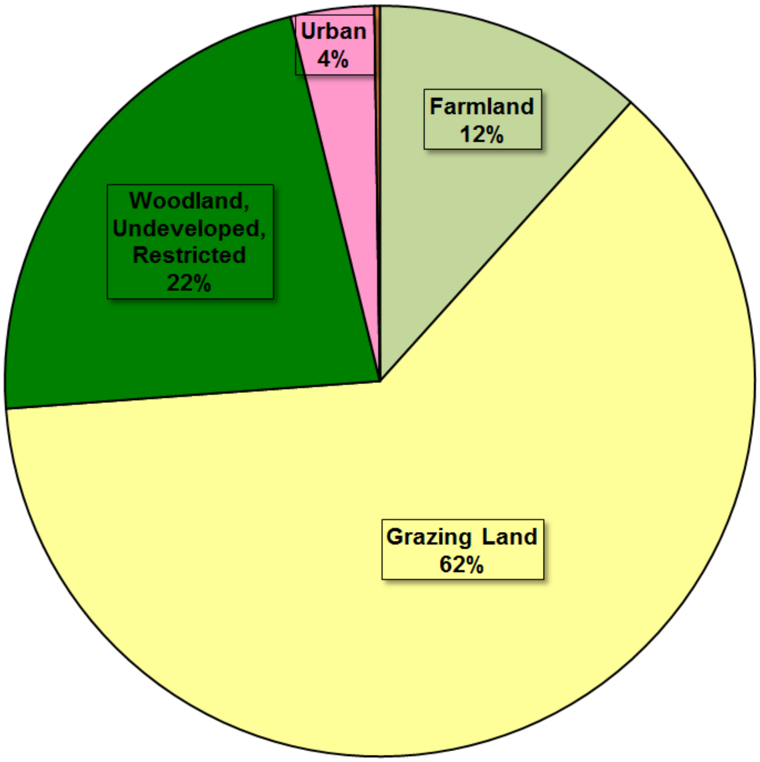
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

Table 3-5 tabulates the distribution of land cover in the Pajaro River basin. The river basin as a whole is largely comprised of grazing lands, woodlands and undeveloped areas. Agricultural lands and urban lands are concentrated in the lowland areas of south Santa Clara Valley, and the Pajaro Valley. The overwhelming majority of identified stream water quality impairments are associated with stream reaches in these lowland areas.

Table 3-6 presents the distribution of land cover at a higher spatial resolution; the table tabulates land cover estimates for all the subwatersheds nested within the Pajaro River basin.

Table 3-7 presents the distribution of land cover in selected drainages of particular interest at the catchment hydrologic scale (i.e., drainages less than 10 square miles in size).

Table 3-5. Tabulation of estimated land use/land cover in the Pajaro River basin (year 2010).

River Basin Land Cover (Year 2010)[A,B]	**U.S. Acres**	**River Basin Land Cover Pie Chart**
Urban and Built-Up Land	29,945	
Farmland	97,114	
Grazing Land	517,322	
Other Land (Woodland, Undeveloped, or Restricted)	185,867	
Open Water	1,964	
Vacant or Disturbed Land [C]	12	
Total	832,225	

[A] Source: Calif. Dept. of Conservation, Farmland Mapping and Monitoring Program (2010)

[B] The total acreage in this table is negligibly smaller (by less than 200 acres) than the size of the Pajaro River basin total drainage area previously reported in Section 3.2 of this report. This is due to very small differences between the Farmland Mapping and Monitoring Program dataset that is reported by county (and thus delineated on the basis of county boundaries) and the Watershed Boundary Dataset that is report by drainage area. The areal extents of these two datasets are slightly different in some areas of the Pajaro River basin. It should be noted that these difference amount to 181 acres total which is insignificant compared to the total size of the Pajaro River basin of over 832,000 acres.

[C] This land cover category is only used and reported by Fresno County in the 2010 Farmland Mapping and Monitoring Program dataset; there is a tiny sliver of Fresno County that overlaps the Pajaro River basin in the upper San Benito River Subbasin area. Other counties in the Pajaro River basin do not use or report this land cover category.

Table 3-6. Estimated land cover (year 2010)[A] tabulated by subwatershed (units = U.S. acres).

Subwatershed Name (HUC-12 drainage scale)	**Farmland**	**Urban & Built Up**	**Woodland, Undeveloped, or Restricted**	**Grazing Lands**	**Open Water**	**Vacant or Disturbed Land**	**Total**
Watsonville Slough	5,049	4,178	5,952	292	0	N.A.	15,472
Lower Pajaro River	11,321	963	9,321	11,680	0	N.A.	33,285
Salsipuedes Creek	4,019	1,342	7,993	2,344	183	N.A.	15,881
Corralitos Creek	2,594	1,108	13,909	178	0	N.A.	17,789
Upper Pajaro River	19,596	1,313	1,070	13,487	0	N.A.	35,466
Bird Creek-San Benito River	3,779	3,034	8,424	17,505	0	N.A.	32,742
San Juan Canyon	6,136	927	5,774	11,360	218	N.A.	24,415
Paicines Reservoir-San Benito River	4,354	16	2,610	26,909	87	N.A.	33,976
Pescadero Creek	672	87	11,420	13,486	0	N.A.	25,665
Stone Creek	5	0	1,922	8,133	0	N.A.	10,060
Lower Tres Pinos Creek	2,179	231	1,468	13,973	0	N.A.	17,850
Middle Tres Pinos Creek	19	0	508	22,470	0	N.A.	22,997
Los Muertos Creek	42	0	710	18176	0	N.A.	18,928
Quien Sabe Creek	3,172	0	116	29268	105	N.A.	32,662

Subwatershed Name (HUC-12 drainage scale)	Farmland	Urban & Built Up	Woodland, Undeveloped, or Restricted	Grazing Lands	Open Water	Vacant or Disturbed Land	Total
Upper Tres Pinos Creek	81	0	2,243	20,916	0	N.A.	23,240
Las Aguilas Creek	0	0	220	24,509	0	N.A.	24,730
Sulphur Creek-San Benito River	461	0	2,802	20911	0	N.A.	24,174
Willow Creek	41	0	2,583	15,962	0	N.A.	18,585
Rock Springs Creek-San Benito River	303	0	6,397	23,080	0	N.A.	29,781
James Creek-San Benito River	10	0	12,401	16,330	0	N.A.	28,740
Hernandez Reservoir-San Benito River	178	0	9,888	8,821	625	N.A.	19,512
Clear Creek-San Benito River	0	0	21,625	13,205	0	12	34,843
Lower Uvas Creek	4,142	1,602	6,269	13,677	0	N.A.	25,690
Upper Uvas Creek	316	201	13,491	15,576	238	N.A.	29,823
Lower Llagas Creek	5,378	5,442	4,467	4,721		N.A.	20,007
Upper Llagas Creek	505	1,232	2,713	14,056	231	N.A.	18,737
Little Llagas Creek	2,216	5,257	2,636	5,284	0	N.A.	15,392
Lower Pacheco Creek	4,172	192	1,717	15,796	109	N.A.	21,986
Upper Pacheco Creek	0	0	222	18,094	0	N.A.	18,316
Cedar Creek	0	0	4,876	7890	0	N.A.	12,766
Lower North Fork Pacheco Creek	0	0	688	24,891	167	N.A.	25,746
Upper North Fork Pacheco Creek	0	0	15,667	1,372	0	N.A.	17,040
South Fork Pacheco Creek	0	0	10	11,497	0	N.A.	11,507
Tequisquita Slough	8,966	1,966	2,393	12,638	0	N.A.	25,964
Santa Ana Creek	7,084	853	1,177	24,603	0	N.A.	33,717
Arroyo De Las Viboras	327	0	184	14,229	0	N.A.	14,740

[A] Land use-Land cover dataset: California Department of Conservation Farmland Mapping and Monitoring Program (2010)
N.A. = not applicable, this land cover category is specific to Fresno County.

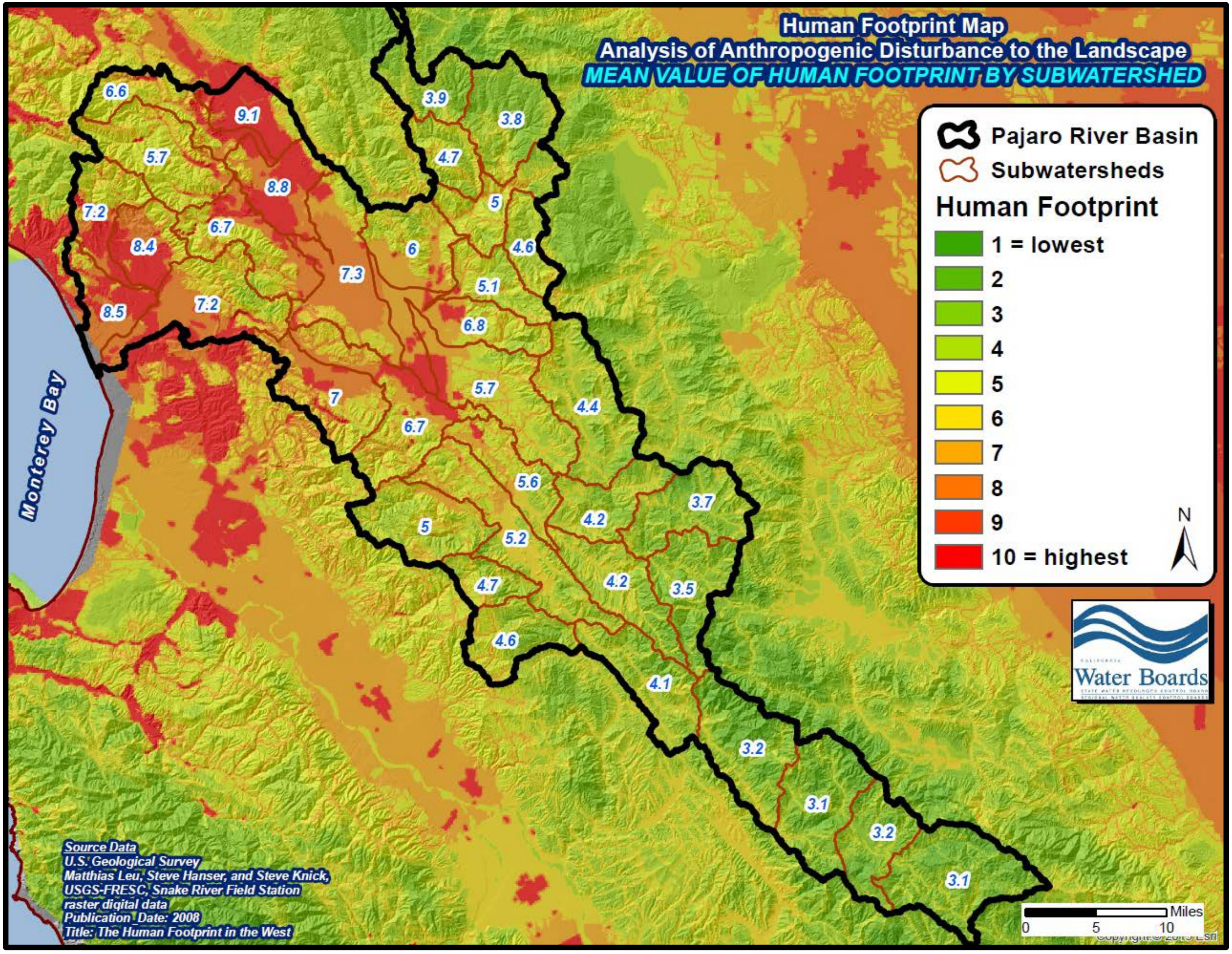
Table 3-7. Estimated land cover of catchment-size drainages of particular interest (units = U.S. acres).

Catchment	this catchment occurs within this subwatershed [A]	Farmland	Urban & Built Up	Woodland, Undeveloped, or Restricted	Grazing Lands	Total
McGowan Ditch [B]	Lower Pajaro River Subwatershed	1,634	258	662	0	2,554
Miller Canal [C]	Upper Pajaro River Subwatershed	3,112	67	75	277	3,531
Beach Road Ditch [D]	Watsonville Slough Subwatershed	1,675	0	0	0	1,675
Watsonville Slough [D]	Watsonville Slough Subwatershed	1,498	1,684	156	0	3,338
Struve Slough [D]	Watsonville Slough Subwatershed	2,051	1,487	376	0	3,914
Gallighan Slough [D]	Watsonville Slough Subwatershed	716	1,433	409	205	2,763
Hanson Slough [D]	Watsonville Slough Subwatershed	200	100	401	301	1.002
Harkins Slough [D]	Watsonville Slough Subwatershed	819	3,385	1,510	1,669	7,383

[A] Refer to Figure 3-4 and Table 3-6 in this report to view subwatershed location and information.
[B] Source: Table 2 in Smalling and Orlando, 2011.
[C] As delineated by Central Coast Water Board staff on the basis of the National Elevation Dataset 30 meter digital elevation model (source: U.S. Geological Survey, EROS Data Center 1999) and an associated flow accumulation grid and stream link raster network developed with the Esri® ArcMap™ 10.1 Spatial Analyst Hydrology Tool. Estimated land cover is based on the Farmland Mapping and Monitoring dataset (2010).
[D] Source: Table 3-1 in Swanson Hydrology & Geomorphology, et. al., 2003.

Human disturbance to the landscape varies spatially across any given river basin. In the context of TMDL development, it is important to be aware of this variation. The establishment of water quality "reference conditions" also relies on knowledge about the magnitude of human disturbance to the landscapes of a river basin (see report Section 3.6). The degree of human disturbance to the landscape can be quantified with data available from the U.S. Geological Survey[17]. Figure 3-7 presents the "human footprint" in the Pajaro River basin. Human footprint is a measure of human disturbance to the landscape. Human footprint values range from one (pristine conditions) to 10 (extremely modified by humans). In general, lowland and valley areas of river basins typically have the highest human footprint, whereas upland areas of the river basin unsurprisingly will have a lower human footprint. For example, human footprint values range from about 3 to 4 in lightly impacted subwatersheds of the Upper San Benito Subbasin and the Upper Pacheco Creek Subbasin. In contrast, human footprint values range from about 7 to 9 in highly modified subwatersheds of the Santa Clara Valley and Watsonville coastal plain. Table 3-8 presents a tabulation of the ranges and averages of human footprint values by individual subwatersheds, and thus illustrates the degree to which subwatershed landscapes of the Pajaro River basin are modified by human activities.

Figure 3-7. Human footprint map (refer back to Figure 3-4 and Table 3-3 for subwatershed names).



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[17] "The Human Footprint in the West" is a geospatial dataset originated by Matthias Leu, Steve Hanser, and Steve Knick, U.S. Geological Survey, Snake River Field Station. Leu, Nahser and Knick developed the map of the human footprint for the western United States from an analysis of 14 landscape structure and anthropogenic features: Online linkage: http://sagemap.wr.usgs.gov/HumanFootprint.aspx

Table 3-8. Tabulation of human footprint values by subwatershed on the basis of map data shown previously in Figure 3-7 (human footprint value of 2 = landscape is undisturbed or near pristine conditions, value of 10 = landscape is extremely modified by humans).

Subwatershed[A]	Human Footprint (minimum)	Human Footprint (maximum)	**Human Footprint (average)**		**Subwatershed**[A]	Human Footprint (minimum)	Human Footprint (maximum)	**Human Footprint (average)**
Clear Creek-San Benito River	2	5	**3.1**		Santa Ana Creek	3	10	**5.7**
Hernandez Reservoir-San Benito River	2	5	**3.2**		Tequisquita Slough	4	10	**6.8**
James Creek-San Benito River	2	6	**3.1**		Watsonville Slough	4	10	**8.5**
Rock Springs Creek-San Benito River	2	6	**3.2**		Lower Pajaro River	4	10	**7.2**
Sulphur Creek-San Benito River	2	6	**4.1**		Arroyo De Las Viboras	4	10	**5.1**
Willow Creek	3	10	**4.6**		Salsipuedes Creek	5	10	**8.4**
Stone Creek	3	7	**4.7**		Lower Pacheco Creek	4	10	**6.0**
Upper Tres Pinos Creek	2	5	**3.5**		South Fork Pacheco Creek	3	7	**4.6**
Middle Tres Pinos Creek	2	6	**4.2**		Lower Uvas Creek	4	10	**6.7**
Pescadero Creek	3	7	**5.0**		Upper Pajaro River	4	10	**7.3**
Las Aguilas Creek	2	6	**3.7**		Corralitos Creek	4	10	**7.2**
Los Muertos Creek	2	6	**4.2**		Upper Pacheco Creek	3	7	**5.0**
Paicines Reservoir-San Benito River	3	10	**5.2**		Lower Llagas Creek	4	10	**8.8**
Lower Tres Pinos Creek	3	10	**5.6**		Cedar Creek	3	7	**4.7**
San Juan Canyon	4	10	**7.0**		Upper Uvas Creek	4	10	**5.7**
Bird Creek-San Benito River	4	10	**6.7**		Little Llagas Creek	4	10	**9.1**
Quien Sabe Creek	3	7	**4.4**		Upper Llagas Creek	5	10	**6.6**

[A] Refer back to Figure 3-4 and Table 3-3 for a map and tabulation of subwatersheds within the Pajaro River basin.

3.4 Hydrology

Assessing the hydrology of a watershed is an important step in evaluating the magnitude and nature of nutrient transport and loading in waterbodies. The entire drainage area contributing to flow in the Pajaro River basin encompasses over 1,300 square miles (refer back to Figure 3-2). Figure 3-8 illustrates some regional hydrographic features and hydrologic characteristics within the Pajaro River basin.

Due to highly variable climatic, hydrologic, anthropogenic, and geomorphic influences within the river basin, stream flows in various stream reaches can range spatially from perennial or sustained flow, to infrequent seasonal or intermittent flows – refer again to Figure 3-8 for illustrations of these variations.

Figure 3-8. Generalized hydrography of the Pajaro River basin: major streams, generalized hydrologic flow conditions, major lakes, estuaries, reported cold water springs and reported geothermal springs.

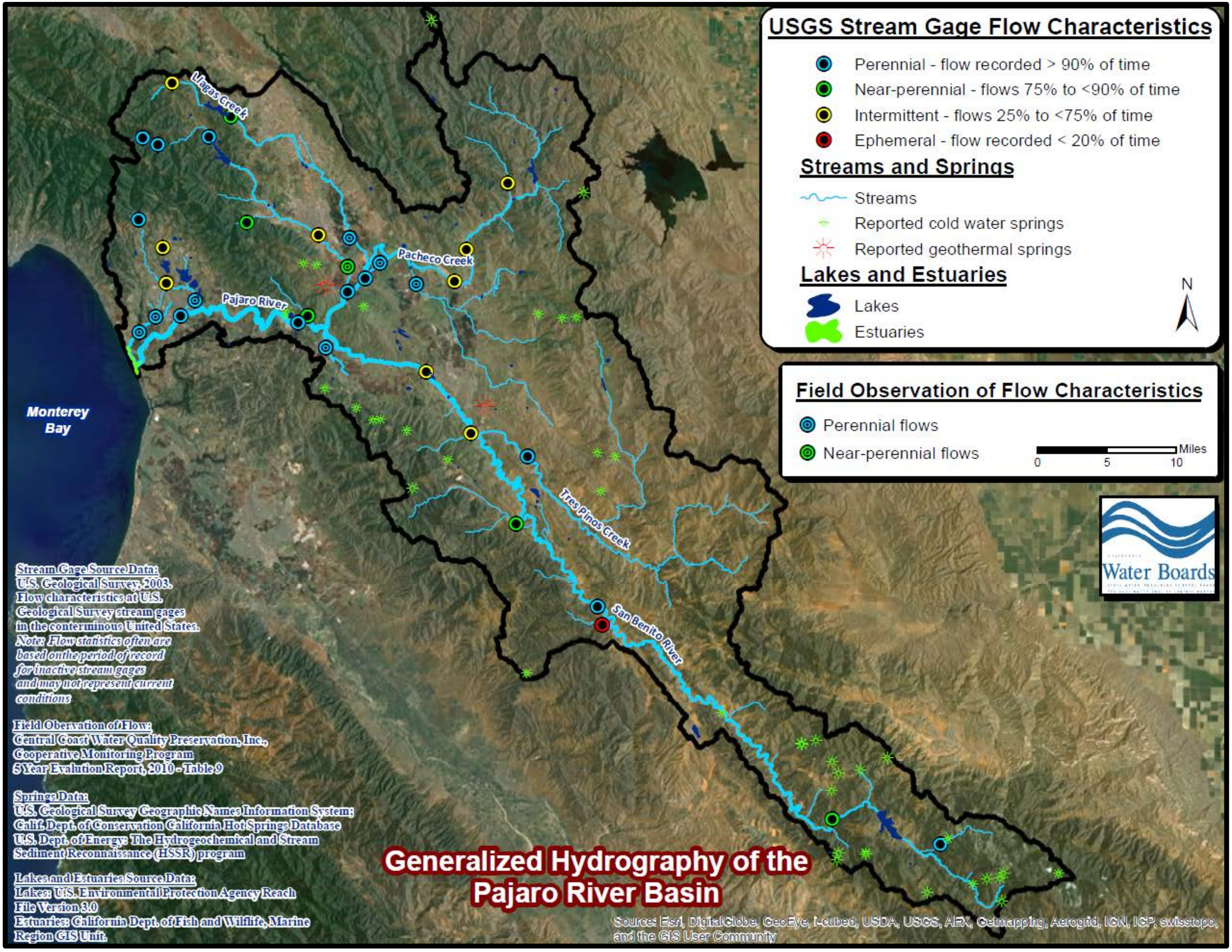

Table 3-9 presents flow statistics for select stream reaches in the Pajaro River basin on the basis of U.S. Geological Survey stream gages.

Table 3-9. Flow statistics from U.S. Geological Survey stream gages in the Pajaro River basin. Flow units = cubic feet sec^{-1}; drainage area units = square miles; BFI = base flow index.

Station No.	Station Name	Period of Record	Ave. Flow	MIN	P10	P25	P50	P75	P90	P95	P99	Max Flow	BFI	Drain Area
11152900	Cedar C Nr Bell Station Ca	1961-1982	4.4	0.0	0.0	0.0	0.0	0.6	4.2	16.0	92.0	832	0.176	13
11153000	Pacheco C Nr Dunneville Ca	1939-1982	34.5	0.0	0.0	0.0	2.0	8.9	38.0	124.0	698.2	7730	0.198	146
11153470	Llagas C Ab Chesbro Res Nr Morgan Hill Ca	1971-1982	9.6	0.0	0.0	0.0	0.6	5.3	22.0	46.0	153.6	508	0.37	10
11153500	Llagas C Nr Morgan Hill Ca	1951-1971	15.5	0.0	0.0	1.1	4.1	16.0	33.0	48.0	178.1	1230	0.603	20
11153700	Pajaro R Nr Gilroy Ca	1959-1982	60.2	0.0	0.5	2.1	5.3	13.0	67.0	245.8	1220.0	11700	0.307	399
11154100	Bodfish C Nr Gilroy Ca	1959-1982	3.8	0.0	0.0	0.1	0.4	1.8	7.0	16.0	63.0	505	0.331	7
11154200	Uvas C Nr Gilroy Ca	1959-1992	38.5	0.0	0.0	0.0	0.0	6.4	61.0	180.2	746.2	6520	0.154	71
11154700	Clear C Nr Idria Ca	1993-2000	5.5	0.1	0.5	1.0	1.9	5.1	14.0	22.0	45.0	464	0.726	14
11156000	San Benito R Bl M C Nr Hernandez Ca	1949-1963	12.4	0.0	0.0	0.8	1.7	4.8	24.0	79.0	160.3	754	0.402	108
11156450	Willow C Trib Nr San Benito Ca	1964-1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	12	0.018	1
11156700	Pescadero C Nr Paicines Ca	1959-1970	1.6	0.0	0.0	0.2	0.6	1.5	2.5	3.8	21.0	160	0.674	38
11157500	Tres Pinos C Nr Tres Pinos Ca	1940-2000	18.2	0.0	0.5	1.2	3.0	6.5	18.0	50.0	290.8	9000	0.431	208
11158500	San Benito R Nr Hollister Ca	1949-1983	37.3	0.0	0.0	0.0	2.5	18.0	40.0	97.0	715.0	8390	0.253	586
11158600	San Benito R A Hwy 156 Nr Hollister Ca	1970-2000	42.5	0.0	0.0	0.0	1.8	11.0	41.0	173.0	800.0	19800	0.289	607
11158900	Pescadero C Nr Chittenden Ca	1970-1981	3.0	0.0	0.0	0.1	0.3	1.5	5.8	14.0	52.0	191	0.38	10
11159150	Corralitos C Nr Corralitos Ca	1957-1972	8.6	0.0	0.1	0.1	0.5	4.1	18.0	41.0	134.0	997	0.232	11
11159200	Corralitos C A Freedom Ca	1956-2000	16.9	0.0	0.0	0.0	0.4	5.5	35.0	81.0	301.8	2290	0.181	28
11159500	Pajaro R A Watsonville Ca	1911-1973	93.8	0.0	0.1	1.0	5.4	26.0	70.0	368.2	2100.4	6570	0.53	1272
11153900	Uvas C Ab Uvas Res Nr Morgan Hill Ca	1961-1982	28.1	0.0	0.3	0.8	2.7	14.0	50.0	116.0	475.6	3390	0.313	21
11156500	San Benito R Nr Willow Creek School Ca	1939-2000	28.1	0.0	0.2	0.5	3.9	24.0	58.0	93.0	382.4	5000	0.471	249
11159000	Pajaro R A Chittenden Ca	1939-2000	173.1	0.0	1.2	4.3	12.0	39.0	270.0	777.5	3420.0	21700	0.344	1186

Data source: U.S. Geological Survey, 2003. *Flow characteristics at U.S. Geological Survey stream gages in the conterminous United States.* Open File Report 03-146.
P = percentiles, for example the P10 attribute is the 10th percentile of daily streamflow values for the period of record.

The spatial distribution of U.S. Geological Survey stream gages is limited, and many of the gages shown above are inactive and only report historical flow data which may, or may not, be representative of current and recent watershed conditions. Therefore, it is prudent to compile other available sources of flow data. Table 3-10 presents recent estimates of mean annual flow on the basis of flow attributes[18] reported in the National Hydrography Dataset Plus (NHDplus).

Table 3-10. Estimates of mean annual flow (unites=cubic ft. sec^{-1}) on the basis of NHDplus attributes.

Stream Reach	Monitoring Site	Mean Annual Flow	Data Source
Carnadero Creek at private property access	305CAR	14.04	NHDplus
Casserly Creek at Paulsen	CA2	0.88	NHDplus
Coward Creek at Carlton Rd	CW	0.17	NHDplus
Furlong Creek at Fraiser Lake Rd	305FUF	0.43	NHDplus

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[18] MAFlowU attribute: Mean annual flow in cubic feet per second as computed by the unit runoff method.

Stream Reach	Monitoring Site	Mean Annual Flow	Data Source
Green Valley Creek at Green Valley Road	GV	0.27	NHDplus
Green Valley Creek Tributary at Casserly Road	GVT	0.40	NHDplus
Harkins Slough at Harkins Slough Rd	305HAR	2.09	NHDplus
Hughes Creek at Casserly Road	HC	0.07	NHDplus
Llagas Creek at Bloomfield Avenue	305LLA	11.94	NHDplus
Pacheco Creek at San Felipe Rd.	305PAC	12.70	NHDplus
Pajaro River at Thurwatcher Rd.	305THU	109.59	NHDplus
Salsipuedes Creek at Hwy 129 downstream of Corralitos Creek	305COR	8.54	NHDplus
San Benito at Y Rd	305SAN	38.60	NHDplus
San Juan Creek at Anzar	305SJN	1.06	NHDplus
Struve Slough at Lee Rd	305STL	0.23	NHDplus
Tequisquita Slough at Shore Rd	305TES	4.23	NHDplus
Watsonville Slough upstream Harkins Slough	305WSA	4.46	NHDplus

Staff developed visual representations of flow variation in the Pajaro River basin in Figure 3-9 and Figure 3-11. Figure 3-9 illustrates mean annual flow estimates within the Pajaro River basin, based on U.S. Geological Survey flow gage data and resolution National Hydrography Dataset Plus (NHDplus)[19], estimates of mean annual flow[20].

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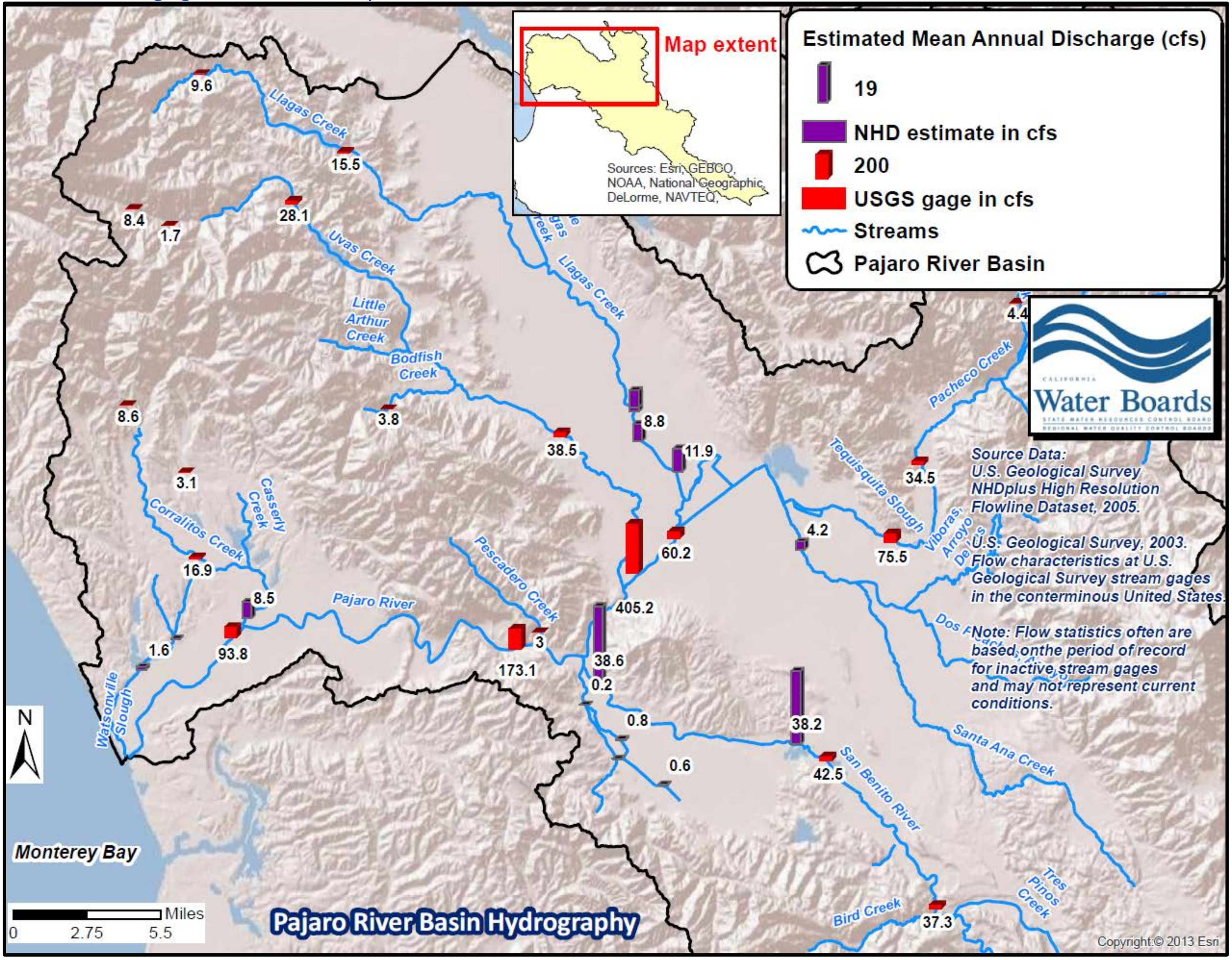
[19] NHDPlus Version 1.0 (2005) was created by the USEPA and the U.S. Geological Survey and is an integrated suite of application-ready geospatial data sets that incorporate many of the features of the National Hydrography Dataset (NHD) and the National Elevation Dataset (NED). NHDPlus includes a stream network (based on the 1:100,000-scale NHD), networking, naming, and "value-added attributes" (VAA's). NHDPlus also includes elevation-derived catchments (drainage areas) produced using drainage enforcement techniques.

[20] U.S. Geological Survey gages provide measured daily flow records (online linkage: http://ca.water.U.S. Geological Survey.gov/). NHDPlus provides modeled mean annual flow estimates; staff used values for the attribute “MAFlowU”. MAFlowU are based on the Unit Runoff Method (UROM), which was developed for the National Water Pollution Control Assessment Model (NWPCAM) (Research Triangle Institute, 2001). Values in “MAFlowU” are based on methods from Vogel et al., 1999. NHDplus uses two flow estimation procedures, both developed by using the Hydro-Climatic Data Network (HCDN) of gages. These gages are usually not affected by human activities, such as major reservoirs, intakes, and irrigation withdrawals; thus, the mean annual flow estimates are most representative of “natural” flow conditions. These estimation methods used the HCDN gages because each method is developed for use at large scales; such as Hydrologic Regions. It was beyond the scope and capabilities of both methods to determine the human-induced effects at this scale.

Figure 3-9. Estimated mean annual discharge in streams of the northern Pajaro River basin on the basis of stream gage data and NHDplus flow estimates; units=cubic feet/sec,.



Source Data:
U.S. Geological Survey NHDplus High Resolution Flowline Dataset, 2005.

U.S. Geological Survey, 2003. Flow characteristics at U.S. Geological Survey stream gages in the conterminous United States.

Note: Flow statistics often are based onthe period of record for inactive stream gages and may not represent current conditions.

In addition to gaged flow data and NHDplus mean annual flow estimates discussed above, several water quality monitoring programs active in the Pajaro River basin periodically collect instantaneous flow data (see Appendix A). These instantaneous flow data can provide some coarse, generalized insight into flow conditions in some stream reaches of the river basin (see Table 3-11 and boxplots[21] in Figure 3-10).

Table 3-11. Numerical summary of instantaneous flow field measurements (years 2005–2011) at select stream locations in the Pajaro River basin.

Stream / Location	mean	0%	10%	25%	50%	75%	90%	100%	Sample Count
Carnadero Creek at Highway 25	34.77	0.00	0.00	0.53	7.78	23.31	54.59	392	75
Llagas Creek at Bloomfield Avenue	4.00	0.00	0.00	3.23	4.45	5.72	7.00	7.24	19
Millers Canal at Frazier Lake Rd	22.14	0.00	1.74	4.58	8.69	13.97	24.01	560	102
Pacheco Creek at San Felipe Rd.	7.94	0.30	0.68	1.44	4.53	12.08	19.06	31.4	33
Pajaro River at Chittenden Gap	98.25	1.10	4.41	13.00	26.00	63.50	139.0	2,430	79

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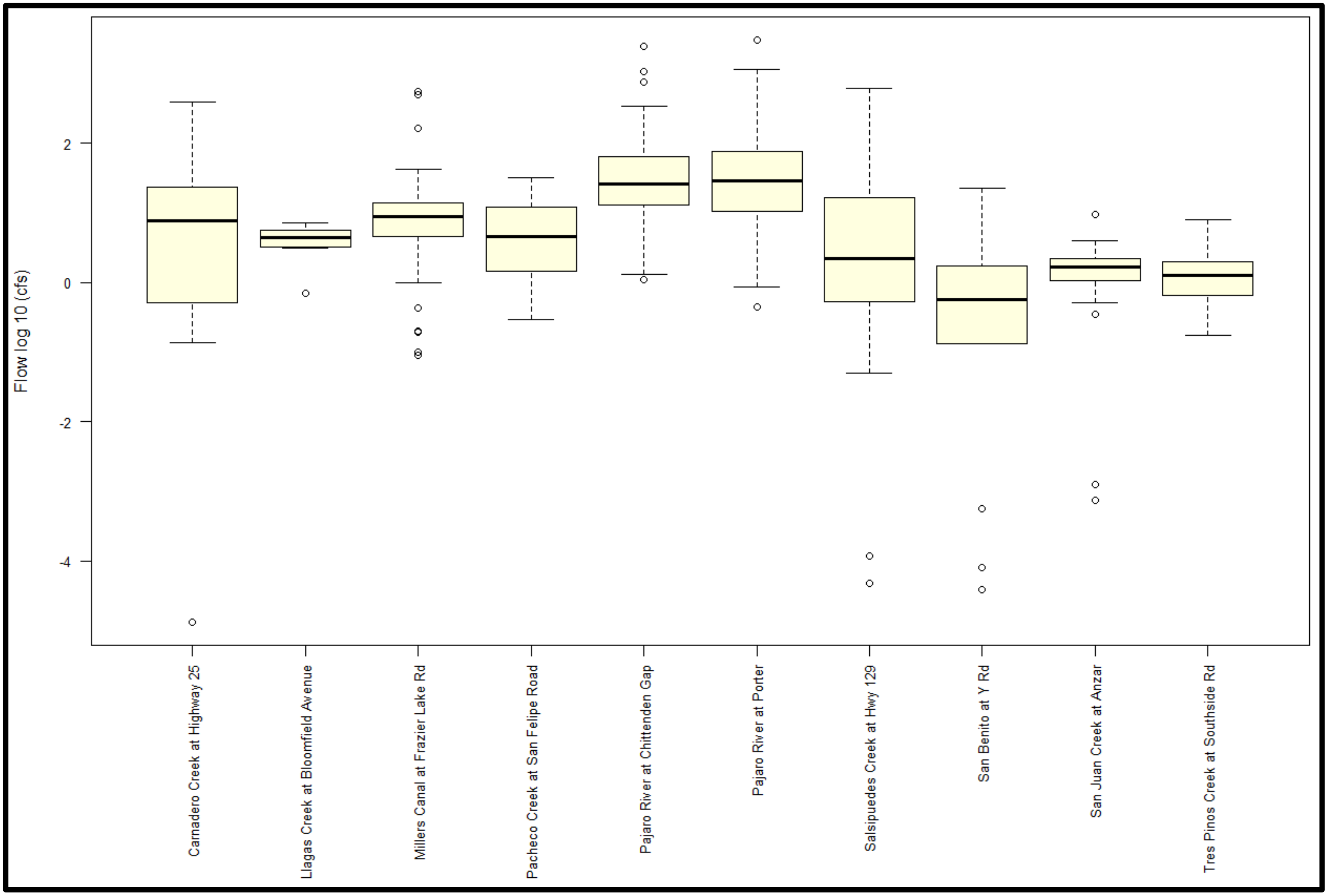
[21] For a description of boxplots, and what they graphically depict, please refer to the boxplot entry in Wikipedia.

Stream / Location	mean	0%	10%	25%	50%	75%	90%	100%	Sample Count
Pajaro River at Porter	108.22	0.44	1.57	10.66	28.59	76.20	137.12	3,000	73
Salsipuedes Creek at Hwy 129	23.15	0.00	0.07	0.57	2.22	16.13	31.71	613	84
San Benito at Y Rd	2.19	0.00	0.00	0.15	0.57	1.70	3.81	22.5	42
San Juan Creek at Anzar Rd.	2.03	0.00	0.31	1.07	1.65	2.22	3.56	9.60	40
Tres Pinos Creek at Southside Rd.	2.03	0.17	0.29	0.65	1.24	2.00	4.22	7.97	20

Figure 3-10. Box plot of instantaenous flow field measurements at select stream locations in the Pajaro River basin (units=log10 cubic ft. sec^{-1}). This box plot is derived from flow data presented in Table 3-11.



Due to the nature and scope of artificial drainage, regulated flows and the Mediterranean climate prevalent in the Pajaro River basin, dry season flow patterns can vary substantially from flow patterns observed from mean annual flow conditions. It is also important to consider dry season flow discharge patterns because biostimulatory impairments of surface waters generally occur in the dry season or summer months. While there are only a handful of active U.S. Geological Survey gages in the Pajaro River basin, various monitoring programs[16] have collected over 1,100 instantaneous flow measurements in the river basin in recent years (see Appendix A – Water Quality Data). Because of the large size of this flow dataset, taking the arithmetic means of the May 1 through October 31 instantaneous flow measurements from selected stream reaches can provide a plausible rough approximation of mean dry season flows. Further, due to the region's Mediterranean climate and the virtual absence of precipitation-driven flow events in the dry season, it is presumed that the May through October instantaneous flow measurements are a plausible representation of the scope and range of dry season flow conditions.

Table 3-12 tabulates a summary of mean annual dry season flows at key stream reaches in the Pajaro River basin.

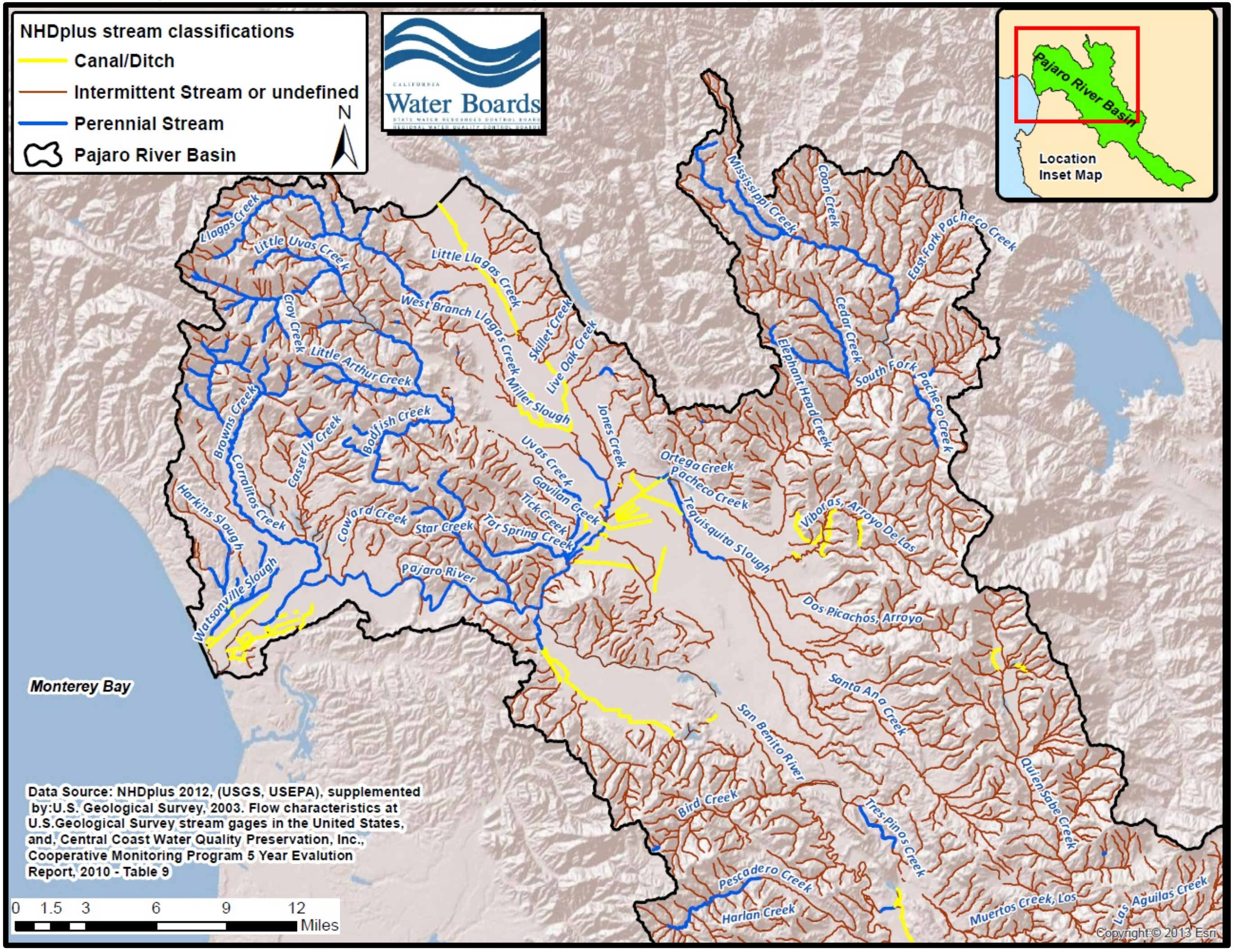
Table 3-12. Estimated mean annual dry season flow (May 1 through Oct. 31) and numerical summary of dry season flow ranges in select stream reaches of the Pajaro River basin (units=cubic ft. sec^{-1}).

Stream Reach	mean	0%	10%	25%	50%	75%	90%	100%	temporal range		sample count	data source
Carnadero Creek at Highway 25	6.51	0.00	0.00	0.21	1.96	8.32	22.44	31.32	May-05	Jun-11	36	instantaneous flow field monitoring
Carnadero Creek at private property access	1.79	0.72	0.72	0.72	0.72	2.32	3.28	3.92	Jul-11	Oct-11	3	instantaneous flow field monitoring
Corralitos Creek at Rider Rd	4.03	0.62	0.90	1.32	1.87	2.90	9.21	13.42	Oct-03	May-06	5	instantaneous flow field monitoring
Corralitos Creek at Brown Valley Road	6.81	0.00	0.01	0.08	1.08	8.86	27.66	29.75	May-05	Oct-11	12	instantaneous flow field monitoring
Furlong Creek at Fraiser Lake Rd	1.10	0.52	0.77	0.82	1.21	1.35	1.45	1.54	May-05	Oct-11	18	instantaneous flow field monitoring
Llagas Creek at Bloomfield Avenue	2.20	0.00	0.00	0.00	0.70	3.79	4.54	7.24	Jun-92	Jun-08	22	instantaneous flow field monitoring
Llagas Creek at Southside	5.08	0.25	0.58	2.07	3.46	5.34	10.17	24.17	May-06	Jun-11	37	instantaneous flow field monitoring
Lllagas Creek at Luchessa Rd	2.25	0.00	0.00	1.15	1.70	3.50	4.20	4.70	Jun-92	Jul-93	11	instantaneous flow field monitoring
Lllagas Creek near California St.	14.09	6.20	7.08	8.40	15.50	18.10	20.78	24.20	Jun-92	Jul-93	13	instantaneous flow field monitoring
Millers Canal at Frazier Lake Rd	6.72	0.00	0.60	2.73	6.47	9.67	13.18	23.13	May-05	Oct-11	54	instantaneous flow field monitoring
Pacheco Creek at San Felipe Lake	5.83	2.12	2.47	3.27	5.83	8.12	9.18	9.89	Jul-05	Aug-06	6	instantaneous flow field monitoring
Pacheco Creek at San Felipe Road	5.55	0.30	0.45	0.90	3.75	6.89	14.66	19.37	May-05	Oct-11	16	instantaneous flow field monitoring
Pajaro River at Betabel Rd	28.45	12.34	12.35	12.41	13.73	30.96	81.87	87.52	May-05	Oct-05	12	instantaneous flow field monitoring
Pajaro River at Chittenden Gap	17.95	0.00	1.6	4.5	12.5	23.2	34.7	90	Jun-92	Jun-11	54	instantaneous flow field monitoring
Pajaro River at Chittenden Gap	24.2	0.48	3	6.7	12	22	43	1,010	May-98	Dec-14	3,128	USGS flow gage 11159000
Pajaro River at Hwy 25	1.22	0.00	0.00	0.00	1.20	2.00	2.64	3.2	Jun-92	Jul-93	13	instantaneous flow field monitoring
Pajaro River at Porter	22.38	0.44	1.47	2.86	11.95	28.59	39.56	153	Jun-05	Jun-11	41	instantaneous flow field monitoring
Salsipuedes Creek at Hwy 129	5.28	0.06	0.20	0.48	1.22	3.00	18.97	31.71	May-05	Jul-11	44	instantaneous flow field monitoring
San Benito at Y Rd	0.39	0.00	0.00	0.00	0.22	0.58	1.00	1.74	May-05	Oct-11	22	instantaneous flow field monitoring
San Benito River dwnstrm Willow Creek	14.31	3.48	4.13	4.49	6.63	28.04	30.87	35.50	May-05	Oct-11	19	instantaneous flow field monitoring
San Juan Creek at Anzar Rd	1.98	0.00	0.72	1.08	1.58	2.05	3.41	8.90	May-05	Oct-11	62	instantaneous flow field monitoring
San Juan Creek at Mission Vineyard Rd	0.51	0.36	0.40	0.46	0.56	0.59	0.60	0.61	May-08	Oct-08	3	instantaneous flow field monitoring
San Juan Creek at Prescott Rd	0.98	0.48	0.61	0.82	1.15	1.23	1.28	1.31	May-08	Oct-08	3	instantaneous flow field monitoring
Tequisiquita Slough at San Felipe Lake	1.32	0.71	0.81	0.97	1.41	1.77	1.77	1.77	Jun-05	Aug-06	4	instantaneous flow field monitoring
Tequisquita Slough at Shore Rd	2.15	0.00	0.00	0.00	0.00	0.00	7.18	24.83	May-06	Jun-11	30	instantaneous flow field monitoring
Tres Pinos Creek at Southside Rd	2.93	0.65	0.65	1.11	1.98	3.81	7.97	7.97	Aug-05	Oct-11	11	instantaneous flow field monitoring

Stream Reach	mean	0%	10%	25%	50%	75%	90%	100%	temporal range		sample count	data source
Uvas Creek at Bloomfield Avenue	10.08	2.06	2.06	2.76	4.89	18.70	23.31	23.31	May-05	Jun-11	6	instantaneous flow field monitoring
Watsonville Slough upstrm of Harkins Slough	0.73	0.00	0.00	0.00	0.00	0.00	0.44	10.8	May-06	Jun-11	31	instantaneous flow field monitoring

Figure 3-11 illustrates the estimated hydrographic stream channel classifications in the Pajaro River basin. The source of these hydrographic stream classification attributes is the U.S. Geological Survey's high resolution NHDplus supplemented by field observation of flow patterns. It should be noted that the NHDplus stream channel classifications carry no formal regulatory status, and have not necessarily been field-checked. In the NHDplus metadata these are described as "value-added" geospatial attributes created to supplement the NHDFlowline shapefiles.

Figure 3-11. Generalized stream classifications in the northern and central Pajaro River basin on the basis of NHDplus flow line attributes and Cooperative Monitoring Program field observations.

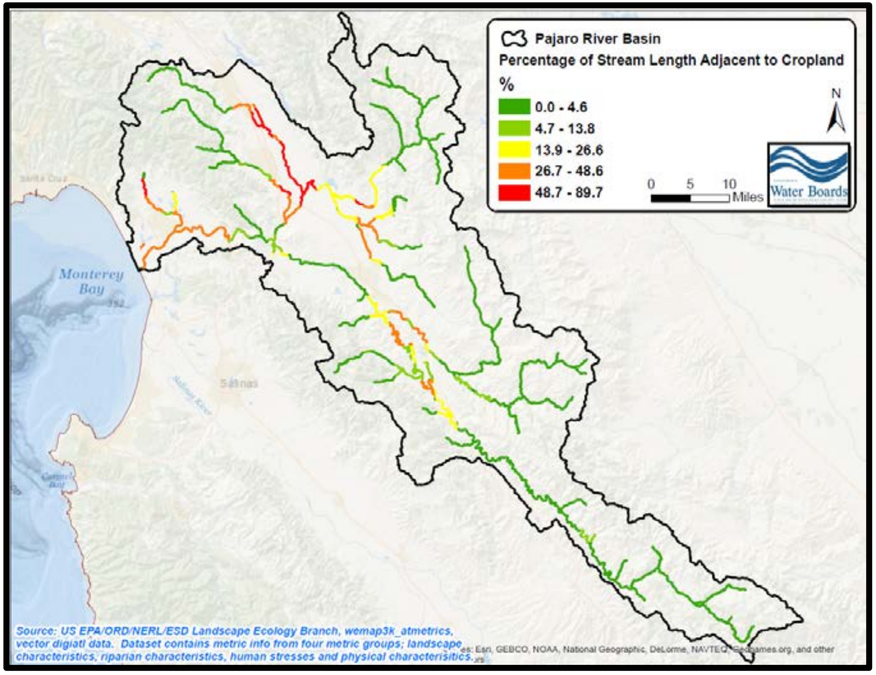


Data Source: NHDplus 2012, (USGS, USEPA), supplemented by:U.S. Geological Survey, 2003. Flow characteristics at U.S.Geological Survey stream gages in the United States, and, Central Coast Water Quality Preservation, Inc., Cooperative Monitoring Program 5 Year Evaluation Report, 2010 - Table 9

Riparian characteristics are often considered in nutrient TMDL development, because riparian cover, canopy shading, and riparian health can play a role in the nature and risk of nutrient pollution of water resources. Stream riparian landscape characteristics have been published as digital datasets by the

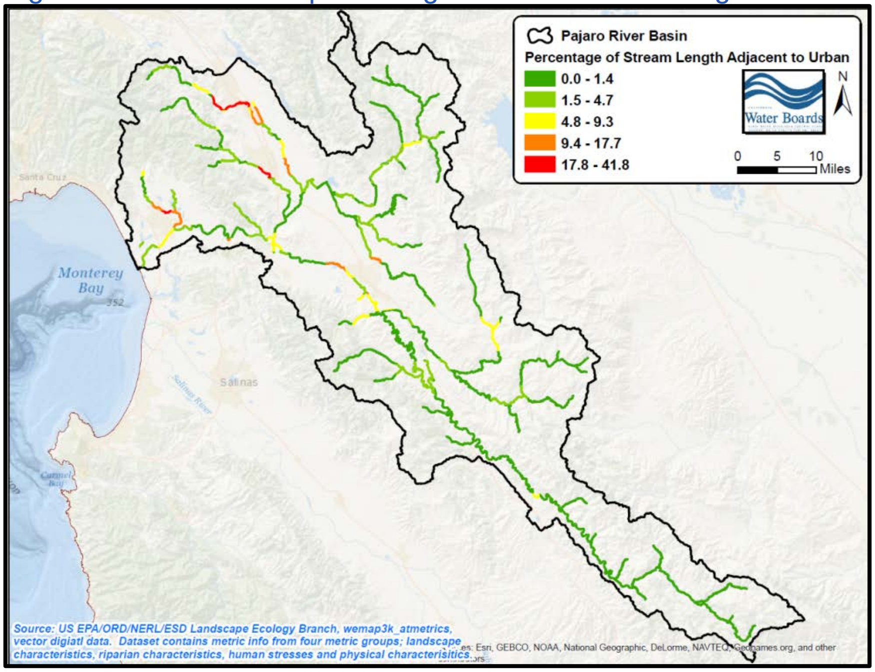
USEPA's Landscape Ecology Branch[22]. Figure 3-12, Figure 3-13, and Figure 3-14 present estimated percentage of stream length that is adjacent to various land cover categories (i.e., cropland, urban, and natural land). Table 3-13 tabulates weighted averages of the digital riparian landscape characteristics shown in the aforementioned figures. Significant proportions of lowland stream reaches of the Pajaro Valley and southern Santa Clara Valley are located adjacent to croplands and developed urban/residential areas. In contrast, stream reaches of the San Benito River Subbasin are largely adjacent to natural landscapes.

Figure 3-12. Estimated percentage of stream reach length which is adjacent to cropland.



Source: US EPA/ORD/NERL/ESD Landscape Ecology Branch, wemap3k_atmetrics, vector digiatl data. Dataset contains metric info from four metric groups; landscape characteristics, riparian characteristics, human stresses and physical characterisitics.

Figure 3-13. Estimated percentage of stream reach length which is adjacent to urban land.



Source: US EPA/ORD/NERL/ESD Landscape Ecology Branch, wemap3k_atmetrics, vector digiatl data. Dataset contains metric info from four metric groups; landscape characteristics, riparian characteristics, human stresses and physical characterisitics.

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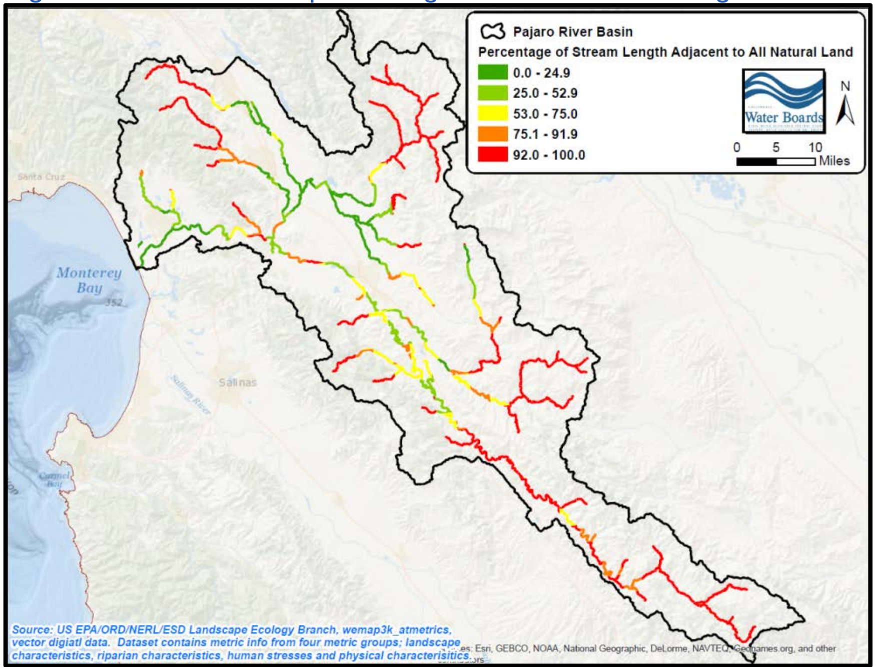
[22] The EMAP-West (Environmental Mapping and Assessment Program-West) metrics, developed by the USEPA's Landscape Ecology Branch, were generated with an ArcView extension called ATtILA (Analytical Tools Interface for Landscape Assessments).

Figure 3-14. Estimated percentage of stream reach length which is adjacent to all natural land.



Source: US EPA/ORD/NERL/ESD Landscape Ecology Branch, wemap3k_atmetrics, vector digiatl data. Dataset contains metric info from four metric groups; landscape characteristics, riparian characteristics, human stresses and physical characterisitics.

Table 3-13. Weighted percentages of select land cover categories occurring within a 100 meter buffer of higher order streams (source data: EMAP-West[23]).

	Land Cover Proportions[A]: Percentages of Land Cover Categories within 100 meter Buffer of Higher Order Streams[B, C]		
Hydrologic Area[D]	Weighted % of land within 100 m stream buffer that is CROPLAND	Weighted % of land within 100 m stream buffer that is URBAN	Weighted % of land within 100 m stream buffer that is ALL NATURAL land cover
Pajaro River Basin	12.6	2.6	73.2
Pajaro River Subbasin	30.0	7.4	52.7
Pacheco Creek Subbasin	11.8	1.4	67.0
San Benito River Subbasin	4.6	0.9	85.4

[A] *Source Data: EMAP-West Landscape Metrics, USEPA – Landscape Ecology Branch.*

[B] *Does not include Strahler first-order head water stream reaches.*

[C] *Cropland, Urban, and All Natural land categories do not sum to 100% for a given hydrologic area because grasslands, wetlands, and shrubland were not included in this land cover tabulation.*

[D] *Refer back to Figure 3-3 for a map showing location of the subbasins within the Pajaro River Basin.*

Agricultural watersheds are often characterized by a significant amount of artificial drainage. Staff was cognizant of this fact during the development of this TMDL. Artificial drainage, such as agricultural runoff, can be an important contributor to flows in some waterbodies of the Pajaro River basin. In watersheds dominated by agriculture, artificial drainage systems can act as efficient conveyance systems which rapidly transport excess water from agricultural soils. Consequently artificial drainage can considerably increase the amount of nutrients exported from agricultural fields to waterways (Strock et al., 2007). Figure 3-15 illustrates the estimated percentage of land area that is subject to the practice of artificial drainage, such as ditches and tile drains. The estimations are from U.S. Geological Survey NHDplus catchment attribute datasets. They are intended for informational value only and are based on data derived by the National Resource Inventory conducted by the NRCS for the year 1992[24], which is

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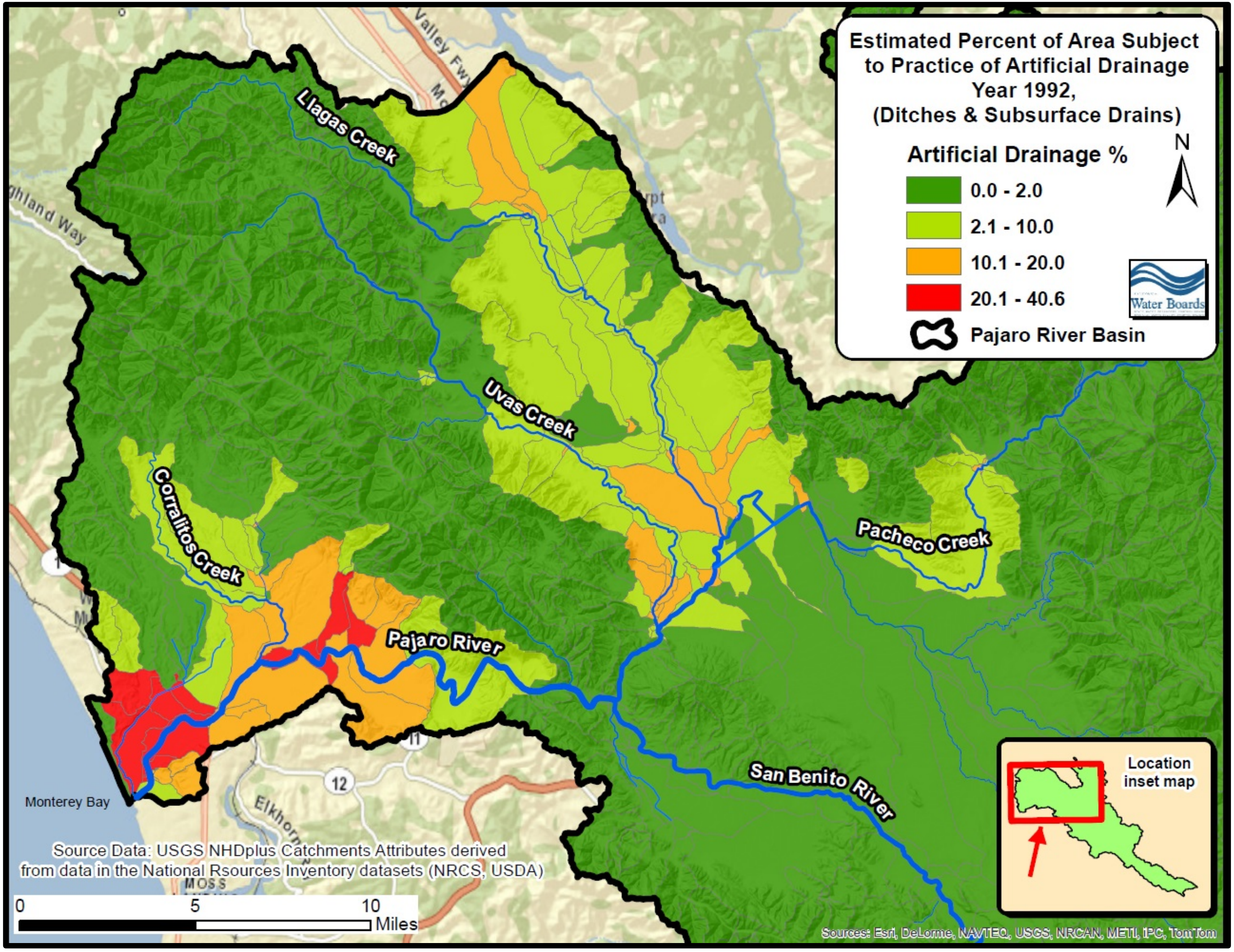
[23] *Ibid*

[24] This tabular dataset was created by the U.S. Geological Survey and represents the estimated area of artificial drainage for the year 1992 and irrigation types for the year 1997 compiled for every catchment of NHDPlus for the conterminous United States.

the best available dataset to estimate artificial drainage. Thus, this dataset is presumed to represent a plausible gross regional approximation of the current percentage of land area subject to artificial drainage practices[25]. The data indicates that artificial drainage is most intensive in the lowermost areas of the Pajaro River basin (i.e., Pajaro Valley) as well as in localized areas around the Llagas Creek, and lower Uvas Creek watersheds.

Figure 3-15. 1992 vintage estimate of percentage of land area subject to artificial drainage practices (ditches & tile drainage) in northern Pajaro River basin.



Source Data: USGS NHDplus Catchments Attributes derived from data in the National Rsources Inventory datasets (NRCS, USDA)

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

3.5 Geomorphology

Pajaro River basin geomorphology was considered in the development of nutrient numeric water quality targets. Because eutrophication is generally assumed to be limited to slow-moving waters in low gradient streams, lakes, ponds, estuaries and bays, a review of Pajaro River basin geomorphology provides insight into where higher risk of biostimulatory effects are to be expected.

In high gradient streams (steep slopes), the residence time of nutrients may be too short to allow nutrient assimilation by primary producers and so impacts on water quality may be minimal. As reported in Tetra Tech (2006), Dodds et al. (2002) reported a negative correlation of benthic chlorophyll a to gradient.

The source datasets were derived from tabular National Resource Inventory (NRI) datasets created by the National Resources Conservation Service. Artificial drainage is defined as subsurface drains and ditches.

[25] It should be noted that the information is this figure should be considered very qualitative and substantial changes at local scales may have occurred since 1992.

Also, high gradient streams in steeper terrains keep water aerated diminishing the potential for anoxic zones (USEPA, 2001a). USEPA reports that headwater systems in temperate zones usually have been found to be limited by phosphorus, thus it is generally assumed that eutrophication effects are expected in downstream ecosystems.

As such, the nutrient concentration that results in impairment in a high-gradient, shaded stream may be much different from the one that results in impairment in a low-gradient, unshaded stream (Tetra Tech, 2006). However, it is important to note that it is generally presumed that excess nutrients in head water reaches will ultimately end up in a receiving body of water where the nutrient concentrations and total load may degrade the water resource.

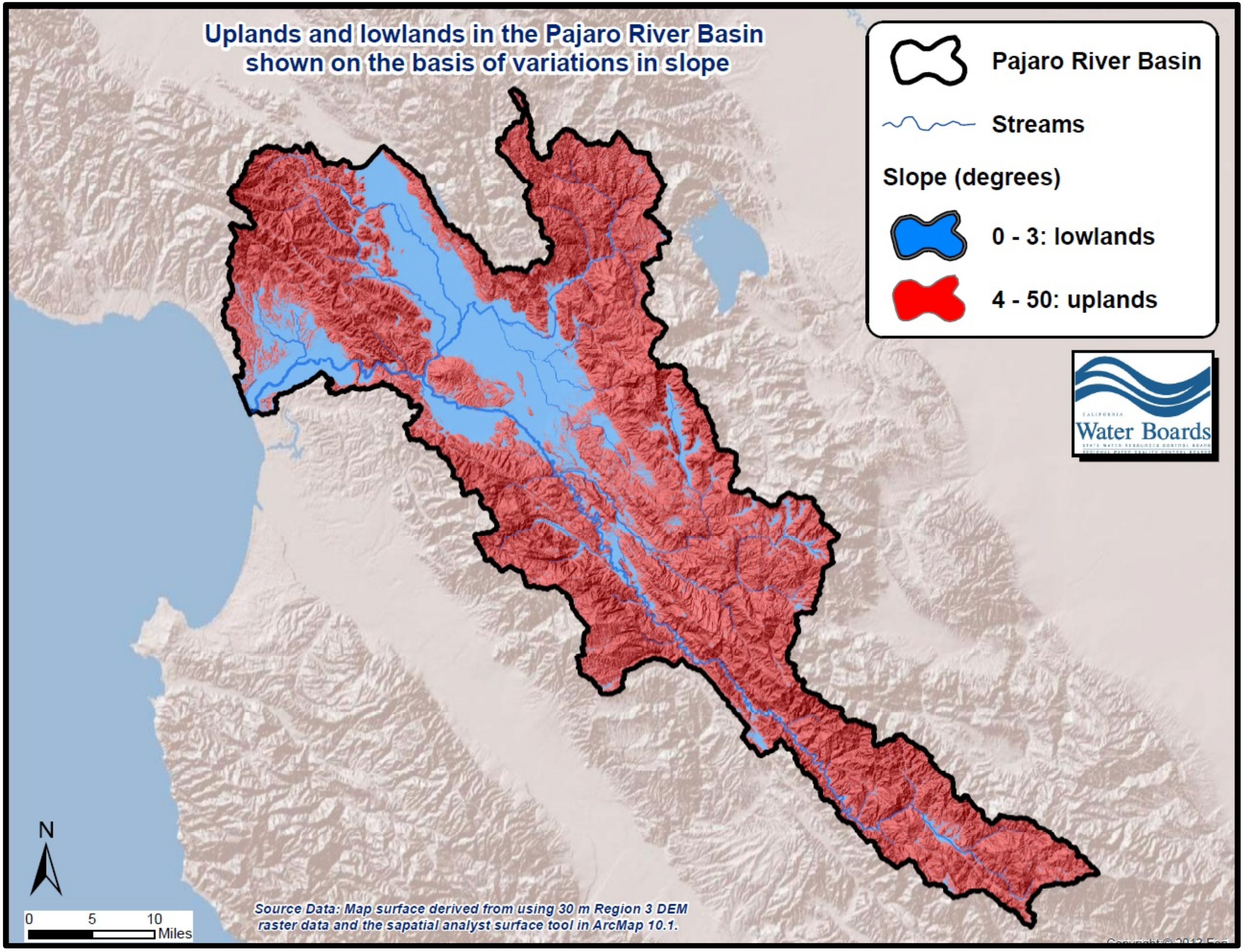
An additional reason for assessing geomorphic conditions in the watershed is that geomorphic conditions can potentially be used in grouping streams into categories, consistent with nutrient water quality target development guidance from USEPA (see Section 6.3).

Further, California central coast researchers have reported a linkage between geomorphology and biostimulatory impairments in the Pajaro River basin:

> "*Sections of the Pajaro River watershed have been listed by the State of California as impaired for nutrient and sediment violations under the Clean Water Act ……**The best evidence linking elevated nutrient concentrations to algae growth was shown when the stream physiography, geomorphology, and water chemistry were incorporated into the survey and analysis.**"**
>
> ***emphasis added***
>
> *From: University of California, Santa Cruz (2009). Final Report: Long-Term, High Resolution Nutrient and Sediment Monitoring and Characterizing In-stream Primary Production. Proposition 40 Agricultural Water Quality Grant Program (Project Lead: Dr. Marc Los Huertos).*

Figure 3-16 broadly illustrates the distribution of lowlands and uplands in the Pajaro River basin, on the basis of variations in slope as derived from a 30 meter digital elevation model.

Figure 3-16. Map showing distribution of lowlands and uplands in the Pajaro River basin on the basis of variations in land slope (degrees).



Source Data: Map surface derived from using 30 m Region 3 DEM raster data and the sapatial analyst surface tool in ArcMap 10.1.

Generalized geomorphic landscape provinces of the Pajaro River basin are presented in Figure 3-17. Landscapes of the northern parts of the river basin include the coastal Monterey Bay Plains and Terraces[26] and the inland, intermontane Santa Clara Valley. These lowlands are characterized by gently sloping to nearly level floodplains, alluvial fans, and stream terraces. These lowlands are dissected by a series of northwest-southeast trending upland features including the Santa Cruz Mountains, the Leeward Hills, and the Western Diablo Range. Landscapes of the southern parts of the Pajaro River basin are dominantly characterized by uplands of the Gabilan and Diablo ranges.

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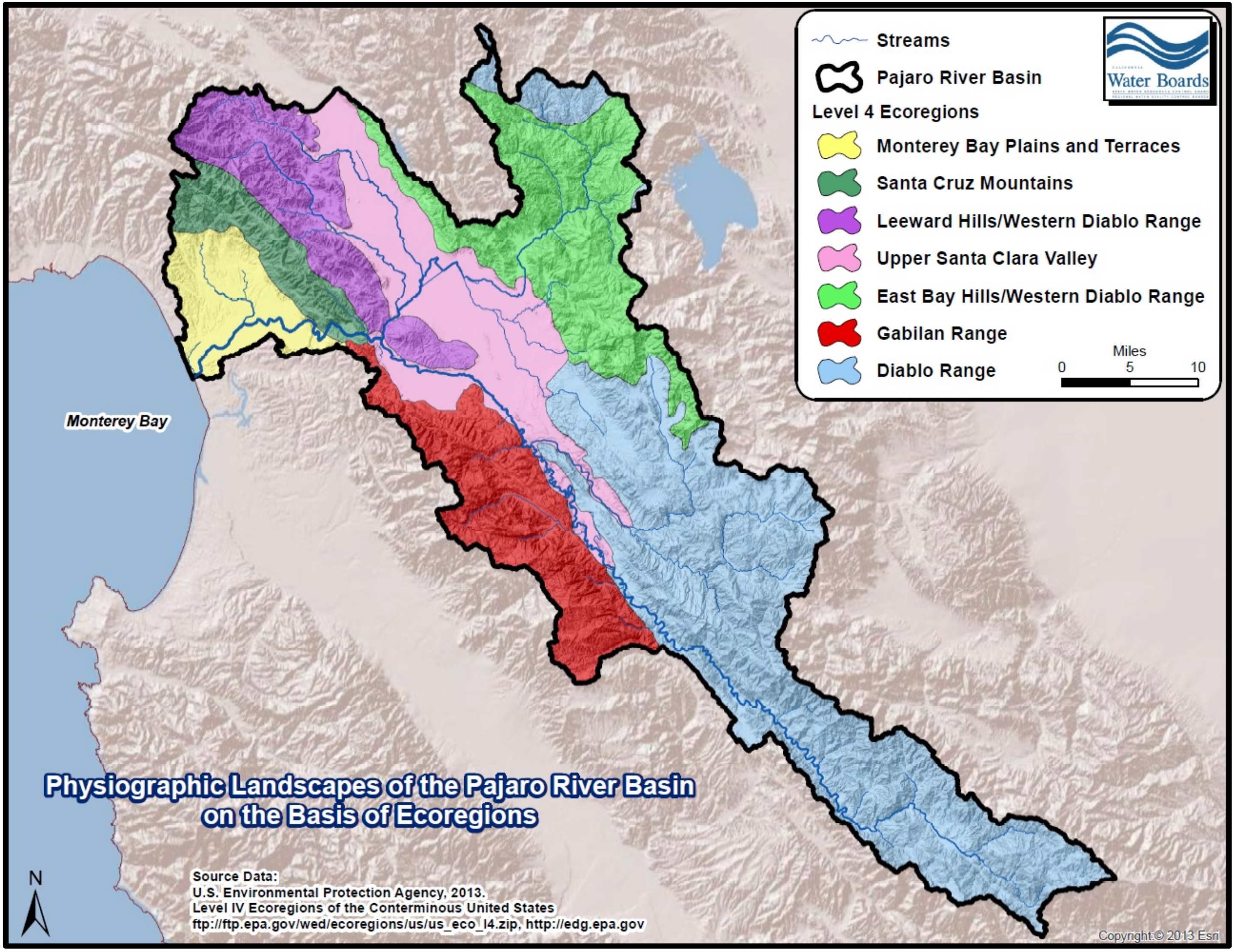
[26] Locally, this geomorphic landscape area is generally known as the "Pajaro Valley"

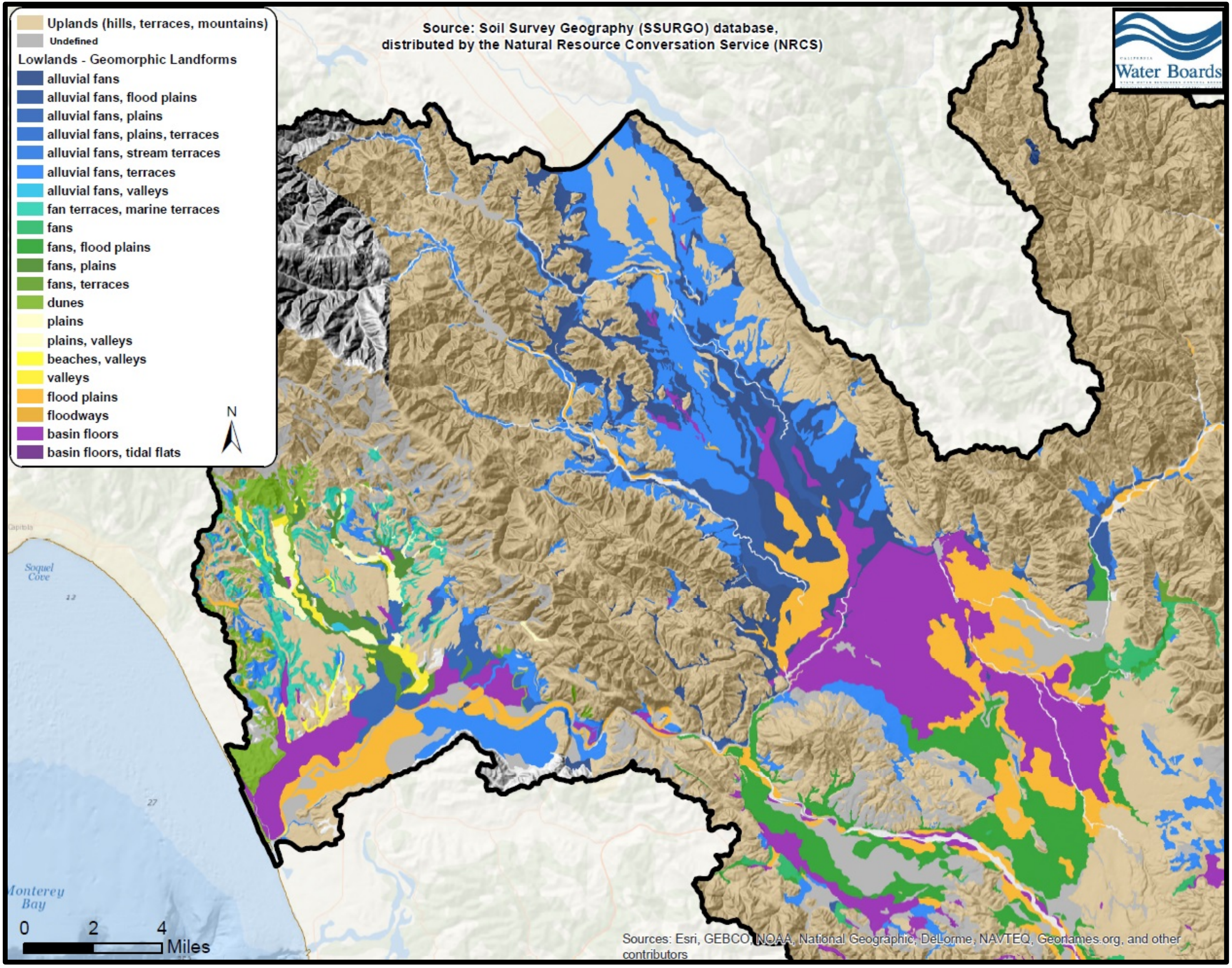
Figure 3-17. Physiographic landscapes of the Pajaro River basin on the basis of Level IV ecoregions.



Source Data:
U.S. Environmental Protection Agency, 2013.
Level IV Ecoregions of the Conterminous United States
ftp://ftp.epa.gov/wed/ecoregions/us/us_eco_l4.zip, http://edg.epa.gov

Figure 3-18 illustrates geomorphic landscape descriptions of the Pajaro River basin; these geomorphic descriptions are available from U.S. Department of Agriculture National Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) Database. Low gradient areas such as basin floors, flood plains, sloughs, and alluvial valleys are physiographic areas that are likely to be at higher risk of summertime algal growth and excessive algal biomass in surface waterbodies, relative to higher gradient, higher canopy, and non-perennial flow upland areas.

Figure 3-18. Geomorphology of the northern Pajaro River basin, with an emphasis on lowland landforms.



3.6 Nutrient Ecoregions & Reference Conditions

Reference conditions refer to water quality conditions associated with relatively undisturbed stream basins, and thus represent water quality conditions that could be expected in the absence of excessive human impacts. Reference conditions are not necessarily pristine and undisturbed natural conditions. Reference conditions can be evaluated in nutrient TMDL development as a way of assessing water quality expected to be associated with water resources that have not been significantly degraded by human inputs.

Since reference conditions are not uniform across the nation or across any given state, due to natural variability, the USEPA has designated nutrient ecoregions that denote areas with ecosystems that are generally similar (e.g., physiography, climate, geology, soils, land use, hydrology). The Pajaro River basin is located largely in Ecoregion III subecoregion 6 – Southern and Central California Chaparral and Oak Woodlands[27] (see Figure 3-19). The primary distinguishing characteristic of this ecoregion is its Mediterranean climate of hot dry summers and cool moist winters, and associated vegetative cover comprising mainly chaparral and oak woodlands; grasslands occur in some lower elevations and patches

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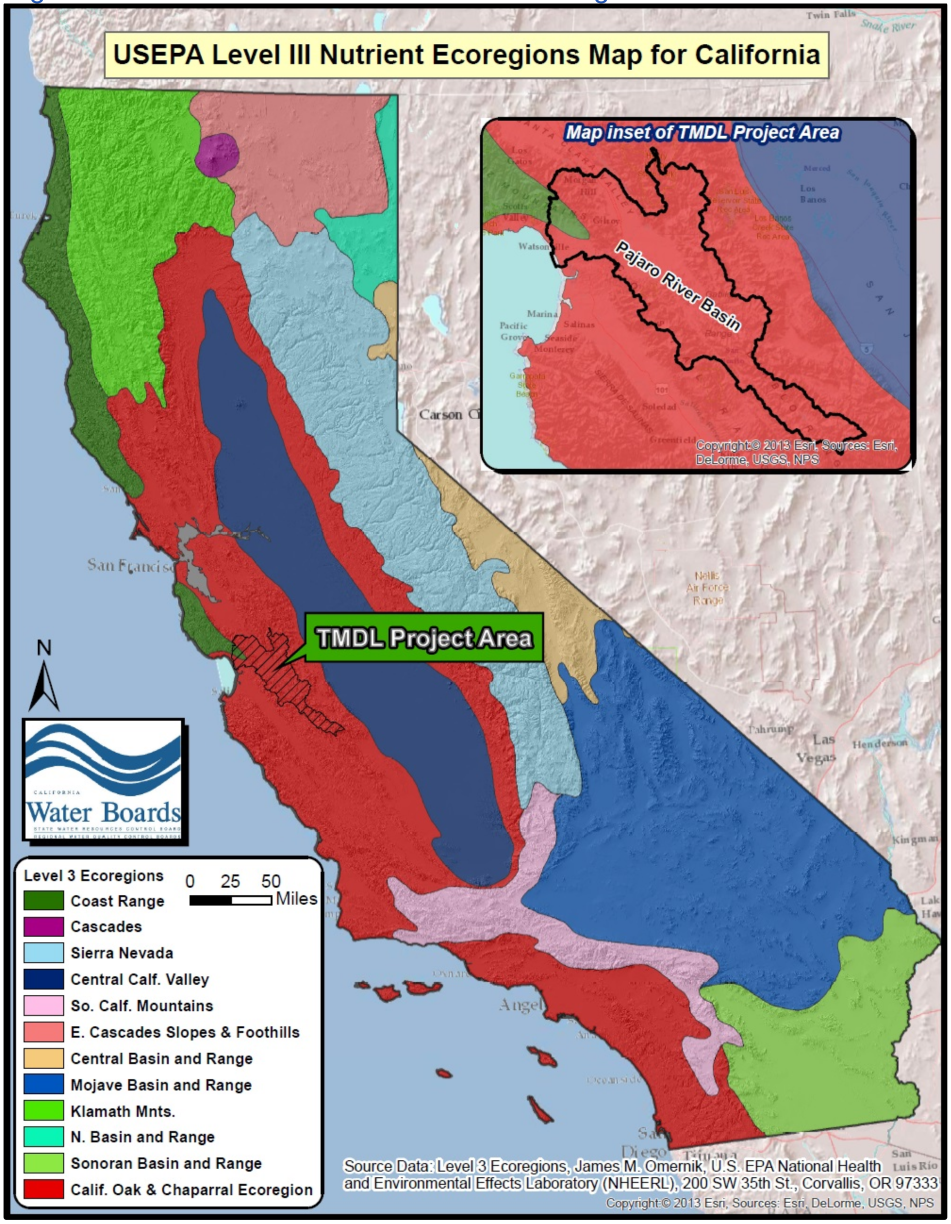
[27] Also referred to throughout this report more concisely as “Nutrient subecoregion 6”.

of pine are found at higher elevations. Most of the California Chaparral and Oak Woodlands ecoregion consists of open low mountains or foothills, but there are areas of irregular plains in the south and near the border of the adjacent Central California Valley ecoregion.

A small portion of the Pajaro River basin (approximately 40 square miles of the Santa Cruz Mountains) is located in Ecoregion II subecoregion 1 – Coast Range[28] (see Figure 3-19). The primary distinguishing characteristic of this subecoregion is its highly productive, rain-drenched coniferous forests that cover the low mountains of the Coast Range. Sitka spruce and coastal redwood forests originally dominated the fog-shrouded coast, while a mosaic of western red cedar, western hemlock, and Douglas-fir blanketed inland areas. Today Douglas-fir plantations are prevalent on the intensively logged and managed landscape.

Figure 3-19. California Level III nutrient ecoregions.



Source Data: Level 3 Ecoregions, James M. Omernik, U.S. EPA National Health and Environmental Effects Laboratory (NHEERL), 200 SW 35th St., Corvallis, OR 97333

Copyright © 2013 Esri, Sources: Esri, DeLorme, USGS, NPS

Ecoregional natural variation illustrates that a single, uniform regulatory numeric nutrient water quality target is not appropriate at the national or state-level scale. At the larger geographic scales, natural ambient nutrient concentrations and associated biostimulatory risks in surface waters are highly variable

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[28] Also referred to more concisely as "Nutrient subecoregion 1."

due to variations in vegetation, hydrology, climate, geology and other natural factors. As such, it is important to consider natural variability of nutrient concentrations locally at smaller geographic scales (e.g., the ecoregional, watershed, or subwatershed-scales). Therefore, note that some subsequent elements or sections of this TMDL Report will reference nutrient water quality conditions in Ecoregion III subecoregion 6 (i.e., Calif. Oak and Chaparral subecoregion).

➢ *USEPA Ecoregional Nutrient Numeric Criteria*

In 2000, the USEPA published ambient numeric criteria to support the development of State nutrient criteria in rivers and streams of Nutrient Ecoregion II and III. Narrative from the 2000 USEPA guidance is reproduced below (emphasis added):

> (The 2000 report) presents EPA's nutrient criteria for **Rivers and Streams in Nutrient Ecoregion II and III.** These criteria provide EPA's recommendations to States and authorized Tribes for use in establishing their water quality standards consistent with section 303(c) of CWA [Clean Water Act]. Under section 303(c) of the CWA, States and authorized Tribes have the primary responsibility for adopting water quality standards as State or Tribal law or regulation. The standards must contain scientifically defensible water quality criteria that are protective of designated uses. **EPA's recommended section 304(a) criteria are not laws or regulations** – they are guidance that States and Tribes may use as a starting point for the criteria for their water quality standards.
>
> In developing these criteria recommendations, EPA followed a process which included, to the extent they were readily available, the following elements critical to criterion derivation:
>
> **Historical and recent nutrient data in Nutrient Ecoregion II & III:** Data sets from Legacy STORET, NASQAN, NAWQA and EPA Region10 were used to assess nutrient conditions from 1990 to 1998.
>
> **Reference sites/reference conditions in Nutrient Ecoregion II & III:** Reference conditions presented are based on 25th percentiles of all nutrient data including a comparison of reference condition for the aggregate ecoregion versus the subecoregions. States and Tribes are urged to determine their own reference sites for rivers and streams within the ecoregion at different geographic scales and to **compare** them to EPA's reference conditions.
>
> The intent of developing ecoregional nutrient criteria is to represent conditions of surface waters that are minimally impacted by human activities and thus protect against the adverse effects of nutrient over enrichment from cultural eutrophication. EPA's recommended process for developing such criteria includes physical classification of waterbodies, determination of current reference conditions, evaluation of historical data and other information (such as published literature), use of models to simulate physical and ecological processes or determine empirical relationships among causal and response variables (if necessary), expert judgment, and evaluation of downstream effects. To the extent allowed by the information available, EPA has used elements of this process to produce the information contained in this document. **The values for both causal (total nitrogen, total phosphorus) and biological and physical response (chlorophyll *a*, turbidity) variables represent a set of starting points for States and Tribes to use in establishing their own criteria in standards to protect uses.** The values presented in this document generally represent nutrient levels that protect against the adverse effects of nutrient over enrichment and are based on information available to the Agency at the time of this publication. However, States and Tribes should critically evaluate this information in light of the specific designated uses that need to be protected.
>
> *-from: Ambient Water Quality Criteria Recommendations – River and Streams in Nutrient Ecoregion III, USEPA December 2000.*

USEPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams (USEPA, 2000a) describes two ways of establishing a reference condition. USEPA proposed that the 25th percentiles of all nutrient water quality data could be assumed to represent unimpacted reference conditions for each aggregate ecoregion, and also provided a comparison of reference condition for the aggregate ecoregion versus the subecoregions.

USEPA characterized 25th percentile values of a population of water quality data as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000a). However, USEPA also cautioned that States and Tribes may "need to identify with greater precision the nutrient levels that protect aquatic life and recreational uses. USEPA also proposed that the 75th percentiles of all nutrient data of reference stream(s) could be assumed to represent unimpacted reference conditions for each aggregate ecoregion, and also provided a comparison of reference condition for the aggregate ecoregion versus the subecoregions. USEPA (U.S. Environmental Protection Agency) defines a reference stream as follows:

> *“A reference stream is a least impacted waterbody within an ecoregion that can be monitored to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans.”*

For reference, USEPA’s 25th percentiles (representing unimpacted reference conditions) for the California Oak and Chaparral subecoregion (i.e., nutrient subecoregion 6) are presented in Table 3-14. Percentiles for Coastal Range subecoregion (i.e., nutrient subecoregion 1) are presented in Table 3-15.

Table 3-14. USEPA Reference conditions for Level III subecoregion 6 streams.

Parameter	**25th Percentiles based on all seasons data for the decade**
Total Nitrogen (TN) – mg/L	0.52
Total Phosphorus (TP) – mg/L	0.03
Chlorophyll *a* – µg/L	2.4
Turbidity - NTU	1.9

Table 3-15 . USEPA Reference conditions for Level II subecoregion 1 streams.

Parameter	**25th Percentiles based on all seasons data for the decade**
Total Nitrogen (TN) – mg/L	0.14
Total Phosphorus (TP) – mg/L	0.010
Chlorophyll *a* – µg/L	1.53
Turbidity - NTU	1.08

It should be re-emphasized that the above ecoregional criteria are not regulatory standards, and USEPA in fact considers them “starting points” developed on the basis of data available at the time. USEPA has recognized that States need to evaluate these values critically, and assess the need to develop nutrient targets appropriate to different geographic scales and at higher spatial resolution.

➢ *Historical Nitrate Concentrations in California Alluvial Valley Rivers*

Development of nutrient water quality criteria could consider variations between lowland ecosystems and upland ecosystems. Often, reference background nitrate water quality conditions are heavily weighted towards undisturbed or lightly-disturbed tributary reaches located in headwater or upland reaches of a river basin. This is because most valley floor areas of California have been developed for agricultural or residential land uses, and thus are not representative of undisturbed systems.

Nutrient criteria development guidance published by the State of California notes that nutrient water quality targets established for main stem river or alluvial valley stream reaches should not be lower than concentrations found in undisturbed tributary reaches or background conditions in the river basin (Tetra Tech, 2006). Also noteworthy, a scientific peer reviewer has previously stated to Central Coast Water Board staff that headwater and lightly-disturbed tributary reaches may not be fully representative of lowland ecosystems (Buetel, 2012). Alluvial river valleys in California, and indeed throughout the world, tend to be highly modified by human activities, because they are generally ideal locations for agriculture, commerce, and human populations. Thus, there can be uncertainty about what ambient, undisturbed, natural background nutrient water quality should be expected in an alluvial valley river.

Table 3-16 presents historical nitrate water quality data from alluvial valley stream reaches in California from sampling conducted in the years 1907 to 1908[29]. The years 1907-08 represents a time when human impacts to surface waters in California rivers undoubtedly tended to be significantly less than

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[29] It is important to recognize that analytical techniques and analytical precision for water sampling have changed over the last century, so the historical 1907-08 nitrate water quality data should be considered informational and anecdotal only, and should not be considered a definitive representation of undisturbed, ambient alluvial valley river conditions.

today. Thus these century-old, vintage nitrate concentration data may be a close proxy to natural or lightly-impacted nitrate concentrations that may be expected in alluvial valley rivers of California. Note that, on average, alluvial valley river waters in 1907-08 contained 0.31 mg/L nitrate as N, with 90 percent of the samples collected having concentrations under 0.45 mg/L. In contrast, recent data indicate that wadeable streams in undisturbed upland and headwater reaches of California (see Table 3-17) collectively tend to have marginally lower nitrate as N concentrations – a mean nitrate as N concentration of 0.15 mg/L, and 90% of the samples having concentrations below 0.23 mg/L nitrate as N[30]. Thus, while data from the historical alluvial valley river waters, and the upland tributary stream waters are both generally quite low in nitrate, it is worth noting that the 1907-08 vintage water quality data from alluvial valley rivers tend to have nitrate concentrations noticeably higher than the sampled upland tributary streams – around 0.31 mg/L vs 0.15 mg/L nitrate as N on average, respectively. Figure 3-20 illustrates the aforementioned information in map-view.

To further probe possible differences between the historical alluvial valley river data and the upland tributary data, a two-sample Wilcoxon Rank Sum Test[31] of the two datasets (i.e., the historical alluvial valley river nitrate data and the upland tributary nitrate data) using R[32] indicates that the alluvial valley river waters are generally higher in nitrate as N concentration (median = 0.181 mg/L) than nitrate as N in waters from the upland tributary streams (median = 0.068 mg/L). Further, the differences in the nitrate concentrations between the two datasets is highly statistically significant (P-value < 2.2e-16)[33] indicating a very small probability of observing this difference by random chance. Practically speaking, this suggests that nitrate concentrations observed in waters of historical alluvial valley rivers of central and southern California are generally higher than nitrate concentrations observed in wadeable streams of headwater and upland tributary reaches of California. While understanding that there are uncertainties in comparing two datasets of substantially different vintages, this constitutes at least a circumstantial line of evidence that ambient waters of alluvial valley rivers are generally higher in nitrate concentration than ambient waters of upland tributary stream reaches in California.

Based on staff's knowledge of state water quality data, it is extremely unlikely that an alluvial valley floor stream could be expected to achieve a water quality condition of 0.11 mg/L nitrate as N, commensurate with the observed undisturbed headwater wadeable stream average condition from Table 3-17[34]. Indeed, as noted previously, headwater and lightly-disturbed tributary reaches may not be fully representative of lowland ecosystems (Buetel, 2012). Further, in contrast to headwater stream reaches, alluvial valley floors are typically characterized by thick, well-developed, and extensive soil profiles, and researchers have stated that waterbodies can be expected to interact with soil nitrogen (for example, Moran et al., 2011).

On the basis of the aforementioned information, in the development of nutrient water quality criteria for alluvial valley rivers and streams, it may be important to ensure that the numeric criteria not be unduly weighted or biased by nutrient water quality data from upland, tributary stream reaches.

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[30] On the basis of data collected by the State Water Resources Control Board, Surface Water Ambient Monitoring Program, Reference Conditions Management Plan to Support Biological Assessment of California's Wadeable Streams.

[31] Also widely known as the Mann-Whitney test.

[32] R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org

[33] By convention, P-values are considered to indicate statistical significance when the P-value < 0.05.

[34] It is important to recognize that nitrogen in aqueous systems exists in many forms other than the nitrate molecule. Hypothetically, in headwater upland reaches, stream nutrients could exist more preferentially in the form of organic matter such as woody debris, and leaf drop (personal communication, Karen Worcester, senior environmental scientist, Central Coast Water Board).

Table 3-16. Numerical summary of early 20th century (1907-1908) river nitrate (as N) water quality from alluvial valley floor river reaches in central and southern California.

River - Sampling Location	Dates sampled	Arithmetic Mean	Min	25th %	50th % (median)	75th %	90th %	Max	No. of Samples
Ventura River at Ventura	Dec. 1907 – Dec. 1908	0.17	0.02	0.07	0.14	0.17	0.27	1.36	35
Salinas River at Paso Robles	Dec. 1907 – Dec. 1908	0.17	0.04	0.09	0.14	0.23	0.30	0.41	30
Salinas River at Spreckels	April 1908 – August 1908	0.26	0.23	0.24	0.26	0.28	0.29	0.29	2
San Antonio River above Bradley	Dec. 1907 – Dec. 1908	0.24	trace	0.16	0.25	0.32	0.40	0.45	37
San Gabriel River near Azusa	Dec. 1907 – Dec. 1908	0.28	0.02	0.07	0.16	0.23	0.40	3.84	32
San Joaquin River at Lathrop	Dec. 1907 – Dec. 1908	0.25	0.08	0.16	0.23	0.32	0.43	0.54	34
Estrella River near San Miguel	Dec. 1907 – Dec. 1908	0.20	trace	0.10	0.16	0.25	0.35	0.90	37
Mojave River at Victorville	March 17, 1908	0.08	0.08	0.08	0.08	0.08	0.08	0.08	1
Nacimiento River near San Miguel	Jan. 1908 – Dec. 1908	0.99	0.05	0.32	0.45	0.88	1.79	9.04	34
Sacramento River above Sacramento	Dec. 1907 – Dec. 1908	0.15	0.02	0.09	0.12	0.20	0.24	0.36	34
Numerical composite summary for all river sampling events	Dec. 1907 to March 1908	0.31	trace	0.1	0.18	0.29	0.45	9.04	276

Data source: U.S. Geological Survey, 1910. Water Supply Paper 237, The Quality of the Surface Waters of California. Note: In the 1910 report, nitrate is reported as the nitrate molecule; in this table staff converted the reported nitrate values to elemental nitrogen equivalent (nitrate as N).

Table 3-17. Numerical summary of nitrate (as N) water quality from wadeable streams in upland and tributary reaches of California .

Stream Types	Sampling locations	Dates sampled	Number of samples	Nitrate as N statistical summary for all samples	
Wadeable streams in upland & headwater reaches	108 upland & headwater streams throughout California	May 2008 – Sept. 2010	108	mean	0.15 mg/L
				min	<0.01 mg/L
				25%	0.022 mg/L
				50%	0.068 mg/L
				75%	0.013 mg/L
				90%	0.23 mg/L
				max	6.5 mg/L

Data source: RCMP – State Water Resources Control Board, Surface Water Ambient Monitoring Program, Reference Conditions Management Plan (RCMP) to Support Biological Assessment of California's Wadeable Streams

Figure 3-20. Map illustrating early 20th century (1907–1908) river nitrate (as N) water quality in central and southern California alluvial valley river reaches on the basis of data previously presented in Table 3-16. The locations of upland tributary and headwater stream monitoring sites from Table 3-17 are also annotated on the map.

Water Quality Source Data:
U.S. Geological Survey, 1910. Water Supply Paper 237.
Alluvial Basins and Valleys from: Soller, D.R., et. al,
RCMP Water Quality Sites: Reference Conditions Management Plan, State Water Resources Control Board
Map Database for Surficial materials in the Conterminous US; USGS, Data Series 425, http://pubs.usgs.gov/ds/425/
Rivers shapefiles from NHD plus

One way to establish plausible reference conditions appropriate for stream reaches of the Pajaro River basin, is to apply the US Environmental Protection Agency (USEPA) reference stream methodology (75th percentile approach, as described previously) for water quality data from natural or lightly-disturbed headwater and tributary reaches in and around the Pajaro River basin (see Figure 3-21) for map of reference conditions monitoring sites). It should be noted that these sites are most directly representative of uplands, since most remaining undisturbed or lightly-disturbed areas of California's central coast region are associated with upland ecosystems. USEPA chose the 75th percentile since this percentile is likely associated with minimally impacted conditions and will be protective of designated uses. For informational purposes, staff also calculated the 90th percentiles of nitrogen and phosphorus compounds concentrations in these reaches to assess plausible "high-end" concentrations of these constituents which might be expected in lightly-disturbed areas. A tabular summary of the reference monitoring sites are presented in Table 3-18 and numerical summaries of the water quality data from these sites are presented in Table 3-19. It can be concluded from these data that nitrate as N and total nitrogen background surface water quality represented by these sites are generally less than 1 mg/L nitrate as N; orthophosphate is generally less than 0.1 mg/L. It is noteworthy that streams of the Santa Cruz Mountains and Monterey Plains ecoregion locally (Pescadero Creek) have anomalously elevated total phosphorus and orthophosphate concentrations. Staff hypothesizes that the presence of phosphatic rocks and phosphatic sediments associated locally with Miocene marine strata may be a contributor to elevated levels of phosphorus in Pescadero Creek waters (see report Section 3.10).

Figure 3-21. Human footprint map and ecoregional stream water quality reference monitoring sites which are plausibly representative of natural background or lightly-disturbed conditions in upland reaches. Reference conditions stream water quality monitoring sites here are grouped on the basis of Level IV ecoregions, refer back to Section X and Figure Y for a map of level IV ecoregions.

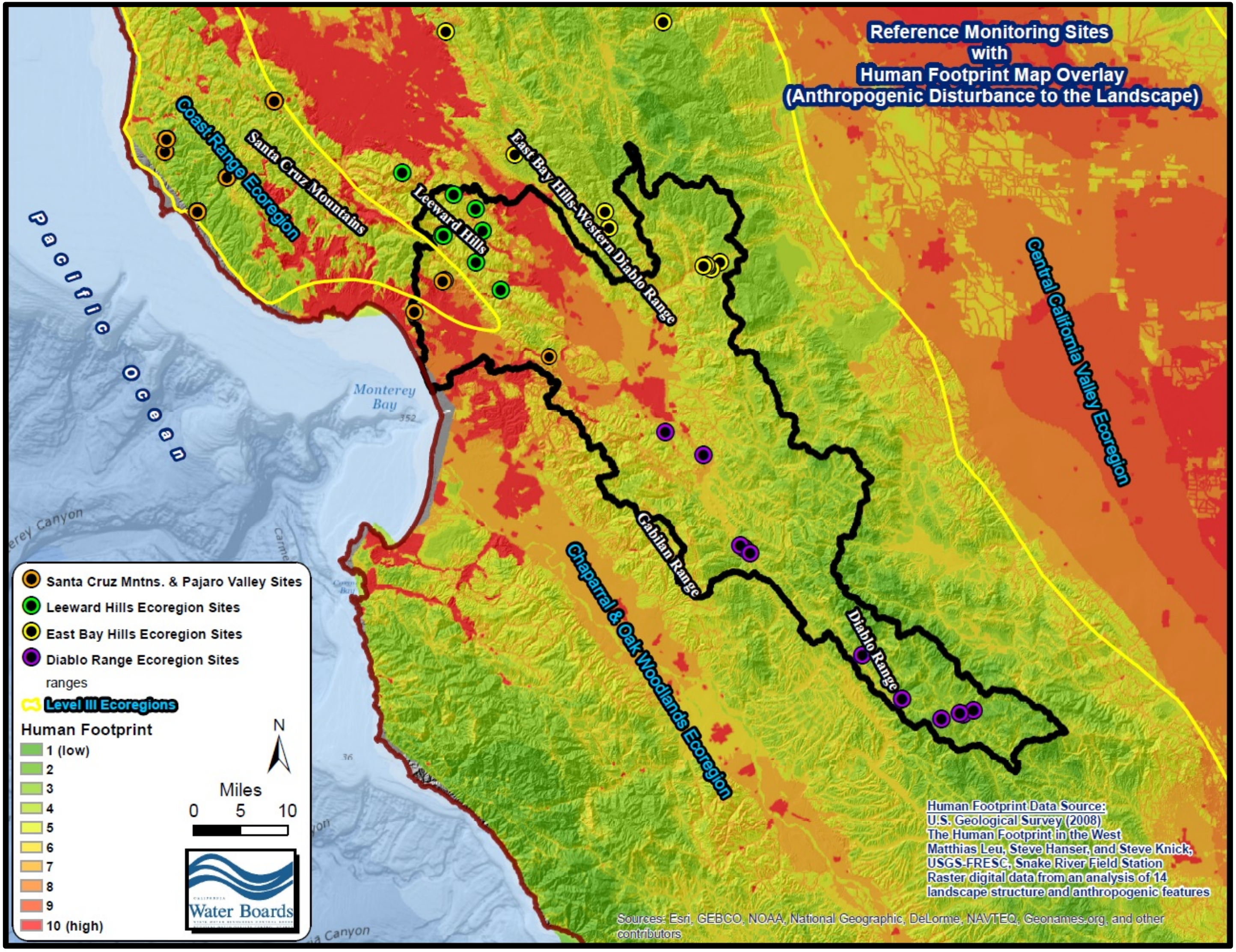


Table 3-18. Level IV ecoregional water quality reference conditions monitoring sites in lightly disturbed reaches in and around the Pajaro River basin. Map view of monitoring sites shown in Figure 3-21.

Level IV Ecoregion(s)[A] (refer back to Figure 3-21) for geographic reference	**Reference Conditions Monitoring Sites**
Santa Cruz Mountains and Monterey Bay Plains and Terraces (Pajaro Valley upland reaches)	San Pedro Creek upstream footbridge
	Little Butano Creek @ Butano State Park
	Upper Stevens Creek
	Sempervirens Creek above Hwy 236
	Butano Creek @ Girl Scout Camp
	Waddell Creek ~1.8mi above Hwy 1
	Browns Creek at Browns Valley Road

Level IV Ecoregion(s)[A] (refer back to Figure 3-21) for geographic reference	**Reference Conditions Monitoring Sites**
	Browns Creek at Browns Rd and Caudill
	Harkins Slough at White Road
	Pescadero Creek NE of Chittendon at RR Tracks
Leeward Hills and Upper Santa Clara Valley (westside upland reaches)	Llagas Creek above Chesbro Reservoir
	Llagas Creek above Baldy Ryan Canyon. Creek
	Swanson Canyon Creek above Uvas Creek
	Uvas Creek above Swanson Canyon Creek
	Little Arthur Creek ~1mi west of Redwood Retreat Rd.
	Blackhawk Canyon Tributary To Bodfish Creek
	Uvas Creek above Uvas Reservoir
	Uvas Creek at Canyon County Park
	Guadalupe Creek above Res
East Bay Hills / Western Diablo Ranges (including the Pacheco Creek Subbasin)	Coyote Creek Hunting Hollows
	Del Puerto Creek
	Upper Penitencia Creek Upper Alum Rock Park
	Coyote Creek ~1.4 mi below Big Canyon.
	Pacheco Creek ~1.3 mi Above South Fork
	Pacheco Creek South Fork 1.1 mi SE/Pacheco Ln
	Pacheco Creek South Fork near Pacheco Lake
	Pacheco Creek just below North Fork Confluence
	Coyote Creek below confluence of West Fork
	Las Animas Creek Below San Felipe Creek
Diablo Range (San Benito River Subbasin)	San Benito River Bridge 1.9 mi downstream of Willow Creek
	Tres Pinos Creek at Southside Rd
	San Benito River below Hernandez Reservoir
	San Benito River 0.4 mi below Willow Creek
	Tres Pinos Creek At Hwy. 25
	Clear Creek
	Laguna Creek
	San Benito River at Willow Creek School

[A] Refer back to Figure 3-17

Table 3-19. Numerical summaries of water quality data from reference conditions monitoring sites.

Level IV Ecoregion [A]	**Parameter [B, C]**	**Dates sampled**	**Arithmetic Mean**	**Min**	**25th %**	**50th % (median)**	**75th %**	**90th %**	**Max**	**No. of Samples**
Santa Cruz Mountains and Monterey Bay Plains and Terraces (Pajaro Valley upland reaches)	Nitrate as N	Dec. 1997-Dec. 2013	0.346	0.006	0.113	0.113	0.226	0.57	9.72	134
	Total Nitrogen	June 2009-June 2010	0.094	0.0402	0.0491	0.0802	0.104	0.158	0.213	6
	Orthophosphate as P	Dec. 1997-June 2013	0.131	0.018	0.05	0.066	0.135	0.293	1.09	60
	Total Phosphorus	Dec. 1997-June 2010	1.04	0.037	0.058	0.067	1.1	3.44	4.8	9
	Dissolved Oxygen	Dec. 1970-June 2010	8.94	6.9	8.4	8.8	9.35	10	12	46
	pH	Dec. 1997-June 2010	7.52	6.95	7.5	7.5	7.5	8	8.4	46
	Chlorophyll *a*	June 2009-June 2010	10.4	3.84	7.71	9.53	14.1	16	16.6	6
Leeward Hills and Upper Santa Clara Valley (westside upland reaches)	Nitrate as N	Feb. 1998-July 2010	0.103	0.005	0.02	0.032	0.12	0.26	0.504	17
	Total Nitrogen	June 2001-July 2010	0.129	0.07	0.078	0.118	0.157	0.195	0.221	5

Level IV Ecoregion [A]	**Parameter** [B, C]	**Dates sampled**	**Arithmetic Mean**	**Min**	**25th %**	**50th % (median)**	**75th %**	**90th %**	**Max**	**No. of Samples**
	Orthophosphate as P	Feb. 1998-July 2010	0.013	0.002	0.007	0.013	0.016	0.02	0.024	17
	Total Phosphorus	Oct. 1975-July 2010	0.036	0.004	0.0124	0.03	0.0358	0.085	0.13	16
	Dissolved Oxygen	Feb. 1998-July 2010	8.94	6.73	8.19	9.5	9.62	10.16	10.87	20
	pH	Feb. 1998-July 2010	7.95	7.53	7.77	7.92	8.09	8.22	8.61	16
	Chlorophyll *a*	Feb. 1998-June 2001	1.4	0.01	0.25	0.87	1	1.8	9.1	12
East Bay Hills / Western Diablo Ranges (including the Pacheco Creek subbasin)	Nitrate as N	Mar1987-June 2010	0.09	0.003	0.006	0.031	0.07	0.2	0.44	8
	Total Nitrogen	Mar1987-June 2010	0.21	0.01	0.089	0.13	0.4	0.42	0.43	5
	Orthophosphate as P	Mar1987-June 2010	0.035	0.006	0.013	0.026	0.036	0.07	0.1	6
	Total Phosphorus	Feb. 1974-June 2010	0.020	0.002	0.008	0.017	0.032	0.036	0.049	11
	Dissolved Oxygen	Feb. 1974-June 2010	10.28	5.72	9.6	10.5	11.2	11.82	13	29
	pH	Mar1987-June 2010	7.98	7.21	7.85	7.96	8.28	8.37	8.53	8
	Chlorophyll *a*		No data for water column chlorophyll							
Diablo Range (San Benito River subbasin)	Nitrate as N	Dec. 1997-Dec. 2011	0.23	0.003	0.021	0.028	0.17	0.82	1.85	109
	Total Nitrogen	July 1994-Dec. 2011	0.53	0.1	0.1	0.23	0.43	0.99	3.9	43
	Orthophosphate as P	July 1994-Dec. 2011	0.026	0.003	0.005	0.01	0.019	0.086	0.18	58
	Total Phosphorus	July 1994-Dec. 2011	0.38	0.003	0.016	0.04	0.12	0.53	6.6	55
	Dissolved Oxygen	Jan. 1953-Dec. 2011	9.79	3.99	8.71	9.7	10.8	11.6	16.9	352
	pH	Jan. 1998-Dec. 2011	8.46	7.57	8.37	8.48	8.58	8.64	9.5	156
	Chlorophyll *a*	Feb. 1998-Dec. 2011	3.2	0	0.88	1.37	3.99	6.31	27.4	49

[A] Refer back to Figure 3-17

[B] Units: all parameters reported in mg/L except chlorophyll *a* = micrograms/L and pH = – [log H+].

[C] Water quality data sources: see TMDL Report Section 5.2 and supplementary data from the State Water Resources Control Board, Surface Water Ambient Monitoring Program – Perennial Stream Survey & the Statewide Reference Condition Management Plan.

Based on the preceding information and data, generalized stream water quality reference conditions in the Pajaro River basin can be estimated as summarized in Text Box 3-1.

Text Box 3-1. Generalized reference conditions that would be expected in undisturbed or lightly-impacted stream reaches in the Pajaro River basin.

1) Creeks in tributary or upland reaches of the river basin:

- Total nitrogen can generally be expected to be well below 1 mg/L. Anomalous outlier water quality samples can rarely range up to 3 or 4 mg/L.
- Total phosphorus can generally be expected to be below about 0.1 mg/L, but concentrations can vary significantly. Anomalous outlier water quality samples can range to above 1 mg/L total phosphorus. Staff hypothesizes that the Santa Cruz mountains ecoregion may be expected, locally, to contribute elevated amounts of natural phosphorus to water resources.
- Dissolved oxygen can generally be expected to range between about 6 mg/L up to 10 or 11 mg/L. Anomalous outlier water quality samples can rarely range up to 12 or 13 mg/L, or as low as 4 to 5 mg/L.
- Chlorophyl *a* concentrations can generally be expected to be well below 10 micrograms/L. Anamalous outlier water quality samples can range up to between about 16 to 27 micrograms/L.

- Average pH can generally be expected to be between 7.5 to 8.5 pH units. Anomalous outlier water quality samples can rarely range up to 9.5 pH units. Reference creek water quality is generally in the alkaline range, with pH units virtually never depressed below about 7 to 7.5 pH units.

2) Historical conditions in early 20th century alluvial valley rivers in central and southern California:

- Nitrate as nitrogen concentrations reported in the early 20th century from various alluvial valley rivers in the region were almost always less than 1 mg/L, with an arithmetic mean of 0.31 mg/L for 276 samples. Anomalous outlier water quality samples did rarely range up to between 1.9 to 9 mg/L in the Nacimiento River, which field researchers at the time attributed to cattle waste in the river during very low flow, or pooled water conditions.

3.7 Climate & Atmospheric Deposition

Precipitation is often considered in the development of TMDLs. Having good estimates of precipitation in the Pajaro River basin is a necessary input parameter of the U.S. Environmental Protection Agency's STEPL source analysis spreadsheet tool staff used for source assessment (see Section 7.1). Further, staff compiled information on atmospheric deposition because atmospheric deposition of nitrogen may be important to consider as a nutrient source loading category.

Precipitation & Climatic Parameters

The Pajaro River basin is located in the Central Coast Drainage Climate Division, as defined by the National Climatic Data Center. Precipitation rain gage data in the Pajaro River basin is available from the National Oceanographic and Atmospheric Administration - Western Regional Climate Center (http://www.wrcc.dri.edu). The Pajaro River basin has a Mediterranean climate, with the vast majority of precipitation falling between November and April (see Table 3-20).

Table 3-20. Pajaro River basin rain gage precipitation records.

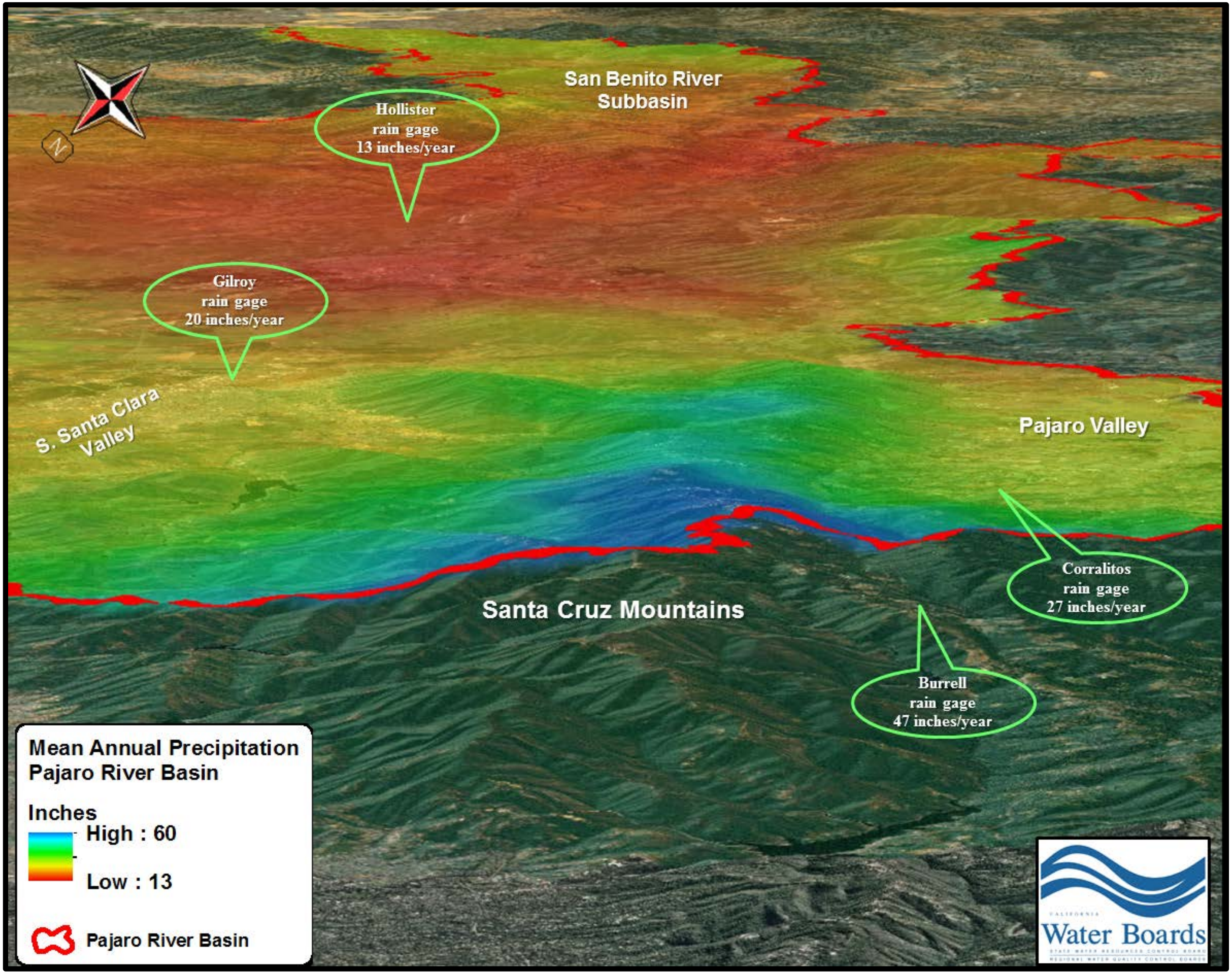
Station	Elevation (ft)	Climatic Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Watsonville Waterworks[A] **(1938-2013)**	95	Average Precipitation (inches)	4.52	3.89	3.02	1.52	0.49	0.14	0.04	0.05	0.30	0.99	2.39	4.18	**21.52**
Gilroy[A] **(1906-2013)**	194	Average Precipitation (inches)	4.70	3.74	3.24	1.40	0.39	0.10	0.05	0.05	0.32	0.90	2.21	3.72	**20.83**
Morgan Hill[A] **(1948-2013)**	375	Average Precipitation (inches)	4.83	4.72	3.21	1.50	0.29	0.00	0.03	0.00	0.04	0.95	2.39	3.70	**21.68**
Hollister 2[A] **(1948-2013)**	275	Average Precipitation (inches)	2.78	2.75	2.15	1.01	0.35	0.06	0.03	0.05	0.29	0.70	1.62	2.06	**13.86**
Pacines 5W[A] **(1948-2011)**	905	Average Precipitation (inches)	3.26	2.82	2.41	1.20	0.34	0.05	0.04	0.04	0.24	0.62	1.86	2.83	**15.71**
Corralitos (COR) [B]	450	Average Precipitation (inches)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	**27.05**
Burrell Station (BRL) [B, C]	1,850	Average Precipitation (inches)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	**42.60**

A: Western U.S. COOP weather station (Source: NOAA Western Regional Climate Center)
B: Calif. Dept. of Forestry weather station – data published in the California Natural Resources Agency CERES database
C: Located in Soquel Creek watershed of Santa Cruz mountains, 3.5 miles west of Pajaro Basin watershed boundary.
NR = not reported

It is important to recognize that rainfall gauging stations have limited spatial distribution, and that gauging stations tend to be located in lower elevations where people live. Consequently, these locations can bias estimates of regional rainfall towards climatic conditions at lower elevations. The topography of the California central coast region however, can result in significant orographic enhancement of rainfall (i.e., enhancement of rainfall due to topographic relief and mountainous terrain – for example, refer back to the higher-elevation Burrell Station rain gauge station shown previously in Table 3-20).

Note that elevations in the Pajaro Basin range from sea level to over 3,000 feet above mean sea level. Topography, elevation, and atmospheric circulation patterns can have pronounced effects on regional precipitation patterns. For example, the coastal Santa Cruz mountains create a substantial orographic effect as moist marine air is lifted, cooled, and condenses passing over the mountains. A noteworthy example is illustrated by rain gage records from March 12-17, 2012 when a couple of remote rain gages in the Santa Cruz mountains near Ben Lomond and Boulder Creek received between 16 and 20 inches of rain over those five days. Meanwhile, during those same five days in San Jose (only 25 miles to the northeast on the downslope, leeward side of the Santa Cruz mountains), only two-thirds of an inch (0.66 inches) of rain fell[35]. Figure 3-22 is an illustration of the orographic effect of the Santa Cruz Mountains. Clearly, it is not appropriate to treat rainfall as a relatively uniform spatial attribute of the Pajaro River basin.

Figure 3-22. Illustration of orographic effects in the Pajaro River basin – oblique view looking southeast across the Pajaro River basin (precipitation source data from rain gages and gridded PRISM estimates)



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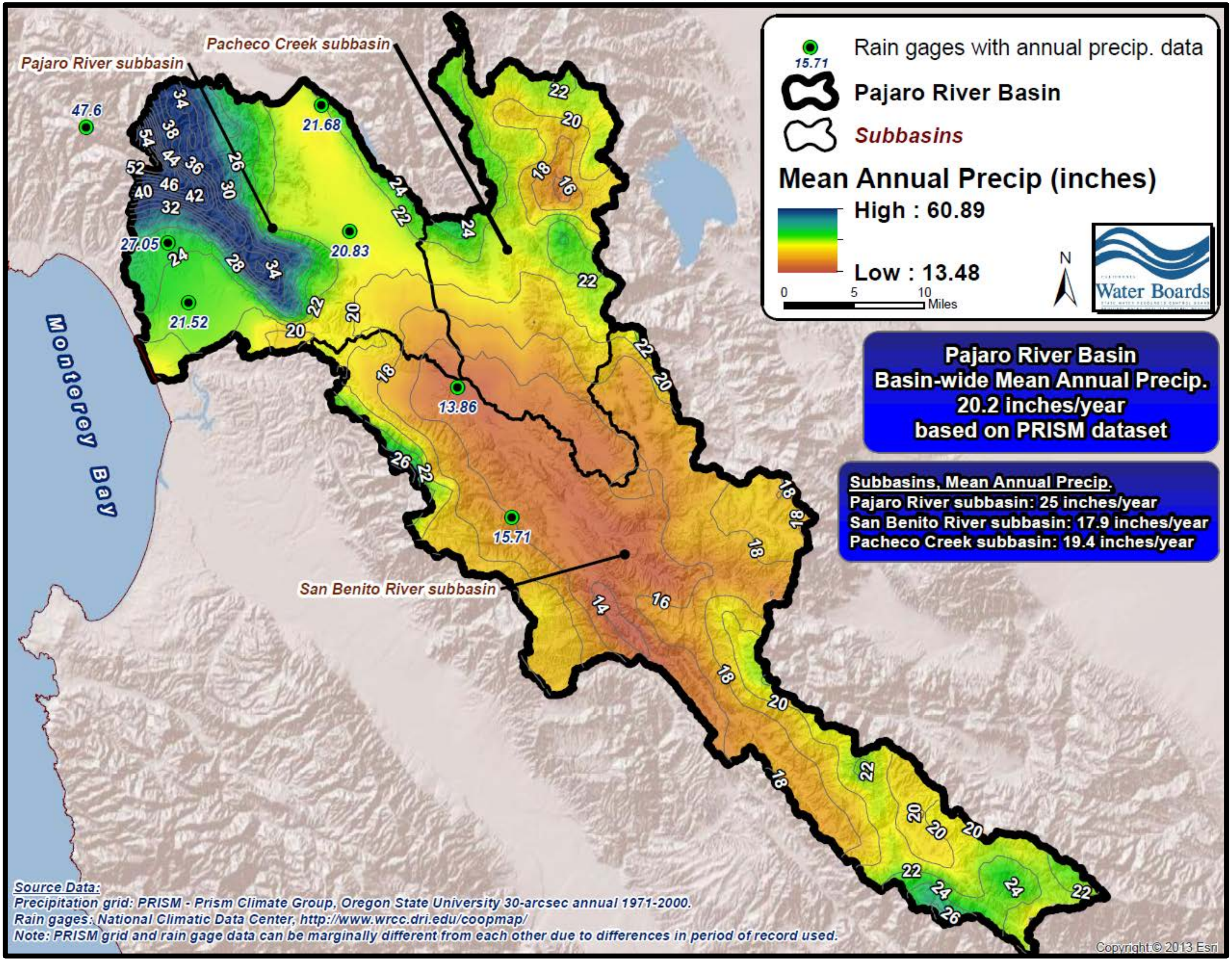
[35] National Weather Service, San Francisco Bay Area, Public Information Statement dated April 11, 2012 and entitled “March 2012 Regional Climate Summary”.

Therefore, due to climatic spatial variability, mean annual precipitation estimates for the Pajaro River basin may be assessed using the Parameter-elevation Regressions on Independent Slopes Model (PRISM)[36]. PRISM is a climate mapping system that accounts for orographic climatic effects and is widely used in watershed studies and TMDL projects to make projections of precipitation into rural or mountainous areas where rain gage data is often absent, or sparse. PRISM is also the U.S. Department of Agriculture's official climatological dataset and PRSIM is used by the U.S. National Weather Service to spatially interpolate rainfall frequency estimates. An isohyetal map for estimated mean annual precipitation in the TMDL project area, with overlays of the hydrologic subbasin boundaries, is presented in Figure 3-23. The precipitation range estimates shown in Figure 3-1 comport reasonably well with regional precipitation range estimates reported by the County of Santa Clara[37].

Figure 3-23. Pajaro River basin estimated mean annual precipitation (1971-2000, source: PRISM).



Pajaro River Basin
Basin-wide Mean Annual Precip.
20.2 inches/year
based on PRISM dataset

Subbasins, Mean Annual Precip.
Pajaro River subbasin: 25 inches/year
San Benito River subbasin: 17.9 inches/year
Pacheco Creek subbasin: 19.4 inches/year

Source Data:
Precipitation grid: PRISM - Prism Climate Group, Oregon State University 30-arcsec annual 1971-2000.
Rain gages: National Climatic Data Center, http://www.wrcc.dri.edu/coopmap/
Note: PRISM grid and rain gage data can be marginally different from each other due to differences in period of record used.

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[36] The PRISM dataset was developed by researchers at Oregon State University, and uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of climatic parameters. The dataset incorporates a digital elevation model, and expert knowledge of climatic variation, including rain shadows, coastal effects, and orographic effects. Online linkage: http://www.prism.oregonstate.edu/

[37] The *2007 Drainage Manual* published by the County of Santa Clara states: *"Mean annual precipitation ranges from 10 inches in the inland valley areas to 56 inches at the top of the Santa Cruz Mountains."*

Due to spatial variation in rainfall, it is prudent to develop not only a basin-wide estimate of mean annual rainfall, but also estimates of mean annual rainfall at the smaller subbasin scale. For example, it is clear that regional precipitation patterns and intensity in the Pajaro River subbasin are different than in the San Benito River subbasin. Consequently, based on the statistical summaries as calculated by ArcMap® 10.1 for digitally clipped PRISM rainfall grids, average precipitation estimates in the in the TMDL project area can be summarized as follows (see Table 3-21):

Table 3-21. Mean annual precipitation estimates within the Pajaro River basin.

Hydrologic Area	**Estimated mean annual precipitation, accounting for orographic effects** *(period of record 1971-2000)*
Pajaro River basin (basin-wide)	20.2 inches/year
Pajaro River subbasin	25 inches/year
Pacheco Creek subbasin	19.4 inches/year
San Benito River subbasin	17.9 inches/year

Further, PRISM precipitation grids allow for rainfall estimates at higher resolution spatial scales. Table 3-22 presents estimates of mean annual precipitation in subwatersheds in the Pajaro River basin.

Table 3-22. Estimated mean annual precipitation[A] within subwatersheds of the Pajaro River basin.

Subwatershed Name[B]	**Mean Annual Precipitation** (Inches) 1971-2000		**Subwatershed Name**[B]	**Mean Annual Precipitation** (Inches) 1971-2000
Clear Creek-San Benito River	22.2		Tequisquita Slough	17.8
Hernandez Reservoir-San Benito River	21.3		Watsonville Slough	23.1
James Creek-San Benito River	20.0		Lower Pajaro River	23.2
Rock Springs Creek-San Benito River	18.4		Arroyo De Las Viboras	20.2
Sulphur Creek-San Benito River	16.0		Salsipuedes Creek	26.2
Willow Creek	17.6		Lower Pacheco Creek	21.5
Stone Creek	17.9		South Fork Pacheco Creek	21.6
Upper Tres Pinos Creek	18.2		Lower Uvas Creek	24.4
Middle Tres Pinos Creek	16.4		Upper Pajaro River	19.4
Pescadero Creek	17.8		Corralitos Creek	32.5
Las Aguilas Creek	18.0		Upper Pacheco Creek	20.3
Los Muertos Creek	16.1		Lower Llagas Creek	21.0
Paicines Reservoir-San Benito River	15.2		Cedar Creek	21.2
Lower Tres Pinos Creek	14.8		Upper Uvas Creek	32.7
San Juan Canyon	19.5		Little Llagas Creek	21.2
Bird Creek-San Benito River	17.0		Upper Llagas Creek	28.8
Quien Sabe Creek	17.2		Lower North Fork Pacheco Creek	20.0
Santa Ana Creek	15.7		Upper North Fork Pacheco Creek	21.3

[A] Source data: PRISM Climate Group, Oregon State University, 30-arcsec annual precipitation grid, 1971-2000. PRISM precipitation zonal statistics were extracted for subwatersheds using the ArcMap 10.1™ Spatial Analyst extension.

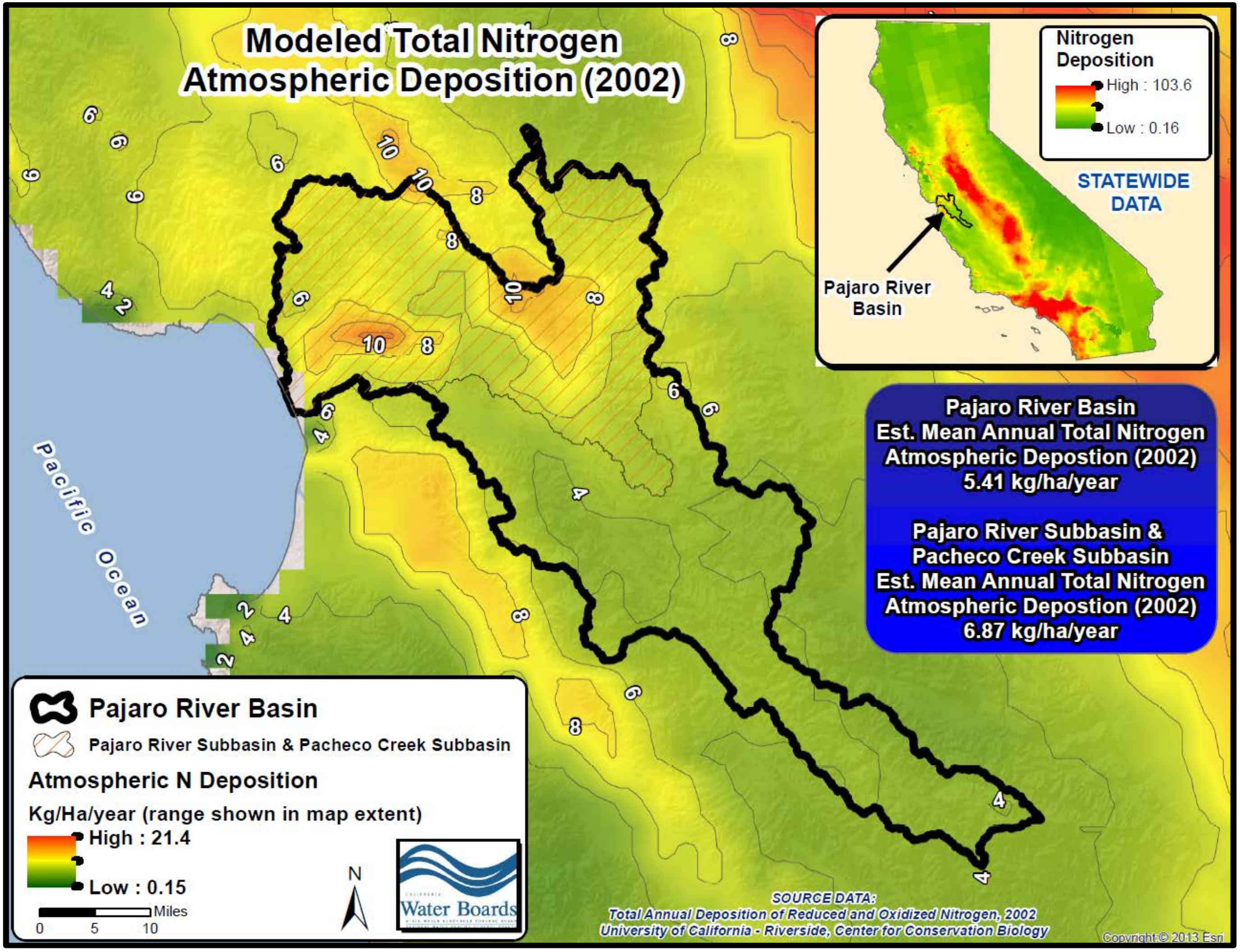
[B] Refer back to Figure 3-4 and Table 3-3 for a map and tabulation of subwatersheds within the Pajaro River basin.

Noteworthy is that staff's estimate of a Pajaro River basin-wide mean of 20.2 inches of mean annual precipitation comports reasonably well with an estimate developed by consulting engineers − in 2001 Raines, Mellon and Carella, Inc. estimated a Pajaro basin-wide average annual rainfall of approximately 19 inches (Raines, Mellon and Carella, Inc., 2001).

➢ *Atmospheric Deposition of Nitrogen*

Input of nutrients in rainfall can locally be a significant source of loading in any given watershed. Because nitrogen can exist as a gaseous phase (while phosphorus cannot), nitrogen is more prone to atmospheric transport and deposition. It is important to recognize however that atmospheric deposition of nutrients is typically more significant in lakes and reservoirs, than in creeks or streams (USEPA, 1999). This is because the surface area of a stream is typically small compared to the area of a reservoir or a watershed. Additionally, it should be recognized that atmospheric deposition of nitrogen compounds is most prevalent downwind of large urban areas, near point sources of combustion (like coal burning power plants), or in mixed urban/agricultural areas characterized by substantial vehicular combustion contributions to local air quality (Westbrook and Edinger-Marshall, 2014). Figure 3-24 presents estimated total atmospheric deposition for the year 2002 in California and in the Pajaro River basin on the basis of a deposition model developed by the University of California-Riverside Center for Conservation Biology[38].

Figure 3-24. Estimated annual atmospheric deposition of nitrogen-N (units=kg/ha/year).



Based on the University of California-Riverside model, atmospheric deposition of total nitrogen in the Pajaro River basin can be characterized as shown in Text Box 3-2:

Text Box 3-2. Estimated annual atmospheric deposition of total nitrogen, Pajaro River basin.

Estimated average basin-wide annual atmospheric of total nitrogen for the *Pajaro River basin:*

5.41 kg/hectare per year

Estimated average annual atmospheric of total nitrogen in the *Pajaro River and Pacheco Creek subbasins:*

6.97 kg/hectare per year

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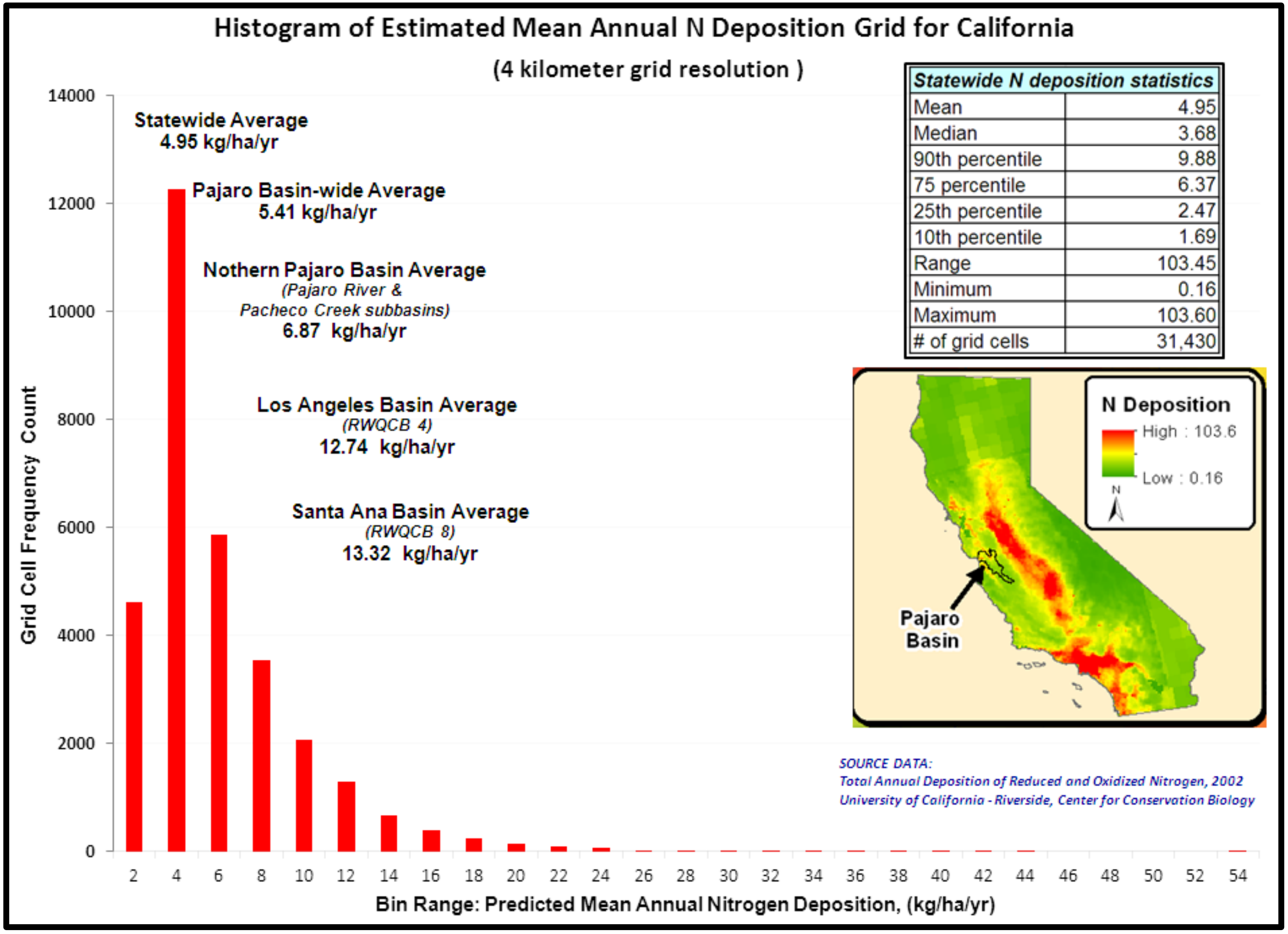
[38] Tonnesen, G., Z. Wang, M. Omary, and C. J. Chien. 2007. University of California-Riverside. Assessment of Nitrogen Deposition: Modeling and Habitat Assessment. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2006-032.

Figure 3-25 illustrates a histogram of the gridded atmospheric total nitrogen deposition model, and summary average deposition estimates for various regions of the state. Based on summary statistics of the gridded nitrogen deposition data, the 25th percentile is 2.5 kg/ha and the median is 3.7 kg/ha – these values presumably could represent a plausible range for lightly-impacted or natural ambient conditions in California. Estimated atmospheric deposition of nitrogen in the Pajaro Basin (5.41 kg/ha) is marginally higher than the aforementioned ambient condition; however deposition in the river basin is substantially lower than in highly developed areas of southern California such as the Los Angeles Basin and the Santa Ana Basin (see Figure 3-25).

Figure 3-25. Histogram of variation in estimated statewide mean annual atmospheric nitrogen (N) deposition (2002) based on UC-Riverside gridded spatial model of N-deposition rates. Note that average N atmospheric deposition in the Pajaro River basin (5.41 kg/ha/yr) is substantially less than areas of the state characterized by high average rates of N atmospheric deposition (e.g., Los Angeles Basin = 12.74 kg/ha/yr, and Santa Ana Basin = 13.32 kg/ha/yr)



Statewide N deposition statistics	
Mean	4.95
Median	3.68
90th percentile	9.88
75 percentile	6.37
25th percentile	2.47
10th percentile	1.69
Range	103.45
Minimum	0.16
Maximum	103.60
# of grid cells	31,430

SOURCE DATA:
Total Annual Deposition of Reduced and Oxidized Nitrogen, 2002
University of California - Riverside, Center for Conservation Biology

3.8 Vegetation & Riparian Tree Canopy

Nutrient-related impacts and biostimulation may often occur in areas where the river is wide, water is shallow, and tree canopy is open and light is readily available. As such, having estimates of variations in tree canopy cover are important to consider in the development of numeric nutrient criteria.

An additional reason for developing plausible canopy distribution data for this TMDL project is that nutrient water quality target development tools staff used require input estimates for riparian canopy as a parameter influencing sunlight availability, and thus affecting algal photosynthesis.

With regard to general vegetation categories in the Pajaro River basin, upland ecosystems of the Santa Cruz Mountains and Gabilan Range ecoregions[39] tend to be characterized primarily by coast live oak woodland, and subsidiary canyon live oak and montane hardwood, on the basis of CALVEG77[40] spatial data. In contrast, upland ecosystems of the Diablo Range and Western Diablo Range ecoregions tend to be characterized by blue oak woodland, with subsidiary amounts of coast live oak in lower Pacheco Creek Subbasin, and Coulter Pine hardwood in the uppermost San Benito River Subbasin. Lowland ecosystems of the Pajaro River basin have been highly modified by agriculture and urbanization, but with some subsidiary lightly-impacted areas of coastal scrub/sumac and annual grassland.

➢ *Nitrogen-fixing Plants & Water Quality*

There is some evidence of an association between nitrogen-fixing vegetation and groundwaters which are naturally enriched in nitrate in semi-arid regions, based on research conducted in West Africa. Most plants rely on the introduction of nitrogen to the soil to be able to use it. Nitrogen-fixing plants are able to utilize nitrogen gas from the atmosphere due to specialized bacteria in the roots of these plants. These bacteria are able to convert inert atmospheric nitrogen into bioavailable compounds of nitrogen. The bioavailable nitrogen is thus added to the soils and stored in the roots of the plant (Rhoades, 2014). Edmunds and Gay (1997) identified high nitrate concentrations in shallow groundwaters (average 11 mg/L NO_3-N) beneath the root zones of natural or introduced nitrogen-fixing leguminous vegetation in northern Senegal. Favreau et al. (2003) found high nitrate concentration shallow groundwaters in southwest Niger in areas where fertilizers or latrine and animal wastes were not plausible sources. Favreau et al. (2003) concluded that the high nitrate in groundwaters was related to soil nitrogen and land clearance, which promoted the leaching of soil nitrogen to the unconfined aquifer.

Based on the aforementioned information and as a matter of due diligence, it is relevant to compile information on native, nitrogen-fixing vegetation reported to exist in the Pajaro River basin on the basis of information available from the U.S. Department of Agriculture. Table 3-23 presents a tabulation of native, nitrogen-fixing plants in the Pajaro River basin that are reported to have medium to high nitrogen fixing efficiency (> 85 lbs. N/acre).

Table 3-23. Native, nitrogen-fixing plants reported to exist in Santa Cruz and Santa Clara counties and classified as “high” nitrogen fixers (>160 lbs. N/acre) or “medium” nitrogen fixers (85–160 lbs. N/acre).

Scientific Name	Common Name(s)	Group	Family	Nitrogen Fixation Efficiency
Alnus rubra	Red Alder (Pacific Coast Alder, Western Alder)	Dicot	Betulaceae	High
Astragalus lentiginosus	Freckled milkvetch	Dicot	Fabaceae	Medium
Ceanothus velutinus	snowbrush ceanothus	Dicot	Rhamnaceae	Medium
Lathyrus littoralis	Silky beach pea	Dicot	Fabaceae	Medium
Lupinus arboreus	Yellow bush lupine	Dicot	Fabaceae	Medium
Robinia pseudoacacia	Black locust	Dicot	Fabaceae	Medium
Trifolium wormskioldii	Cows clover (perennial clover, marsh clover)	Dicot	Fabaceae	Medium

Data source: U.S. Department of Agriculture – Natural Resources Conservation Service Plants Database, online linkage http://plants.usda.gov/adv_search.html

It should be recognized that the native, nitrogen-fixing plants in Table 3-23 are not ubiquitous or pervasive in the Pajaro River basin – see the personal communication below:

> *“In my many treks around Santa Cruz/Santa Clara Counties for forestry field trips, the listed herbaceous and woody plants were not found to be widespread.”*
>
> *–Elaine Sahl, environmental scientist, California Central Coast Water Board staff, personal communication by email, 10/2/2014*

Therefore, these nitrogen-fixing plants would not be expected to significantly contribute to the widespread nitrogen enrichment observed in shallow groundwaters and surface waters of the river basin.

---

[39] Refer back to Figure 3-17 for a map showing Level IV ecoregions of the Pajaro River Basin.

[40] CALVEG77 is a U.S. Forest Service spatial dataset of vegetation throughout California based on mapping done between 1979 and 1981 by U.S. Forest Service ecologists.

➢ *Riparian Tree Canopy & Shading Estimates*

Figure 3-26 and Figure 3-27 presents riparian spatial data which illustrates that, in general, higher amounts (%) of riparian cover are often expected in upland ecosystems of the Pajaro River basin (for example, in the upland stream reaches in the Santa Cruz Mountains); in contrast valley floor and lowland stream reaches (i.e., southern Santa Clara valley) are often characterized by lower amounts (%) of riparian cover. Tree canopy and shading can vary from zero percent, particularly along coastal sloughs and water conveyance structures, to significantly higher in other types of waterbodies (see Figure 3-26 and Figure 3-27).

Figure 3-26. Percent tree canopy in the Pajaro River basin and vicinity.

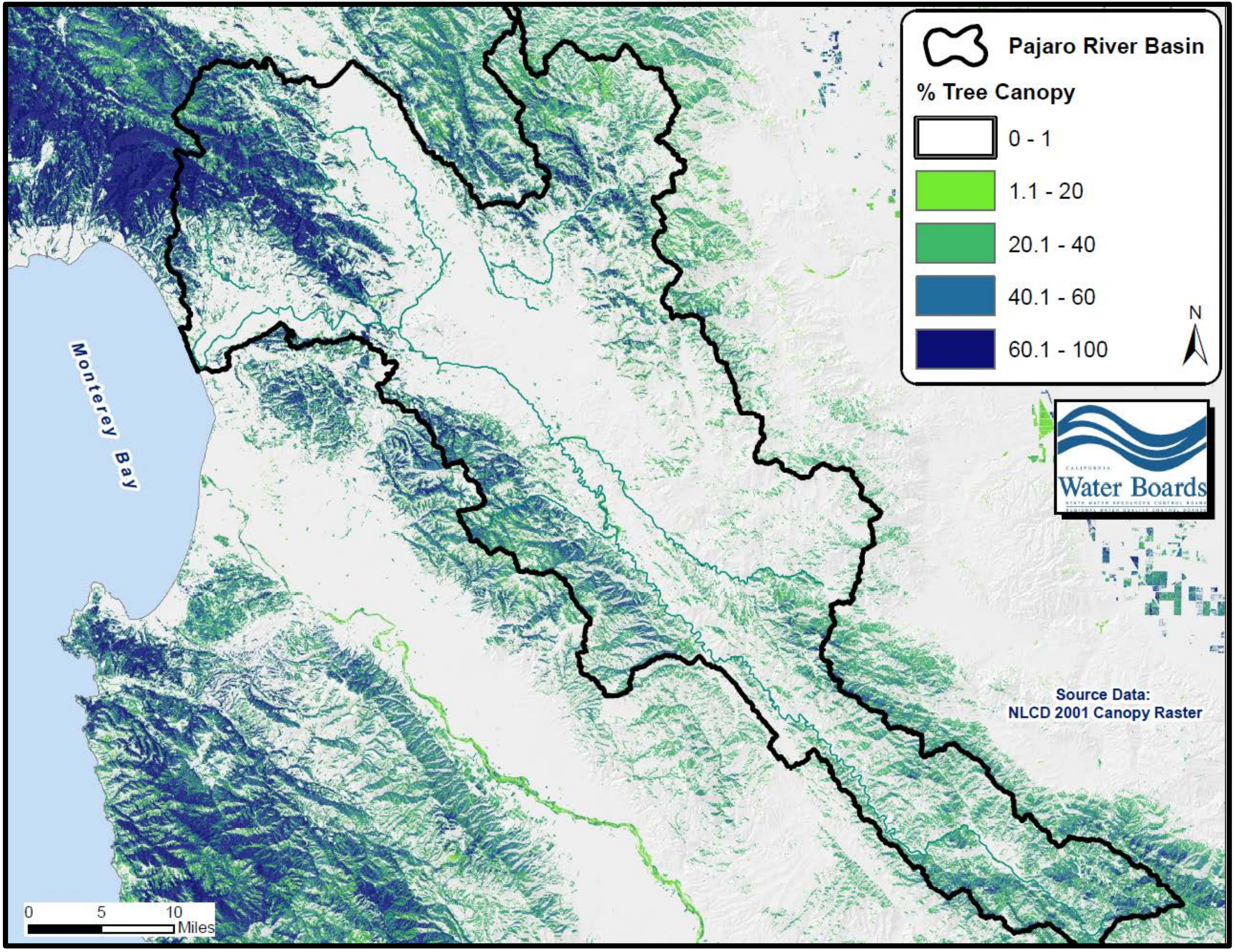
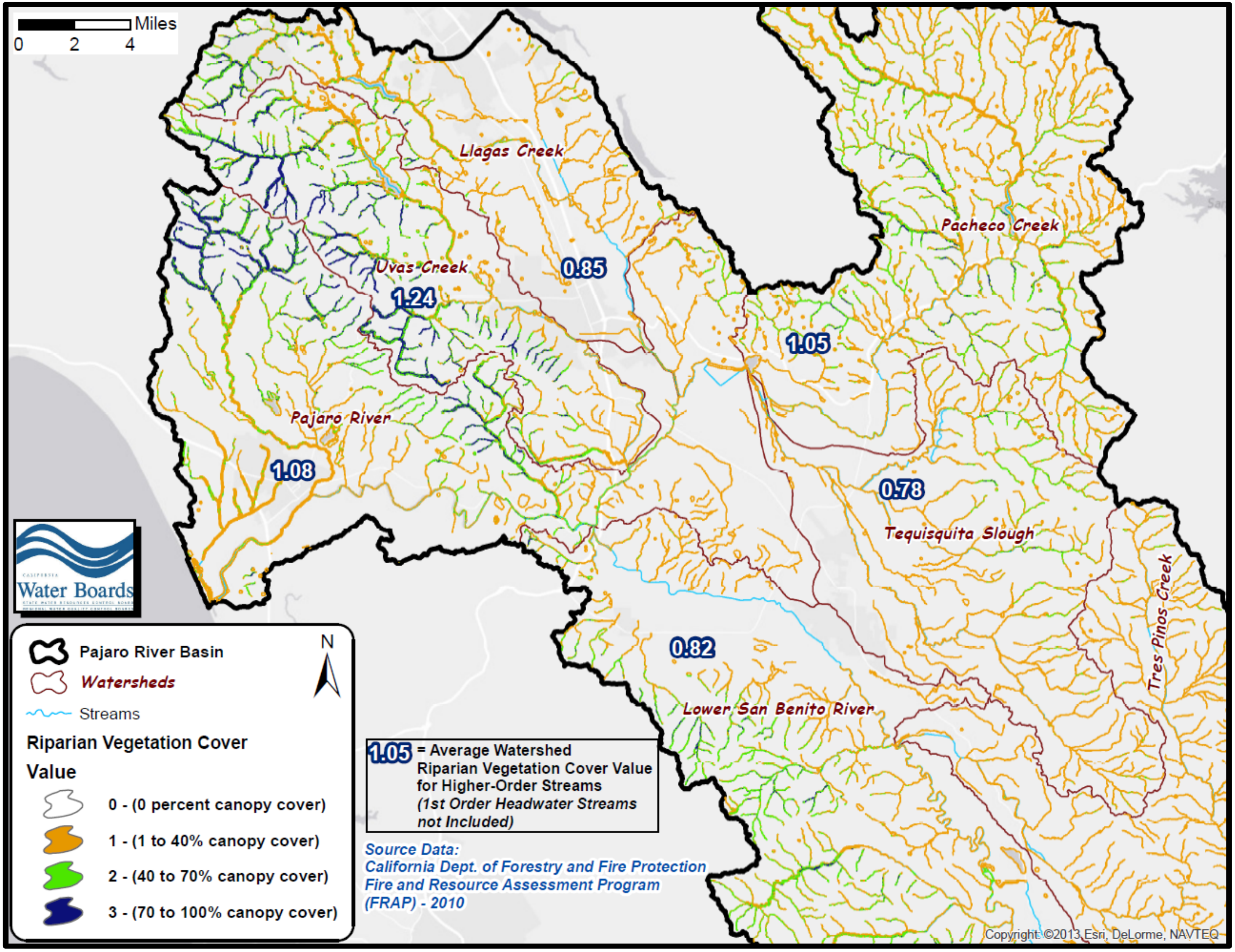


Figure 3-27. Estimated riparian vegetation canopy cover percentages, based on 2010 California Department of Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP).



Source Data: California Dept. of Forestry and Fire Protection Fire and Resource Assessment Program (FRAP) - 2010

As noted previously, estimates of stream shading and stream canopy cover are necessary as input for nutrient water quality criteria development tools used by Central Coast Water Board staff in this TMDL project, and thus it is worth looking at multiple lines of evidence and different datasets regarding riparian canopy. Sunlight penetration and photosynthesis play key roles in the scope of aquatic plant and algae growth in waterbodies. Estimates of percentage canopy cover, and of stream riparian corridor shading are available from raster datasets developed by the Multi-Resolution Land Characteristics Consortium[41] for the National Land Cover Dataset, and also from field reporting by the Central Coast Ambient Monitoring Program[42]. These two sources have different strengths. The Central Coast Ambient Monitoring Program reporting constitutes *direct field observation* of shading at a specific stream monitoring location. The National Land Cover Dataset constitutes a *remote-sensing* dataset, and while not based on direct field observations, it provides more extensive spatial estimates of canopy (compared to site-specific observation) based on imagery processing. It is presumed that the National Land Cover Dataset's remote-sensing estimates of percentage canopy constitute a plausible surrogate for percent

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[41] The Multi-Resolution Land Characteristics (MRLC) consortium is a group of federal agencies who coordinate and generate consistent and relevant land cover information at the national scale for a wide variety of environmental, land management, and modeling applications. Online linkage http://www.mrlc.gov/index.php

[42] The Central Coast Ambient Monitoring Program (CCAMP) is the Central Coast Regional Water Quality Control Board's regionally scaled water quality monitoring and assessment program. Online linkage: http://www.ccamp.org/

canopy shading along riparian corridors. To derive the riparian estimates, 60 meter buffers around representative stream reaches were created digitally in ArcMap 10.1™. These buffers were used as masks to digitally clip the National Land Cover Dataset canopy raster data to the riparian stream corridors. ArcMap 10.1™ can calculate statistics of a user-defined raster, such as the stream buffer-clipped rasters delineated by staff. Therefore, the stream-buffer clipped canopy data were used to derive estimates of the mean amount of canopy cover in the riparian corridors at the stream reach-scale.

Table 3-24 presents the field observations of canopy cover at specific monitoring sites based on the Central Coast Ambient Monitoring Program field reporting.

Figure 3-28 presents a visual illustration of the digital stream buffers used to clip the National Land Cover Dataset canopy raster, while Table 3-25 tabulates the canopy statistics associated with these stream corridor buffers.

Also worth noting, as shown previously in Figure 3-27, riparian canopy cover ranges from one to 40% in most alluvial valley stream reaches, while riparian cover in upland stream reaches of the Santa Cruz, Gabilan, and Western Diablo ranges are often in the range of 40 to 70%, on the basis of California Department of Forestry and Fire Protection digital data. Thus, riparian canopy estimates for streams of the Pajaro River basin from three different data sources used here are generally in broad agreement and comport reasonably well with each other.

In general, it can be concluded that valley floor and lowland ecosystem stream reaches have canopy shading of around 25% or less, while stream reaches in upland ecosystems or headwater reaches tend to have higher canopy shading, on the order of 50% or more. It should be recognized that lowland streams tend to be broader and wider than upland streams, generally allowing for more sunlight penetration to the stream channel. Human modification of lowland ecosystems can also locally play a role in the nature and extent of riparian canopy cover.

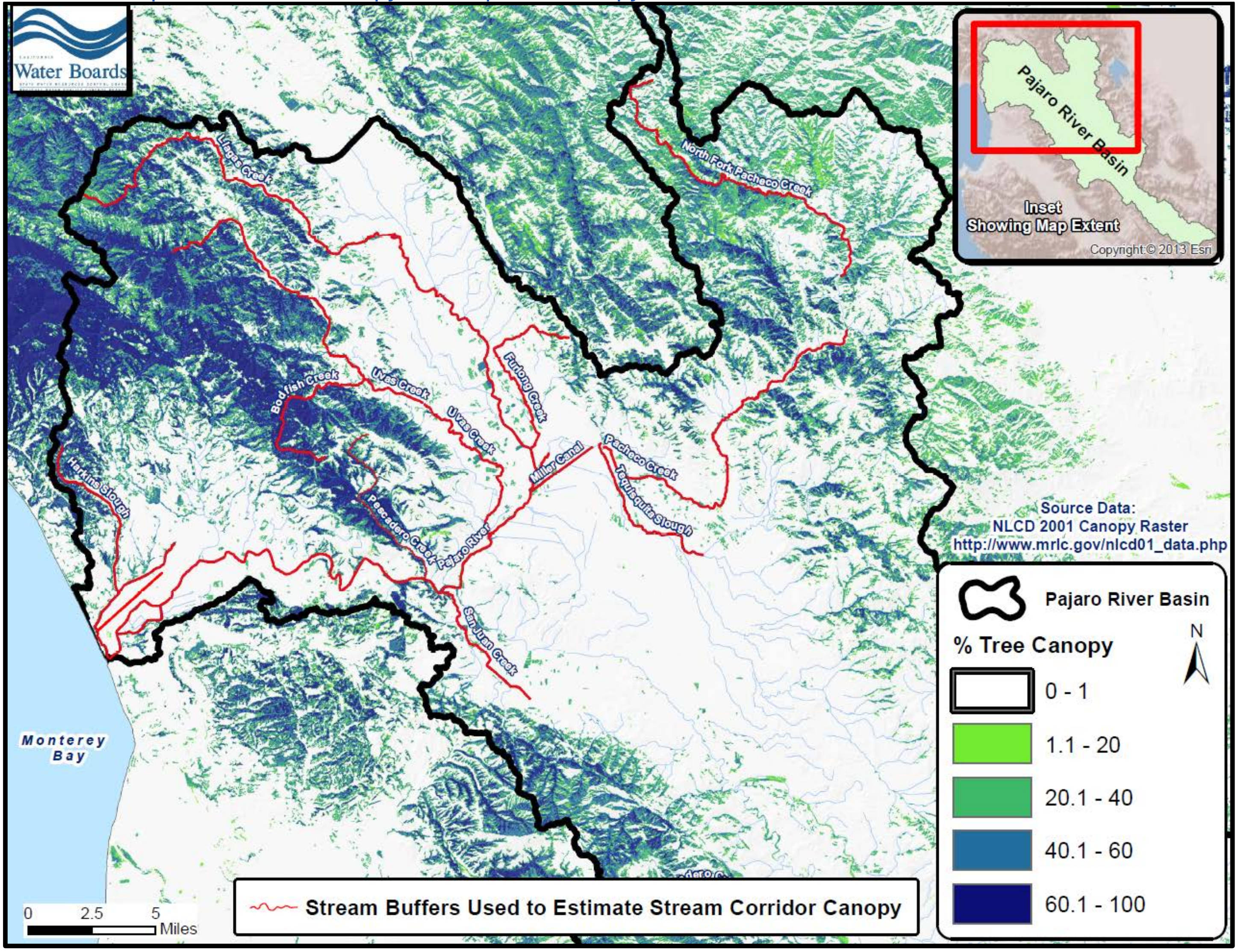
Table 3-24. Numerical summaries of riparian corridor shading (units = %) in streams of the Pajaro River basin on the basis of field observation[A].

Stream Monitoring Site	Mean	Std. Dev	0%	25%	50 %	75 %	100 %	Number of Observations
Carnadero Creek at private property access	55.9	21.1	20	36.2	62.5	70	90	26
Corralitos Creek at Brown Valley Road	28.3	23.6	5	10	20	35	85	21
Furlong Creek at Fraiser Lake Road	38.7	28.9	5	15	30	60	90	27
Harkins Slough at Harkins Slough Road	3.6	3.2	1	1	2	5	10	14
Llagas Creek at Bloomfield Avenue	65.9	23.1	12	50	75	80	98	29
Llagas Creek at Buena Vista Avenue	50.0	NA	50	50	50	50	50	1
Llagas Creek at Chesbro Reservoir	1.0	NA	1	1	1	1	1	1
Llagas Creek at Holsclaw below Leavesley Road	25.0	NA	25	25	25	25	25	1
Llagas Creek at Leavesley Road	9.9	11.1	0	1.25	5	17.5	30	10
Llagas Creek at Luchessa Avenue-Southside Drive	25.0	NA	25	25	25	25	25	1
Llagas Creek at Monterey Road	0.0	NA	0	0	0	0	0	1
Llagas Creek at Oak Glen Avenue	100.0	NA	100	100	100	100	100	1
Millers Canal at Frazier Lake Road	9.7	10.7	0	1.5	5	17.5	40	27
Pacheco Creek at San Felipe Road	48.9	25.5	10	30	47.5	75	90	28
Pajaro River at Betabel Road	26.2	17.9	5	15	22.5	31.2	75	28
Pajaro River at Chittenden Gap	32.0	21.7	5	15	30	35	100	28
Pajaro River at Murphys Crossing	18.0	8.6	2	15	15	25	35	28
Pajaro River at Porter	15.4	11.6	1	7.75	15	20	50	34
Pajaro River at Thurwatcher Road	10.2	14.2	1	5	5	10	95	115
Pescadero Creek NE of Chittendon at RR tracks	60.0	NA	60	60	60	60	60	1
Salsipuedes Creek at Hwy 129 downstream of Corralitos Creek	22.6	26.8	0	1.75	15	31.2	95	28

Stream Monitoring Site	Mean	Std. Dev	0%	25%	50 %	75 %	100 %	Number of Observations
San Benito at Y Road	47.3	22.5	10	32.5	47.5	67.5	80	28
San Benito River Bridge downstream Willow Creek	11.6	17.3	0	1	2	15	70	26
San Juan Creek at Anzar	12.5	18.6	0	0.5	5	15	80	27
Struve Slough at Lee Road	36.6	25.7	3	20	35	40	90	13
Tequisquita Slough at Shore Road	0.0	NA	0	0	0	0	0	1
Tres Pinos Creek at Southside Road	4.4	4.9	0	1	2	5	15	16
Uvas Creek at Bloomfield Avenue	33.5	22.7	0	17.5	25	47.5	80	19
Watsonville Slough upstream Harkins Slough	77.8	28.0	5	68.75	95	98.2	100	20

[A] Source Data: Central Coast Ambient Monitoring Program, 1997-2012 field observation data.

Figure 3-28. Map of percent tree canopy closure and illustration of 60 meter stream buffers used to estimate riparian corridor canopy. The riparian canopy esimates are tabulated below in Table 3-25.



Source Data: NLCD 2001 Canopy Raster http://www.mrlc.gov/nlcd01_data.php

Table 3-25. Numerical summaries of estimated percent tree canopy closure in select stream corridors (60 meter buffer proximity to stream) of the Pajaro River basin on the basis of Landsat satellite imagery analysis available from the National Land Cover Dataset (2001). Units = %

Stream Reach	Mean Percent Canopy	Minimum Percent Canopy	Maximum Percent Canopy	Level IV Ecoregion(s)[A]
Beach Road Ditch	0.3	0	38	Monterey Bay Plains and Terraces
Bodfish Creek	53.9	0	91	Santa Cruz Mountains & Leeward Hills
Furlong Creek	7.3	0	79	Upper Santa Clara Valley
Upper Llagas Creek *from headwaters downstream to confluence with Little Llagas Creek near Hwy. 101*	26.2	0	87	Leeward Hills
Lower Llagas Creek *from confluence of Little Llagas Creek downstream to confluence with the Pajaro River.*	7.9	0	60	Upper Santa Clara Valley
McGowan Ditch	6	0	81	Monterey Bay Plains and Terraces
Miller Canal	1.6	0	50	Upper Santa Clara Valley
Pacheco Creek, main stem	10.2	0	76	Western Diablo Range & Upper Santa Clara Valley
Pacheco Creek, North Fork	19.4	0	83	Western Diablo Range
Pajaro River *entire reach, from Santa Clara Valley to Pacific Ocean*	21.9	0	86	Upper Santa Clara Valley & Monterey Bay Plains and Terraces
Pescadero Creek (Santa Cruz County)	53.2	0	89	Santa Cruz Mountains
San Juan Creek	7	0	81	Upper Santa Clara Valley
Tequisquita Slough	1.8	0	53	Upper Santa Clara Valley
Uvas/Carnadero Creek *excluding the first and second Strahler Order headwater reach*	21	0	85	Leeward Hills & Upper Santa Clara Valley
Watsonville Slough and Harkins Slough	10.2	0	82	Monterey Bay Plains and Terraces

[A] Source data: Level IV Ecoregions of the Conterminous United States, 2013. U.S. Environmental Protection Agency Office of Research and Development - National Health and Environmental Effects Research Laboratory.

3.9 Groundwater

TMDLs do not directly address pollution of groundwater by controllable sources. However, shallow groundwater baseflow pollutant inputs to streams, and groundwater recharge designated beneficial uses[43] of streams may be considered in the context of TMDL development. Groundwaters and surface waters are not closed systems that act independently from each other; it is well known that groundwater discharge to surface waters can be a source of nutrients or salts to any given surface waterbody. The physical interconnectedness of surface waters and groundwater is widely recognized by scientific agencies, researchers, and resource professionals, as highlighted below:

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[43] See Section 4.1.2 of this report.

"Traditionally, management of water resources has focused on surface water or ground water as separate entities….Nearly all surface-water features (streams, lakes reservoirs, wetlands, and estuaries) interact with groundwater. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water. Thus, effective land and water management requires a clear understanding of the linkages between ground water and surface water as it applies to any given hydrologic setting."

From: U.S. Geological Survey, 1998. Circular 1139: "Groundwater and Surface Water – A Single Resource"

"While ground water and surface water are often treated as separate systems, they are in reality highly interdependent components of the hydrologic cycle. Subsurface interactions with surface waters occur in a variety of ways. Therefore, the potential pollutant contributions from ground water to surface waters should be investigated when developing TMDLs."

From: U.S. Environmental Protection Agency, Guidance for Water Quality-Based Decisions: The TMDL Process – Appendix B. EPA 440/4-91-001.

"Although surface water and groundwater appear to be two distinct sources of water, they are not. Surface water and groundwater are basically one singular source of water connected physically in the hydrologic cycle...Effective management requires consideration of both water sources as one resource."

From: California Department of Water Resources: Relationship between Groundwater and Surface Water
http://www.water.ca.gov/groundwater/groundwater_basics/gw_sw_interaction.cfm.

"Surface water and ground water are increasingly viewed as a single resource within linked reservoirs. The movement of water from streams to aquifers and from aquifers to streams influences both the quantity and quality of available water within both reservoirs."

From: C. Ruehl, A. Fisher, C. Hatch, M. Los Huertos, G. Stemler, and C. Shennan (2006), *Differential gauging and tracer tests resolve seepage fluxes in a strongly-losing stream.* Journal of Hydrology, volume 330, pp. 235-248.

"Surface water bodies are hydraulically connected to ground water in most types of landscapes…Even if a surface water body is separated from the ground-water system by an unsaturated zone, seepage from the surface water may recharge the ground water. Because of the interchange of water between these two components of the hydrologic cycle, development or contamination of one commonly affects the other."

From: Thomas C. Winter, U.S. Geological Survey Water Resources Division (2000). *Interaction of Ground Water and Surface Water.*. Proceedings of the Ground-Water/Surface-Water Interactions Workshop, 2000, pp. 15-20. EPA/542/R-00/007

"It's a myth that groundwater is separate from surface water and also a myth that it's difficult to legally integrate the two….California's groundwater and surface water are often closely interconnected and sometimes managed jointly."

From: Buzz Thompson, Professor of Natural Resources Law, Stanford University Law School, quoted in *Managing California's Groundwater*, by Gary Pitzer in Western Water January/February 2014, *and* from Public Policy Institute of California, *California Water Myths*, www.ppic.org.

The reporting shown above recognizes the potential for polluted streams to degrade underlying groundwater. In addition, it is likewise widely recognized by local resource professionals that subsurface infiltration of river waters can affect, alter, or degrade the water quality and/or water supply of an underlying groundwater resource, as highlighted below:

"The distinguishing feature of the (Pajaro River Valley) East Area is that ***its groundwater is recharged primarily from the Pajaro River****…Boron originates from geological sources, generally in the San Benito watershed… Related to this recharge, wells in this area produce mixed-ion or sodium-carbonate water, with virtually every well in the East Area having a boron concentration exceeding 0.2 mg/L****. This local boron concentration is a water-quality fingerprint of recharge (sic) Pajaro River waters*."***

From: Pajaro Valley Water Management Agency, Draft Environmental Impact Report for the Basin Management Plan Update, October 2013.

> *“Category 2 is recent or young groundwater…The TDS range for this category is 300-1,100 mg/L **depending on the source of the recharging water* (Pajaro River, Corralitos and Carneros Creek**, precipitation, and applied water). The best quality groundwater in this basin…is outside the spheres of influence of the seawater intrusion **and the plume of poor quality water associated with Pajaro River infiltration*.”***
>
> *From: California Department of Water Resources, California’s Groundwater Bulletin 118, Pajaro Valley Groundwater Basin.*

> *“Groundwater quality within…the Pajaro Valley is influenced by factors related to hydrology, geochemistry, well construction, groundwater pumping, and land use….**Nitrate contamination has been identified as a problem** in areas of high residential septic tank density and **in some areas that are recharged by the Pajaro River*.***
>
> *From: Pajaro Valley Water Management Agency, 2012 Basin Management Plan Update, January 2013 draft.*

> *“Runoff from watersheds tributary to the Llagas groundwater basin have very limited direct use for irrigation and domestic purposes in the San Martin area, but it **constitutes a major source of water available to replenish the groundwater basin by direct or controlled percolation” *.***
>
> *From: Brown and Caldwell Geotechnical Consultants, County of Santa Clara San Martin Area Water Quality Study, Phase 1 Report, January 1981.*
>
> ** all emphasis shown in above text boxes added by Central Coast Water Board staff*

To highlight the importance of the nexus between surface waters and groundwaters, it is worth noting that a water budget hydrologic model reported by the Pajaro Valley Water Management Agency indicates that stream flow infiltration into the subsurface accounts for 30% of all water inputs into Pajaro Valley groundwater basin aquifers[44].

The range of information discussed above is illustrated conceptually in Figure 3-29.

Figure 3-29. Streams are intimately connected to the groundwater system.

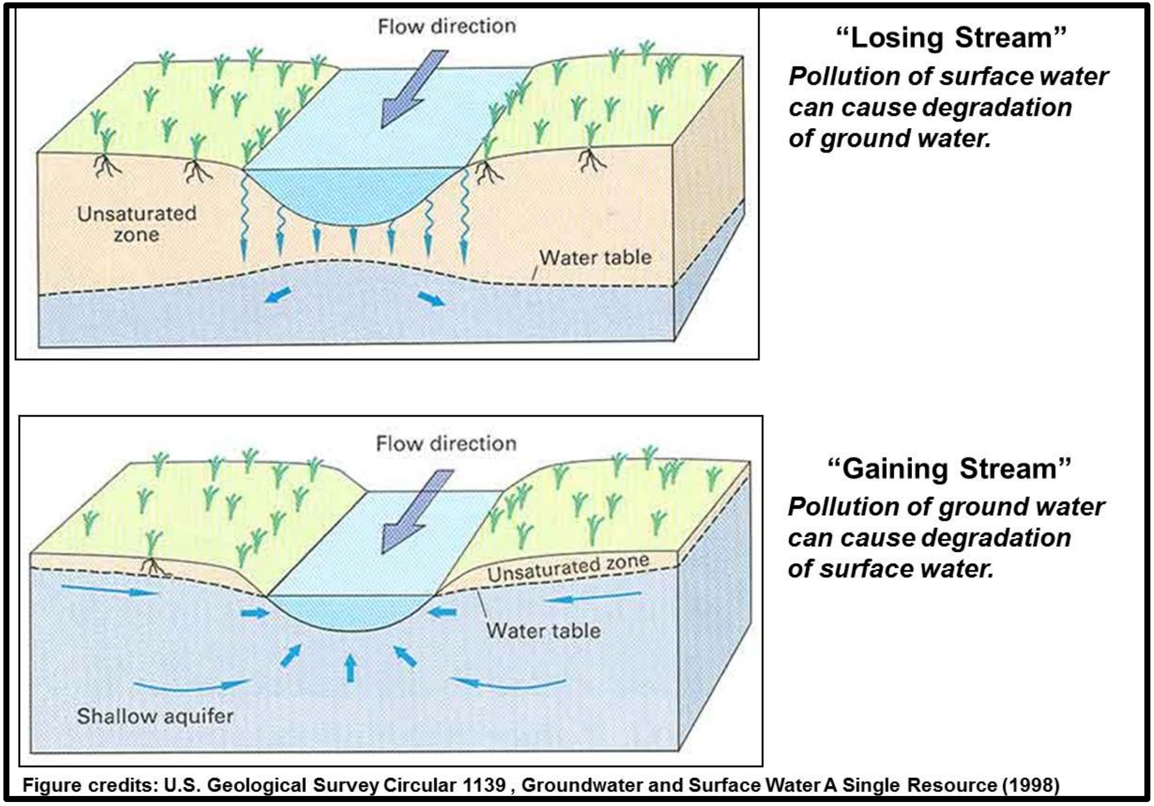

Figure credits: U.S. Geological Survey Circular 1139 , Groundwater and Surface Water A Single Resource (1998)

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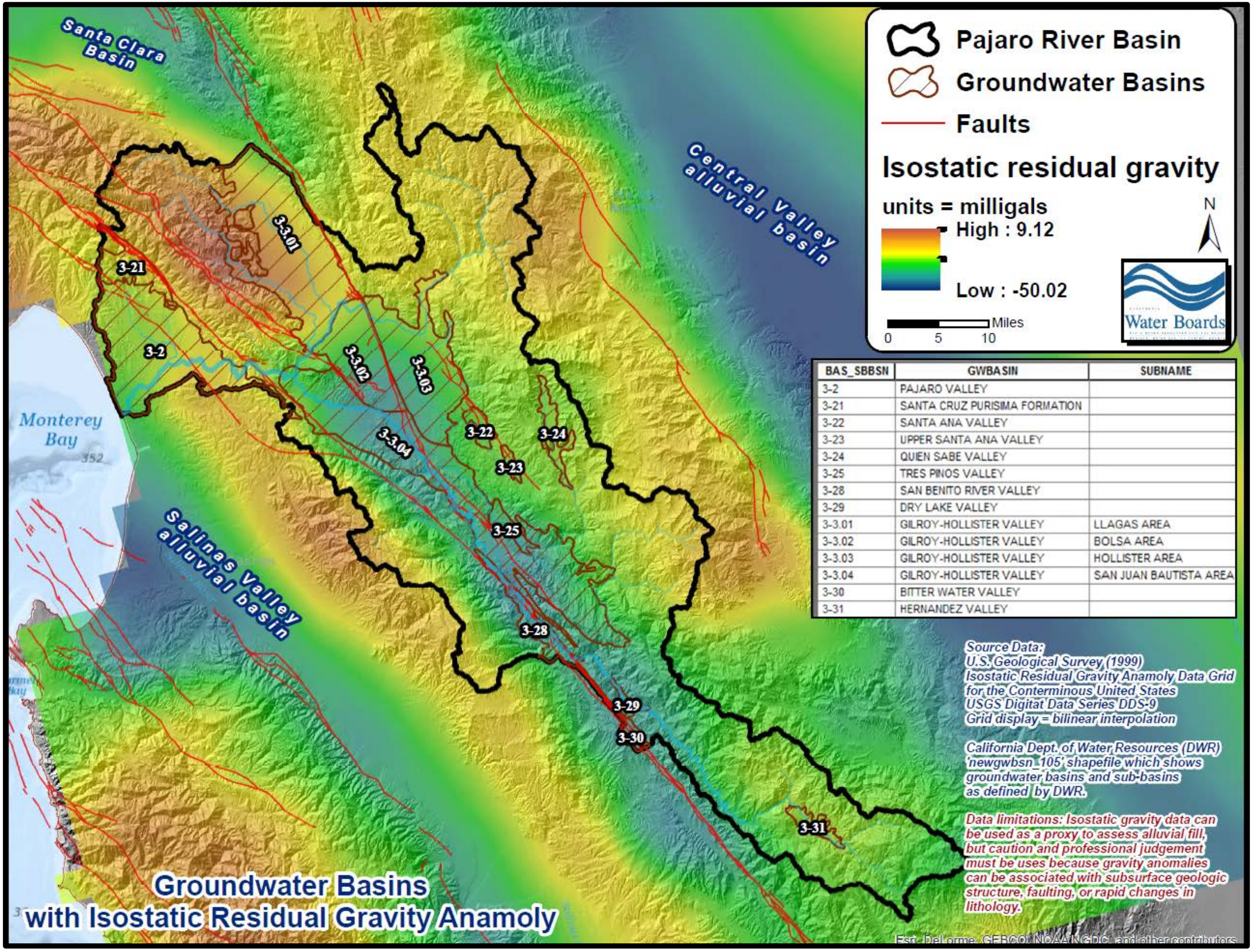
[44] Pajaro Valley Water Management Agency, Annual Simulated Water Budget. Inputs – 16,000 acre feet stream recharge + 35,000 acre feet from precipitation and applied water + 2,000 acre feet from subsurface inflow.

Based on the aforementioned concepts and information, it is relevant to consider the nexus between groundwaters and surface water in this TMDL project. In addition, groundwater information is needed for the pollutant source characterization spreadsheet model used in this TMDL project.

➢ *Groundwater Basins & Groundwater Recharge Areas*

As with any watershed study, it is worth being cognizant of the distribution of alluvial groundwater basins located within the Pajaro River basin. Alluvial groundwater basins in and around the Pajaro River basin, with an isostatic residual gravity anomalies overlay[45], are presented in Figure 3-30. Note that groundwater basins are three-dimensional in architecture, and gravity data can thus give some insight into the shape and distribution of alluvial basins. A number of groundwater basins and groundwater subbasins underlie the Pajaro River basin; hydrologic communication between these groundwater basins are limited to an extent by faulting and geologic structure, as illustrated in Figure 3-30.

Figure 3-30. Groundwater basins in the Pajaro River basin with regional isostatic residual gravity anomalies color gradation overlay.



BAS_SBBSN	GWBASIN	SUBNAME
3-2	PAJARO VALLEY	
3-21	SANTA CRUZ PURISIMA FORMATION	
3-22	SANTA ANA VALLEY	
3-23	UPPER SANTA ANA VALLEY	
3-24	QUIEN SABE VALLEY	
3-25	TRES PINOS VALLEY	
3-28	SAN BENITO RIVER VALLEY	
3-29	DRY LAKE VALLEY	
3-3.01	GILROY-HOLLISTER VALLEY	LLAGAS AREA
3-3.02	GILROY-HOLLISTER VALLEY	BOLSA AREA
3-3.03	GILROY-HOLLISTER VALLEY	HOLLISTER AREA
3-3.04	GILROY-HOLLISTER VALLEY	SAN JUAN BAUTISTA AREA
3-30	BITTER WATER VALLEY	
3-31	HERNANDEZ VALLEY	

Source Data:
U.S. Geological Survey (1999)
Isostatic Residual Gravity Anamoly Data Grid
for the Conterminous United States
USGS Digitat Data Series DDS-9
Grid display = bilinear interpolation

California Dept. of Water Resources (DWR)
'newgwbsn_105' shapefile which shows
groundwater basins and sub-basins
as defined by DWR.

Data limitations: Isostatic gravity data can be used as a proxy to assess alluvial fill, but caution and professional judgement must be uses because gravity anomalies can be associated with subsurface geologic structure, faulting, or rapid changes in lithology.

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

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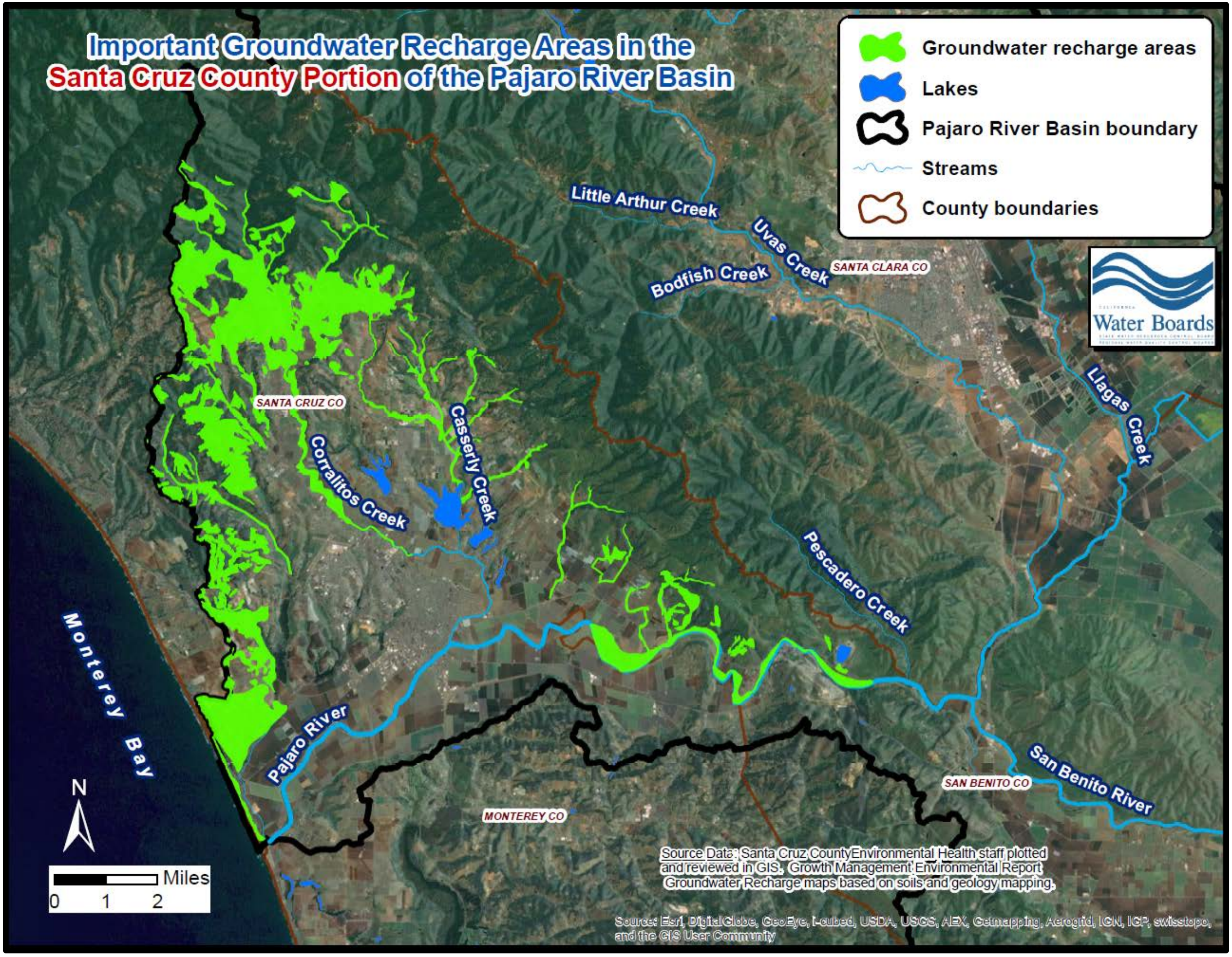
[45] Isostatic residual gravity anomaly data are a geophysical attribute that represents density contrasts, and can be used as a proxy to assess the presence and the depth or thickness of alluvial fill. Caution and professional judgment must be used, because gravity anomalies can also be associated with subsurface geologic structure, faults, and rapid changes in lithology (rock types). Isostatic residual gravity data source: U.S. Geological Survey (1999), *Isostatic residual gravity anomaly data grid for the conterminous U.S.*

The County of Santa Cruz Department of Environmental Health Service has published spatial data highlighting areas which are particularly important for groundwater recharge in the Santa Cruz County portion of the Pajaro River basin[46], which are presented in Figure 3-31. On the basis of these data, It is worth noting that some reaches of the Pajaro River are considered a particularly important source of groundwater recharge. It should also be noted that groundwater recharge (GWR) is a designated beneficial of many streams and rivers in the Pajaro River basin and elsewhere in the central coast region (refer to report Section 4.1.2).

Figure 3-31. Important groundwater recharge areas of the Santa Cruz County portion of the Pajaro River basin. Note important recharge areas associated with some inland reaches of the Pajaro River.



Source Data: Santa Cruz County Environmental Health staff plotted and reviewed in GIS. Growth Management Environmental Report Groundwater Recharge maps based on soils and geology mapping.

Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

➢ *Shallow Groundwater & Hydraulic Connectivity with Surface Waters*

An additional reason for developing groundwater data for this TMDL project is that many nutrient loading models (e.g., STEPL, refer to Section 7.1) require data input for shallow groundwater nutrient concentrations to allow for baseflow load estimates to surface waters. Shallow groundwater zones and perched groundwater, which can contribute to stream flows, are known to exist in the Pajaro River basin:

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[46] County of Santa Cruz Department of Environmental Health Service. GIS Layer Number = 36/ Original Mapping Source: Growth Management Environmental Report Groundwater Recharge Maps based on soils and geology mapping.

> *"… stream flow in lower Pacheco Creek (from Highway 156 and downstream) was **the result of perched groundwater resurfacing***, which maintained surface flows to San Felipe Lake".*
>
> *"**Perched groundwater*** from Lower Llagas Creek **sustains*** the portion of the Pajaro River between Llagas Creek and Miller Canal."*
>
> *From: Casagrande (2011). Aquatic Species and Habitat Assessment of the Upper Pajaro River basin, Santa Clara and San Benito Counties, California: Summer 2011.*
>
> *******emphasis added by Central Coast Water Board staff*

Los Huertos et al. (2001) also reported the presence of a laterally continuous, nitrogen-saturated shallow groundwater table in the lower Pajaro Valley which locally interacts with surface water flows:

> *"…results suggest this area of the lower Pajaro River Valley contains a **shallow water table*** that is N saturated. Based on the locations sampled to date this water table extends at least several square kilometers."*
>
> *From: Los Huertos et al (2001). Land Use and Stream Nitrogen Concentrations in Agricultural Watersheds Along the Central Coast of California. The Scientific World Journal (1):615-622.*
>
> ******* *emphasis added by Central Coast Water Board staff*

Consulting scientists from Balance Hyrologics, Inc. (2014) collected and reported groundwater piezometer data from the Watsonville Slough area in an effort to describe the nature and degree of connectivety between surface waters in the slough channel and the local shallow groundwater system. These consulting scientists reported that groundwater elevations in areas around the slough were generally higher that the surface water elevations in the sloughs, thus indicating that shallow groundwater flows towards, and into the sloughs on a local or seasonal basis.

> *"With the exception of Piezometer PWWS…groundwater levels were always **higher*** than in the sloughs. This suggests a slope in water elevations towards the north, and thus presumably shallow groundwater flow in the area of the piezometer array is generally **toward*** Watsonville Slough."*
>
> *From: Balance Hydrologics, Inc. 2014. Watsonville Slough Hydrology Study. Prepared for: Santa Cruz Resource Conservation District. February 14, 2014.*
>
> ******* *emphasis added by Central Coast Water Board staff*

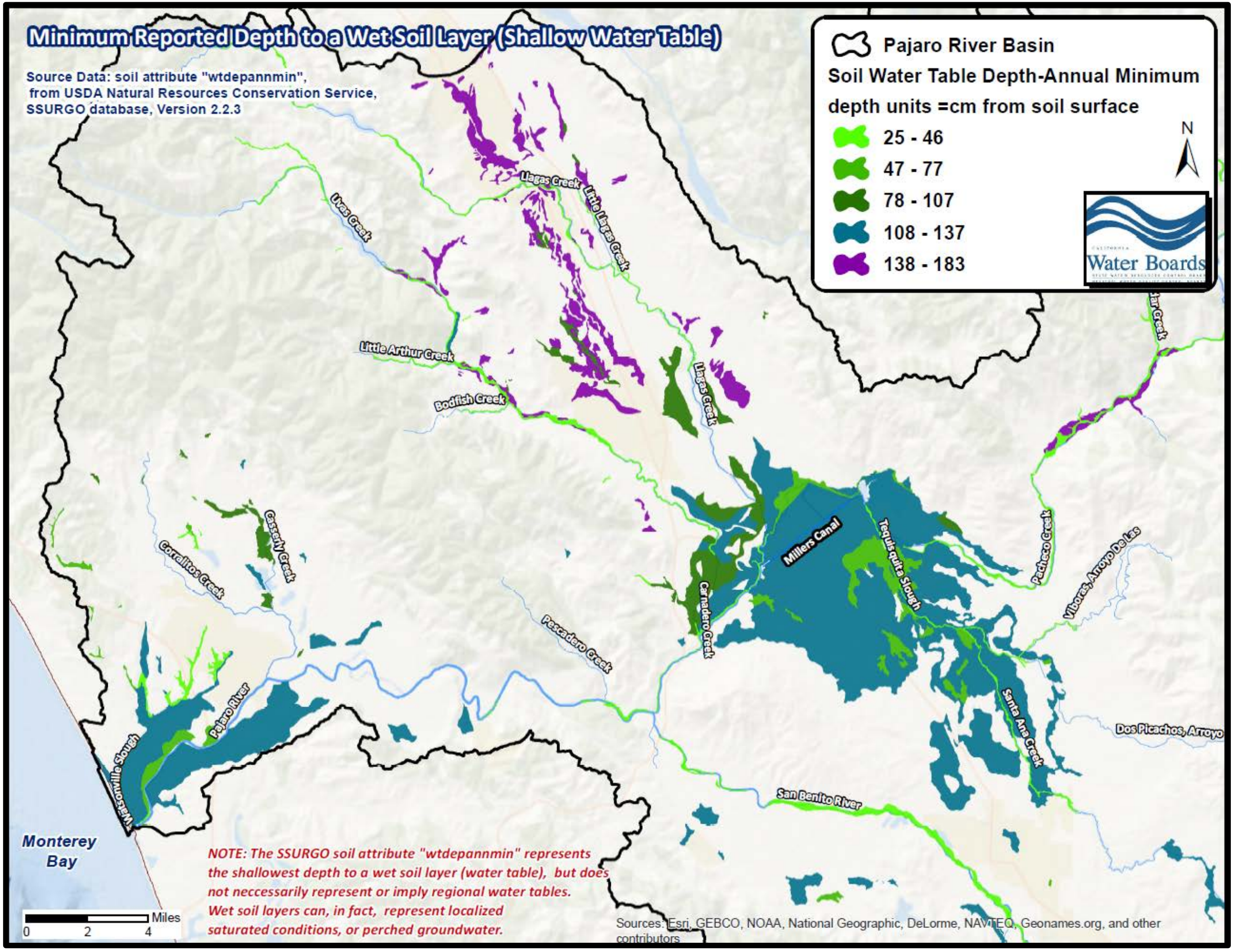
Furthermore, Central Coast Water Board staff report that Llagas Creek in the lower part of the South Santa Clara Valley is generally a gaining stream, indicating that shallow or perched groundwater inputs can contribute to streamflow in the these reaches of the creek (personal communication Dean Thomas engineering geologist Central Coast Water Board, January 24, 2014). Locally, groundwater has been observed at less than 2 feet below ground surface in the lower Llagas Creek area (personal communication Monica Barricarte, water resources control engineer, Central Coast Water Board, October 7, 2014). Further, groundwater inputs to streamflow in upper Uvas Creek and Swanson Canyon Creek are suggested by the presence groundwater-associated amphipods of the genus *Stygobromus* (Herbst et al., 2014).

Also worth noting, some parts of the lower Pajaro River Valley near Watsonville contain shallow (~two feet below ground surface) clay hardpan layers, and thus these subsurface conditions can cause perched groundwater horizons and horizontal flow of shallow perched groundwater (personal communication Richard Casale, District Conservationist, U.S. Dept. of Agriculture Natural Resources Conservation Service, July 22, 2014). This type of shallow groundwater lateral flow therefore has the potential to result in hydraulic communication locally with surface waterbodies.

Shallow groundwater or perched groundwater zones can provide base flows to streams and can locally be a major source of surface water flows during the dry season. The water stored in wetland and riparian areas can also contribute base flow to a stream during times of the year when surface water would otherwise cease to flow (DWR 2003). Therefore, dissolved nitrate in groundwater can be important nitrate sources during dry periods or low flow periods. Therefore, it is relevant to consider the scope and importance of shallow groundwater and base flow contributions to stream reaches in the Pajaro River basin. Figure 3-32 illustrates the minimum reported depth (centimeters) to a wet soil layer (shallow groundwater) in northern parts of the Pajaro River basin, based on soils data available from the U.S. Department of Agriculture Natural Resource Conservation Service. These reported data do not represent or imply all possible or known locations of shallow or perched groundwater, but do constitute best available spatial data for the distribution of occurences of shallow groundwater. In the Pajaro River basin, these shallow groundwater horizons are typically associated with lowland areas in the Pajaro Valley, the Santa Clara Valley, and locally within the riparian corridors of many stream reaches.

The interactions between groundwater and surface water can vary even at the stream reach scale. For example, a 3-mile section of the lower Pajaro River between the Rogge Lane Bridge and downstream to Murphy Crossing is generally known to be a “losing” reach, where river water infiltrates through the stream substrate and recharges the underlying groundwater (Hatch, et al., 2010). However, even within this discrete 3-mile reach there are exceptions to this trend; researchers have documented a pool-riffle sequence in this section of the Pajaro River where groundwater flows *into* the river contributing to stream flow, and thus this particular segment of the river is a “gaining” reach (Hatch, et al., 2010).

Figure 3-32. Minimum reported depth (cm) to a wet soil layer (shallow groundwater) in the northern parts of the Pajaro River basin.



Minimum Reported Depth to a Wet Soil Layer (Shallow Water Table)

Source Data: soil attribute "wtdepannmin", from USDA Natural Resources Conservation Service, SSURGO database, Version 2.2.3

NOTE: The SSURGO soil attribute "wtdepannmin" represents the shallowest depth to a wet soil layer (water table), but does not neccessarily represent or imply regional water tables. Wet soil layers can, in fact, represent localized saturated conditions, or perched groundwater.

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

Regarding the hydraulic connection of streams and groundwater systems, it is important to recognize the significance of the fluvial morphology of streams. Rivers, creeks, and ditches are incised vertically into the alluvial floodplain (see Figure 3-33, Figure 3-34, and Figure 3-35). Stream elevation cross section profiles reported for the Pajaro and San Benito Rivers and for Llagas Creek indicate that these streams are vertically incised into the surrounding flood plains by depths ranging from 8 to 30 feet, as measured from the flood plain elevation to the stream channel bottom (ESA PWA, 2013; Raines, Meltion & Carella, Inc. 2001(b); and Raines, Meltion & Carella, Inc. 2005). Thus, shallow groundwater zones observed in wells on the surrounding alluvial flood plains can be intersected or penetrated locally by incised stream channels. Consequently, in areas characterized by shallow groundwater zones, the groundwater may locally flow into the incised stream channels, thus contributing – in part – to total stream flow.

Figure 3-33. Photo of Pajaro River channel bottom and channel bank.

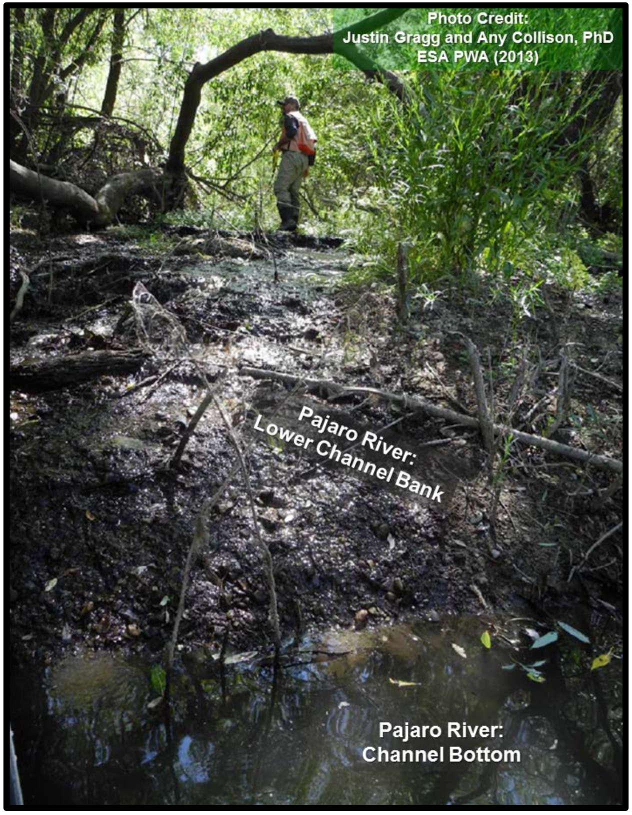
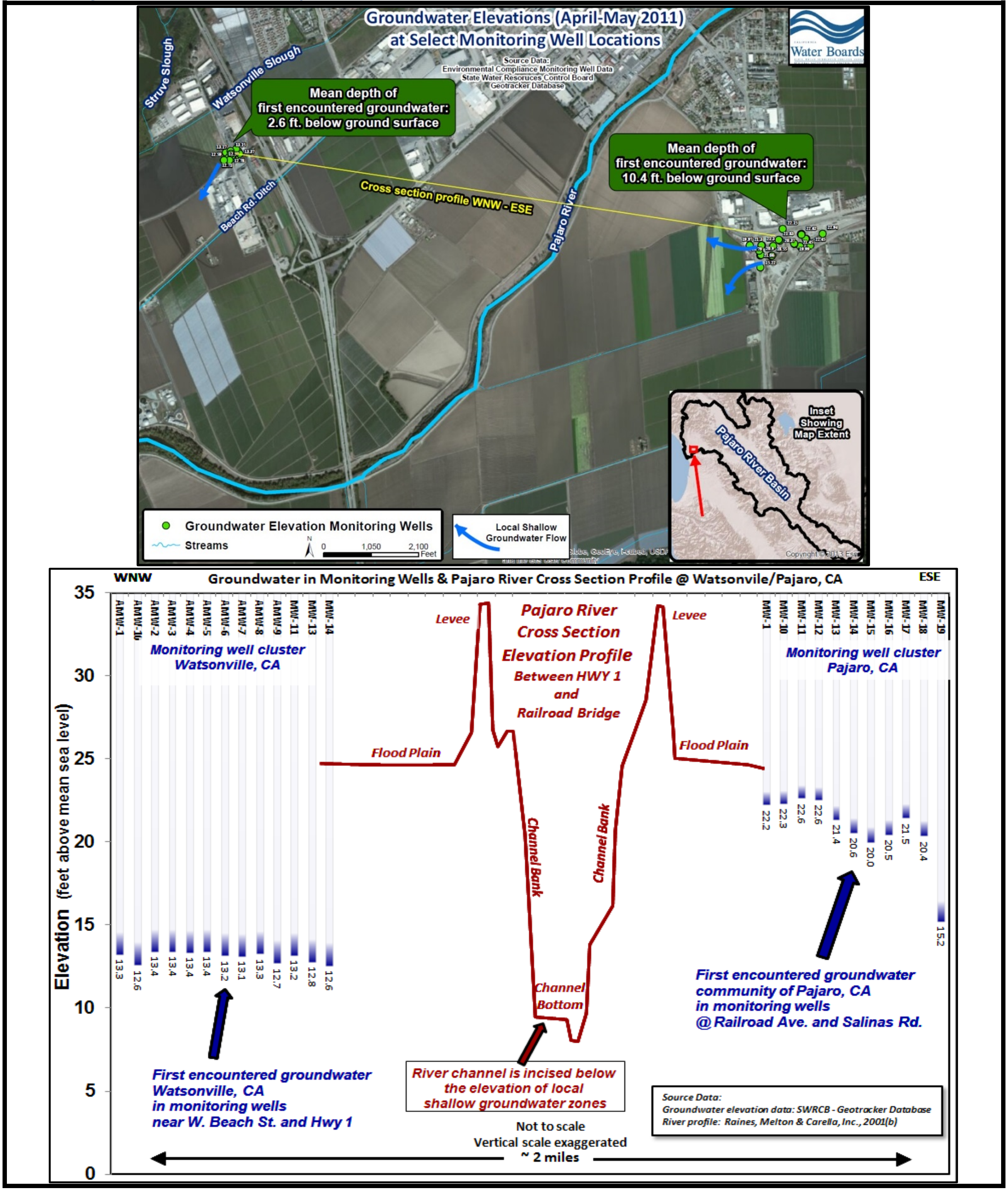


Figure 3-34. Photo of Miller Canal channel bottom and channel bank.

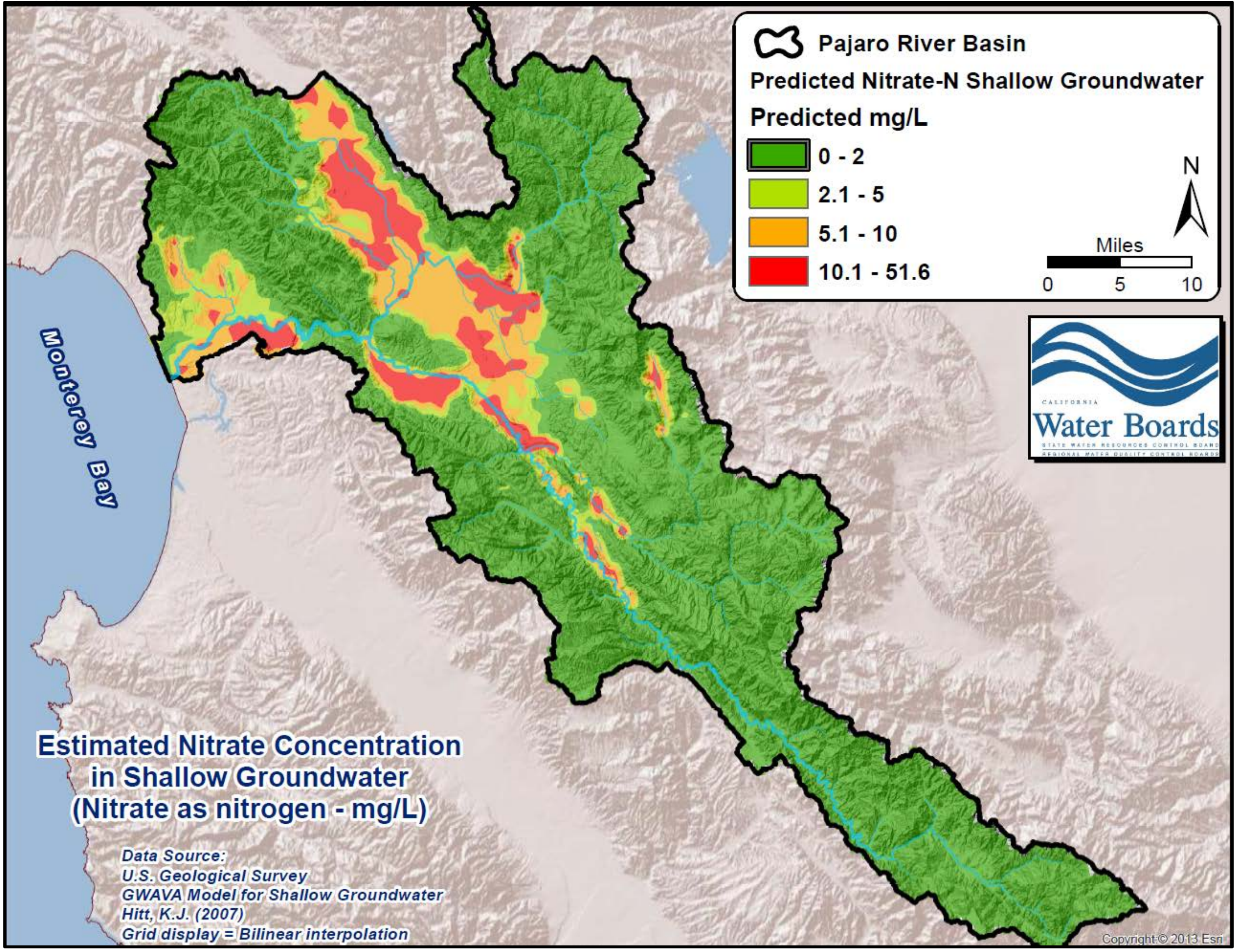
Figure 3-35. Map and associated cross section elevation profile, lower Pajaro River basin near Watsonville. The cross section profile illustrates that the Pajaro River channel is vertically incised below the elevation of local shallow groundwater tables observed in monitoring wells, thus indicating that shallow groundwater can locally flow into the stream channel and contribute to stream flow.



➢ *Estimated N Concentrations in Shallow Groundwater*

As previously noted, stream baseflow resulting from these shallow water-bearing hydrogeologic zones can contribute to nutrient loading to streams. Figure 3-36 illustrates the estimated nitrate as nitrogen concentration in shallow, recently-recharged groundwater of the Pajaro River basin (data source: U.S. Geological Survey GWAVA model[47]). Shallow, recently recharged groundwater is defined by the U.S. Geological Survey in the GWAVA dataset as groundwaters less than 15 meters below ground surface.

Figure 3-36. Predicted nitrate as nitrogen concentrations in shallow, recently-recharged groundwater, Pajaro River basin (year 2007).



Nitrate groundwater concentrations are not uniform throughout the Pajaro River basin, and to a significant extent are related to land use/land cover. Pollutant source assessment tools used by staff (see Section 7) require inputs of nitrate concentrations in shallow groundwater for specific land use categories. Therefore, it is necessary to develop plausible estimates of nitrate concentrations in shallow groundwaters of the Pajaro River basin. Paired land use/groundwater nitrate as N concentration estimates are presented in Figure 3-37 and in Table 3-26.

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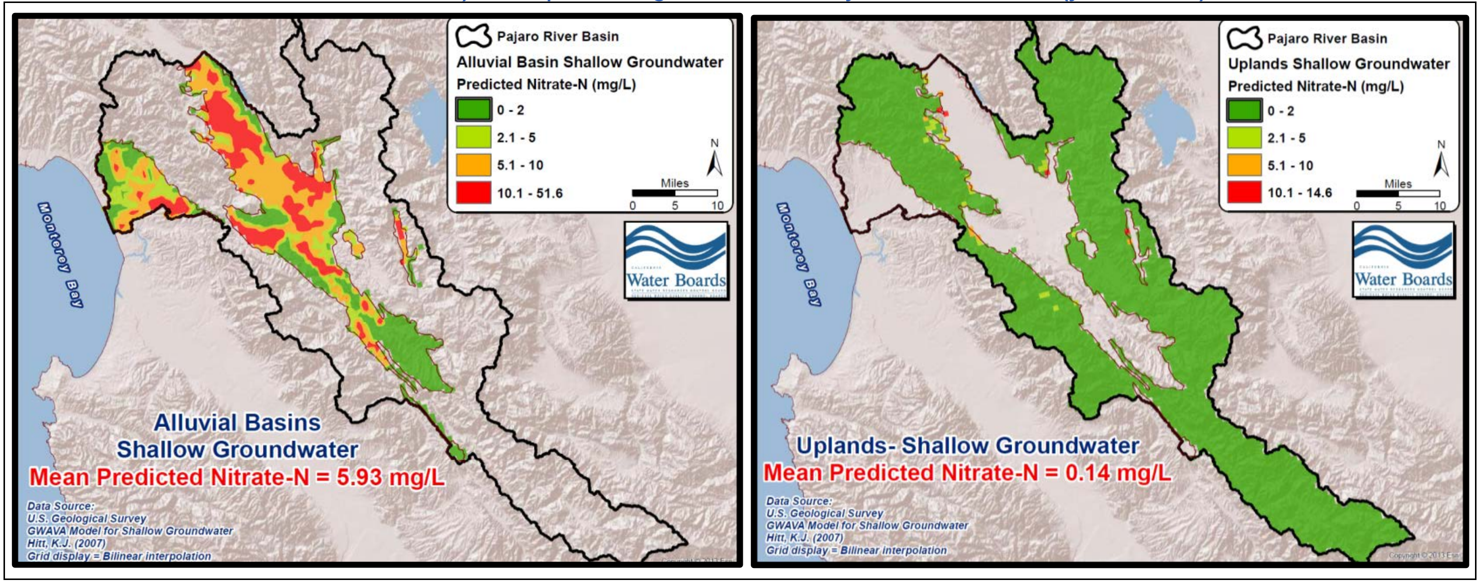
[47] The GWAVA dataset represents predicted nitrate concentration in shallow, recently recharged groundwater in the conterminous United States, and was generated by a national nonlinear regression model based on 14 input parameters. Online linkage: http://water.U.S. Geological Survey.gov/GIS/metadata/U.S. Geological Surveywrd/XML/gwava-s_out.xml

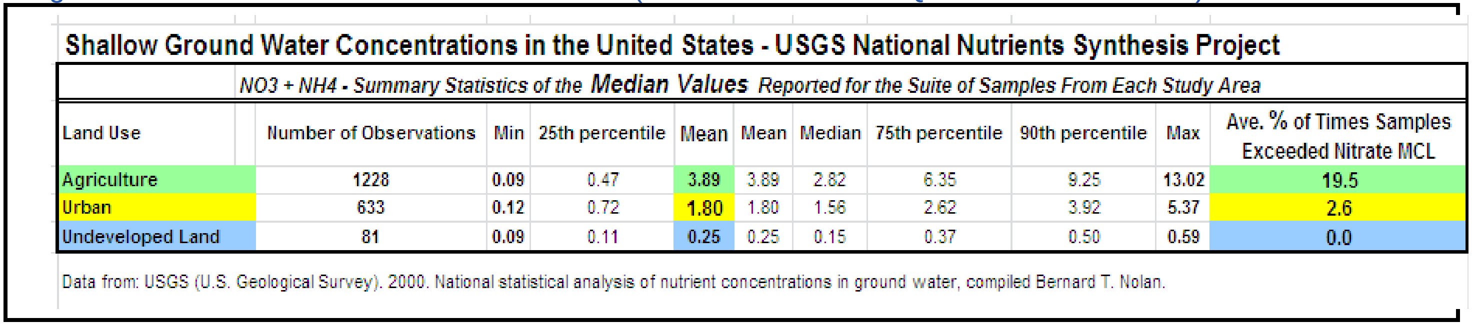
The agricultural, alluvial valley floor basin has substantially higher predicted nitrate concentrations than predicted nitrate in the alluvial fill and fractured bedrock groundwaters of upland and rangeland areas.

Figure 3-37. Estimated nitrate as N concentrations and averages in shallow groundwaters of 1) the alluvial basin floor areas; and 2) the upland regions of the Pajaro River basin (year 2007).



Data Source:
U.S. Geological Survey
GWAVA Model for Shallow Groundwater
Hitt, K.J. (2007)
Grid display = Bilinear interpolation

Table 3-26. Measured nitrate as N concentrations and average measures of nitrate as N in shallow groundwaters beneath U.S. urbanized areas (table – source NAWQA studies 1991-1998).



Shallow Ground Water Concentrations in the United States - USGS National Nutrients Synthesis Project

NO3 + NH4 - Summary Statistics of the ***Median Values*** *Reported for the Suite of Samples From Each Study Area*

Land Use	Number of Observations	Min	25th percentile	Mean	Mean	Median	75th percentile	90th percentile	Max	Ave. % of Times Samples Exceeded Nitrate MCL
Agriculture	1228	0.09	0.47	3.89	3.89	2.82	6.35	9.25	13.02	19.5
Urban	633	0.12	0.72	1.80	1.80	1.56	2.62	3.92	5.37	2.6
Undeveloped Land	81	0.09	0.11	0.25	0.25	0.15	0.37	0.50	0.59	0.0

Data from: USGS (U.S. Geological Survey). 2000. National statistical analysis of nutrient concentrations in ground water, compiled Bernard T. Nolan.

Since nitrogen occurs naturally in the environment, it is also important to recognize that nitrate-impacted groundwater has both a natural, ambient background load, and a load attributable to human activities. Natural, background nitrate concentrations in groundwater in the alluvial valley floor reaches[48] of the Pajaro River basin can be approximated using data obtained by Moran et al., (2011) in an agricultural valley basin area located in the Salinas Valley of central Monterey County. Using isotopic data, Moran et al. (2011) found that precipitation-derived ambient nitrate from observed wells in agricultural areas adjacent to the Arroyo Seco River were always at concentrations less than 4 mg/L, with a mean for all the observed ambient groundwater samples calculated as 1.21 mg/L nitrate as N[49,50]. Staff uses this

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[48] It should be noted that ambient, background groundwater nitrate in alluvial valley basins with thick soil profiles may be different (possibly higher) than background nitrate found in bedrock aquifers and alluvial fill of many upland areas. Moran et al. (2011) indicate that rainwater which percolates through alluvial valley soil profiles would interact with soil nitrogen during infiltration and recharge.

[49] The estimate that natural, background nitrate in alluvial valley groundwater is approximately an order of magnitude lower than anthropogenic nitrate in groundwater underlying agricultural areas is consistent with the Salinas Valley and Tulare Lake basin study of the University of California-Davis (2012). In this University of California-Davis study the authors reported that "natural nitrate is a comparatively unimportant source of groundwater N".

[50] Moran et al. (2011) report nitrate as NO3; however staff chose to report this value as nitrate-N herein, because in staff's judgment and based on the body of scientific literature presented herein, it is plausible that any alluvial valley groundwater less than about 5 mg/L nitrate-NO3 could be representative of ambient background conditions, or conditions that have no significant

value (1.21 mg/L) as a plausible estimate of background nitrate as nitrogen in groundwaters of the Pajaro River basin. Worth noting is that this estimated alluvial valley groundwater background nitrate as N concentration (1.21 mg/L) comports quite well with estimates of background nitrate concentrations reported by the U.S. Geological Survey – as illustrated below – thus providing some additional confidence in staff's estimate:

> *"In general, we use* ***1 mg/L**** *(nitrate-N) as a national background level (see http://water.usgs.gov/nawqa/nutrients/pubs/circ1350/). Note that this is a nationally derived value and that regional background levels can vary."*
>
> *− B.T. (Tom) Nolan, Hydrologist, U.S. Geological Survey, personal communication 12/19/2012 in an email exchange with Central Coast Water Board staff regarding background levels of nitrate-N in groundwater.*
>
> *******emphasis added by Central Coast Water Board staff.*

> *"Nitrate (as N) concentrations in samples from background sites generally were* ***less than 2 mg/L*** *for groundwater."*
>
> *− Mueller and Helsel, 1996. "Nutrients in the Nation's Waters: Too Much of a Good Thing?" U.S. Geological Survey Circular 1136.*
>
> *******emphasis added by Central Coast Water Board staff.*

While groundwater research from basins elsewhere in the world are not necessarily directly relevant to groundwater of the Pajaro River basin, it is worth noting that natural background nitrate levels in groundwater in semi-arid regions of China and in Australia comport quite well with the background estimates provided above – thus adding some assurance that these ranges of background nitrate concentrations in groundwater (generally less than 2 mg/L nitrate as N) are frequently observed around the world:

> *"In the (semi)arid northern China, the median values of nitrate baseline for the three large regions (Tarim river basin, TRB; Loess Plateau of China, LPC; North China Plain, NCP) range from 2 to 9 mg/L nitrate as* NO_3*" [or* ***0.45 to 2.0 mg/L**** *in the nitrate as nitrogen reporting convention]"*
>
> *− Huang, T. et al. 2013. Nitrate in groundwater and the unsaturated zone in (semi)arid northern China: baseline factors controlling transport and fate. Environmental Earth Sciences, Vol. 70, Issue 1, pp. 145-156.*
>
> ******* *emphasis and unit conversion parenthetical note added by Central Coast Water Board staff.*

> *"Background nitrate concentrations in groundwater across Australia are in the order of* ***less than 2 mg/L*** NO_3 ***(as N)****."*
>
> *Bolger, P. and M. Stevens. 1999. Land and Water Resources Research and Development Corporation (LWRRDC). Contamination of Australian Groundwater Systems with Nitrate. LWRRDC Occasional Paper 03/99.*
>
> *******emphasis added by Central Coast Water Board staff.*

Another line of evidence to assess background concentrations of nitrate in groundwater can be developed with tritium data[51]. Tritium is a geochemical tracer which has been used to identify relative

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human impacts. Further, staff endeavors to develop biostimulatory targets that would not be infeasible to achieve because of plausible background conditions.

[51] Tritium, a radioactive isotope of hydrogen, is measured and used to indicate differences in the relative age of groundwaters. Elevated levels of tritium were introduced into the atmosphere by nuclear weapons testing between 1952 and 1980. Therefore groundwaters with relatively high levels of tritium indicate recharge of atmospheric meteoric waters after 1952. By convention, groundwaters with less than 0.8 TU represent groundwaters which were recharged before 1952 (see U.S. Geological Survey, 2007).

groundwater ages. By convention (U.S. Geological Survey 2007), relative groundwater ages are identified on the basis of the following tritium concentration ranges (tritium units[52]):

1. Less than about 0.8 tritium units – generally represents premodern groundwater (groundwater recharged prior to 1952);
2. About 0.8 to about four tritium units – generally represents a mixture of premodern groundwater (recharged prior to 1952) and recent groundwater (recharged after 1952); and
3. Greater than four tritium units – represents groundwater substantially comprised of recently recharged groundwater (recharged after 1952).

Staff used paired groundwater data available from the U.S. Geological Survey to estimate nitrate concentration ranges in various types of groundwaters in California – these numerical summaries are presented in Table 3-27.

Table 3-27. Numerical summaries of nitrate as N concentrations in various types of groundwaters in California (nitrate as N units = mg/L). Groundwater types are differentiated on the basis of tritium concentrations. See Figure 3-38 for a map of the sampling sites.

Groundwater Type *(on the basis of tritium concentrations)*	**Sample Dates**	**Arithmetic Mean**	**Min**	**25th %**	**50th % (median)**	**75th %**	**90th %**	**Max**	**No. of Samples**
Premodern groundwater[A] *(recharged before 1952)*	March 1984 – Aug. 2012	2	0.02	0.06	0.64	2.5	5.35	45.3	873
Mixed premodern groundwater and recently recharged groundwater	Apr. 1988 – Aug. 2012	4.54	0.02	0.35	1.98	5.37	11.04	77.3	657
Mostly recently recharged groundwater *(comprised mostly of water recharged after 1952)*	Sept. 1981 – Apr. 2012	7.26	0.002	0.46	2.72	8.25	18.12	185	487

Source Data: U.S. Geological Survey, National Water Information System, online linkage: http://waterdata.usgs.gov/nwis

[A] Some samples collected in recent years could potentially represent very recently recharged groundwater, since groundwater recharged within the last decade may be indistinguishable from pre-1952 era groundwater on the basis of tritium data – see report narrative.

Figure 3-38 illustrates the sampling locations for the paired tritium-nitrate groundwater samples, and suggests reasonably good spatial representation across the state. "Premodern" groundwaters (groundwater recharged prior to 1952, and thus less likely to have been influenced by human activities) generally have the lowest nitrate as N concentration ranges (median = 0.64 mg/L, mean = 2 mg/L). The nitrate as N concentrations of these "premodern" groundwaters plausibly represent natural background conditions, and the median and mean nitrate as N concentrations observed comport reasonably well with the estimates of natural background groundwater nitrate as N reported in the scientific literature noted previously. In contrast, recently recharged groundwater (which are more likely to be influenced by human activities) have generally higher nitrate as N concentrations (median = 2.72 mg/L, mean = 7.28 mg/L) – see

Table 3-27 – consistent with the presumption of a greater human influence on recently recharged groundwaters.

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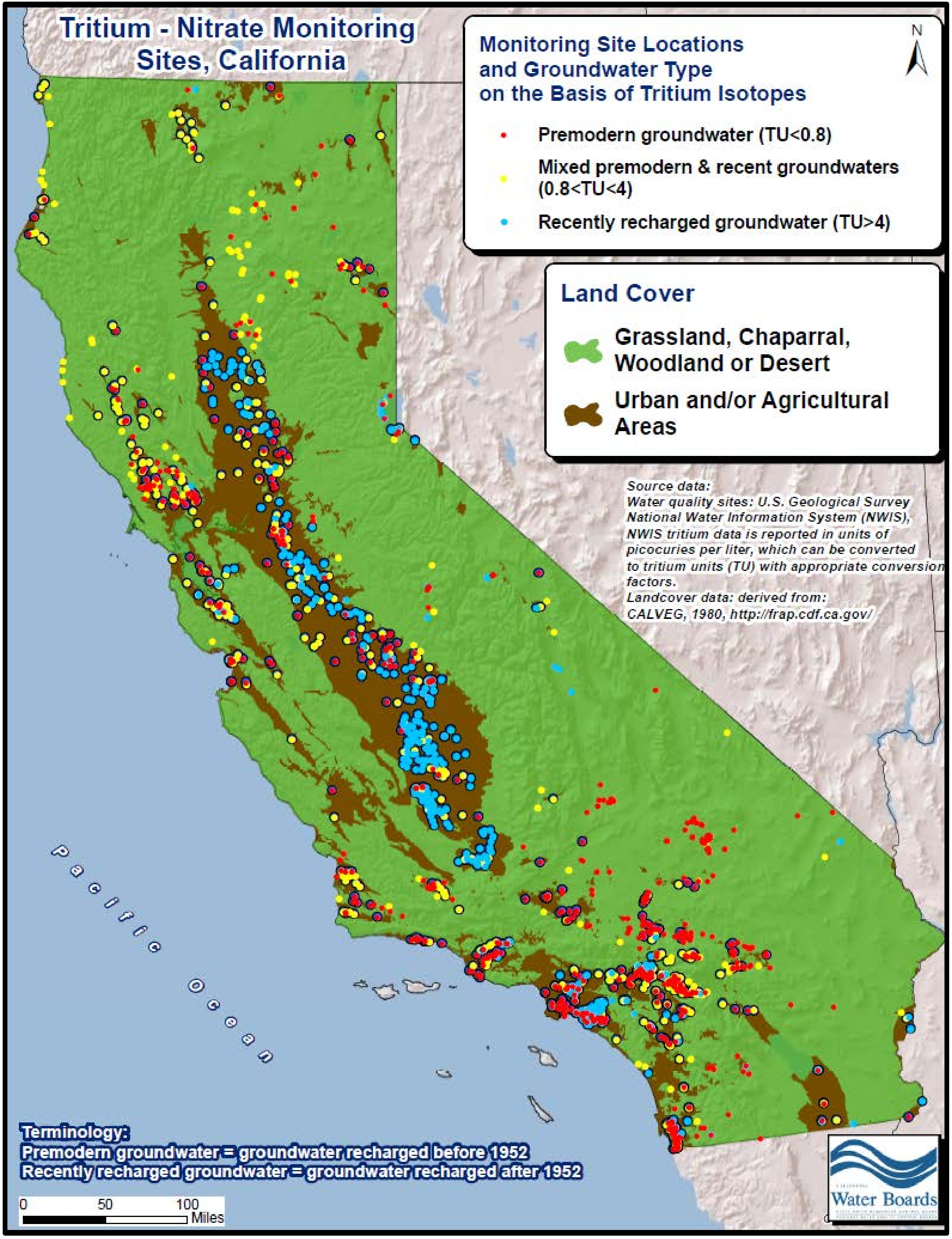
[52] 1 tritium unit (TU) is equal to 3.22 picocuries per liter. See U.S. Geological Survey conversion factors, online linkage: http://pubs.usgs.gov/sir/2010/5229/section.html

Figure 3-38. Groundwater monitoring sites in California which have paired nitrate-tritium water quality data (source U.S. Geological Survey, National Water Information System) and color-coded to illustrate estimated relative age and groundwater type based on tritium isotope concentrations.



Source data:
Water quality sites: U.S. Geological Survey National Water Information System (NWIS), NWIS tritium data is reported in units of picocuries per liter, which can be converted to tritium units (TU) with appropriate conversion factors.
Landcover data: derived from: CALVEG, 1980, http://frap.cdf.ca.gov/

It should be noted that the half-life of tritium is relatively short (12.32 years)[53], and since atmospheric nuclear testing ended by 1980, atmospheric levels of tritium began to return to pre-atomic testing, natural

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[53] Tritium naturally decays to a non-radioactive isotope of helium (^{3}He). http://en.wikipedia.org/wiki/Tritium

background levels around the mid–1990s. Therefore, the utility of tritium as a geochemical tracer of relative groundwater ages is approaching an expiration date. Modern precipitation increasingly becomes indistinguishable from precipitation from the pre-atomic testing era on the basis of tritium data alone.

Nonetheless, tritium as a tracer of atomic testing-era precipitation and recharge dating will remain useful for the next several decades (Eastoe, et al. 2011). Indeed, tritium is still being used in recent studies of groundwater age (U.S. Geological Survey 2007, U.S. Geological Survey 2011). Noteworthy, is that the paired tritium-nitrate California data staff assessed came from a wide range of sampling dates going back to the early 1980s, providing reasonably good temporal variation, Further, a non-parametric Wilcoxon rank sum test[54] using R[55] of premodern California groundwaters and recently recharged California groundwaters indicates that these two groups of groundwaters are highly statistically significantly different from each other (P value = 2.2e-16)[56], indicating a very small probability of observing this difference by random chance.

Also highlighting the differences between these groundwater types, Table 3-28 illustrates that approximately 21 percent of recently recharged California groundwaters exceed the nitrate human health water quality standard of 10 mg/L (nitrate as N), compared to only approximately 3% of groundwater samples from the premodern category. This is due to the fact that groundwaters recharged after 1952 are more likely to be influenced by human activities and land use practices.

Table 3-28. Percent of samples that exceed, or are less than, the nitrate human health water quality standard (MCL) in different groundwater types in California.

	% of Samples Exceeding Nitrate MCL*	**% of Samples Less Than Nitrate MCL***	**No. of Samples**
Mostly Recently Recharged Groundwater	20.7%	79.3%	487
Mixture of Premodern & Recent Groundwater	11.6%	88.4%	657
Mostly Premodern Groundwater	3.2%	96.8%	873

* MCL = maximum contaminant level – the human health water quality standard (10 mg/L nitrate as nitrogen)

Recapping, multiple lines of evidence assessed above, including groundwater studies in the nearby Salinas Valley, personal communication and reporting from the U.S. Geological Survey, scientific literature, and tritium isotope data indicate that natural background concentrations of nitrate as N in groundwaters of the Pajaro River basin could be expected to be in the range 1 to 2 mg/L. Staff is using the aforementioned Moran et al., 2011 study, as a quantification of average natural background nitrate as N in groundwaters of the Pajaro River basin.

Additionally, the information and data presented previously also provides insight into expected average concentrations of nitrate as N in shallow groundwaters of agricultural areas, urbanized areas, rangelands and woodlands of the river basin.

Text Box 3-3 below summarizes staff's conclusions drawn from this information.

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[54] Also widely known as the Mann-Whitney test.

[55] R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org

[56] By convention, P-values are considered to indicate statistical significance when the P-value < 0.05.

Text Box 3-3. Estimates of average nitrate as N concentrations in shallow, recently recharged groundwaters of the Pajaro River basin.

Based on the information developed in this section of the TMDL report, estimated average shallow groundwater nitrate (nitrate as N) in the Pajaro River basin can be summarized as follows:

- **ALLUVIAL VALLEY AMBIENT BACKGROUND:** *Ambient natural background nitrate as N concentration that would be expected in unimpacted shallow groundwater underlying the alluvial valley floor:*
    - **1.21 mg/L** (see preceding discussions on background nitrate in groundwaters)
- **AGRICULTURAL AREAS:** *Average, shallow groundwater nitrate as N concentration expected to underlie agricultural areas of the Pajaro River basin:*
    - **5.93 mg/L** (refer back to Figure 3-37)
- **URBAN AREAS:** *Average, shallow groundwater nitrate as N concentration attributable to urban influence that would be expected to underlie urban areas of the Pajaro River basin:*
    - **1.8 mg/L**[57]
- **WOODLAND, RANGELAND, UPLAND REACHES:** *Average, shallow groundwater nitrate as N concentration that would be expected in bedrock aquifers and alluvial fill underlying woodland and rangeland in upland ecosystems of the Pajaro River basin:*
    - **0.14 mg/L** (refer back to Figure 3-37)

➢ *Estimated P Concentrations in Shallow Groundwater*

Except under certain geochemical and physical soil conditions, phosphorus typically does not readily leach to groundwater from land use activities in substantial amounts because phosphorus readily adsorbs to sediment and soils and is not as mobile in the environment as nitrate (Domagalski and Johnson, 2012). Nonetheless, phosphorus is found in groundwaters generally as a result of the leaching of subsurface geologic materials.

Figure 3-39 and Table 3-29 present observed phosphorus concentrations in groundwaters and spring waters of the Pajaro River basin. Thus, our estimate of average phosphorus as P concentrations in groundwaters of the Pajaro River basin is presented in Text Box 3-4:

Text Box 3-4. Estimated average phosphorus as P concentration in shallow groundwaters of the Pajaro River basin.

On the basis of National Geochemical Dataset water quality data, a plausible estimate of average groundwater phosphorus concentration within the river basin can be identified from the geometric mean of the available data, which is: **0.04 mg/L** phosphorus as P.

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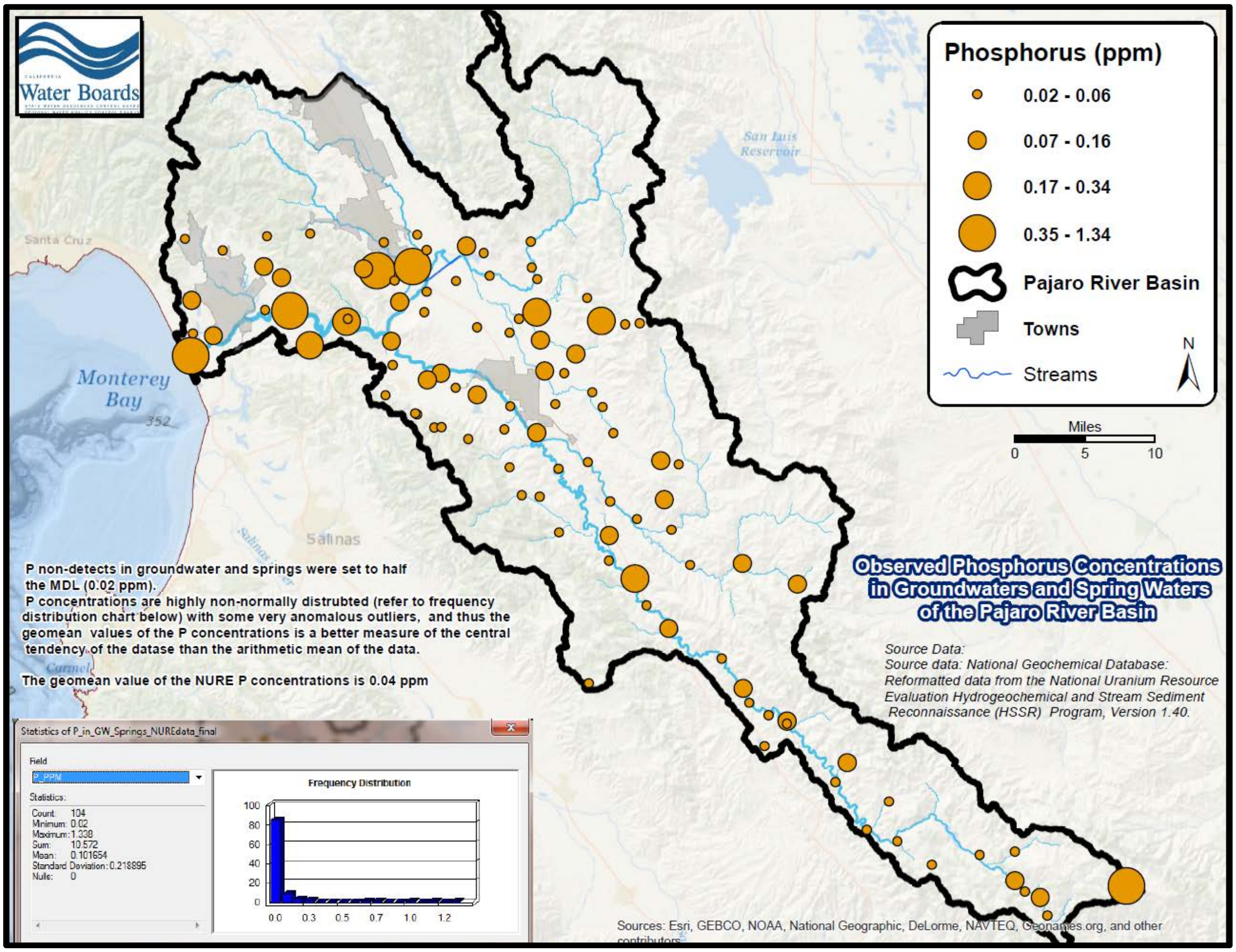
[57] Average of national median values, refer back to table in Table 3-26

Figure 3-39. Observed phosphorus concentrations in groundwaters of the Pajaro River basin on the basis of National Geochemical Database datasets.



P non-detects in groundwater and springs were set to half the MDL (0.02 ppm).
P concentrations are highly non-normally distrubted (refer to frequency distribution chart below) with some very anomalous outliers, and thus the geomean values of the P concentrations is a better measure of the central tendency of the datase than the arithmetic mean of the data.

The geomean value of the NURE P concentrations is 0.04 ppm

Statistics of P_in_GW_Springs_NUREdata_final

Field: P_PPM

Statistics:
Count: 104
Minimum: 0.02
Maximum: 1.338
Sum: 10.572
Mean: 0.101654
Standard Deviation: 0.218895
Nulls: 0

Observed Phosphorus Concentrations in Groundwaters and Spring Waters of the Pajaro River Basin

Source Data:
Source data: National Geochemical Database: Reformatted data from the National Uranium Resource Evaluation Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program, Version 1.40.

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

Table 3-29. Observed concentrations of phosphorus in groundwaters and spring waters of the Pajaro River basin (units = mg/L) on the basis of National Geochemical Database datasets.

Groundwater Constituent	Sampling Dates	Geometric Mean	Min	50th % (median)	75th %	90th %	Max	No. of Samples
Observed phosphorus as P concentrations in groundwaters of the Pajaro River basin[A]	Jan.to Feb. 1980	0.04	0.02	0.02	0.08	0.16	1.34	104

[A] Source data: National Geochemical Database: Reformatted data from the National Uranium Resource Evaluation Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program, Version 1.40. Begun in 1975 and ending in 1980, the HSSR program was initiated by a consortium of federal agencies and included planned systematic sampling of sediments, groundwater, and surface water over the conterminous United States.

➢ *Base Flow Indices*

As noted previously, groundwater inputs to streamflow as baseflow is a hydrologic process that varies in magnitude and importance based on numerous physical, climatic, geomorphic, geologic, and characteristics. Figure 3-40 illustrates regional estimates and spatial variation of base flow[58] (measured as base flow indices) in the Pajaro River basin. This map should be considered a coarse, gross regional approximation of base flow indices mathematically interpolated between stream gages; there will be substantial variation in the magnitude of base flow at localized and site-specific scales. It can be concluded that shallow groundwater locally is an important hydrologic process contributing to total stream flow, locally in the Pajaro River basin. Where groundwater is a significant contributor to total

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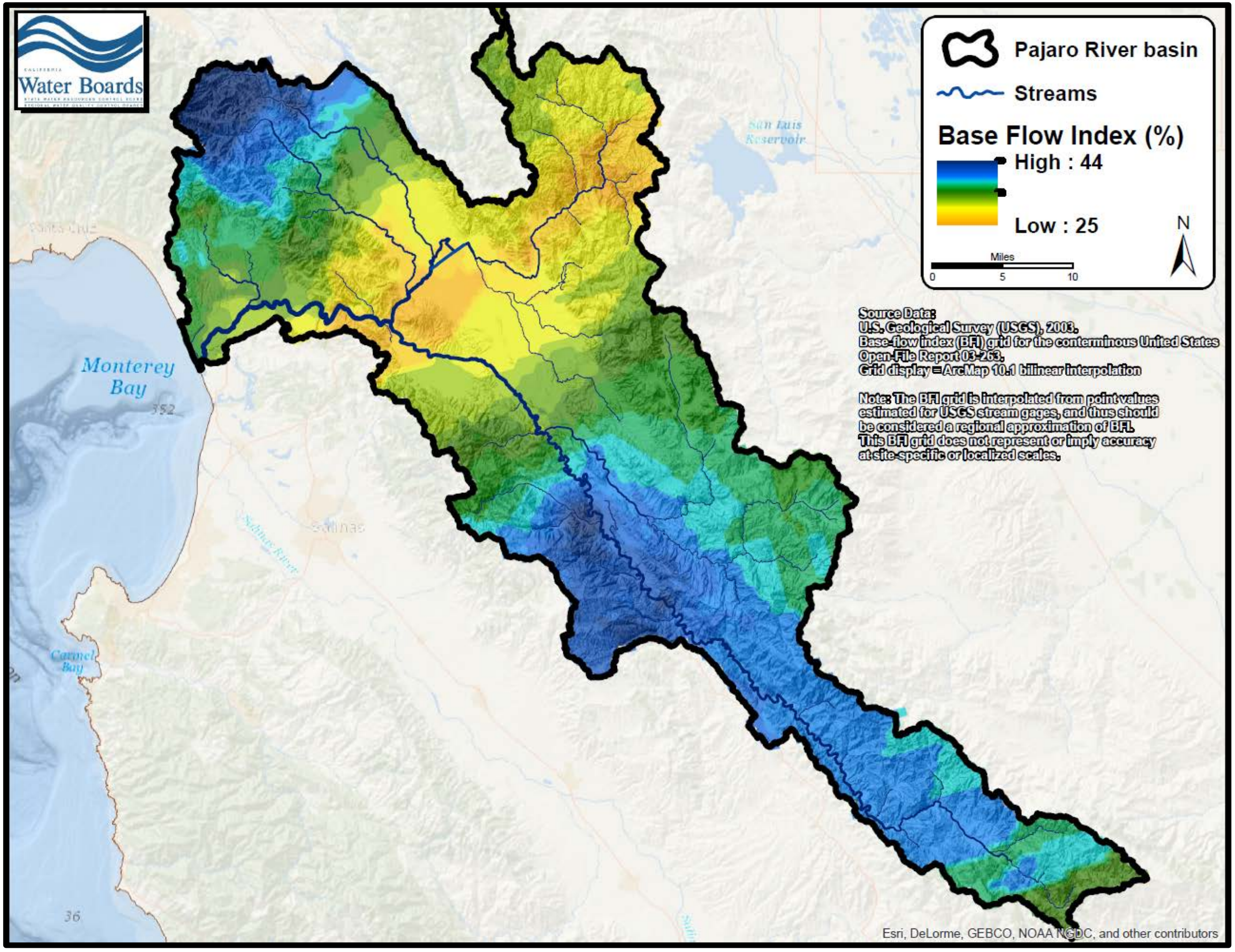
[58] Baseflow is the component of stream flow that can be attributed to groundwater discharge into streams.

stream flow, pollution present in shallow groundwater has the potential to locally degrade surface water (refer back to Figure 3-29).

Figure 3-40. Estimated regional average base flow indices in the Pajaro River basin, on the basis of interpolation of reported U.S. Geological Survey stream gage data.



Source Data:
U.S. Geological Survey (USGS), 2003.
Base-flow index (BFI) grid for the conterminous United States
Open-File Report 03-263.
Grid display = ArcMap 10.1 bilinear interpolation

Note: The BFI grid is interpolated from point values estimated for USGS stream gages, and thus should be considered a regional approximation of BFI. This BFI grid does not represent or imply accuracy at site-specific or localized scales.

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

➢ *Heterogeneity of Subsurface Alluvial Depositional Systems*

Because groundwater exists in three-dimensional space it is relevant to be cognizant of potential spatial variation in groundwater-bearing zones. It is well known that due to the depositional nature of fluvial depositional systems[59], the subsurface stratigraphic architecture of alluvial basins are highly heterogeneous both laterally and vertically (see Figure 3-41, Figure 3-42 and Figure 3-43 for conceptual examples). Thus, perched or shallow groundwater systems[60] and groundwater flow will preferentially occur in shallow, laterally discontinuous permeable[61] zones (sands and gravel), In fluvial deposits, these discontinuous permeable sand and gravel zones constitute the channel belt facies[62] of the depositional system, and generally nest within or interfinger with fine-grained aquitard strata (silts and clays) of the floodplain and overbank facies.

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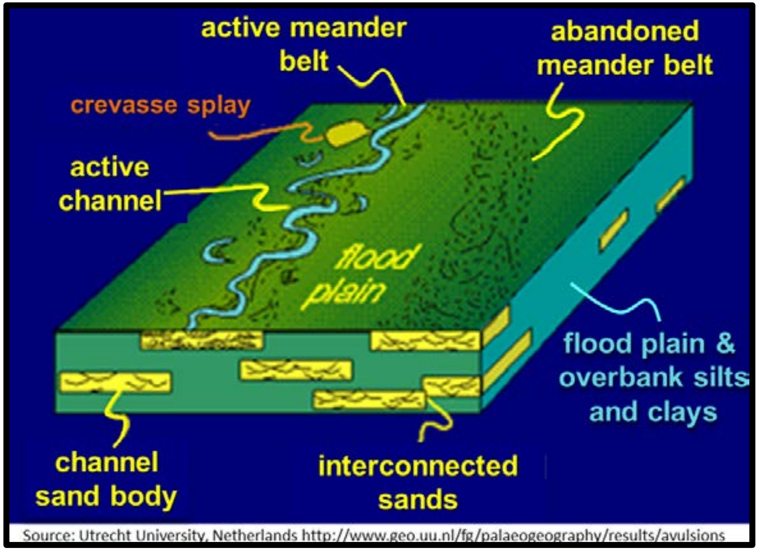
[59] "Fluvial" is a term used in physical geography and geology to refer to the processes associated with rivers and streams including the sedimentary deposits and landforms created by them. Sedimentary material deposited by rivers and streams is commonly referred to as alluvium, or alluvial deposits.

[60] "Perched groundwater" refers to shallow zones of saturation, typically in shallow, subsurface sands and gravels, which exist vertically above the main zone of saturation.

[61] Permeability is a measure of a soil or rock's ability to transmit fluid.

[62] Facies (sometimes also called "lithofacies") – An assemblage of sediment types deposited in a specific depositional environment (aka, tidal flats, alluvial flood plains, river channel belt, river deltas, shallow offshore marine environments, etc).

Figure 3-41. Generalized block model of a fluvial depositional system (figure credit: Utrecht University, Department of Physical Geography).



Source: Utrecht University, Netherlands http://www.geo.uu.nl/fg/palaeogeography/results/avulsions

Figure 3-42. Seismic block model of alluvial deposits in the shallow subsurface of the San Joaquin Valley, illustrating heterogeneity in subsurface hydraulic properties (figure credit: Hyndman et al., 2000).

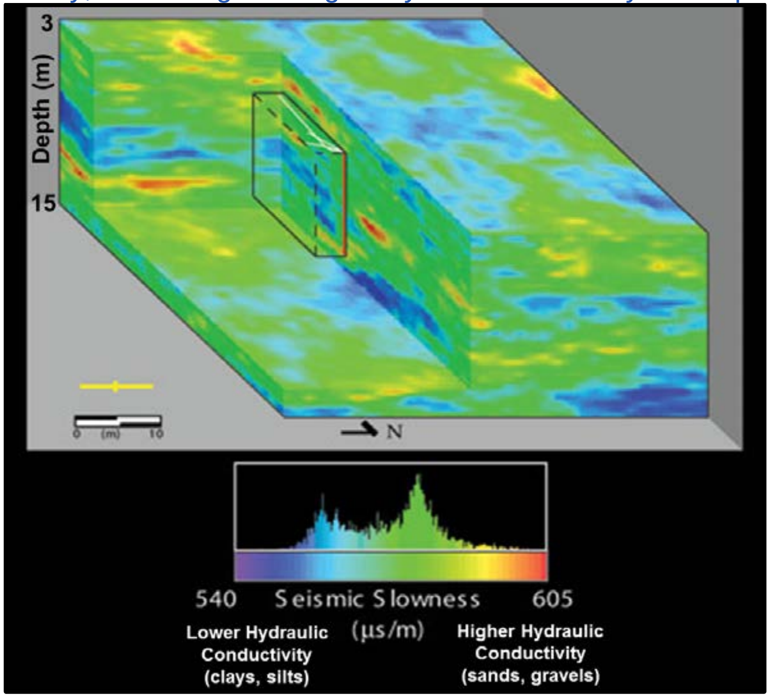
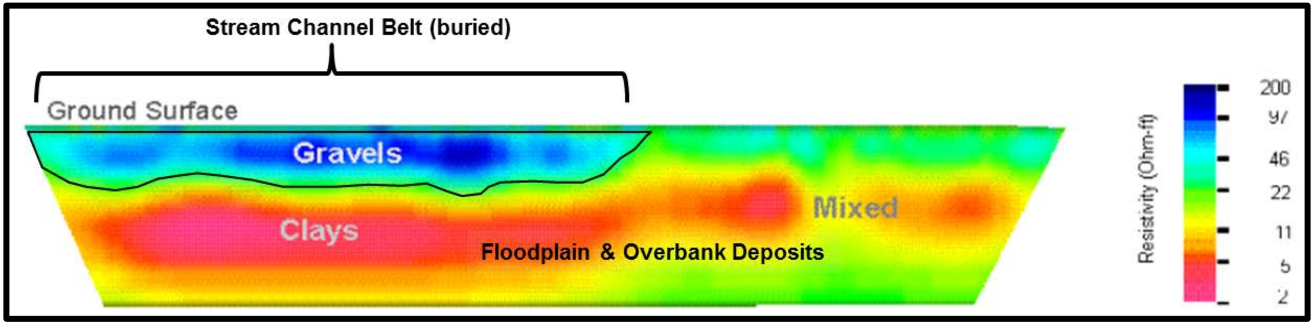
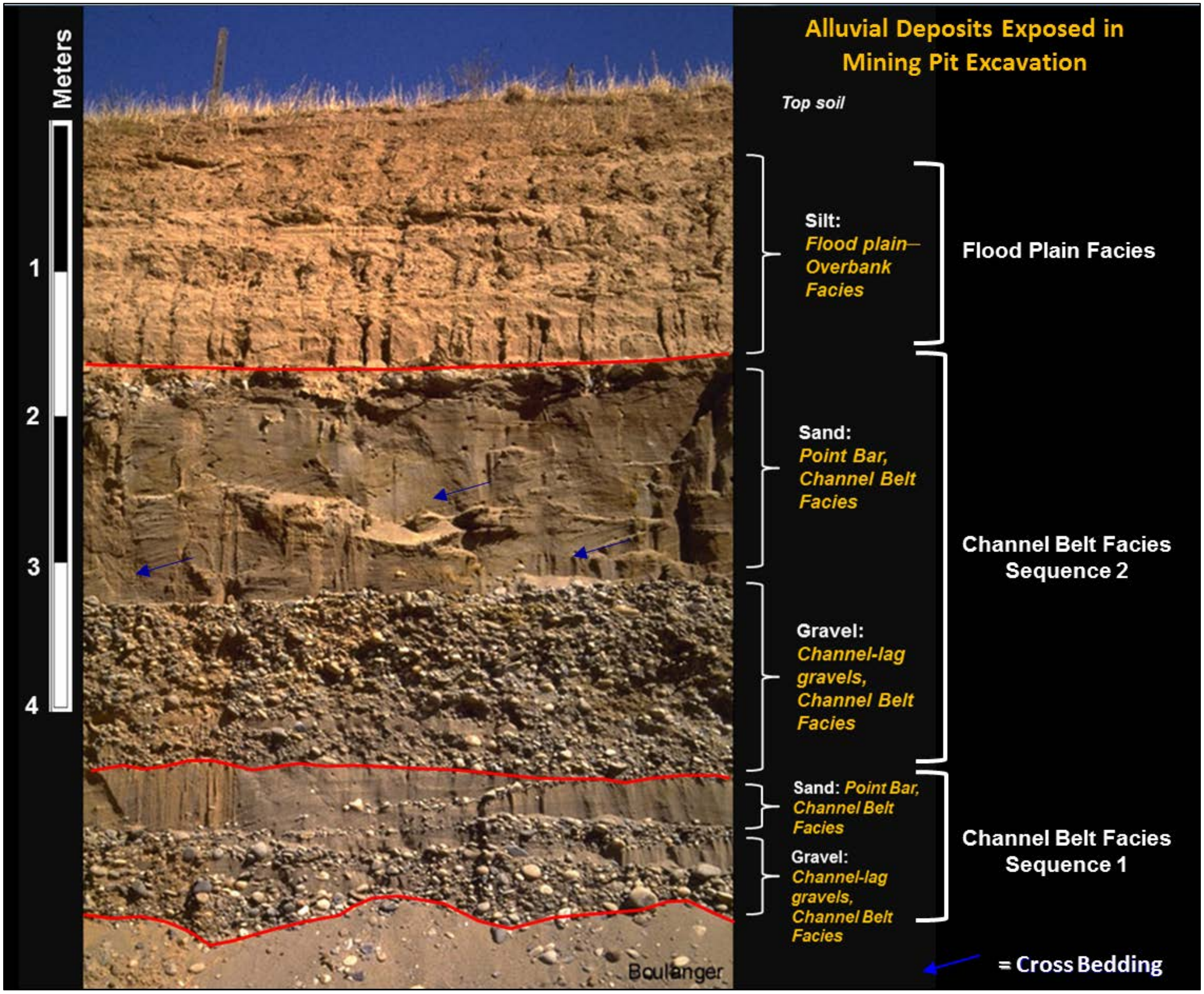


Figure 3-43. Electrical resistivity profile of buried stream channel belt & floodplain deposits in the shallow subsurface (figure credit: JR Associates Civil Engineers – www.greatgeophysics.com/fielde).



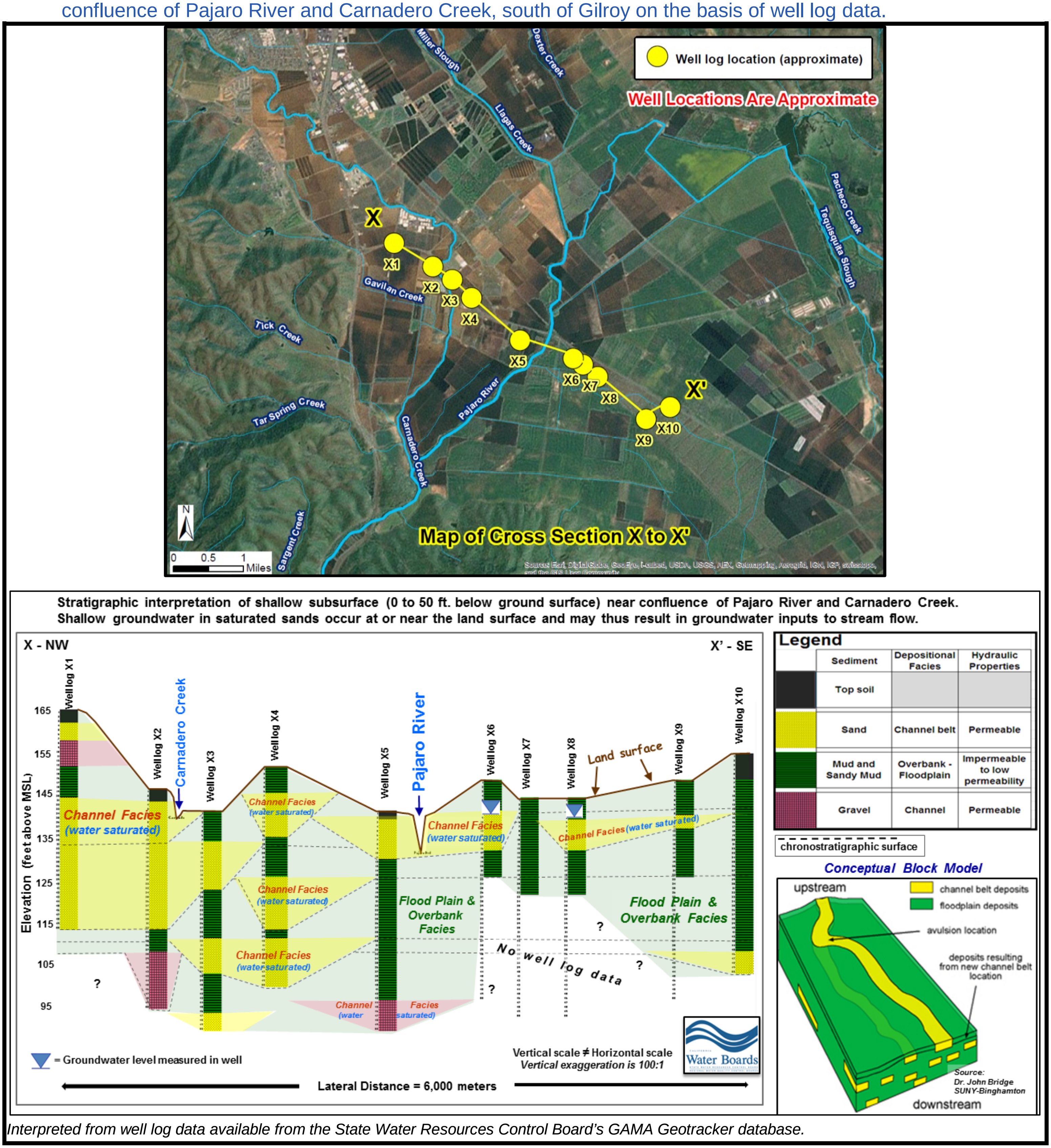
In valley floor areas characterized by low-permeability surficial soils and sediments, it might be assumed that conditions are not present favoring lateral groundwater flows in the shallowmost subsurface (e.g., less than five meters depth below ground surface). However, due to the lateral and vertical heterogeneity of fluvial depositional systems, low-permeability surficial clays and silts can locally be underlain by high-permeability river gravels and sands present in the shallow subsurface (see Figure 3-44), which potentially promote shallow, lateral groundwater flow, perched groundwater horizons, and hydraulic communication with nearby streams given appropriate hydrogeologic conditions.

Figure 3-44. Excavation exposing Sacramento Valley alluvial sedimentary deposits. This exposure illustrates a one to two meter thick surficial flood plain silt, underlain by high-permeability river channel sands and gravels present in the shallow subsurface (photo courtesy of Dr. Ross W. Boulanger – stratigraphic interpretation by Central Coast Water Board staff).



Indeed, Figure 3-45 illustrates that shallow, laterally-discontinuous high permeability facies (channel belt sands and gravels) locally occur at very shallow depths (five to 20 feet below ground surface) in the basin floor reaches of the southern Santa Clara Valley. These shallow, discontinuous permeable strata would be expected to be potential zones for perched groundwater horizons, and conduits for shallow groundwater flow and baseflow contributions to streams. Indeed, as shown in Figure 3-45, groundwater elevation measurements and lithofacies indicate that shallow groundwater in permeable sand bodies present in the shallow subsurface underlying valley floor areas can locally be in direct hydraulic communication with waters in the Pajaro River channel.

Figure 3-45. Map and stratigraphic interpretation of shallow subsurface (cross section X – X') near confluence of Pajaro River and Carnadero Creek, south of Gilroy on the basis of well log data.

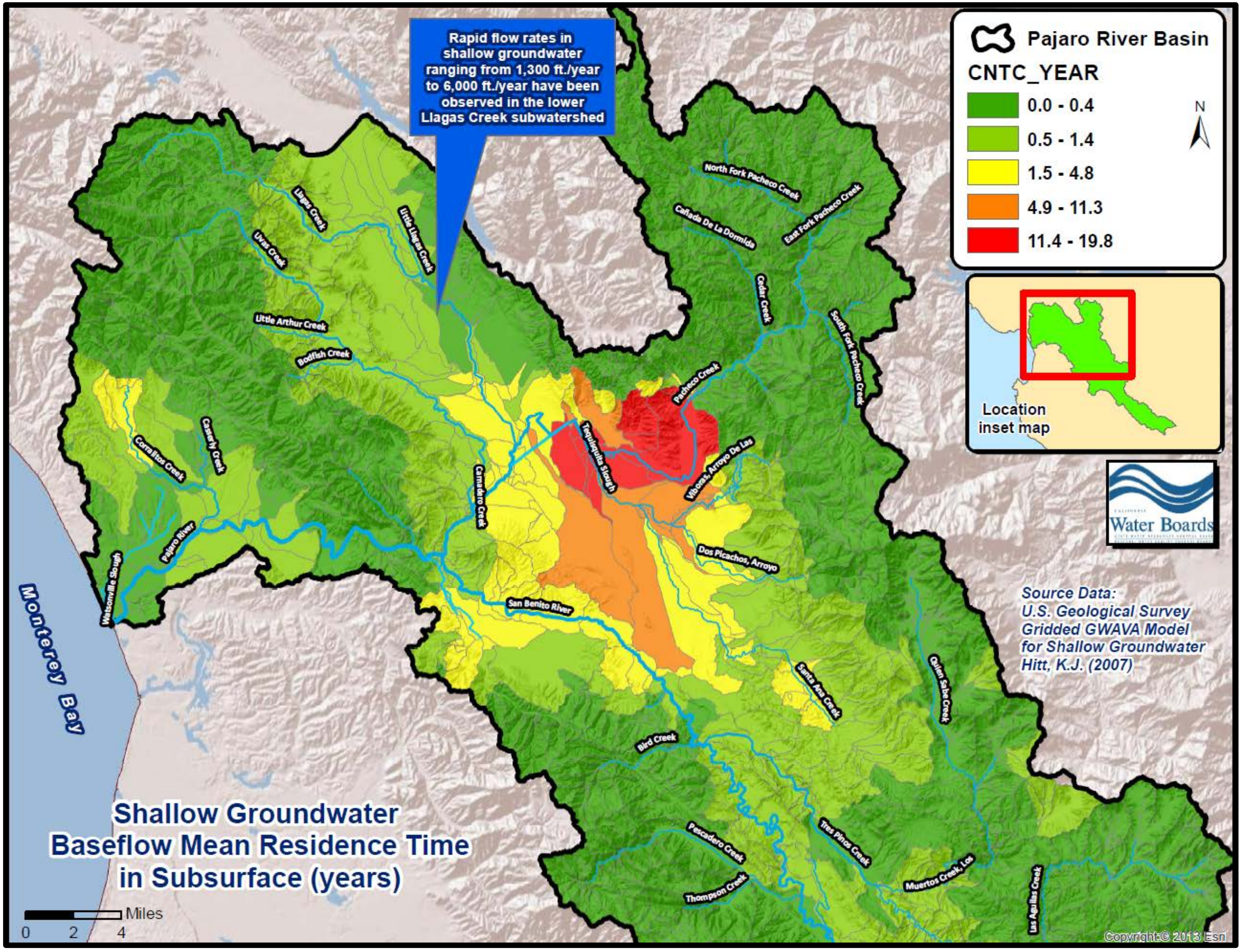


Interpreted from well log data available from the State Water Resources Control Board's GAMA Geotracker database.

➢ *Residence Time of Baseflow in the Shallow Subsurface*

Finally, it may be important to consider the possibility of existing legacy pollution of shallow groundwater, and the residence time in the subsurface before the groundwater is expressed as baseflow. Legacy pollution (associated with long-residence times in groundwater) may be unrelated to current land use practices, and could potentially be a result of land use practices that occurred many years ago. From an implementation perspective, it could be important to consider whether nitrate pollutant loads in shallow groundwater may express themselves as creek base flow relatively rapidly; or alternatively whether the subsurface residence time of baseflow is on the order of years to decades. Figure 3-46 illustrates estimated mean groundwater baseflow residence time in the subsurface[63] on the basis of NHD catchments. It should be noted that "contact time", as defined by the U.S. Geological Survey (U.S. Geological Survey) metadata for this dataset represents an "average" amount of time groundwater is in the subsurface before being expressed as stream baseflow.

Figure 3-46. Estimated baseflow mean contact time in the northern Pajaro River basin.



The U.S. Geological Survey baseflow contact time estimates suggest that nitrate pollution of shallow groundwater, and nutrient loads associated with ambient baseflow to streams in some alluvial basin floor reaches of the southernmost Santa Clara Valley (e.g., Upper Pajaro River subwatershed, Lower Pacheco Creek subwatershed, Tequisquita Slough subwatershed) may locally be partially attributable to legacy pollution. Also worth noting, in recent national study U.S. Geological Survey researchers reported

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[63] Data source: Attributes for NHDplus Catchments, Contact Time, 2002. This dataset was created by the U.S. Geological Survey and represents the average contact time, in units of days, compiled for every catchment of NHDplus for the conterminous United States. Contact time is the baseflow residence time in the subsurface.

that legacy nutrients present in shallow groundwater may sustain high nitrate levels in some streams which are characterized by substantial groundwater inputs for decades to come (Tesoiero et al. 2013).

Many other parts of the river basin, for example the Llagas Creek watershed around Gilroy, are expected to generally have relatively short baseflow contact times based on the information shown above in Figure 3-46). An independent supporting line of evidence from the Lawrence Livermore National Laboratory (2005) indicates that lateral flow in shallow groundwater around the city of Gilroy (lower Llagas Creek subwatershed) locally can be quite rapid, ranging from 1,300 to 6,000 feet per year. These rapid lateral flow rates in shallow groundwater locally in the Lower Llagas Creek subwatershed suggest consistency with the information regarding contact times presented previously in Figure 3-46. In these cases, shallow groundwater would be expected to react fairly rapidly to changes in overlying land use practices.

3.10 Geology

Geology can have a significant influence on natural, background concentrations of nutrients and other inorganic constituents in stream waters. The linkage between geologic conditions and stream water chemistry has long been recognized (for example, U.S. Geological Survey, 1910 and U.S. Geological Survey, 1985). Stein and Kyonga-Yoon (2007) reported that catchment geology was the most influential environmental factor on water quality variability from undeveloped stream reaches in lightly-disturbed, natural areas located in Ventura, Los Angeles, and Orange counties, California. Stein and Kyonga-Yoon (2007) concluded that catchments underlain by sedimentary rock had higher stream flow concentrations of metals, nutrients, and total suspended solids, as compared to areas underlain by igneous rock.

Additionally, the Utah Geological Survey hypothesized that organic-rich marine sedimentary rocks in the Cedar Valley of southern Utah may locally contribute to elevated nitrate observed in groundwater (Utah Geological Survey, 2001). Nitrogen found in the organic material of these rock strata are presumed by the Utah Geological Survey researchers to be capable of oxidizing to nitrate and may subsequently leach to groundwater.

Further, the Las Virgenes Municipal Water District (LVMWD, 2012) recently reported that high background levels of biostimulatory substances (nitrogen and phosphate) in the Malibu Creek Watershed appear to be associated with exposures of the Monterey/Modelo Formation. Also worth noting, Domagalski (2013) states that knowledge about natural and geologic sources of phosphorus in watersheds are important for developing nutrient management strategies.

Consequently, in evaluating the effect of anthropogenic activities on nutrient loading to streams, it is also relevant to consider the potential impact on nutrient water quality which might result from local geology.

➢ *Regional Geologic Setting*

The 1,300 square mile Pajaro River basin extends across three distinct geologic provinces[64]. To a large extent, geologic provinces in the river basin are defined by the location of the northwest-trending San Andreas Fault. Figure 3-47 illustrates geologic provinces of the Pajaro River basin, with a gamma-ray radiometric map overlay. Aerial measurements of gamma-ray flux measure natural background radioactivity in surficial geologic materials[65], and can provide insight into geologic variation. West of the San Andreas Fault, coastal areas of the lowermost Pajaro River basin, and the western margins of the San Benito River subbasin in the Gabilan Range[66], are part of the distinct Salinian Block geologic terrain which is associated with the Central Coastal geologic province (see U.S. Geological Survey, 1995a).

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[64] The convention for geologic provinces used here is based on digital data from U.S. Geological Survey, 2000 – U.S. Geological Survey's Digital Data Series DDS-60: *Geologic Provinces of the World, 2000 World Petroleum Assessment, all defined provinces.* Geologic provinces are defined on the basis of structural style, dominant lithologies, and age of the geologic strata.

[65] Low levels of naturally-occurring radioactive elements occur in all rock material. Aerial gamma-ray surveys measure the gamma-ray flux produced by the radioactive decay of the naturally occurring elements K-40, U-238, and Th-232 in the top few centimeters of rock or soil (K= potassium, U= uranium, Th= thorium).

[66] Figure 3-2 previously illustrated the location of major mountain ranges associated with the Pajaro River Basin.

The Central Coastal geologic province is characterized by a prevailing Pliocene to Oligocene stratigraphy (including the Miocene-age Monterey Formation) and a series of ranges and intermontane valleys exhibiting northwest-oriented topographic and geologic structural trends typical of this part of California: The granitic nature of basement rock of the Salinian Block is illustrated by the gamma-ray radiometric data – note that higher radiometric signatures (greater than about 18 K+Th+U gamma ray composite[67]) in surficial geologic materials of the Gabilan Range are typical of outcropping acidic to intermediate igneous rock, such as granite and granodiorite (see Figure 3-47).

East of the San Andreas Fault, most of the rest of the Pajaro River basin is associated with the Northern Coastal geologic province; this province includes the Diablo Range, the Santa Clara Valley, the San Francisco Bay Area, and the northern Coast Ranges. This geologic province is characterized by a prevailing Holocene to Pliocene stratigraphy. Furthermore, in contrast to the granitic basement rock of the Central Coastal geologic province, the basement rock of the Northern Coastal geologic province is characterized by highly deformed marine sedimentary rock of the Jurassic-Cretaceous Franciscan Complex (U.S. Geological Survey, 1995a).

Finally, the uppermost San Benito River subbasin is associated with the San Joaquin Basin geologic province. Basement rock of the western San Joaquin Basin geologic province is presumed to be Coast Range ophiolite and rocks of the Franciscan Complex (U.S. Geological Survey, 2007).

The broadly-defined geologic provinces of the Pajaro River basin can be subdivided into distinct smaller scale fault blocks. Fault blocks vary in basement rock composition, structural style, and stratigraphy, (see McLaughlin, et al, 2001). These fault block terrains are bounded by faults and fault zones such as the San Andreas Fault zone and the Calaveras Fault zone. Examples of fault blocks within the Pajaro River basin includes the Santa Cruz block (associated with the Pajaro Valley), and the New Almaden Block (which includes the Uvas and Llagas Creek watersheds). Geologic attributes of these fault blocks, such as faulting, lithology, and hydrostratigraphy can influence the nature and distribution of water resources of the Pajaro River basin.

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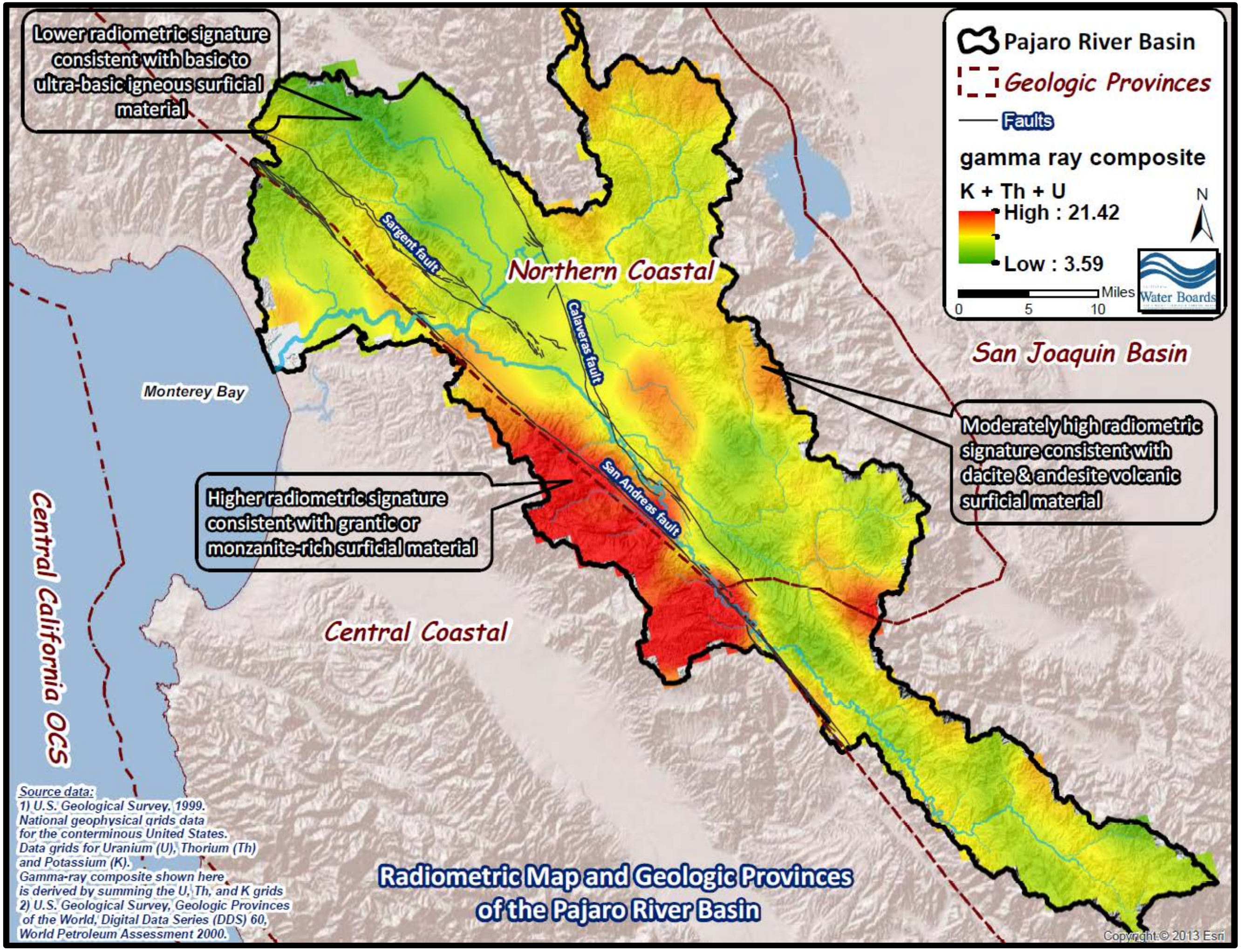
[67] See Table 1 in Ward, H.S. Undated. Gamma-Ray Spectrometry in Geological Mapping and in Uranium Exploration. Department of Geology and Geophysics, University of Utah Research Institute GL04048.

Figure 3-47. Generalized geologic provinces of the Pajaro River basin, with gamma-ray radiometric map overlay shown as color gradient illustrating some aspects of geologic variation in the river basin.



Lower radiometric signature consistent with basic to ultra-basic igneous surficial material

Higher radiometric signature consistent with grantic or monzanite-rich surficial material

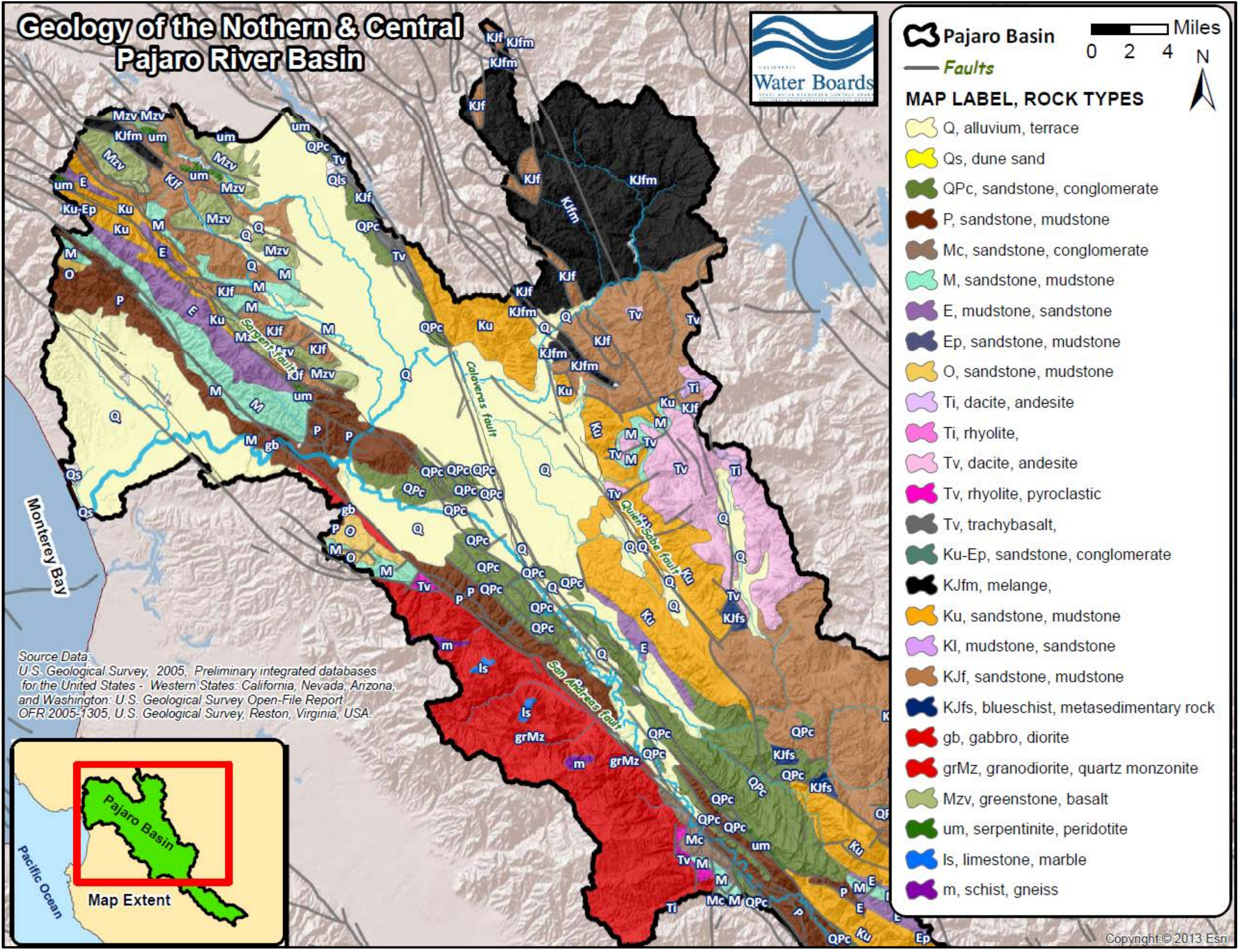
Moderately high radiometric signature consistent with dacite & andesite volcanic surficial material

Radiometric Map and Geologic Provinces of the Pajaro River Basin

Source data:
1) U.S. Geological Survey, 1999. National geophysical grids data for the conterminous United States. Data grids for Uranium (U), Thorium (Th) and Potassium (K). Gamma-ray composite shown here is derived by summing the U, Th, and K grids
2) U.S. Geological Survey, Geologic Provinces of the World, Digital Data Series (DDS) 60, World Petroleum Assessment 2000.

Figure 3-48 presents a generalized geologic map of the Pajaro River, Pacheco Creek, and lower San Benito River subbasins. Geology in the Pajaro River basin includes unconsolidated Quaternary deposits along stream reaches and valleys of lowland areas of the river basin; Tertiary and Mesozoic sedimentary rocks in many upland areas of the river basin; granodiorites and quartz monzonites in the Gabilan Range, and mafic and ultramafic rocks (basalt, greenstone, and serpentinite) in some upland reaches of the Santa Cruz Mountains (Llagas and Uvas Creek watersheds).

Figure 3-48. Generalized geologic map of the northern and central Pajaro River basin.



Source Data:
U.S. Geological Survey, 2005, Preliminary integrated databases for the United States - Western States: California, Nevada, Arizona, and Washington: U.S. Geological Survey Open-File Report OFR 2005-1305, U.S. Geological Survey, Reston, Virginia, USA.

Unit Label	Unit Age	Unit Label	Unit Age	Unit Label	Unit Age
Q	Pliocene to Holocene	Ep	Paleocene	KJf	Jurassic to Cretaceous
Qls	Quaternary	Ti	Tertiary	Mzv	Jurassic to Cretaceous
QPc	Miocene to Pleistocene	Tv	Tertiary (2.5-3.5 Ma)	um	Middle to Late Jurassic
Qs	Quaternary	Tv	Tertiary (9.5-13 Ma)	gb	Triassic to Cretaceous
P	Miocene to Pleistocene	Tv	Tertiary (22-24 Ma)	ls	Paleozoic to Mesozoic
Mc	Oligocene to Pleistocene	Ku-Ep	Late Cretaceous to Paleocene	m	Early Proterozoic to Cretaceous
M	Oligocene to Pliocene	Ku	Late Cretaceous		
O	Eocene to Miocene	grMz	Early to Late Cretaceous		
E	Paleocene to Oligocene	KJfs	Early Cretaceous		

➢ Nitrogen Geochemistry

While the aforementioned researchers (Stein and Kyonga-Yoon, 2007) indicate that catchment geology can influence “nutrient” concentrations, for clarity’s sake it should be noted that igneous and metamorphic geology are likely to only influence phosphorus concentrations. Phosphorus is a relatively common minor element in all crystalline mineral assemblages, in contrast nitrogen is not a typical minor element found in crystalline material[68]. Nitrogen-enriched minerals are rare, and are only found in nitrate minerals formed in highly-arid evaporative environments[69]. The TMDL project area of the Pajaro River basin does not contain nitrate-enriched evaporative sedimentary rocks.

From the perspective of the geosphere (i.e., geologic materials and the solid parts of the earth), soils are in fact the most concentrated and active ambient reservoir for nitrogen in the geosphere (Illinois State Water Survey website, 2011). Almost all soil nitrogen exists in organic compounds. As such, ambient background nitrogen concentrations in Pajaro River basin surface waters are more likely to be associated with the natural nitrogen cycle (e.g., soils, nitrification, and atmospheric deposition), and are not likely to be associated with watershed geology.

With regard to non-mineralogical forms of nitrogen, organic nitrogen is indeed more abundant in sedimentary rocks than in igneous or metamorphic rocks. Nitrogen in sedimentary rocks is generally associated with organic matter, which is commonly deposited with sedimentary strata, mostly marine shales or mudstones (University of California-Davis, 2012, Utah Geological Survey, 2001). Some organic-rich marine mudstones can contain 600 ppm nitrogen on average (U.S. Geological Survey, 1985). Note that in contrast, organic compounds are only an infrequent and trace component in most igneous or metamorphic rocks, as these rocks are originally created at depth quite apart from the biosphere and surficial organic matter. It is worth noting that some parts of the Santa Cruz Mountains and Leeward Hills regions of the Pajaro River basin contain significant amounts of marine mudstones, or Monterey Formation outcroppings (see Figure 3-49). These types of geologic materials conceivably might have elevated amounts of organic matter containing some nitrogen compounds, and thus could locally be a source of nitrogen to water resources of the river basin.

While organic-rich geologic materials can be a minor source of nitrogen to water resources, it should be recognized that although nitrogen can originate from geologic sources and other natural processes, elevated nitrogen concentrations present in streams, lakes, and groundwaters at concentrations exceeding drinking water standards (10 mg/L) are primarily due to anthropogenic (human) activities (State Water Board, 2013).

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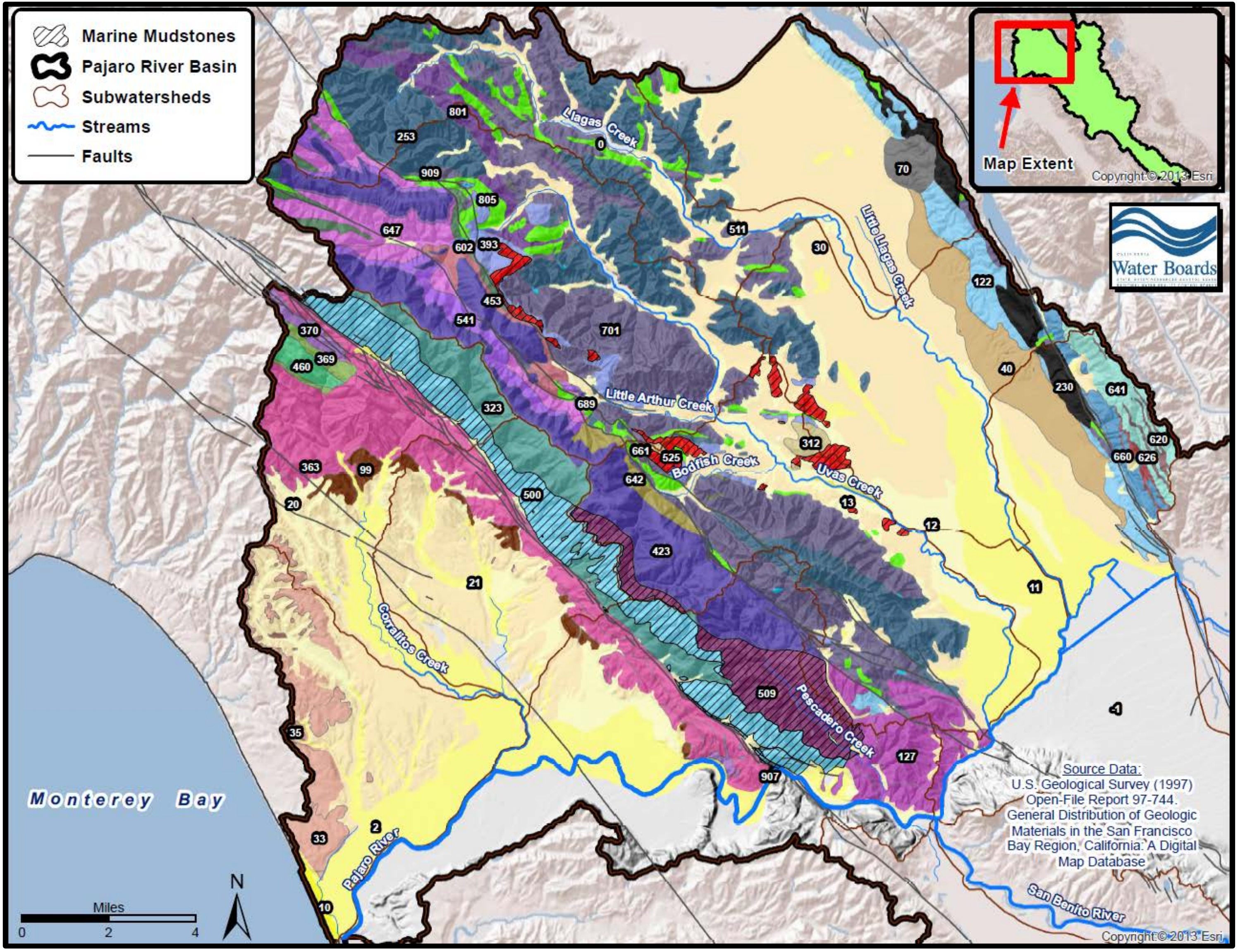
[68] See: U.S. Geological Survey, 1985, *Study and Interpretation of the Chemical Characteristics of Natural Water.* USGS Water-Supply Paper 2254.

[69] For example, the unique, nitrate-rich mineral deposits in the Atacama Desert of northern Chile (see: U.S. Geological Survey, 1981. Professional Paper 1188, *Geology and Origin of the Chilean Nitrate Deposits*)

Figure 3-49. Detailed map of geologic units and geologic materials (with associated numeric identifiers) in the Santa Cruz County and Santa Clara Valley portions of the Pajaro River basin. Line-hatched units indicate marine mudstones or other rock units which conceivably might have elevated amounts of organic matter containing nitrogen compounds. A legend for the geologic units and geologic materials and their associated numeric identifiers shown on this map is presented in Figure 3-50.



Source Data:
U.S. Geological Survey (1997)
Open-File Report 97-744.
General Distribution of Geologic
Materials in the San Francisco
Bay Region, California: A Digital
Map Database

Figure 3-50. Legend for the geologic map shown previously in Figure 3-49.

— Faults

Geologic Unit

🟨 2, fine-grained Holocene alluvium (Qhaf)
🟨 10, Holocene beach and dune sand
🟨 11, medium-grained Holocene alluvium (Qham)
🟨 12, coarse-grained Holocene alluvium (Qhac)
🟨 13, Holocene stream-channel deposits (Qhsc)
🟨 20, undiv. unmapped Quaternary deposits incl. colluvium between surficial deposits and hillside materials and mapped colluvium
🟨 21, undiv. mapped Quaternary deposits: alluvium terrace deposits Millerton Fm undivided Quaternary and some bedrock islands
🟨 30, late Pleistocene alluvium (Qpa)
🟧 33, eolian deposits of Sunset Beach and of Manresa Beach and eolian lithofacies of Aromas Sand
🟫 35, Pleistocene marine terrace deposits (Qpmt)
🟫 40, Early Pleistocene alluvium (Qpea)
⬛ 70, landslide deposit
🟫 99, undiv. nonmarine sand and silt
🟦 122, sedimentary rocks
🟪 127, Purisima Fm and siltstone and sandstone equiv. to Purisima Fm (Allen 1946)
⬛ 230, basalt
🟦 253, greenstone of Franciscan assemblage and quartz keratophyre
🟨 312, sandstone
🟩 323, Lompico Sandstone Butano Sandstone Zayante Sandstone and sandstone of Mt madonna area
🟥 363, unnamed sandstone and Purisima Fm
🟩 369, Vaqueros Sandstone Butano Sandstone and Locatelli Fm
🟪 370, Butano Sandstone
🟦 393, Temblor(?) Sandstone
🟦 423, sandstone
🟥 453, unnamed sedimentary unit
🟩 460, Lobitos Mudstone Mbr of Purisima Fm Lambert Sh San Lorenzo Fm Rices Mudstone Mbr of San Lorenzo Fm and mdst of Mayamus Flat
🟦 500, Pomponio Mudstone Member of Purisima Fm Monterey Group Santa Cruz Mudstone Lambert Shale and shale of Mt Pajaro area
🟪 509, shale and sandstone
🟩 511, chert and metachert of Franciscan assemblage
🟥 525, Monterey Group
🟪 541, mudstone
🟩 602, conglomerate unit of Great Valley sequence
🟫 620, mapped sandstone in unnamed unit
🟥 626, sandstone unit of Great Valley sequence
🟩 641, shale and sandstone in unnamed unit
🟨 642, shale and sandstone
🟪 647, sandstone and shale unit of Great Valley sequence and sandstone of Nibbs Knob area
🟦 660, shale unit of Great Valley sequence
🟪 661, shale unit of Great Valley sequence
🟧 689, shale unit including Knoxville Fm of Crittenden (1951)
🟪 701, sandstone and shale of Franciscan assemblage
🟥 800, severely sheared rocks of Franciscan assemblage
🟪 801, melange of largely clastic rocks of Franciscan assemblage
🟩 805, sheared serpentinite
🟦 909, limestone of Franciscan assemblage including Calera Limestone of Lawson (1902)

Another geologic attribute of the Pajaro River basin that one might consider as a background source of nitrogen are natural oil seeps. Crude oils are complex mixtures of hydrocarbons containing minor amounts of sulfur and nitrogen as well as other elements. Natural oil seeps are not generally identified as a source of background nitrogen in U.S. Environmental Protection Agency-approved nitrogen TMDLS. However, some scientific researchers and organizations have noted that oil seeps can be a source of water degradation at localized scales[70] – therefore as a matter of due diligence, staff evaluated possible nitrogen contributions from natural oil seeps in the Pajaro Basin.

In general, California natural crude oils reportedly have relatively high nitrogen content relative to crude oils from other petroleum-producing areas of the United States (Smith, 1968). Historical published

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[70] See: U.S. Geological Survey, Pacific Coastal & Marine Science Center webpage "The Effects of Seeps on the Environment" http://walrus.wr.usgs.gov/seeps/environment.html or see *Environmental Science: A Global Concern 6th ed.* 2001. William P. Cunningham and Barbara Woodworth Saigo. Summary outline as accessed Jan. 2014 at: http://zoology.muohio.edu/oris/cunn06/

chemical analyses from central coast oil fields in Ventura and Santa Barbara counties indicate the nitrogen content of these crude oils range from 1.25 to 1.7 percent composition (Rogers, 1919).

Oil production in the Pajaro River basin historically has been limited in scope; as the river basin is not a major oil producing province. Almost all historical commercial oil production in the river basin is limited to the petroleum reservoirs of the Sargent Oil Field located around Tar Spring Creek in southwestern Santa Clara County. Natural surface oils seeps are known to be associated with this oil field[71]. Figure 3-51 illustrates the locations of reported natural oil seeps in the vicinity of the Sargent Oil Field; these seeps are located along Tar Spring Creek which is located in the Lower Uvas Creek subwatershed (refer back to map of subwatersheds previously presented in Figure 3-4). In addition, photo documentation of a natural oil seep along Tar Spring Creek is presented in Figure 3-52.

Published field reconnaissance report that some of these oil seeps actively discharge, while other seeps are inactive (California Dept. of Conservation−Division of Oil and Gas, 1987). The maximum reported seep discharge along Tar Springs Creek was reported to discharge between zero to two gallons per day (California Dept. of Conservation−Division of Oil and Gas, 1987). As of 2002, Fedasko and Carnahan (2002) reported that oil and gas still seep from these areas and minor amounts reach Tar Creek, quantified as “less than one barrel a day” seeping into Tar Creek according to the Fedasko and Carnahan, (2002) report.

Also worth noting, a geochemical study (Magoon et a., 2002) of Sargent Field oil samples indicated these are high density oils (12.6 to 24.3 API gravity), and thus these oils seeps locally would thus be expected to be relatively high in nitrogen content, perhaps 1.5 to over 2 weight percent nitrogen[72], consistent with other California crude oils.

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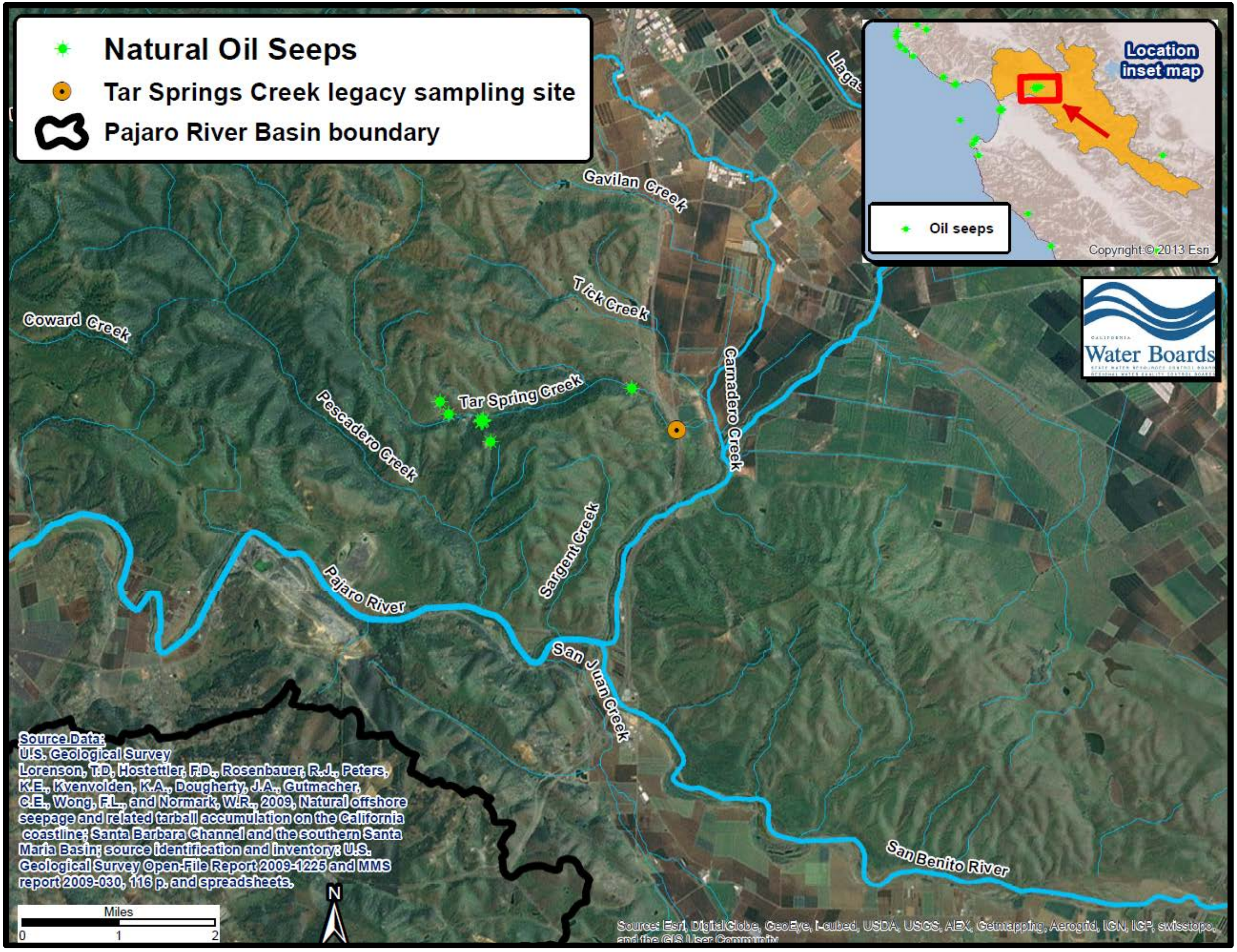
[71] Northern Coastal Province (007), by Richard Stanley in National Oil and Gas Assessment, 1995. Online linkage: http://certmapper.cr.usgs.gov/noga/broker1995.jsp?theProvince=07&thePage=basin&theServlet=NogaMainResultsServ

[72] *“Heavy oil differ from light oils by their high viscosity (resistance to flow) at reservoir temperatures, high density (low API gravity), and significant contents of nitrogen, oxygen, and sulfur compounds and heavy-metal contaminants.”* Source wikipedia: http://en.wikipedia.org/wiki/Heavy_crude_oil. Emphasis added.

Figure 3-51. Location of reported natural oil seeps in the Pajaro River basin (Tar Springs Creek catchment) and location of legacy (1969-70) Tar Springs Creek water quality sampling site.



Source Data:
U.S. Geological Survey
Lorenson, T.D, Hostettler, F.D., Rosenbauer, R.J., Peters, K.E., Kvenvolden, K.A., Dougherty, J.A., Gutmacher, C.E., Wong, F.L., and Normark, W.R., 2009, Natural offshore seepage and related tarball accumulation on the California coastline; Santa Barbara Channel and the southern Santa Maria Basin; source identification and inventory: U.S. Geological Survey Open-File Report 2009-1225 and MMS report 2009-030, 116 p. and spreadsheets.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Based on available data, it is possible to calculate a plausible estimate of the total mass of nitrogen discharged to land from reported natural oil seeps in this part of the Pajaro Basin. It should be emphasized that these estimates should be considered maximum values ("worst case" scenario), based on a maximum observed seep discharge of 2 gallons per day. As noted previously some of these oil seeps are inactive and in fact are not discharging to land and thus have a discharge rate of zero.

Table 3-30 presents plausible estimates for the maximum amount of nitrogen discharged to land in the Tar Springs Creek catchment from these natural oils seeps. Accordingly, staff estimates that a maximum of approximately 3.7 pounds nitrogen per day are discharged to land from reported natural oil seeps in the northern Pajaro River basin.

Figure 3-52. Photo documentation of a natural oil seep along Tar Spring Creek, June 2000 (photo source: California Dept. of Conservation, Division of Oil. Gas, and Geothermal Resources, 2002).

Table 3-30. Estimated maximum amount of nitrogen discharged to land from natural oils seeps in Pajaro River basin

Ave. specific gravity of central coast crude oil (kg/m^3)[A]	Ave. mass of one gallon of central coast crude oil (pounds)	Maximum seep discharge rate (gallons/day)[B]	Total number of identified seeps[C]	Maximum total mass of crude oil dishcarged[D] (pounds/day)	Average nitrogen content of crude oil (weight percent)[E]	Approximate total pounds of nitrogen discharged
943	**15.7**	**2**	**8**	(15.7 x 2) 8 = **251**	**1.48%**	**3.7 lbs/day** ***or*** **1,351 lbs./year**

[A] Data source: Rogers, 1919

[B] Data source: California Dept. of Conservation−Division of Oil and Gas, 1987

[C] Data source: Spatial data, see Figure 3-51. Note that some oil seeps spatially plot on top of one another at this geographic scale.

[D] On the basis of an estimated (2X8)= 16 gallons of oil discharge per day. This esimtate comports resonably well with Fedasko and Carnahan, (2002) whom estimated that "less than 1 barrel a day" oil from seeps discharge to Tar Springs Creek.

[E] Data source: Rogers, 1919

Even assuming all of this land-discharged oil seep nitrogen is transported to a surface waterbody, this represents a miniscule fraction of nitrogen loading to the Pajaro River and its tributaries. Based on the aforementioned information it is implausible that natural oil seeps in the Pajaro River basin are a significant or noteworthy contributing factor to the exceedances of nitrogen water quality objectives found in surface waters of the Pajaro River basin. It should be noted however, that the Tar Springs Creek area reportedly includes outcroppings of tar sands (California Dept. of Mines and Geology, 1980), which presumably could contain nitrogen-rich hydrocarbons. The extent to which tar sands influences localized nitrogen surface water quality is unknown. Two nitrate water quality samples were collected from Tar Spring Creek at Highway 101 in 1969 and 1970 (see Figure 3-51 for sampling site location). The nitrate concentrations of these two samples were 0.97 mg/L and 2.71 mg/L, for an average nitrate concentration of 1.84 mg/L. This site does not appear to be influenced by upstream agriculture, residential, or developed land uses, and the observed nitrate concentrations were marginally elevated or at the high-end of nitrate concentrations one generally expects in lightly-impacted or undeveloped California central coast upland ecosystems. Obviously, two 1969-70 vintage nitrate water quality samples from Tar Spring Creek are completely inadequate to draw sweeping inferences from; however staff *hypothesizes* that these marginally elevated legacy nitrate water quality concentrations observed could possibly have resulted from localized stream contributions of nitrogen-bearing hydrocarbons from local oil seeps; from tar sands; from cattle manure sources[73]; or from a combination of the aforementioned.

➢ *Phosphorus Geochemistry*

Rocks and natural phosphatic deposits are the main natural reservoirs of phosphorus inputs to aquatic systems (USEPA, 1999). In contrast to geologic nitrogen, geologic phosphorus is largely concentrated in mineral material rather than in the organic matter of the rock matrix (see Table 5 of U.S. Geological Survey, 1995b). The potential for these natural phosphorus inputs may be assessed using digital data for California geology and rock geochemistry available from the U.S. Geological Survey's Mineral Resources On-line Spatial Data webpage and National Geochemical Database (http://mrdata.U.S. Geological Survey.gov/).

Phosphorus-prone Miocene Marine Sedimentary Rocks in California

Staff of the Central Coast Water Board previously reviewed geological data and concluded that in the California Central Coast region, Miocene-age marine sedimentary rocks could locally be an important natural source of elevated phosphorus yields to streams (Central Coast Regional Water Quality Control Board, 2012 and 2013). Also noteworthy, a U.S. Geological Survey researcher recently reached the same conclusion regarding the nexus between stream phosphorus water quality and California Miocene sedimentary rocks (Domagalski, 2013).

In the central coast region of California, most phosphate-enriched rocks are associated with Miocene-aged marine sedimentary rocks; primarily Miocene phosphatic mudstones and shales (U.S. Geological Survey, 2002). Phosphatic facies have been reported in the literature to exist in the Miocene-age Monterey and Santa Margarita formations (U.S. Geological Survey, 2002a); both of these formations are located in California's central coast region. These unusual phosphatic deposits were formed in marine basins under special paleo-oceanic and tectonic conditions that existed along the western North American continental margin during the middle Miocene Epoch, approximately 10.8 to 15.5 million years ago (Hoppie and Garrison, 2001; White, undated power point presentation), with the majority of phosphatic deposition occurring approximately 13 to 14.8 million years ago (i.e., the Luisan to Early Mohnian stages of the Middle Miocene epoch) – see Figure 3-53. These marine phosphatic deposits were subsequently tectonically uplifted and are now exposed on land in parts of the California Coast Ranges.

It is important to recognize that phosphatic rocks are generally limited to the Middle Miocene strata (Luisian to Mohnian geologic stages) of the Monterey Formation (see Figure 3-53 for graphic illustration), and thus surface exposure of phosphatic rocks would not be expected to universally occur *everywhere* that Miocene sedimentary rocks outcrop at the land surface of the California central coast region.

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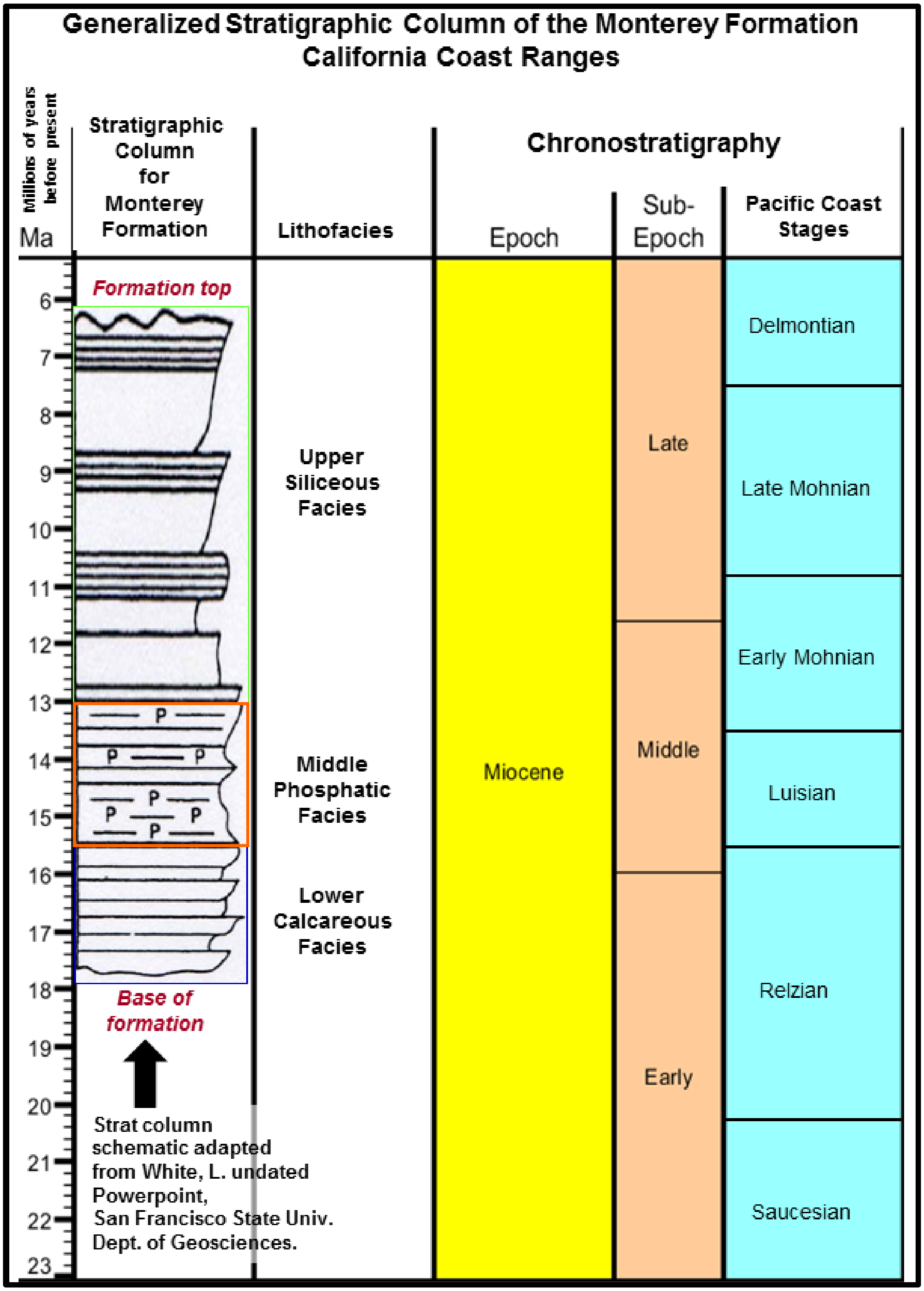
[73] Calf. Dept. of Fish and Game (CDFG) staff surveyed Tar Creek in 1978 and reported "wallowing in the streambed by cattle". Source: CDFG (1978) as reported in Center for Ecosystem Management and Restoration (2008) – Steelhead/Rainbow Trout *(Oncorhynchus mykiss)* Resources South of the Golden Gate, California.

Figure 3-53. Generalized stratigraphic column for the Monterey Formation, Calif. Central Coast ranges. Stratigraphic equivalents of the Monterey Formation occur in parts of the upland regions of the Pajaro River subbasin.



Strat column schematic adapted from White, L. undated Powerpoint, San Francisco State Univ. Dept. of Geosciences.

Figure 3-54 illustrates the distribution of Miocene-aged marine sedimentary rocks of the California central and southern coastal regions; these distributions constitute areas where there is presumably potential for phosphate-enriched mudstones and shales. Phosphorus geochemical samples (as weight percent P_2O_5) are available from the U.S. Geological Survey national geochemical database – sampling locations are illustrated on Figure 3-54.

Staff disaggregated U.S. Geological Survey rock and sediment phosphorus geochemical samples from the California central coast region into two groupings: samples collected from 1) areas containing Miocene-aged marine sedimentary rocks, and 2) areas NOT containing Miocene-aged marine sedimentary rocks. Cursory data review using histograms and quantile comparison plots in R[74] indicated that the raw phosphorus geochemical data was not normally distributed, while the log-transformed data appears to be normally distributed. Consequently, a non-parametric statistical evaluation approach was used. A two-sample Wilcoxon Test[75] of the two groupings of rock and sediment phosphorus geochemical data indicates that geologic materials in areas of Miocene marine sedimentary deposits are generally higher in phosphorus concentration (median = 0.440 P_2O_5 weight percent) than phosphorus in areas NOT containing Miocene marine sedimentary deposits (median = 0.228 P_2O_5 weight percent). In other words, the median of Miocene geologic materials are about twice as high in phosphorus (weight %) than the median of non-Miocene geologic materials.

Further, the differences in phosphorus content is highly statistically significant (P-value = 2.2e-16)[76] indicating a very small probability of observing this difference by random chance. Practically speaking, this suggests that geologic materials associated with Miocene marine deposits throughout California's central coast are generally higher in phosphorus content than geologic materials not associated with Miocene marine deposits. One uncertainty associated with these data is that the U.S. Geological Survey geochemical dataset come from many different sources, and do not necessarily represent a truly random, representative population of samples from across California or the nation – some geochemical sampling events reported in the dataset could be driven and biased by economic considerations, such as mineral prospecting or oil and gas exploration.

R statistical summaries and Wilcoxon Test outputs for the Miocene and non-Miocene rock phosphorus geochemical samples discussed above are presented in Figure 3-55.

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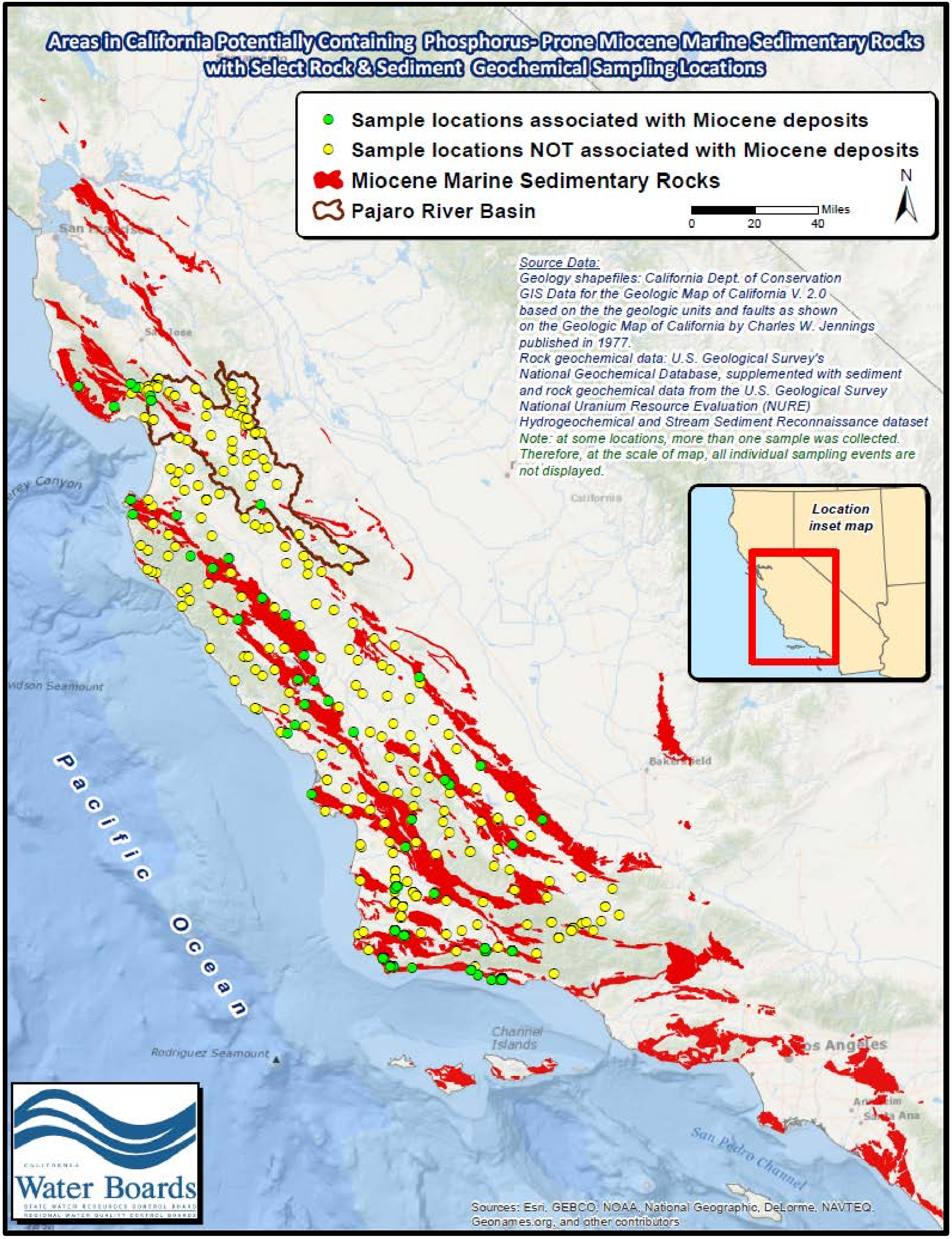
[74] R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org

[75] Also widely known as the Mann-Whitney test.

[76] By convention, P-values are considered to indicate statistical significance when the P-value < 0.05.

Figure 3-54. Map of Miocene-age marine sedimentary rocks in California, and locations of US Geological Survey phosphorus rock and sediment geochemical sampling locations.

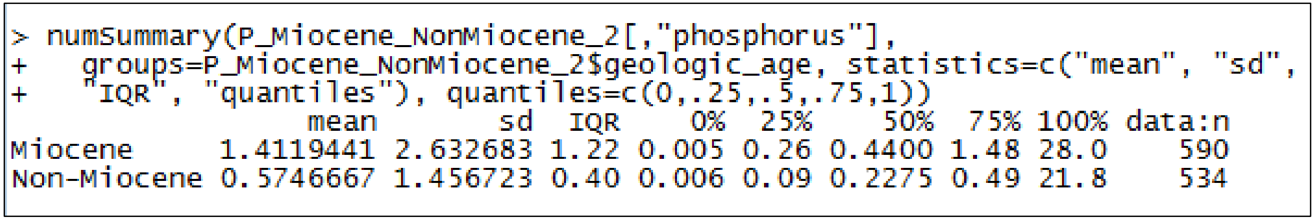


Source Data:
Geology shapefiles: California Dept. of Conservation GIS Data for the Geologic Map of California V. 2.0 based on the the geologic units and faults as shown on the Geologic Map of California by Charles W. Jennings published in 1977.
Rock geochemical data: U.S. Geological Survey's National Geochemical Database, supplemented with sediment and rock geochemical data from the U.S. Geological Survey National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance dataset
Note: at some locations, more than one sample was collected. Therefore, at the scale of map, all individual sampling events are not displayed.

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

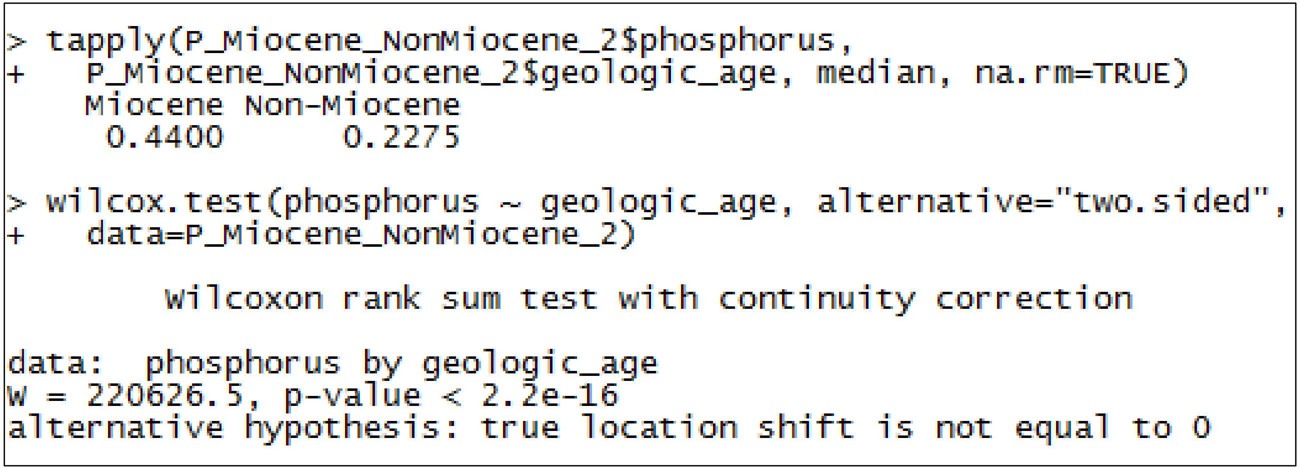
Figure 3-55. Screen prints of R outputs for Miocene and non-Miocene geologic materials samples.

R numerical summary for 1) phosphorus geochemical data in areas associated with Miocene marine deposits and 2) phosphorus geochemical data in areas not associated with Miocene marine deposits (refer to Figure 3-54 for sampling locations).



```
> numSummary(P_Miocene_NonMiocene_2[,"phosphorus"],
+   groups=P_Miocene_NonMiocene_2$geologic_age, statistics=c("mean", "sd",
+   "IQR", "quantiles"), quantiles=c(0,.25,.5,.75,1))
                 mean       sd  IQR    0%  25%    50%  75% 100% data:n
Miocene     1.4119441 2.632683 1.22 0.005 0.26 0.4400 1.48 28.0    590
Non-Miocene 0.5746667 1.456723 0.40 0.006 0.09 0.2275 0.49 21.8    534
```

R two-sample Wilcoxon test output for 1) phosphorus geochemical data in areas associated with Miocene marine deposits and 2) phosphorus geochemical data in areas not associated with Miocene marine deposits (refer to Figure 3-54 for sampling locations).



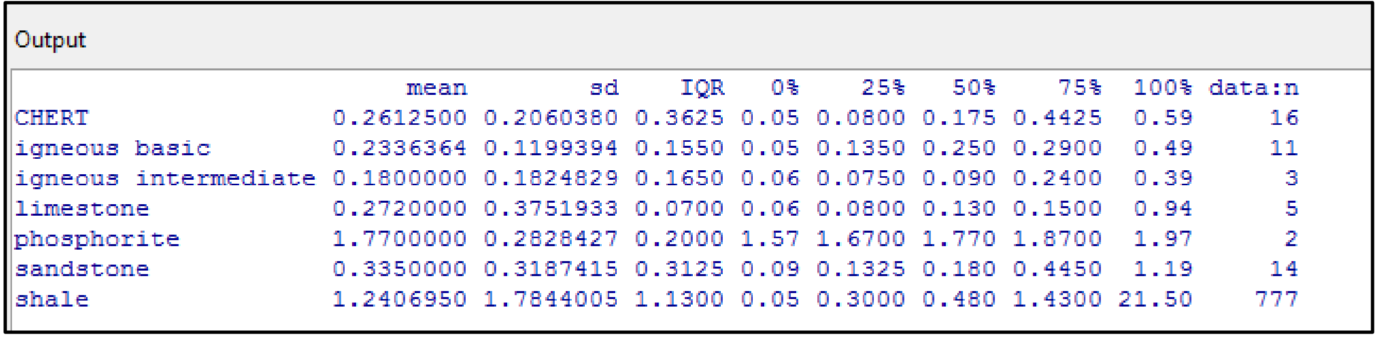
```
> tapply(P_Miocene_NonMiocene_2$phosphorus,
+   P_Miocene_NonMiocene_2$geologic_age, median, na.rm=TRUE)
    Miocene Non-Miocene
     0.4400      0.2275

> wilcox.test(phosphorus ~ geologic_age, alternative="two.sided",
+   data=P_Miocene_NonMiocene_2)

        Wilcoxon rank sum test with continuity correction

data:  phosphorus by geologic_age
W = 220626.5, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
```

With regard to the phosphorus content of various rock types, Table 3-31 and Figure 3-56 present statistical summaries of the P_2O_5 weight percent of sampled rock types in the California central coast region. Note that sedimentary rock, such as sandstone and in particular, shale tends to be elevated in phosphorus content relative to other rock types[77].

---

[77] Note that these statistical summaries report values for phosphorite, which is an unusual and rare chemical sedimentary rock containing abnormally high amounts of phosphate.

Table 3-31. R numerical summary for phosphorus content (P_2O_5 weight %) reported in rock samples collected in the California central coastal region watersheds.



Output

```
                          mean        sd    IQR   0%    25%   50%    75%  100% data:n
CHERT                0.2612500 0.2060380 0.3625 0.05 0.0800 0.175 0.4425  0.59     16
igneous basic        0.2336364 0.1199394 0.1550 0.05 0.1350 0.250 0.2900  0.49     11
igneous intermediate 0.1800000 0.1824829 0.1650 0.06 0.0750 0.090 0.2400  0.39      3
limestone            0.2720000 0.3751933 0.0700 0.06 0.0800 0.130 0.1500  0.94      5
phosphorite          1.7700000 0.2828427 0.2000 1.57 1.6700 1.770 1.8700  1.97      2
sandstone            0.3350000 0.3187415 0.3125 0.09 0.1325 0.180 0.4450  1.19     14
shale                1.2406950 1.7844005 1.1300 0.05 0.3000 0.480 1.4300 21.50    777
```

Figure 3-56. Box and whiskers plot of phosphorus content (P_2O_5 weight %) in select rock type samples in the California central coastal region watersheds (sample locations: see Figure 3-54)

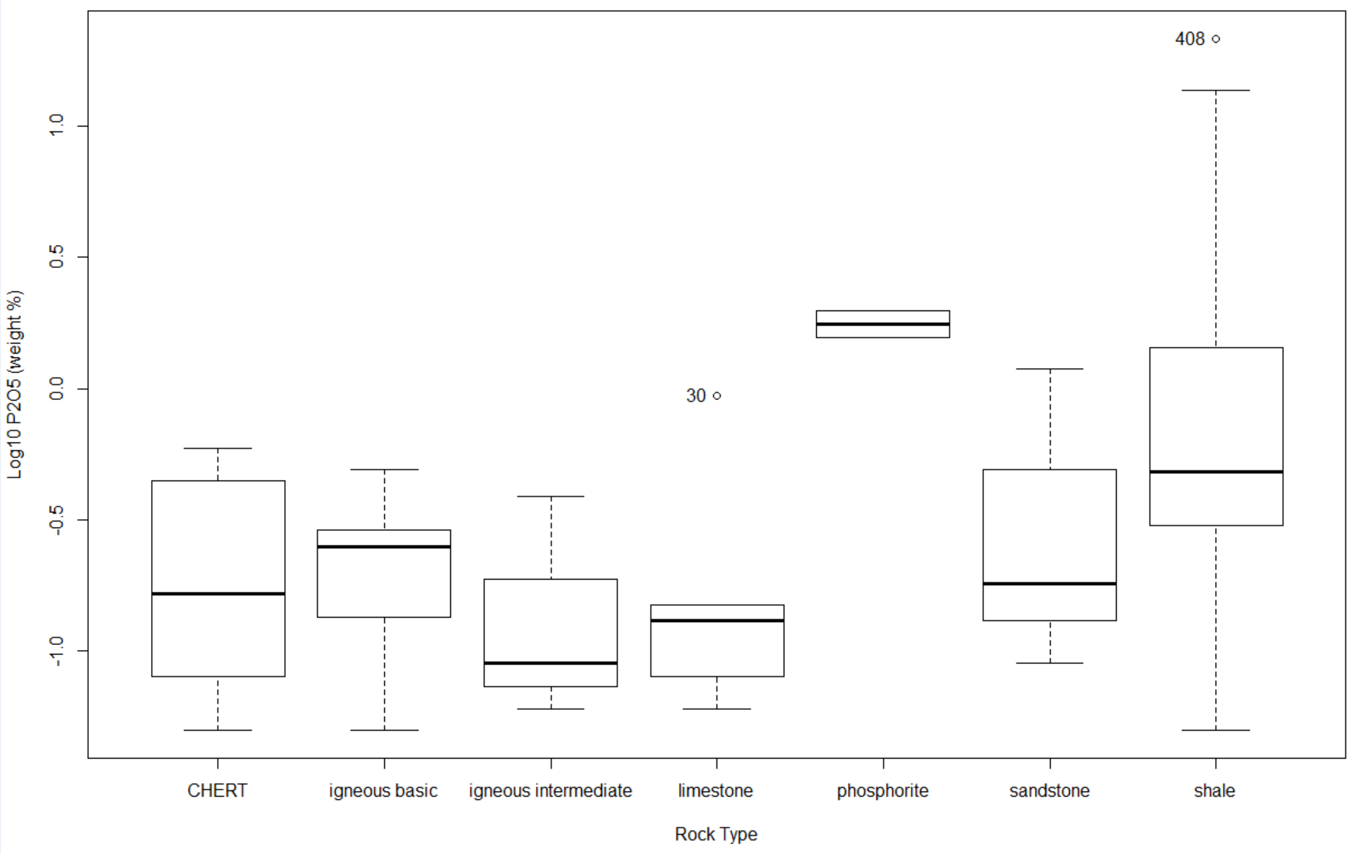
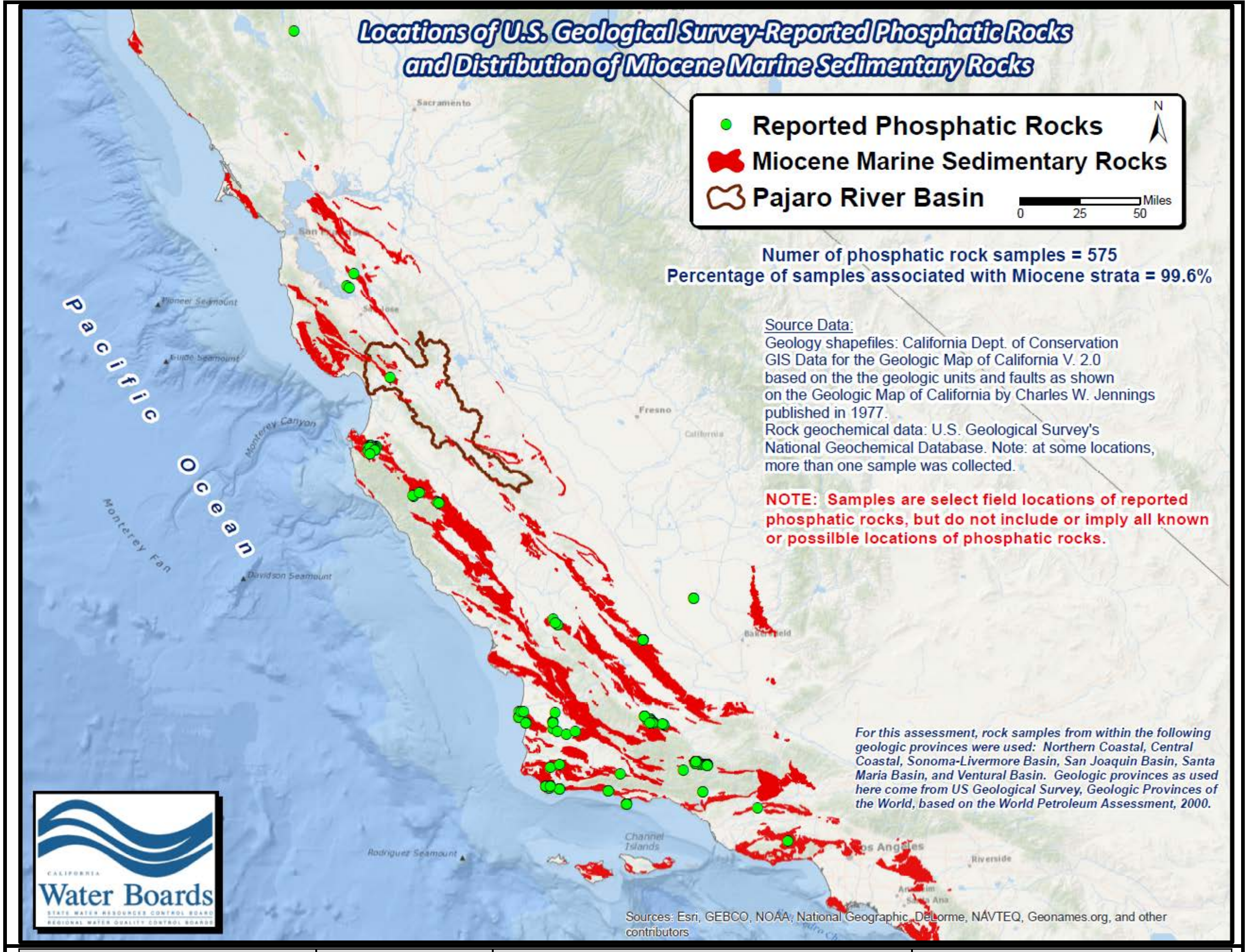


Figure 3-57 illustrates the locations of phosphatic rocks that have been sampled in the California. Noteworthy is that virtually all of these samples come from Miocene strata, as illustrated on Figure 3-57.

Figure 3-57. Map showing 1) locations of U.S. Geological Survey-reported phoshatic rocks; and 2) reported distribution of Miocene marine sedimentary rocks. Table that details findings included.



Numer of phosphatic rock samples = 575
Percentage of samples associated with Miocene strata = 99.6%

Source Data:
Geology shapefiles: California Dept. of Conservation GIS Data for the Geologic Map of California V. 2.0 based on the the geologic units and faults as shown on the Geologic Map of California by Charles W. Jennings published in 1977.
Rock geochemical data: U.S. Geological Survey's National Geochemical Database. Note: at some locations, more than one sample was collected.

NOTE: Samples are select field locations of reported phosphatic rocks, but do not include or imply all known or possilble locations of phosphatic rocks.

For this assessment, rock samples from within the following geologic provinces were used: Northern Coastal, Central Coastal, Sonoma-Livermore Basin, San Joaquin Basin, Santa Maria Basin, and Ventural Basin. Geologic provinces as used here come from US Geological Survey, Geologic Provinces of the World, based on the World Petroleum Assessment, 2000.

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

Stratigraphy/Formation	Geologic Age	Phosphatic Lithologies Present and Reported	Number of Reported Rock Geochemical Samples from the Formation
Santa Margarita Formation	Miocene	Phosphatic mudstones, phosphatic conglomerate, phosphorite, phosphatic sandstone, phosphatic siltstone,	411
Chamisal Formation	Miocene	Phosphatic sandstone	4
Monterey Group	Miocene	Phosphatic mudstone, phospatic conglomerate, phosphatic dolomite, phosphatic limestone, phosphorite, phosphatic siltstone, phosphatic sandstone	156
Great Valley Sequence	Cretaceous	Phosphatic siltstone	1
Modelo Shale	Miocene	Phosphatic pellets	1
Sisquoc Formation	Pliocene	Phospatic conglomerate	1
Temblor Formation	Miocene	Phosphatic sandstone	1

The occurrence of Miocene marine rocks in the Pajaro River basin is illustrated in Figure 3-58. It is worth nothing that Pescadero Creek (Santa Clara County)[78], a creek located in the Lower Pajaro River subwatershed, drains areas containing geologic materials characterized as Middle Miocene-age marine sediments[79] – recall that Middle Miocene strata of the California Central Coast are well known to contain abundant phosphatic rocks. Field reporting documents the presence of laminated phosphatic shales

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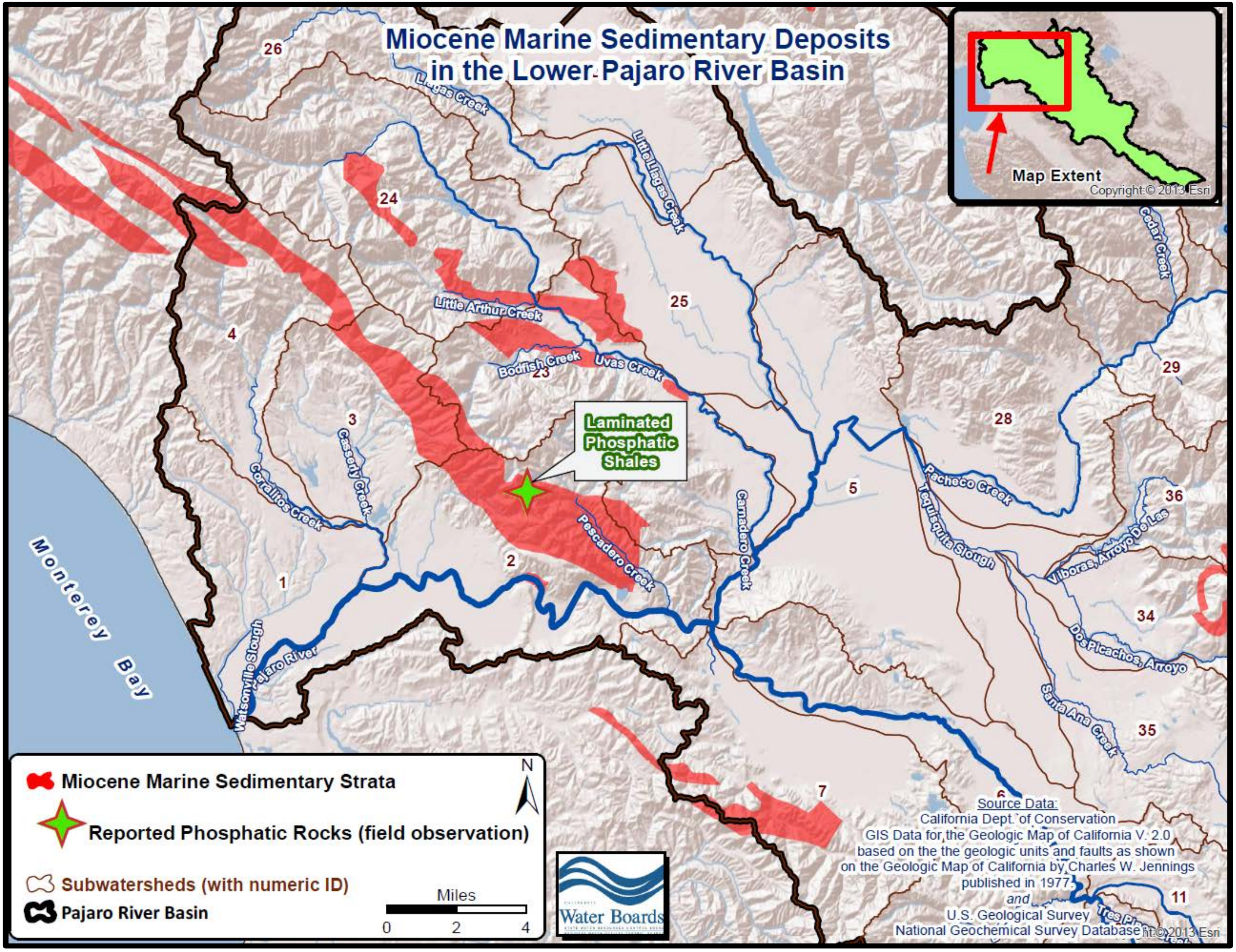
[78] Note that there is also a "Pescadero Creek" located in the San Benito County portion of the Pajaro River basin.

[79] According to the Calif. Dept. of Conservation's online geologic maps website. Online linkage: http://www.conservation.ca.gov/cgs/geologic_mapping/Pages/googlemaps.aspx#atlasseries

locally in outcropping Miocene rocks of the river basin (see Figure 3-58). Also noteworthy, the phosphate as P concentration in water samples collected from Pescadero Creek tends to be quite high, with an average of 3 mg/L. Water quality samples from other stream reaches in the Pajaro River basin are typically around 0.5 mg/L phosphate as P, or lower. It should be emphasized here that the presence of Miocene marine rocks should not be construed universally as unequivocal evidence of a natural phosphorus influence on water resources – for example phosphatic rocks are reportedly generally limited to the Middle Miocene (Luisian to Mohnian stages) strata of the Monterey Formation (refer back to Figure 3-53). Accordingly, staff merely concludes that Miocene marine rocks of California are *prone* to being relatively higher in phosphorus – but, undoubtedly that there is substantial variation in the geochemistry and lithology of California's Miocene deposits.

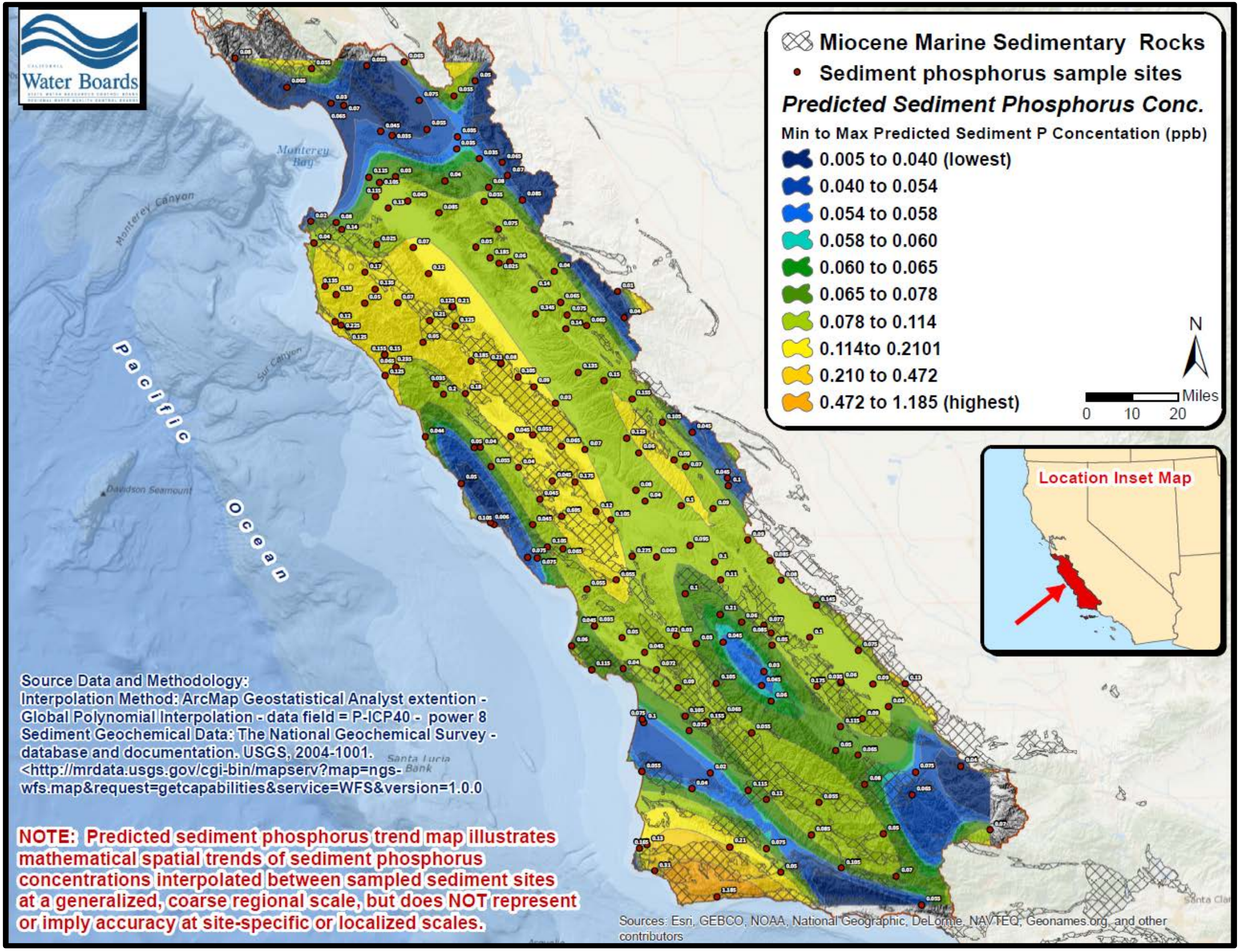
Figure 3-58. Distribution of Miocene marine strata in the northern Pajaro River basin (refer back to Table 3-3 for listing of paired subwatershed name-numeric identifiers). Field observation reporting indicates phosphatic shales have been observed locally in Miocene marine strata of the Santa Cruz Mountains.



Source Data:
California Dept. of Conservation
GIS Data for the Geologic Map of California V. 2.0
based on the the geologic units and faults as shown
on the Geologic Map of California by Charles W. Jennings
published in 1977
and
U.S. Geological Survey
National Geochemical Survey Database

Figure 3-59 presents predicted spatial trends of sediment phosphorus concentrations based on a mathematical interpolation between sampling locations. Areas of the central coast region with the highest sediment phosphorus concentrations are often geographically associated with Miocene marine deposits. It should be noted that some areas of Miocene deposits have relatively moderate or average phosphorus concentrations. In general, the map suggests that stream bed sediments high in phosphorus concentrations can often be located in drainages associated with Miocene deposits, but this in not universally true and there is evidently substantial variation and other confounding factors influencing phosphorus concentrations in sediments and stream beds. For example, in areas draining Monterey Formation deposits, phosphatic-rich lithofacies are reportedly mostly associated with Middle Miocene strata (Luisian to Early Mohnian-stage)[80]. Geographic areas containing relatively younger Monterey Formation rocks (upper Early Mohnian to Delmontian-stage Miocene strata) may not be expected to contain abundant phosphatic facies (refer back to Figure 3-53).

Figure 3-59. Map showing interpolated values of sediment phosphorus concentrations in the California central coast region. The map illustrates predicted mathematical spatial trends of sediment phosphorus concentrations interpolated at a generalized coarse regional scale between sampled sites, but does NOT represent or imply accuracy at site-specific or localized scales.



Source Data and Methodology:
Interpolation Method: ArcMap Geostatistical Analyst extention - Global Polynomial Interpolation - data field = P-ICP40 - power 8
Sediment Geochemical Data: The National Geochemical Survey - database and documentation. USGS, 2004-1001.
<http://mrdata.usgs.gov/cgi-bin/mapserv?map=ngs-wfs.map&request=getcapabilities&service=WFS&version=1.0.0

NOTE: Predicted sediment phosphorus trend map illustrates mathematical spatial trends of sediment phosphorus concentrations interpolated between sampled sediment sites at a generalized, coarse regional scale, but does NOT represent or imply accuracy at site-specific or localized scales.

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

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[80] See: *Field Guide to Diagenesis, Deformation, and Fluid Flow in the Miocene Monterey Formation: Ventura-Santa Barbara-Jalama Beach-Grefco Quary/Lompoc.* Online linkage: http://www.beg.utexas.edu/eichhubl/Pages/Roadlogtext.html

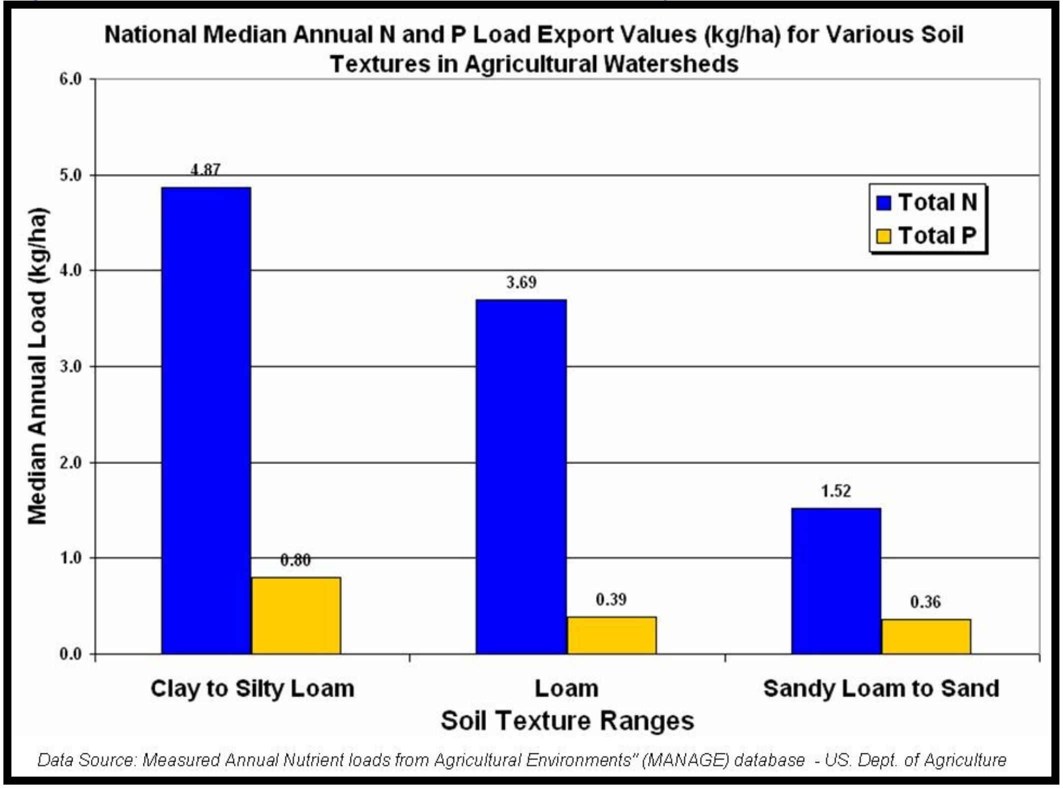
Text Box 3-5. Summary assessment of influence of geological materials in the Pajaro River basin on nutrient water quality.

In summary, geologic materials are generally not expected to cause or contribute significantly to exceedances of nutrient water quality criteria in the Pajaro River basin. However it is important to recognize that phosphorus-prone Miocene marine sedimentary rocks (associated locally with fault blocks of the Santa Cruz Mountains) may be expected to influence nutrient water quality, specifically phosphorus concentrations, locally in some stream reaches. Published water quality guidelines for phosphorus may be anticipated to be unachievable locally in some stream reaches that drain phosphatic sediments associated with Miocene marine sedimentary deposits, on the basis of high observed phosphate concentrations in Pescadero Creek.

3.11 Soils & Stream Substrates

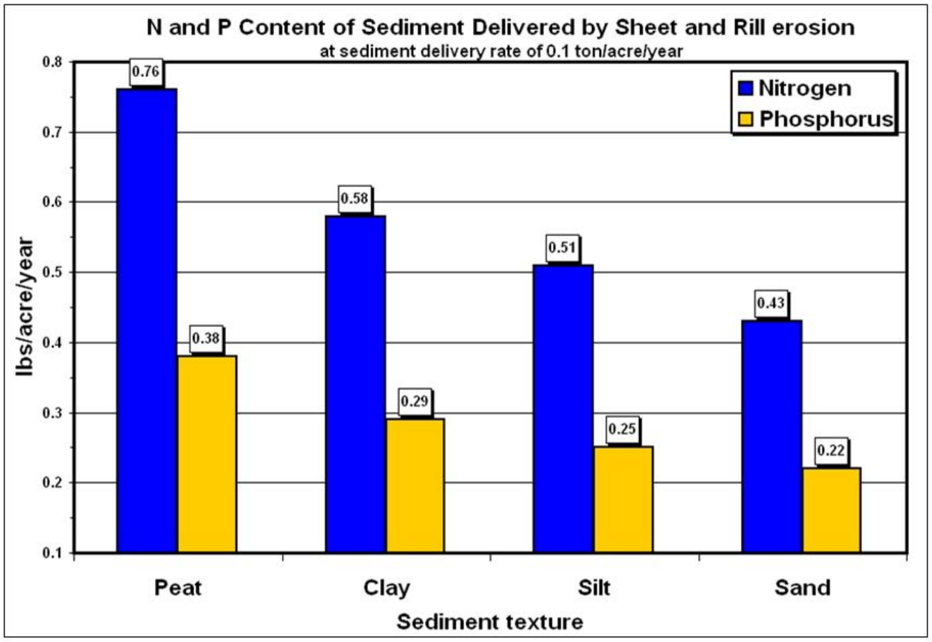
Soils have physical and hydrologic characteristics which may have a significant influence on the transport and fate of nutrients. Watershed researchers and TMDL projects often assess soil characteristics in conjunction with other physical watershed parameters to estimate the risk and magnitude of nutrient loading to waterbodies (Mitsova-Boneva and Wang, 2008; McMahon and Roessler, 2002). The relationship between nutrient export (loads) and soil texture are illustrated in Figure 3-60 and Figure 3-61. Generally, fine-textured soils with lower capacity for infiltration of precipitation/water are more prone to runoff, and are consequently typically associated with a higher risk of nutrient loads to surface waters.

Figure 3-60. Median annual Total N and Total P export for various soil textures.



Data Source: Measured Annual Nutrient loads from Agricultural Environments" (MANAGE) database - US. Dept. of Agriculture

Figure 3-61. N and P content of sediment delivered by sheet and rill erosion.



Data source: Derived from AGNPS equations in Young, R.A., C.A. Onstad, D.D. Bosch, and W.P. Anderson, 1987. AGNPS, Agricultural –Non-Point-Source Pollution Model; A Large Watershed Analysis Tool. U.S. Department of Agriculture – Agriculture Res. Serv., Conservation Resource Report 35 – and reported in *"Pollutants Controlled Calculation And Documentation For Section 319 Watersheds Training Manual, Michigan Department of Environmental Quality.*

Thus, in the development of nutrient TMDLs it can be important to evaluate ambient concentrations of nutrients in soils. Soil nutrients can be a contributing source to nutrients in stream waters. Furthermore, the spreadsheet pollutant source estimation tool used in this TMDL project requires user-inputs for soil nutrients concentrations (refer to Section 7.1).

Predictive models and data on soil nitrogen are available from the International Geosphere-Biosphere Programme Data and Information Services (IGBP-DIS)[81] – see Figure 3-62, Table 3-32 and Figure 3-63 – and also from soil nitrogen data compiled by Post and Mann (1990) – see Table 3-33 and Figure 3-64. These data can be used to infer a plausible average soil nitrogen content that could be expected in the Pajaro River basin.

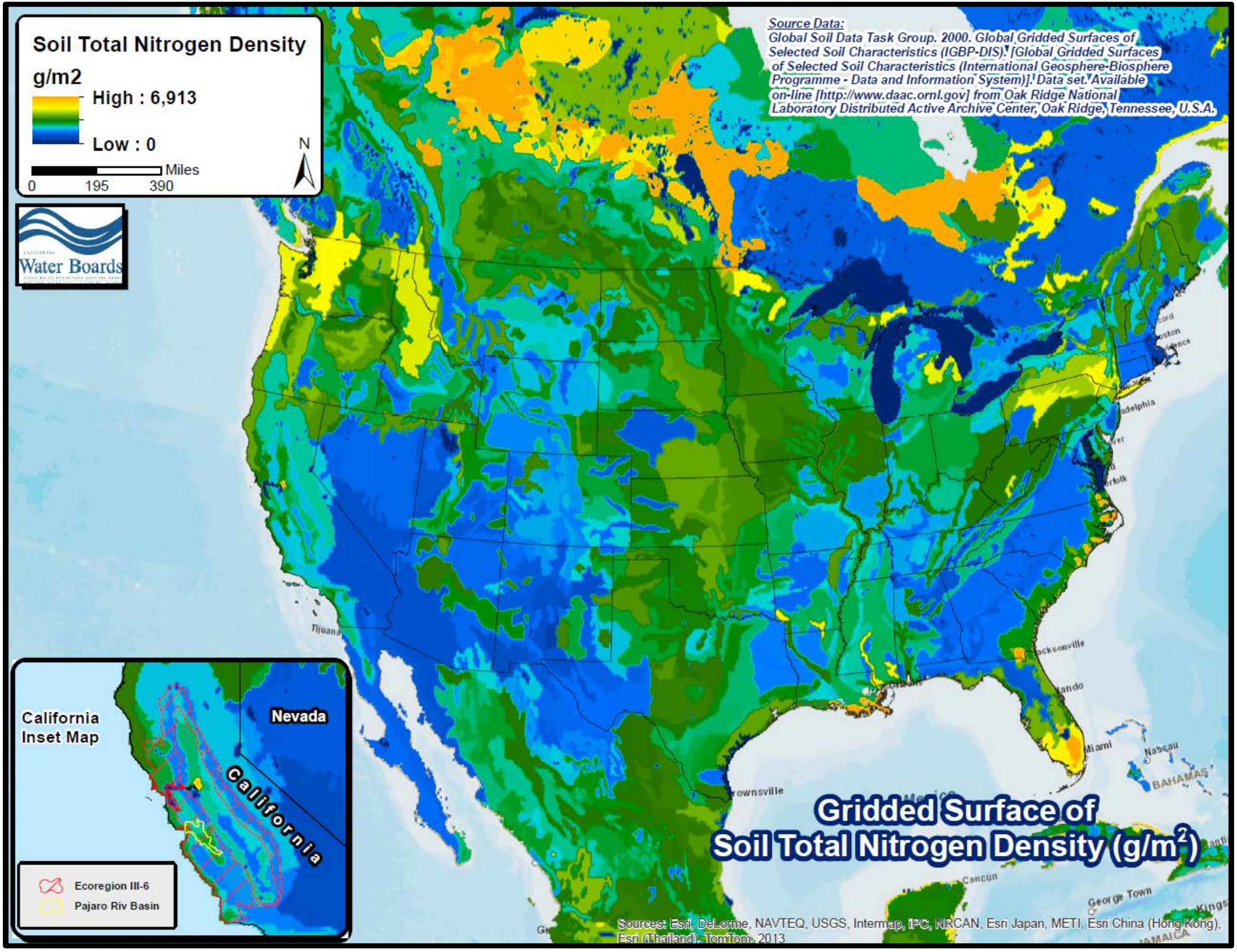
Numerical summaries and box plots of the grid cell values from the IGBP-DIS gridded surface[82] indicate that the median soil total nitrogen density (g/m^2) for the Pajaro River basin is quite similar to the median soil total nitrogen density for the conterminous United States (see Table 3-32 and Figure 3-63). It should be noted that a cursory review of quantile-comparison plots of the IGDP-DIS data indicates the gridded cell values are highly non-normally distributed, and thus the *median* (rather than the arithmetic mean) grid cell value is a better measure of the central tendency or "average" of the grid cell values for soil total nitrogen density.

---

[81] The IGBP-DIS Global Gridded Surfaces of Selected Soil Characteristics data set contains a data surfaces for total nitrogen density. The data surface was generated by the SoilData System, which was developed by the Global Soil Data Task of the IGBP-DIS. The SoilData System uses a statistical bootstrapping approach to link the pedon records in the Global Pedon Database to the Food and Agriculture Organization of the United Nations/United Nations Educational, Scientific and Cultural Organization (FAO/UNESCO) Digital Soil Map of the World. Available from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC).

[82] A gridded surface is a way of representing a surficial feature of the earth digitally. In GIS analysis, a gridded surface is stored as raster data. Raster data is a rectangular matrix of cells, represented in rows and columns. Each cell represents a defined square area on the earth's surface and holds a value that is static across the entire cell.

Figure 3-62. Gridded surface of estimated soil total nitrogen density (g/m^2),from the IGBP-DIS dataset.



Source Data: Global Soil Data Task Group. 2000. Global Gridded Surfaces of Selected Soil Characteristics (IGBP-DIS). [Global Gridded Surfaces of Selected Soil Characteristics (International Geosphere-Biosphere Programme - Data and Information System)]. Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

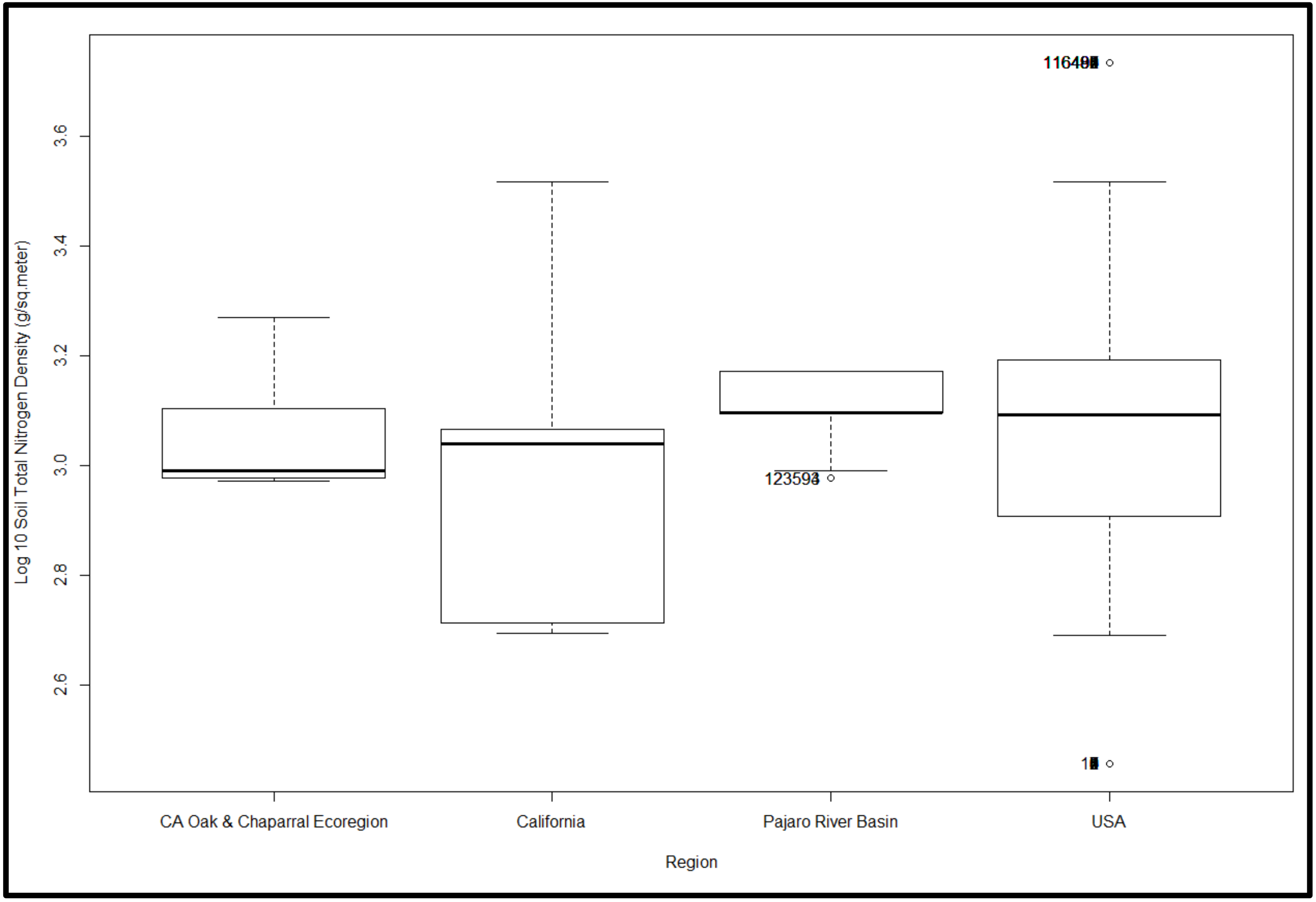
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, IPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Table 3-32. Soil total nitrogen density statistics: Grid cell value statistics from the IGBP-DIS gridded surface shown previously in Figure 3-62 clipped to various geographic regions. Units = g/m^2.

Region	Mean	Standard Deviation	Min	25th %	50th % (median)	75th %	Max	Number of Grid Cell Values
Calif. Oak & Chaparral Ecoregion [A]	1,138	223	938	947	980	1,270	1,859	1,135
California (State-wide)	1,024	403	494	516	1,097	1,163	3,284	5,948
Pajaro River basin	1,330	165	947	1,245	1,245	1,483	1,483	50
Conterminous USA	1,234	486	287	808	1,238	1,557	5,404	116,509

[A] See U.S. Environmental Protection Agency Level III and IV ecoregions of the continental United States online linage: http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm

Figure 3-63. R-generated box and whiskers plot for soil total nitrogen density (g/m^2) for select geographic regions on the basis of the IGBP-DIS dataset.



Staff used the observed soil nitrogen analytical field data (Post and Mann, 1990) in conjunction with modelled soil nitrogen grids (IGBP-DIS) to infer a plausible average soil nitrogen concentration in the Pajaro River basin. Figure 3-64 and Table 3-33 present box plots and numerical summaries of observed soil nitrogen concentration (%) on the basis of soil data reported by Post and Mann, 1990. Noteworthy, is that the median soil nitrogen concentration value for the entire dataset (i.e., the composite of all vegetation-land cover categories) is 0.068% (see Table 3-33). Also, recall as previously noted, that the median (50th percentile) soil total nitrogen density (g/m^2) in the Pajaro Basin is approximately equal to median soil total nitrogen density for the conterminous United States on the basis of IGBP-DIS gridded surface models (refer back to Table 3-32 and Figure 3-63). Thus, the median soil nitrogen concentration expected in the Pajaro River basin comports reasonably well with a median expected soil nitrogen concentration for the conterminous United States. Therefore, a plausible median soil nitrogen content on a percentage basis (%) for the Pajaro River basin can be assumed to be equal to the median soil nitrogen concentration derived from the Post and Mann (1990) data in Table 3-33, which is 0.068 % nitrogen.

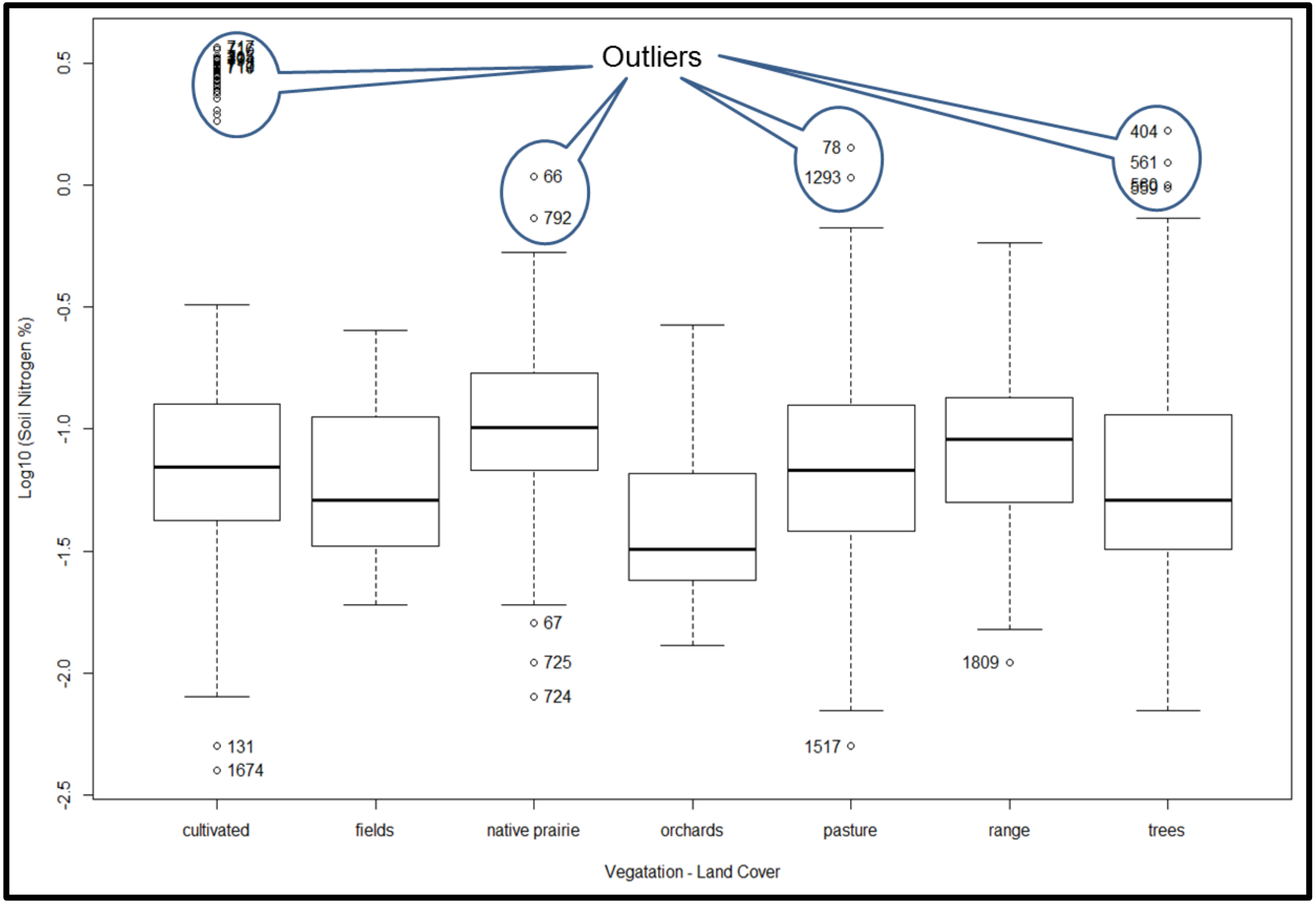
Table 3-33. Numerical summaries of United States observed soil total nitrogen (units = %) for select vegetative land cover systems on the basis of data used in Post and Mann, 1990^A.

Vegetation-Land Cover	Mean	Standard Deviation	Min	25th %	50th % (median)	75th %	Max	Number of Samples
cultivated	0.203694	0.565534	0.004	0.042	0.07	0.12675	3.67	654
fields	0.080465	0.064178	0.019	0.033	0.051	0.112	0.255	43
native prairie	0.142215	0.134856	0.008	0.068	0.101	0.1695	1.088	191
orchards	0.054706	0.061158	0.013	0.024	0.032	0.066	0.266	17

Vegetation-Land Cover	Mean	Standard Deviation	Min	25th %	50th % (median)	75th %	Max	Number of Samples
pasture	0.103363	0.126064	0.005	0.038	0.068	0.125	1.422	383
range	0.111329	0.096355	0.011	0.05025	0.0905	0.13475	0.581	82
trees	0.106121	0.155925	0.007	0.032	0.051	0.115	1.67	497
Numerical summary for composite of entire dataset	0.142525	0.355064	0.004	0.039	0.068	0.126	3.67	1869

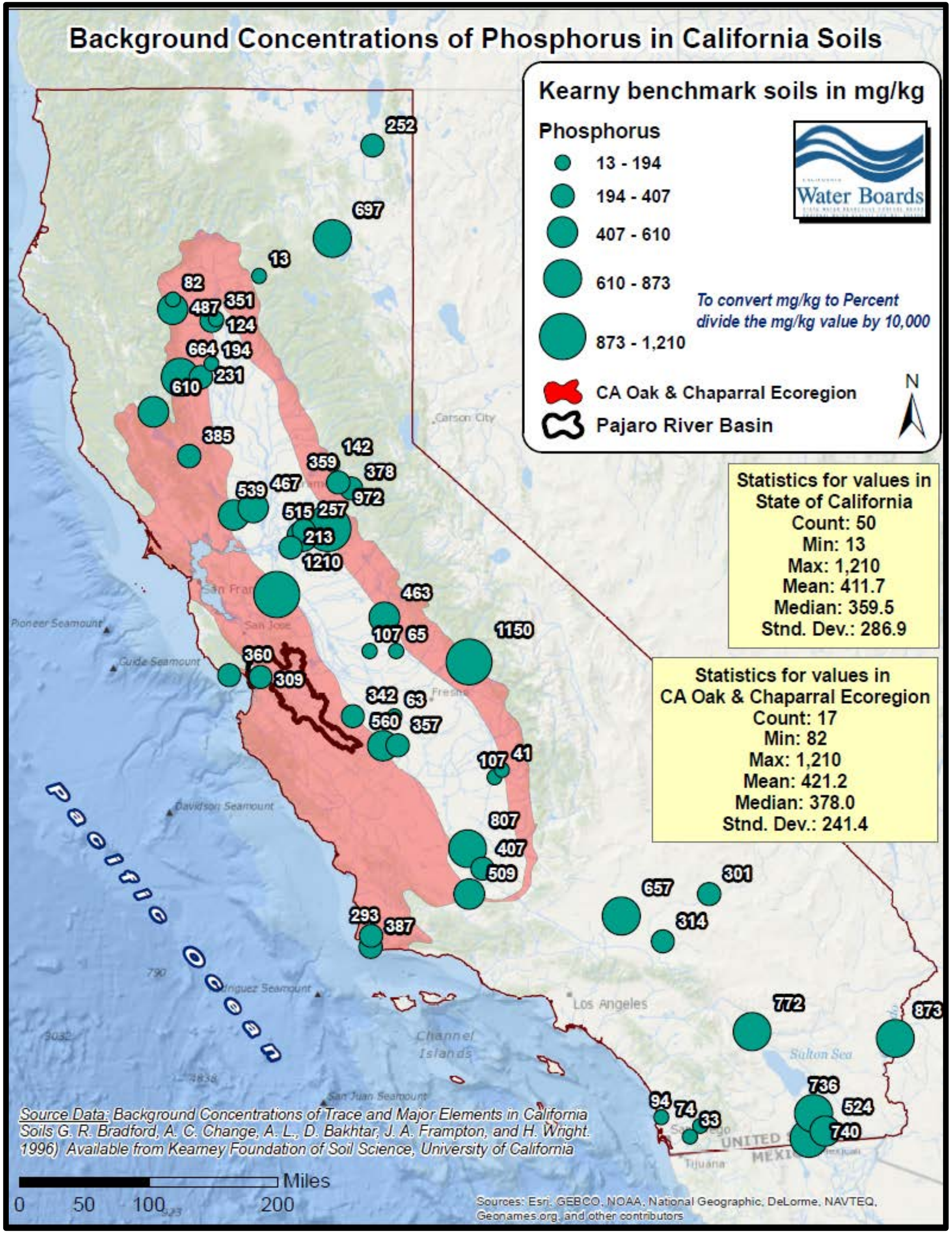
[A] Post, W.M. and L.K. Mann. 1990. *Changes in Soil Organic Carbon and Nitrogen as a Result of Cultivation*. In A.F. Bowman, editor, *Soils and the Greenhouse Effect*, John Wiley and Sons. The authors assembled and analyzed a data base of soil organic carbon and nitrogen information from a broad range of soil types from over 1100 profiles and representing major agricultural soils in the United States, using data compiled by the U.S. Dept. of Agriculture Soil Conservation Service National Soils Analytical Laboratory.

Figure 3-64. R-generated box and whiskers plot for soil total nitrogen (%) for select vegetative land cover systems, on the basis of data used in Post and Mann, 1990.



Data on ambient soil concentrations of phosphorus in California soils is available from the University of California–Kearney Foundation of Soil Science (Kearney Foundation, 1996). Figure 3-65 illustrates background concentrations of phosphorus in California soils on the basis of Kearney benchmark soils selected from throughout the state (Kerney Foundation, 1996). The median soil phosphorus content in benchmark soils from within the California Oak and Chaparral Subecoregion is 378 mg/kg (0.038 weight percent) – thus, this value may constitute a plausible average ambient background soil phosphorus content for the Pajaro River basin (for a discussion of nutrient ecoregions refer back to Section 3.6).

Figure 3-65. Background concentrations of phosphorus in California soils.



Source Data: Background Concentrations of Trace and Major Elements in California Soils G. R. Bradford, A. C. Change, A. L., D. Bakhtar, J. A. Frampton, and H. Wright. 1996) Available from Kearney Foundation of Soil Science, University of California

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

Text Box 3-6. Estimated average concentration of soil nitrogen (%) and soil phosphorus (%) in soils of the Pajaro River basin.

Based on the aforementioned information, estimated average soil nutrient content (%) in the Pajaro River basin can be summarized as follows:

AVERAGE SOIL NITROGEN CONTENT (%) IN THE PAJARO RIVER BASIN:

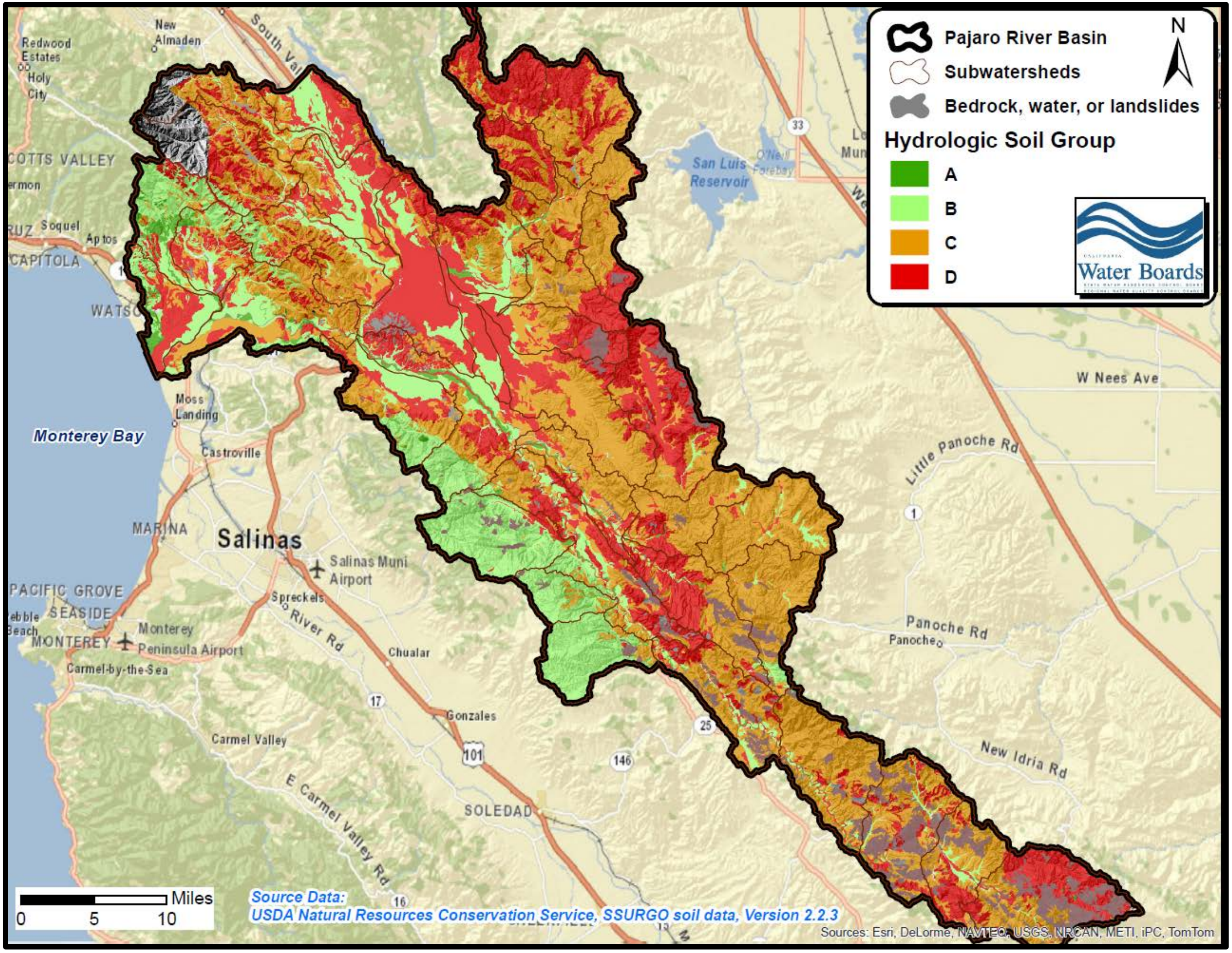
0.068%

AVERAGE SOIL PHOSPHORUS CONTENT (%) IN THE PAJARO RIVER BASIN:

0.038%

Soils also play a key role in drainage, runoff, and subsurface infiltration in any given watershed. The U.S. Department of Agriculture National Resources Conservation Service's (NRCS) compiled soil survey by counties is available online under the title of Soil Survey Geographic (SSURGO) Database. SSURGO has been updated with extensive soil attribute data, including Hydrologic Soil Groups. Hydrologic Soil Groups are a soil attribute associated with a mapped soil unit, which indicates the soil's infiltration rate and potential for runoff. Information on hydrologic soil groups in a necessary input parameter in the spreadsheet source estimation tool used in this TMDL project (see Section 7.1). Therefore, it is necessary to compile information on hydrologic soil groups in the Pajaro River basin. Figure 3-66 illustrates the distribution of hydrologic soil groups in the Pajaro River basin along with a tabular description of the soil group's hydrologic properties.

Figure 3-66. Hydrologic soil groups in the Pajaro River basin.



Source Data: USDA Natural Resources Conservation Service, SSURGO soil data, Version 2.2.3

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

Hydrologic Soil Group Descriptions:	
A	Well-drained sand and gravel; high permeability
B	Moderate to well-drained; fine to moderately course texture; moderate permeability
C	Poor to moderately well-drained; moderately fine to fine texture; slow permeability
D	Poorly drained; clay soils, or shallow soils over nearly impervious layers(s)

As indicated in Table 3-34 and previously in Figure 3-66, the most frequently occurring soil groups in the Pajaro River basin are poor to moderately well-drained hydrologic soil groups (HSG group C), followed by poorly drained clay soils or impervious layers (HSG group D). HSG group B soils are often associated with valley floor reaches of the river basin, or associated with the courser-grained granitic bedrock of the Gabilan Range. Occurrences of well-drained sand and gravel (HSG group A) are mostly limited to the channel belts depositional facies associated with streams corridors.

Table 3-34: Most frequently occurring Hydrologic Soil Groups (HSGs) in subwatersheds of the Pajaro River basin.

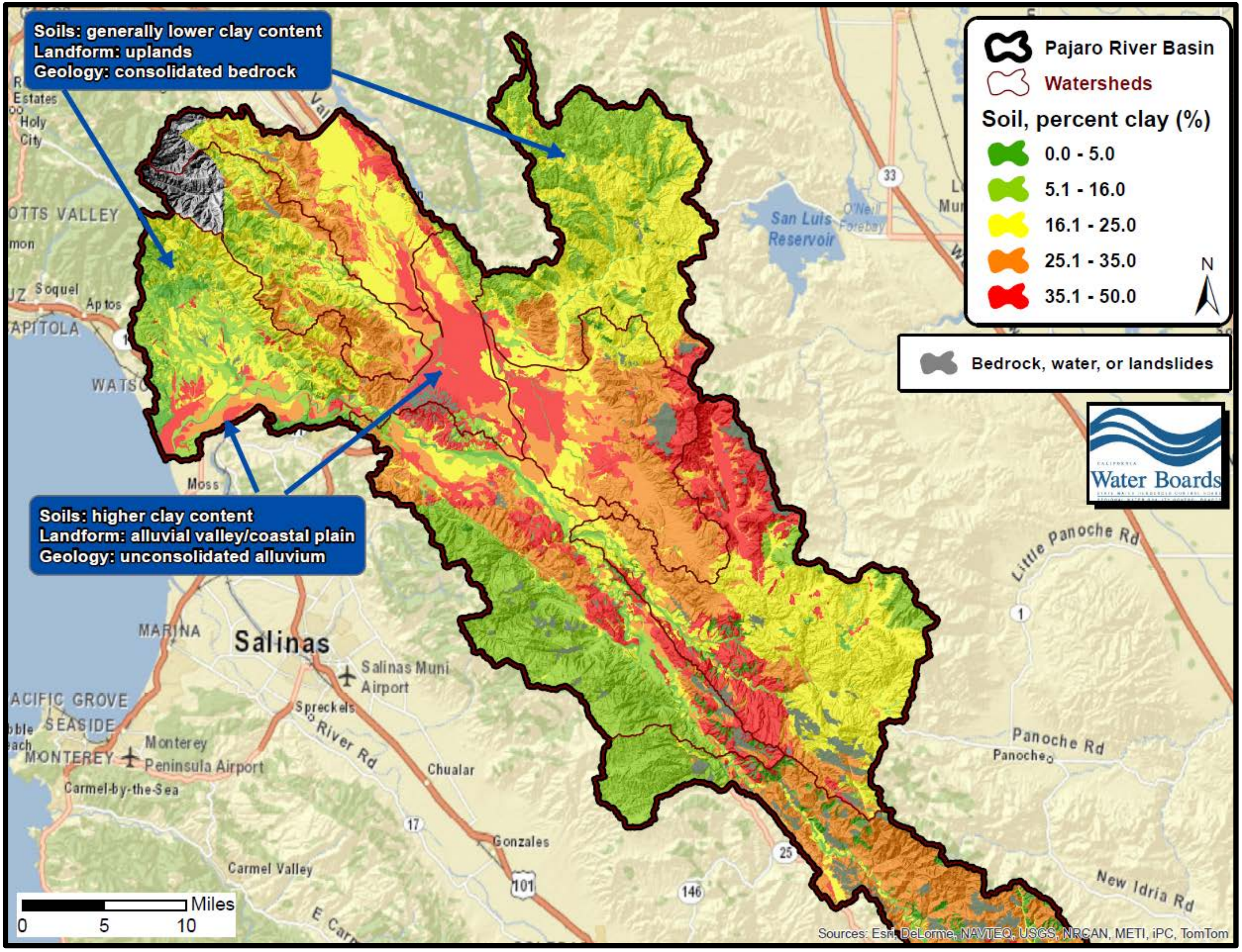
Subwatershed	Most frequently occurring HSG[A]	Subwatershed	Most frequently occurring HSG[A]
Arroyo De Las Viboras	C	Pescadero Creek	B
Bird Creek-San Benito River	B	Quien Sabe Creek	D
Cedar Creek	D	Rock Springs Creek-San Benito River	C
Clear Creek-San Benito River	D	Salsipuedes Creek	B
Corralitos Creek	B	San Juan Canyon	C
Hernandez Reservoir-San Benito River	D	Santa Ana Creek	C
James Creek-San Benito River	C	South Fork Pacheco Creek	C
Las Aguilas Creek	C	Stone Creek	B
Little Llagas Creek	D	Sulphur Creek-San Benito River	C
Los Muertos Creek	C	Tequisquita Slough	D
Lower Llagas Creek	D	Upper Llagas Creek	C
Lower North Fork Pacheco Creek	D	Upper North Fork Pacheco Creek	D
Lower Pacheco Creek	C	Upper Pacheco Creek	C
Lower Pajaro River	C	Upper Pajaro River	D
Lower Tres Pinos Creek	C	Upper Tres Pinos Creek	C
Lower Uvas Creek	C	Upper Uvas Creek	C
Middle Tres Pinos Creek	D	Watsonville Slough Frontal	D
Paicines Reservoir-San Benito River	C	Willow Creek	B

[A] Determined by spatial analysis – staff extracted digital SSURGO soil data using the spatial attributes of subwatershed shapefiles as a digital mask.

Additionally, the benthic sediment composition of streams is an important factor to consider, because the physical characteristics of stream substrates may play a role in algal productivity; for example, by influencing the turbidity (and therefore, light availability) of the overlying water column.

A cursory evaluation of regional soil textures and regional geology illustrate the substantial variability in soil conditions even at the reach-scale or subwatershed-scale. Figure 3-73 illustrates soil textures in terms of percent clay in the Pajaro River basin. Turbidity conditions in agricultural alluvial valleys with clay-rich soils and substrates would often be expected to have substantially different ambient turbidity conditions relative to stream reaches in upland areas, or in areas underlain by consolidated bedrock and sandy soil and substrate conditions. It should be recognized that unlike sand, silt, or gravel, which are typically transported as bedload, clay is often transported in colloidal suspension in the water column even at very low stream velocities, thereby contributing to ambient turbidity.

Figure 3-67. Soil texture (% clay) in the Pajaro River basin.



Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

3.12 Fish & Wildlife

Water quality plays an important role in fish and wildlife habitat. A number of the designated aquatic habitat beneficial uses for Pajaro River basin waterbodies (refer to Section 3.2 and Table 3-2) may be adversely affected by higher than natural nutrient levels and associated water quality stressors (wide dissolved oxygen and pH swings) that occur within the river basin. Biostimulatory impairments, or toxicity associated with elevated nutrients and/or unionized ammonia can affect the entire aquatic food web, from algae and other microscopic organisms, through benthic macroinvertebrates (principally aquatic insect larvae), through fish, to the mammals and birds at the top of the food web. Consequently, it is relevant to be cognizant of and consider available information on aquatic habitat and fish resources in the Pajaro River basin. Is should also be noted that while there remains a fairly significant extent of viable estuarine and brackish water habitat in the Monterey Bay and northern Santa Cruz County coastal areas, the cumulative effect of human activities in the last century has degraded, reduced and restricted viable fresh water habitat in the Pajaro River basin.

Further, it has long been recognized that biostimulation, excess nutrients, and water quality degradation has substantially degraded aquatic habitat locally in surface waters of the Pajaro River basin. For example, over 20 years ago Swanson and Associates (1993) reported high nutrient levels in surface waters entering the Pajaro River lagoon which were resulting in dense phytoplankton blooms adversely impacting the natural oxygen balance of lagoon waters, and resulting in "shading" which limited natural benthic aquatic plant growth in deeper sections of the lagoon. Similarly, Williamson et al. (1994) stated: "the Pajaro River and Llagas Creek exhibit periodic nuisance algae conditions resulting in dissolved oxygen depletion and other deleterious chemical, physical, and biological alterations". Also, according to a report by Central Coast Water Board staff in 1983 (Central Coast Regional Water Quality Control Board, 1983), algae problems in the Pajaro River and Llagas Creek were recognized by staff of the Department of Fish and Game[83] staff of the Santa Cruz Office of Watershed Management, and by the Association of Monterey Bay Area Governments. Also worth noting, Smith in 1982 (as reported in Moyle et al., 1995) attributes disappearance of monterey roach fish in Monterey Bay watersheds to habitat alteration and lowered water quality including low dissolved oxygen.

It should be noted that algae are a natural part of freshwater and marine ecosystems, and episodic algae blooms are sometimes a natural phenomenon. Staff reviewed early 20th century legacy reporting from the U.S. Geological Survey on stream water quality of the California central coast region (U.S. Geological Survey, 1910, 1924) and there does not appear to be any mention of algae problems in streams of the region. However, it cannot be ruled out that algae blooms were observed by the field researchers, but just not reported. Water quality data reported in these legacy reports also indicated that nitrate concentrations in sampled streams were quite low region-wide.

Fish are the most noticeable components of aquatic ecosystems, and their declines signals ecosystem deterioration; alternatively, healthy fish assemblages signal clean and healthy waters (Moyle, 2002). The California Department of Fish and Wildlife reported in the second edition of Fish Species of Special Concern in California that the decline of California's fishes, and of other aquatic organisms, will continue and many extinctions will occur unless the widespread nature of the problem is addressed in a systematic effort to protect aquatic habitat in all drainages of the State (Moyle, et al., 1995). Note that researchers have recently reported that, due to the continuing impacts of anthropogenic changes, California is likely to lose a large proportion of its remaining native fish diversity (Marchetti et al., 2006). Stream reaches in the Pajaro River basin provide a range of potential warm freshwater, cold freshwater, and estuarine aquatic habitat. Even modified drainage canals and ditches may locally and episodically provide migratory habitat or reproductive habitat for fishes and amphibians (Dr. Jerry Smith, written personal communication, July 3, 2013) – indeed, carp and fathead minnow have been observed spawning in Miller's Canal and in a flooded ditch that flows to Miller's Canal (J.R. Casagrande, 2010).

One way to begin to assess freshwater aquatic habitat of the Pajaro River basin is to review regional information and the spatial distribution of California's zoogeographic provinces – see Figure 2-57. The Pajaro River basin is located in the Monterey Bay zoogeographic subprovince. This subprovince is composed of the three major rivers that flow into Monterey Bay: the San Lorenzo River, the Pajaro River, and the Salinas River. Historically, the Monterey Bay subprovince and the Pajaro River had an array of freshwater native fish species characteristic of the Central Valley subprovince (Sacramento sucker, California roach, hitch, Sacramento blackfish, Sacramento pikeminnow, speckled dace, thicktail chub, Sacramento perch, tule perch, and riffle sculpin), as well as saltwater dispersant fishes including the Pacific Lamprey, threespine stickleback, prickly sculpin, and steehead (Moyle, 2002).

The similarity of the freshwater fish fauna of the Monterey Bay subprovince with the Central Valley is likely due to hydrologic connectivity between the subprovince and the Central Valley sometime during the middle or late Pleistocene epoch, between 12 thousand to 50 thousand years ago[84] (Moyle, 2002).

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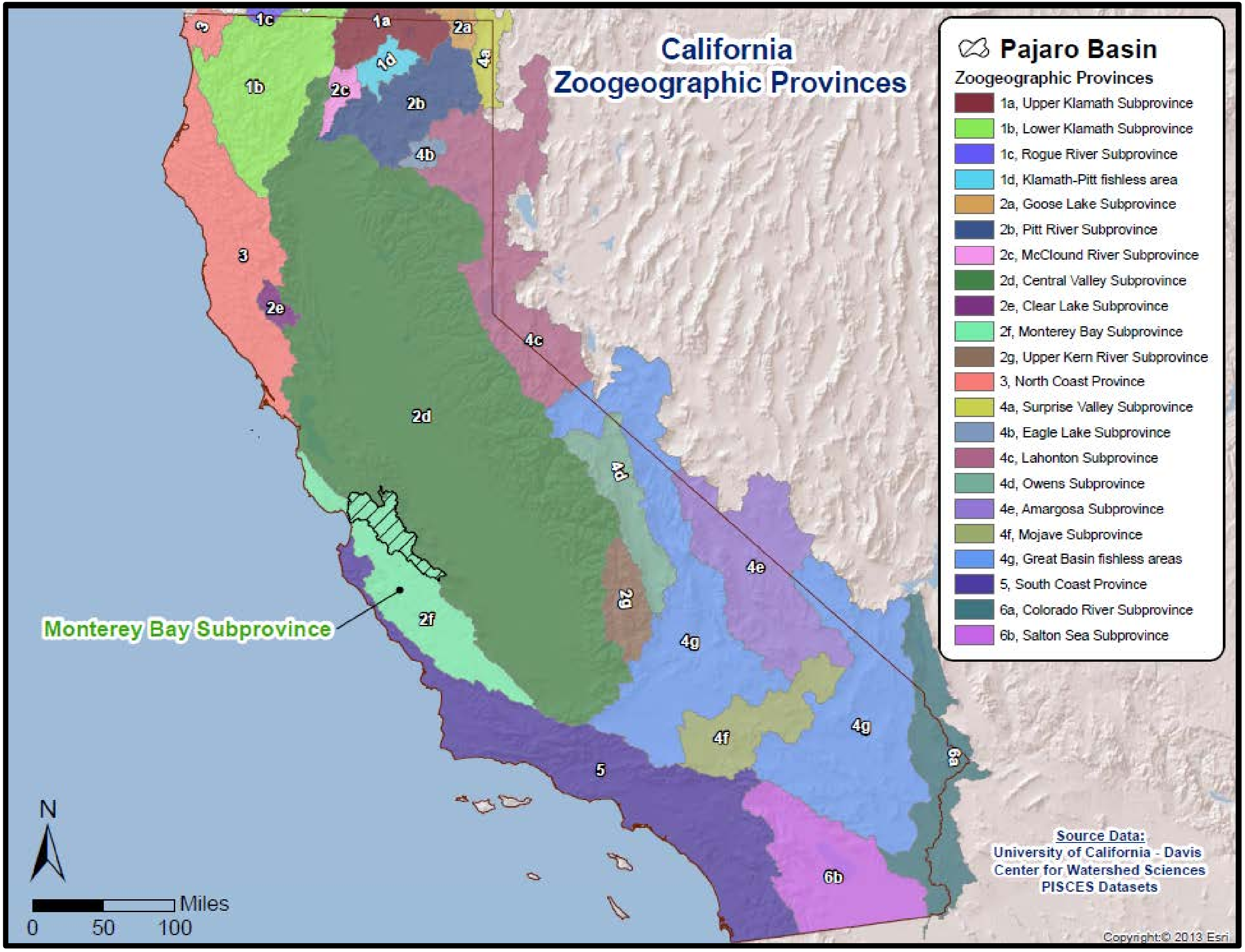
[83] This agency is currently known as the Department of Fish and Wildlife.

[84] Geologic evidence suggests that upper Coyote Creek (which now flows to the San Francisco Bay) has episodically changed course in the past, sometimes flowing into Llagas Creek, a Pajaro River tributary – thus providing a plausible hydrologic connection for lowland fishes of the Central Valley zoogeographic subprovince to have migrated into the Pajaro River Basin (Banner, 1907 as reported in Moyle, 2002).

Figure 3-68. Zoogeographic provinces of California.



Source Data:
University of California - Davis
Center for Watershed Sciences
PISCES Datasets

➢ *Special Status Aquatic Species (Fish and Amphibians)*

The Pajaro River basin provides habitat to six special-status aquatic species[85] (fish, amphibians, and a crustacean) listed under the federal Endangered Species Act, and include:

- South-central California Coast steelhead distinct population segement (Federal Status: threatened);
- Tidewater goby (Federal Status: endangered);
- California red-legged frog (Federal Status: threatened);
- California tiger salamander (Federal and State Status: threatened)
- Santa Cruz long-toed salamander (Federal and State Status: endangered)
- Vernal pool fairy shrimp (Federal Status: threatened)

➢ *Aquatic Species of Special Concern (Fish and Reptile)*

A Species of Special Concern (SSC) is a species, subspecies, or distinct population of an animal native to California that currently satisfies one or more criteria, as defined by the California Department of Fish and Wildlife (CDFW)[86]. "Species of Special Concern" is an administrative designation and carries no formal legal status. The intent of designating SSCs is to focus attention on animals at conservation risk

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[85] Source: California Dept. of Fish and Game – California Natural Diversity Database, 2013

[86] See Calif. Department of Fish and Game species of special concern webpage, accessed January 2014, online linkage: http://www.dfg.ca.gov/wildlife/nongame/ssc/.

and achieve conservation and recovery of these animals before they meet California Endangered Species Act criteria for listing as threatened or endangered. In terms of aquatic species, streams in the Pajaro River basin locally provide habitat for the following aquatic Species of Special Concern:

- Rainbow Trout (fish), designated by CDFW as a Class 1[87] species (population threatened)
- Tidewater Goby (fish), designated by CDFW as a Class 1 species (population endangered)
- Monterey Hitch (fish), designated by CDFW as a Class 2 species (population vulnerable)
- Monterey Roach (fish) designated by CDFW as a Class 3 species (watch list species)
- Riffle Sculplin (fish) designated by CDFW as a Class 4 species
- Central California Roach (fish), designated by CDFW as a Class 3 species (watch list species)
- White Sturgeon (fish), designated by CDFW as a Class 4 species
- Pacific Lamprey (fish), designated by CDFW as a Class 3 species (watch list species)
- Western pond turtle, which is designated by CDFW as a special concern species (has been noted to occupy the Pajaro River Flood Control Channel[88],

Clusters of Fish Recommended for Coordinated Ecosystem-Level Management

The California Department of Fish and Wildlife (CDFW) has recommended coordinated special ecosystem management strategies for regional clusters of potentially endangered species with similar environmental requirements (Moyle et al., 1995). These CDFW-identified fish clusters carry no formal legal status but constitute recommendations as part of a systematic effort towards protecting and restoring fish resources of the State. CDFW recommended a cluster of fish species needing coordinated ecosystem management for Monterey Bay streams (Moyle et al., 1995), which includes the following fish species found within the Pajaro River basin:

- Winter steelhead
- Monterey roach
- Monterey hitch
- Speckled dace
- Sacramento sucker
- Tidewater goby

Fish Resources in the Pajaro River Basin

Figure 3-69 illustrates estimated current presence of native fish assemblages in the Pajaro River basin and their presumed distributions. It should be noted that these estimates of native fish distributions are subject to uncertainties and some assumptions, and are based on the best professional judgment of fisheries biologists at the University of California-Davis[89]. Figure 3-70 illustrates the estimated number of native species losses (extirpations) locally by individual subwatershed within the Pajaro River basin. To reiterate, these estimates of native fish distributions are subject to uncertainties and some assumptions, and are based on the best professional judgment of fisheries biologists at the University of California-Davis[90].

Table 3-35 presents a tabulation of current estimated species range for native fishes by subwatershed within the Pajaro River basin based on the best professional judgment of fisheries biologists at the University of California-Davis[91]. Table 3-36 presents a tabulation of recent field observations of native and introduced fish species, reported in surveys by Casagrande (2011) and others.

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[87] In the species of special concern convention, the taxa's vulnerability decreases from class 1 to class 4. Class 1 taxa conform to the state definitions of threatened or endangered species, while class 4 species are presumed either stable, or in decline but still reasonable abundant.

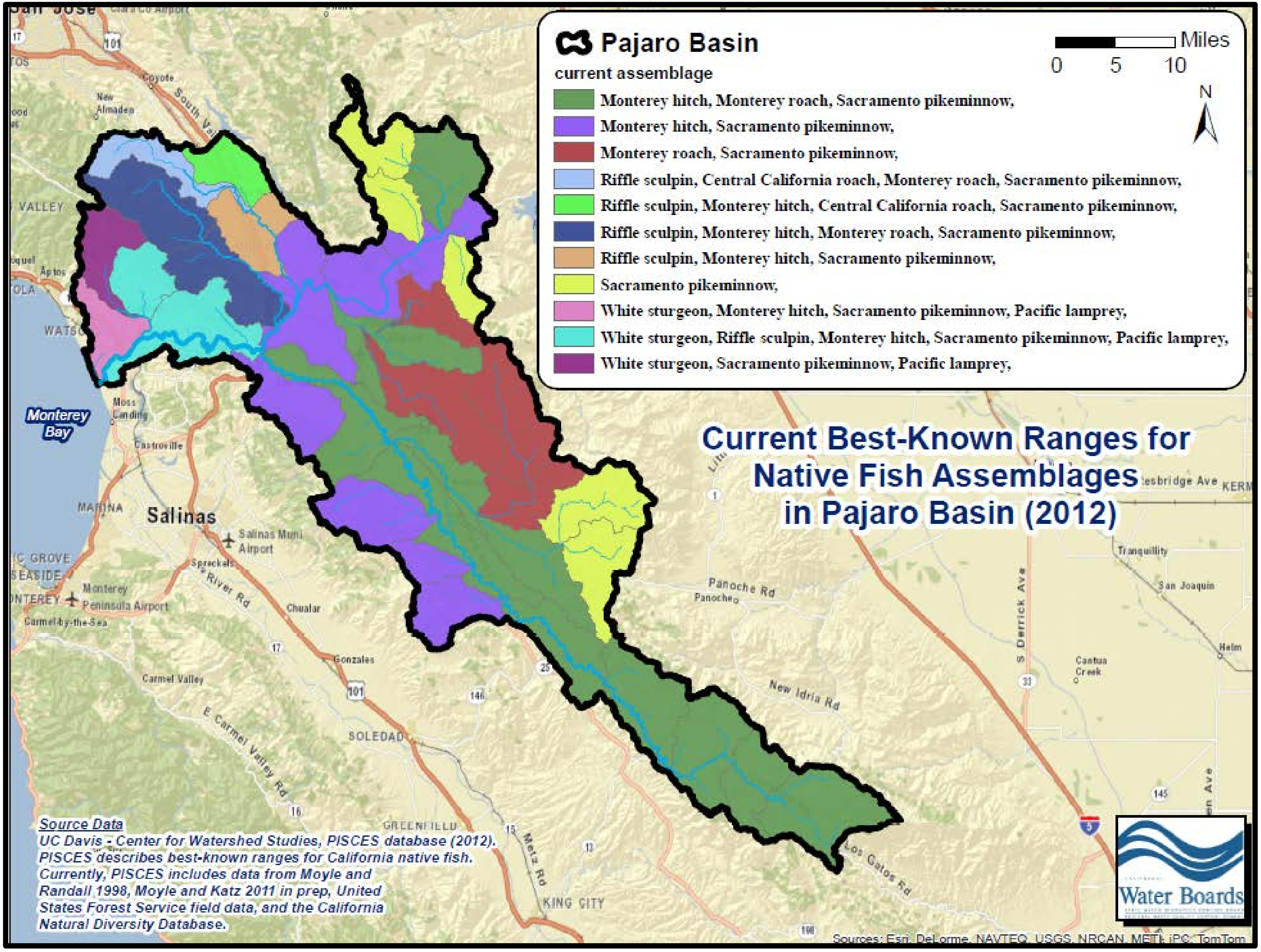
[88] Source: Kittleson Environmental Consulting, 2009 Pajaro River Western Pond Turtle Survey – Draft Report, October 22, 2009.

[89] University of California, Davis – Center for Watershed Sciences, PISCES species occurrence database. PISCES is a database that standardizes, maps, and analyzes the distribution of fish species in California based on watershed units.

[90] *Ibid*

[91] *Ibid*

Figure 3-69. Best-known current ranges for native fish assemblages in Pajaro Basin (2012).



Source Data
UC Davis - Center for Watershed Studies, PISCES database (2012).
PISCES describes best-known ranges for California native fish.
Currently, PISCES includes data from Moyle and Randall 1998, Moyle and Katz 2011 in prep, United States Forest Service field data, and the California Natural Diversity Database.

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

Figure 3-70. Estimated number of native species losses (extirpations) locally by individual subwatershed (source: PICSES database).

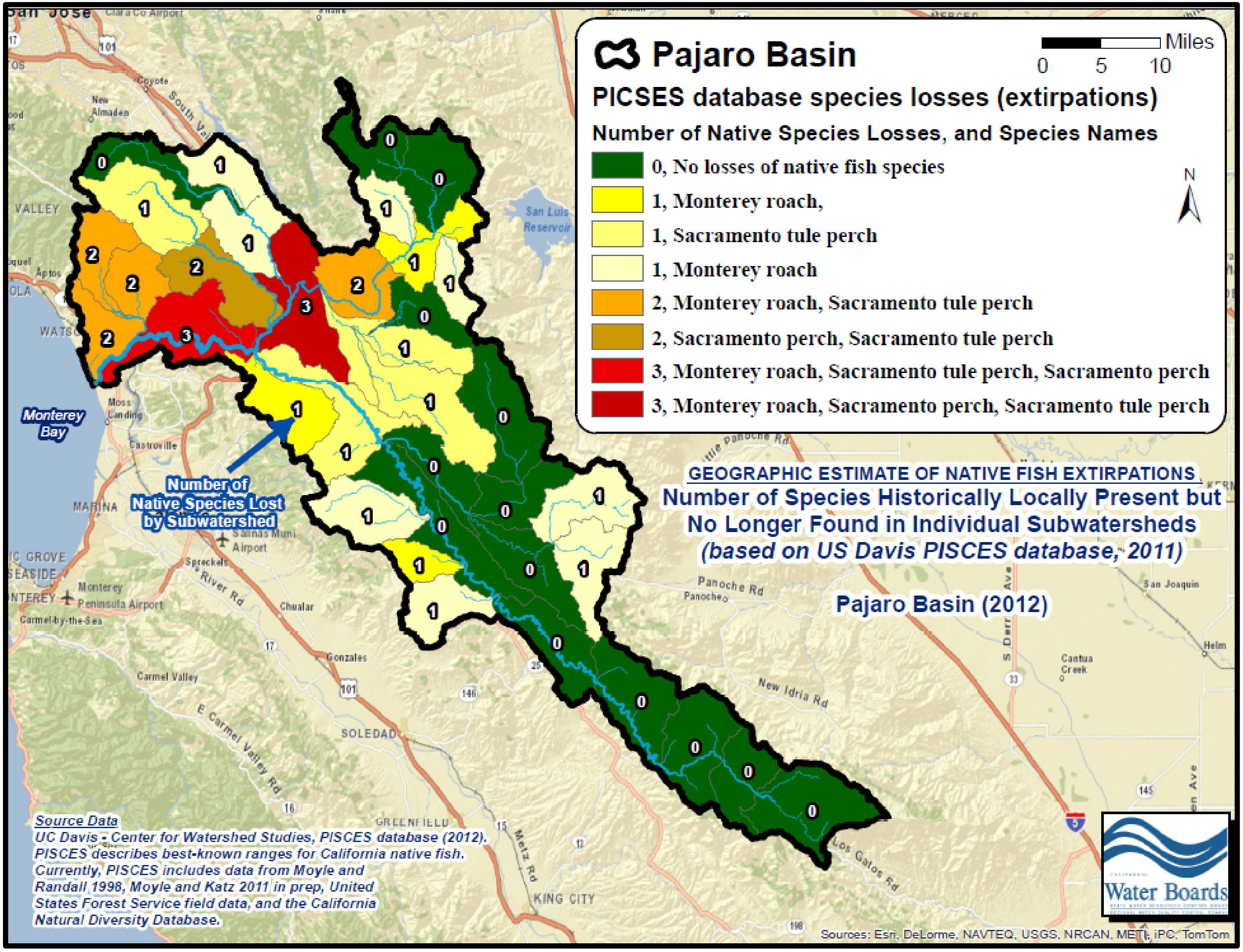


Table 3-35. Current estimated range[A] of native riverine fish species in the Pajaro River basin.

subbasin	**Subwatershed**	**Rainbow Trout** *Oncorhynchus mykiss*	**Tidewater Goby** *Eucyclogobius newberryi*	**Monterey Hitch** *Lavinia exilicauda*	**Monterey Roach** *Lavinia symmetricus subditus*	**Sacramento Pikeminnow** *Ptychocheilus grandis*	**Riffle Sculpin** *Cottus gulosus*	**Central Calif. Roach** *Lavinia symmetricus symmetricus*	**White Sturgeon** *Acipenser transmontanus*	**Pacific Lamprey** *Lampetra tridentata*	**Speckled Dace** *Rhinichthys osculus*	**Threespine Stickleback** *Gasterosteus aculeatus*	**Staghorn Sculpin** *Leptocottus armatus*
Pajaro River subbasin	Upper Pajaro River	x		x		x					x		
	Upper Llagas Creek	x			x	x	x	x			x	x	
	Little Llagas Creek			x		x	x	x				x	
	Lower Uvas Creek	x		x	x	x	x				x		
	Upper Uvas Creek	x		x	x	x	x					x	
	Lower Llagas Creek	x		x		x	x						
	Watsonville Slough Frontal			x		x			x	x		x	x
	Lower Pajaro River	x	x	x		x	x		x	x	x	x	x
	Salsipuedes Creek	x		x		x	x		x	x		x	
	Corralitos Creek	x				x			x	x		x	
Pacheco Creek subbasin	Tequisquita Slough	x		x	x	x							
	Lower North Fork Pacheco Creek	x		x	x	x							
	Lower Pacheco Creek	x		x		x							
	Upper Pacheco Creek			x		x							
	Santa Ana Creek				x	x					x		
	Arroyo De Las Viboras				x	x							
	South Fork Pacheco Creek	x				X							
	Cedar Creek	x				X							
	Upper North Fork Pacheco Creek					x							
San Benito River subbasin	Paicines Reservoir-San Benito River	x		x	x	x					x		
	Bird Creek-San Benito River	x		x	x	x					x		
	Lower Tres Pinos Creek			x	x	x					x		
	Middle Tres Pinos Creek			x	x	x					x		
	Rock Springs Creek-San Benito River	x		x	x	x					x		
	Sulphur Creek-San Benito River	x		x	x	x					x		
	James Creek-San Benito River	x		x	x	x					x		
	Clear Creek-San Benito River	x		x	x	x					x		
	Hernandez Reservoir-San Benito River	x		x	x	x					x		
	San Juan Canyon			x		x					x		
	Stone Creek			x		x					x		
	Pescadero Creek	x		x		x					x		
	Willow Creek			x		x					x		
	Quien Sabe Creek				x	x							
	Los Muertos Creek				x	x					x		

subbasin	**Subwatershed**	**Rainbow Trout** *Oncorhynchus mykiss*	**Tidewater Goby** *Eucyclogobius newberryi*	**Monterey Hitch** *Lavinia exilicauda*	**Monterey Roach** *Lavinia symmetricus subditus*	**Sacramento Pikeminnow** *Ptychocheilus grandis*	**Riffle Sculpin** *Cottus gulosus*	**Central Calif. Roach** *Lavinia symmetricus symmetricus*	**White Sturgeon** *Acipenser transmontanus*	**Pacific Lamprey** *Lampetra tridentata*	**Speckled Dace** *Rhinichthys osculus*	**Threespine Stickleback** *Gasterosteus aculeatus*	**Staghorn Sculpin** *Leptocottus armatus*
	Upper Tres Pinos Creek					x					x		
	Las Aguilas Creek					x					x		

[A] Source: Unviersity of California, Davis Center for Watershed Studies, PISCES database. THE PISCES database describes the best-known ranges for California's native fishes. The data are compiled from multiple sources and fish biology experts and is stored and exported as range maps. It should be noted that these estimates of native fish distributions are subject to uncertainties and some assumptions, and are based on the best professional judgment of fisheries biologists at the University of California-Davis.

Table 3-36. Field survey observations of native and introduced fish in the Pajaro River basin.

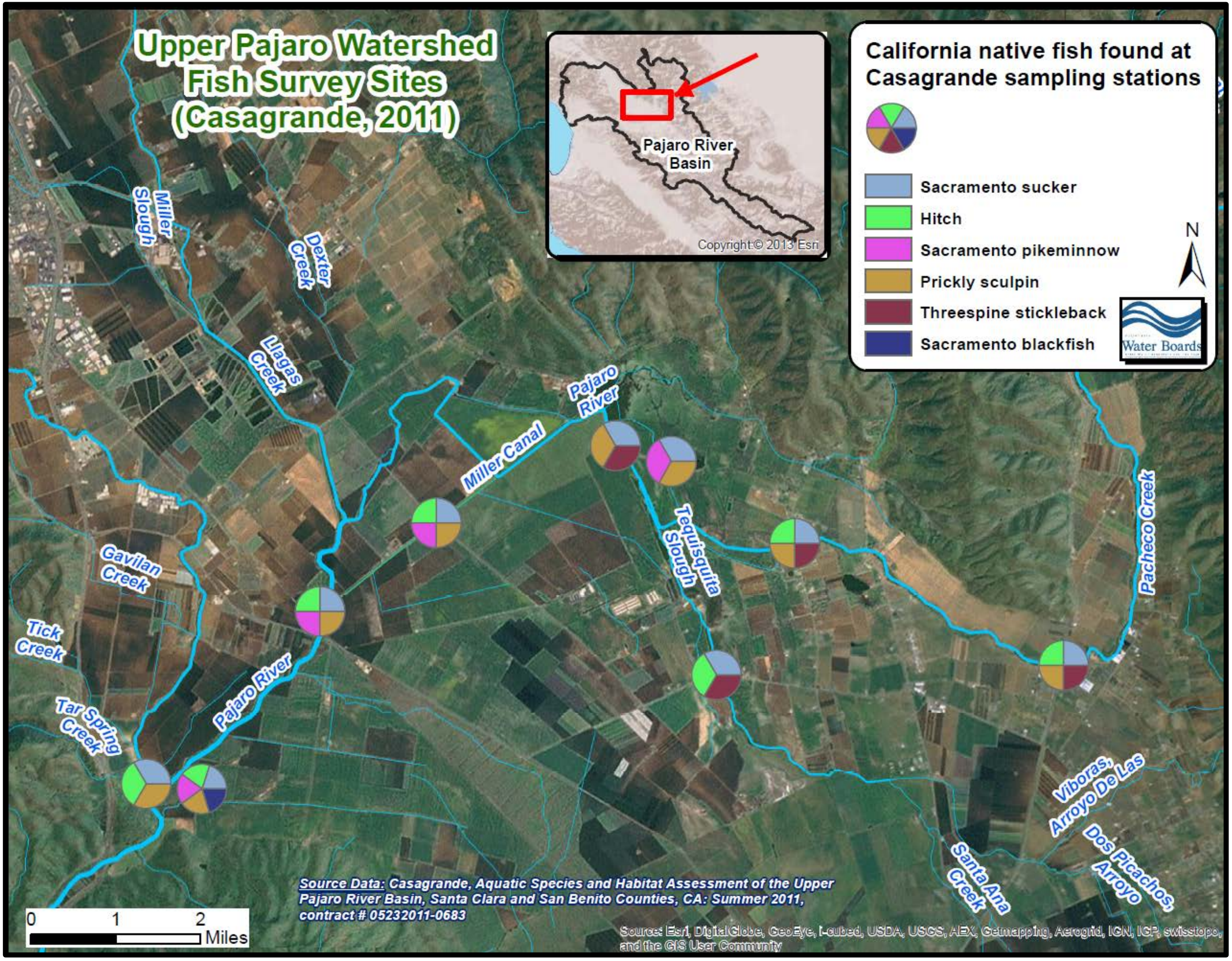
Watershed (HUC 10)	Waterbody	Fish Species Observed	Scientific Name	Relative Abundance	Literature Source
Pajaro River Watershed (Upper)	Pajaro River @ Carnadero Creek Confluence	Sacramento Sucker	*Catostomus occidentalis*	Common	Casagrande (2011)
		Hitch	*Lavinia exilicauda*	Abundant	
		Sacramento pikeminnow	*Ptychocheilus grandis*	Rare	
		Sacramento blackfish	*Orthodon microlepidotus*	Rare	
		Bluegill	*Lepomis macrochirus*	Rare	
		Black crappie	*Pomoxis nigromaculatus*	Rare	
		White catfish	*Ameiurus catus*	Rare	
		Common carp	*Cyprinus carpio*	Rare	
		Goldfish	*Carassius auratus*	Rare	
		Striped bass	*Morone saxatilis*	Common	
		Prickly sculpin	*Cottus asper*	Common	
		Fathead minnow	*Pimephales promelas*	Rare	
	Pajaro River @ Miller Canal Confluence	Sacramento Sucker	*Catostomus occidentalis*	Common	Casagrande (2011)
		Hitch	*Lavinia exilicauda*	Rare	
		Sacramento pikeminnow	*Ptychocheilus grandis*	Rare	
		Brown Bullhead	*Ameiurus nebulosus*	Rare	
		Striped Bass	*Morone saxatilis*	Common	
		Prickly sculpin	*Cottus asper*	Common	
		Common carp	*Cyprinus carpio*	Rare	
	Miller's Canal @ Frazer Lake Road	Sacramento sucker	*Catostomus occidentalis*	Common	Casagrande (2011)
		Hitch	*Lavinia exilicauda*	Common	
		Sacramento pikeminnow	*Ptychocheilus grandis*	Rare	
		Prickly sculpin	*Cottus asper*	Abundant	
		Bluegill	*Lepomis macrochirus*	Rare	
		Fathead minnow	*Pimephales promelas*	Rare	
		Mosquitofish	*Gambusia affinis*	Rare	
		Common carp	*Cyprinus carpio*	Not reported	
Pajaro River Watershed (Lower)	Beach Road Drainage Ditch	Mosquito fish	*Gambusia affinis*	Abundant	Kittleson (2005)
		Threespine stickleback	*Gasterostus aculaetus*	Common	
	Harkins Slough	Sacramento blackfish	*Orthodon microlepidotus*	Not reported	Swanson Hydrology and

Watershed (HUC 10)	Waterbody	Fish Species Observed	Scientific Name	Relative Abundance	Literature Source
Pajaro River Watershed (Lower)		Stickleback	*Gasterostus*	Not reported	Geomorphology (2003)
		Carp	*Cyprinus carpio*	Not reported	
		Mosquito fish	*Gambusia*	Not reported	
		Black crappie	*Pomoxis nigromaculatus*	Not reported	
	Struve Slough	Stickleback	*Gasterostus*	Not reported	
	Larkin Creek from Harkins Slough upstream to about Windsong Way	Mosquito fish	*Gambusia*	Not reported	
		Stickleback	*Gasterostus*	Not reported	
		Prickly sculpin	*Cottus asper*	Not reported	
	Pajaro River Estuary	Brown smoothhound	*Mustelus henlei*	Rare	Swanson and Associates (1993)
		Round stingray	*Urolophus halleri*	Rare	
		Pacific herring	*Clupea harengis*	Abundant	
		Pacific sardine	*Sardinops sagax*	Uncommon	
		Northern anchovy	*Engraulis mordax*	Common	
		Coho (adult)	*Oncorhynchus kisutch*	Rare	
		Steelhead (hatchery)	*Oncorhynchus mykiss*	Uncommon	
		Plainfin midshipman	*Porichthys notatus*	Rare	
		Topsmelt	*Atherinops affims*	Abundant	
		California Grunion	*Leuresthes tenuis*	Uncommon	
		Threespine stickleback	*Gasterosteus aculeatus*	Common	
		Bay pipefish	*Syngnathus leptorhynchus*	Common	
		Staghorn sculpin	*Leptocottus armatus*	Abundant	
		Striped bass	*Morone saxatilis*	Uncommon	
		Shiner surfperch	*Cymatogaster aggregata*	Uncommon	
		Walleye surfperch	*Hyperprosopon argenteum*	Uncommon	
		White surfperch	*Phanerodonfurcatus*	Rare	
		Barred surfperch	*Amphistichus argentus*	Rare	
		Pile surfperch	*Damalichthys vacca*	Rare	
		Arrow goby	*Clevlandia ios*	Abundant	
		Tidewater goby	*Eucyclogobius newberryi*	Common	
		California Halibut	*Paralichthyes californicus*	Uncommon	
		Diamond Turbot	*Hypsopsetta guttulata*	Rare	
		English sole	*Parophyrs vetulus*	Uncommon	
		Starry Flounder	*Platichthyes stellatus*	Common	
Uvas Creek Watershed	Lower Carnadero Creek	Sacramento sucker	*Catostomus occidentalis*	Common	Casagrande (2011)
		California roach	*Lavinia symmetricus*	Common	
		Hitch	*Lavinia exilicauda*	Common	
		Prickly sculpin	*Cottus asper*	Abundant	
		steelhead	*Oncorhynchus mykiss*	Rare	
		Common carp	*Cyprinus carpio*	Rare	
Tequisquita Slough Watershed	Tequisquita Slough @ Shore Road	Sacramento sucker	*Catostomus occidentalis*	Rare	Casagrande (2011)
		Hitch	*Lavinia exilicauda*	Rare	
		Threespine stickleback	*Gasterosteus aculeatu*	Rare	

Watershed (HUC 10)	Waterbody	Fish Species Observed	Scientific Name	Relative Abundance	Literature Source
		Fathead minnow	*Pimephales promelas*	Rare	
		Common carp	*Cyprinus carpio*	Rare	
		Mosquitofish	*Gambusia affinis*	Common	
	Tequisquita Slough upstream of San Felipe Lake	Sacramento sucker	*Catostomus occidentalis*	Common	
		Prickly sculpin	*Cottus asper*	Abundant	
		Threespine stickleback	*Gasterosteus aculeatu*	Abundant	
		Green sunfish	*Lepomis cyanellus*	Rare	
		Fathead minnow	*Pimephales promelas*	Common	
		Common carp	*Cyprinus carpio*	Rare	
		Brown bullhead	*Ameiurus nebulosus*	Common	
Pacheco Creek Watershed	Pacheco Creek @ Hwy 156	Sacramento sucker	*Catostomus occidentalis*	Rare	Casagrande (2011)
		Hitch	*Lavinia exilicauda*	Common	
		Prickly sculpin	*Cottus asper*	Abundant	
		Threespine stickleback	*Gasterosteus aculeatu*	Common	
		Green sunfish	*Lepomis cyanellus*	Common	
	Pacheco Creek @ Lovers Lane	Sacramento sucker	*Catostomus occidentalis*	Rare	
		Hitch	*Lavinia exilicauda*	Rare	
		Prickly sculpin	*Cottus asper*	Common	
		Threespine stickleback	*Gasterosteus aculeatu*	Rare	
		Green sunfish	*Lepomis cyanellus*	Common	
		Largemouth bass	*Micropterus salmoides*	Rare	
		Common carp	*Cyprinus carpio*	Rare	
	Pacheco Creek upstream of San Felipe Lake	Sacramento sucker	*Catostomus occidentalis*	Common	
		Sacramento pikeminnow	*Ptychocheilus grandis*	Rare	
		Prickly sculpin	*Cottus asper*	Abundant	
		Green sunfish	*Lepomis cyanellus*	Rare	
		Bluegill	*Lepomis macrochirus*	Rare	

Casagrande (2011) assessed aquatic species in the upper Pajaro River subbasin and the lower Pacheco Creek subbasin in the summer of 2011 and found a total of 19 fish species; 8 native and 11 non-native species. The fish survey sites reported by Casagrande (2011) are illustrated in Figure 3-71.

Figure 3-71. Fish survey sites, upper Pajaro Watershed. Survey data from Casagrande 2011 (only native fish are shown in pie charts).

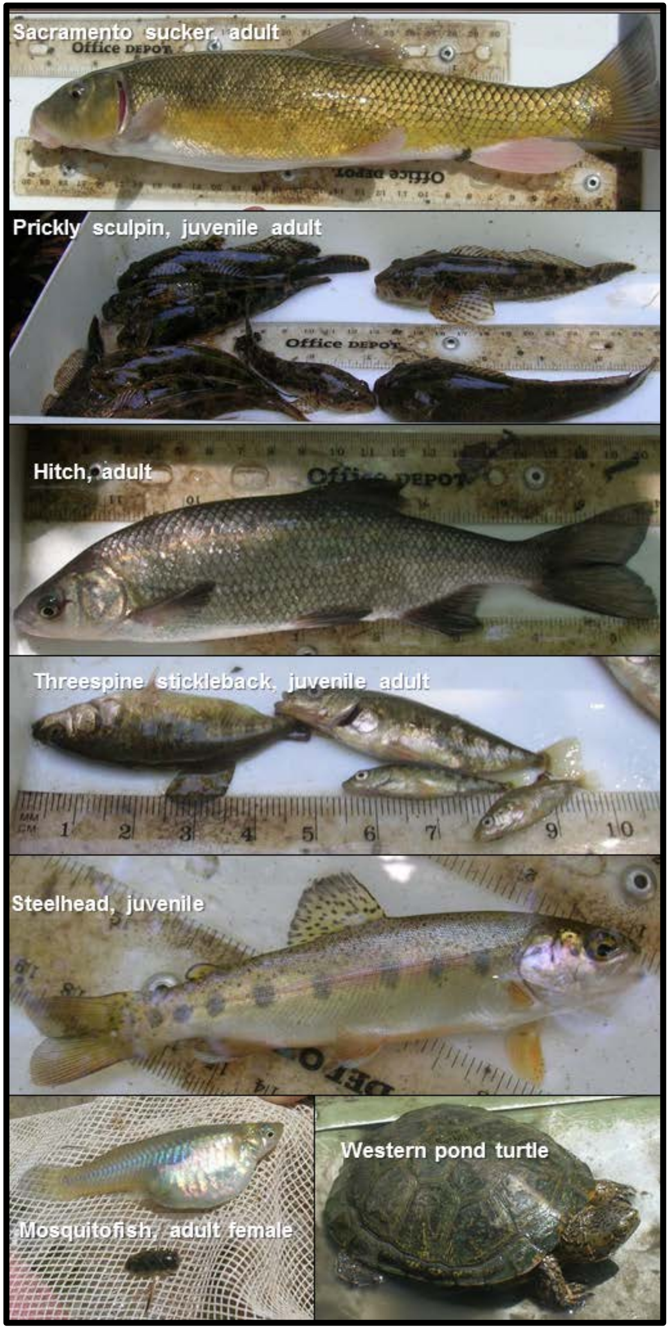


Source Data: Casagrande, Aquatic Species and Habitat Assessment of the Upper Pajaro River Basin, Santa Clara and San Benito Counties, CA: Summer 2011, contract # 05232011-0683

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 3-72 presents recent photo documentation of several fish and turtle species by Casagrande (2011) from the fish survey sites illustrated previously in Figure 3-71.

Figure 3-72. Photo documentation of several native fish and turtle species observed recently in the upper Pajaro River subbasin and/or the lower Pacheco Creek subbasin (photo credits: Joel Casagrande, 2011).



➢ *Tidewater Goby Critical Habitat & Steelhead Migratory & Spawning Habitat*

Figure 3-73 illustrates identified critical habitat for the endangered tidewater goby in coastal confluence areas of the Pajaro River basin. “Critical habitat” is a term defined and used in the federal Endangered Species Act. It refers to specific geographic areas that contain features essential to the conservation of a threatened or endangered species and that may require special management and protection. Critical habitat may include areas that are not currently occupied by the species but that will be needed for its recovery[92].

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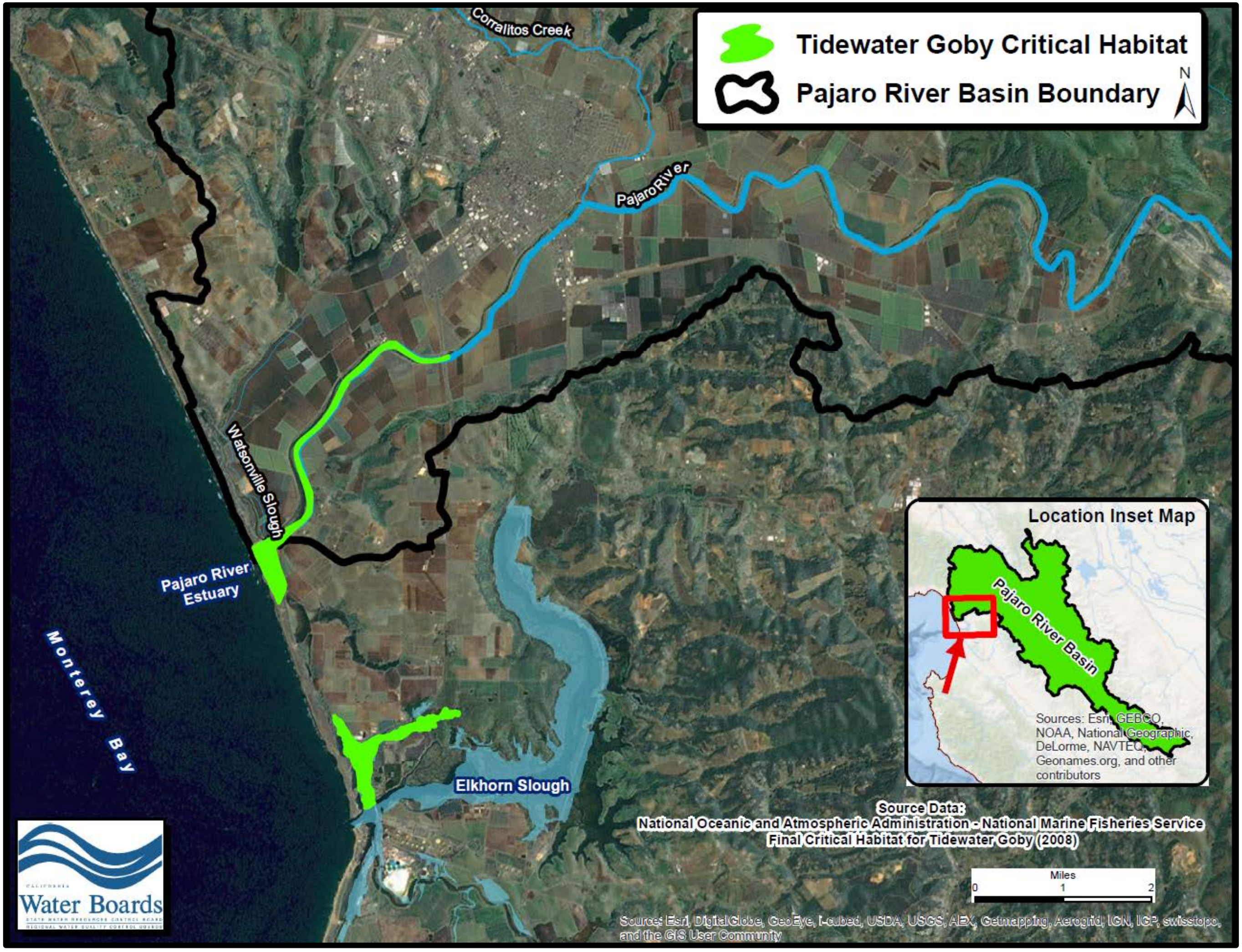
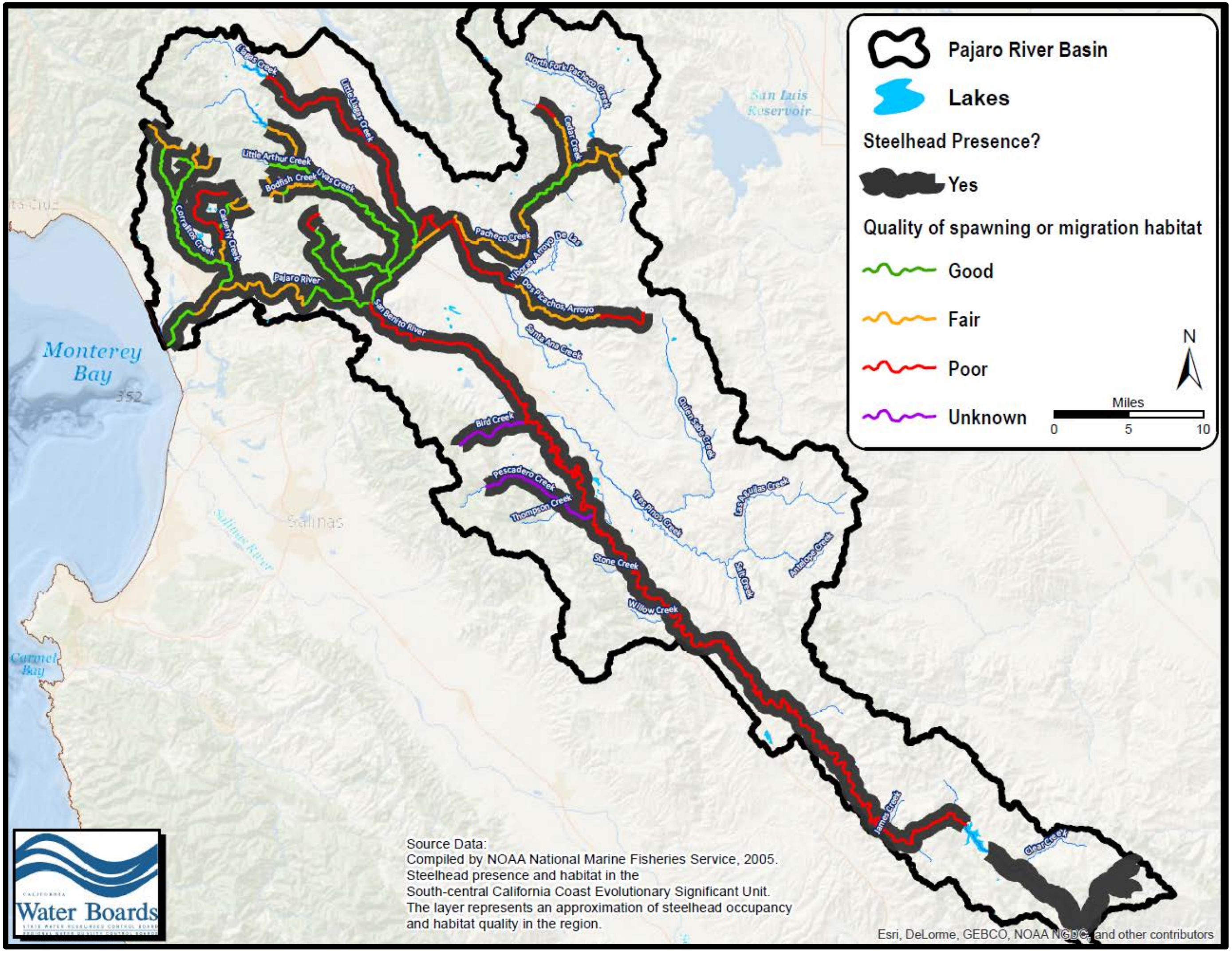
[92] See U.S. Fish and Wildlife Service, Critical Habitat frequently asked question webpage. Online linkage: http://www.fws.gov/endangered/what-we-do/critical-habitats-faq.html

Figure 3-73. Reported critical habitat areas for tidewater goby in the Pajaro River estuary/Elkhorn Slough coastal areas of Monterey Bay.



The Pajaro River and some tributaries provide migration and/or spawning habitat for steelhead trout, a federally listed endangered species. Figure 3-74 illustrates steelhead presence or absence in the Pajaro River basin. This is observational data for the status of salmonid occupancy in a stream segment (stream reaches known or believed to be used by steelhead) but does not imply the existence of routine, robust and viable steelhead runs in all assessed reaches. The data is based on the South-central California Coast Evolutionary Significant Unit and was compiled by the National Marine Fisheries Service Southwest Regional Office in an effort to designate critical habitat for steelhead in California.

Figure 3-74. Known or presumed steelhead presence and habitat quality in the Pajaro River basin.



Source Data:
Compiled by NOAA National Marine Fisheries Service, 2005.
Steelhead presence and habitat in the
South-central California Coast Evolutionary Significant Unit.
The layer represents an approximation of steelhead occupancy
and habitat quality in the region.

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

The National Marine Fisheries Service reported to Central Coast Water Board staff in a letter dated November 10, 2011[93] that on January 5, 2006, the South-central California Coast steelhead distinct population segment was reaffirmed listed as threatened under the Federal Endangered Species Act. National Marine Fisheries Service also indicated to Water Board staff that the most recent status review concluded that populations of the South-central California Coast distinct population segment steelhead are likely to become extinct in the next 50 years without intervention (Good et al., 2005 as reported by National Marine Fisheries Service, communication, Nov. 10, 2011).

Habitat components for the survival and recovery of South-central California Coast steelhead include, but are not limited to, uncontaminated estuarine areas and substrate and sufficient water quality to support growth and development. National Marine Fisheries Service reports that the Pajaro, Salinas, Nacimiento/Arroyo Seco, and Carmel Rivers have experienced declines in steelhead runs of 90 percent or more during the last 30 years. Central Coast estuaries and lagoons play important roles in steelhead growth and survival. National Marine Fisheries Service also communicated to Water Board staff that the most recent status review concluded that populations of South-central California Coast distinct population segment steelhead are likely to become extinct in the next 50 years without intervention

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[93] Letter to Water Board staff from NOAA-NMFS, Steve A.Edmundson, Southwest Regional Habitat Manager, Habitat Conservation Division, dated November 10, 2011.

(Good et al., 2005 as reported by National Marine Fisheries Service, communication, Nov. 10, 2011). Habitat components for the survival and recovery of South-central California Coast steelhead include, but are not limited to, uncontaminated estuarine areas and substrate and sufficient water quality to support growth and development.

Also worth noting, Coho salmon were once present in the Pajaro River, but these salmon have not been seen in the river since at least the late 1960s (Pajaro River Watershed Integrated Regional Water Management Plan, 2007).

➢ *Other Aspects of the Pajaro River Basin's Aquatic Habitat*

Finally, the Water Board is required to protect, maintain, or restore aquatic habitat beneficial uses of waters of the State broadly for the full array of species dependent on aquatic habitats, including vegetation, fish or wildlife, including invertebrates (refer to Section 4.1.4). A comprehensive review of the ecological resources and special-status animal and plant species of the Pajaro River basin is available in the Pajaro River Watershed Integrated Regional Water Management Plan (2007.) It should be noted that the Pajaro River basin contains many areas that are known to contain a number of rare amphibian species (see Figure 3-75) on the basis of biological richness data compiled by the California Department of Fish and Wildlife – thus highlighting the fact that viable freshwater aquatic habitat is critical for an entire terrestrial ecosystem in the broadest sense.

Also noteworthy is that while the focus in this section of the report is on fish, larval aquatic insects and other invertebrates are the most common form of animal life in streams and lakes. Bioassessment field surveys in the Pajaro River and in Corralitos, Pacheco, and Llagas creeks have documented the presence of many species of mayflies, caddisflies, stoneflies, midges, aquatic worms, copepods (a type of zooplankton), cyclopoida (a type of small crustacean), as well as other types of aquatic invertebrates. (for example, Applied Science and Engineering Inc., 1999) – see Figure 3-76. Macroinvertebrates play important roles in the ecosystem and in the aquatic food web; they help break down organic debris, recycle nutrients, and provide food for fish, amphibians, and riparian birds[94]. While some macroinvertebrate organisms can live and thrive in polluted conditions, many others require clean water to survive[95]. The health of an aquatic ecosystem can often be inferred from the types and diversity of aquatic macroinvertebrates present.

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[94] See California Invertebrate Digital Reference Collection, online linkage: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/351e_bugstogo0414.pdf

[95] *Ibid*

Figure 3-75. Biological richness map for rare amphibian species, Pajaro River basin & vicinity (2010).

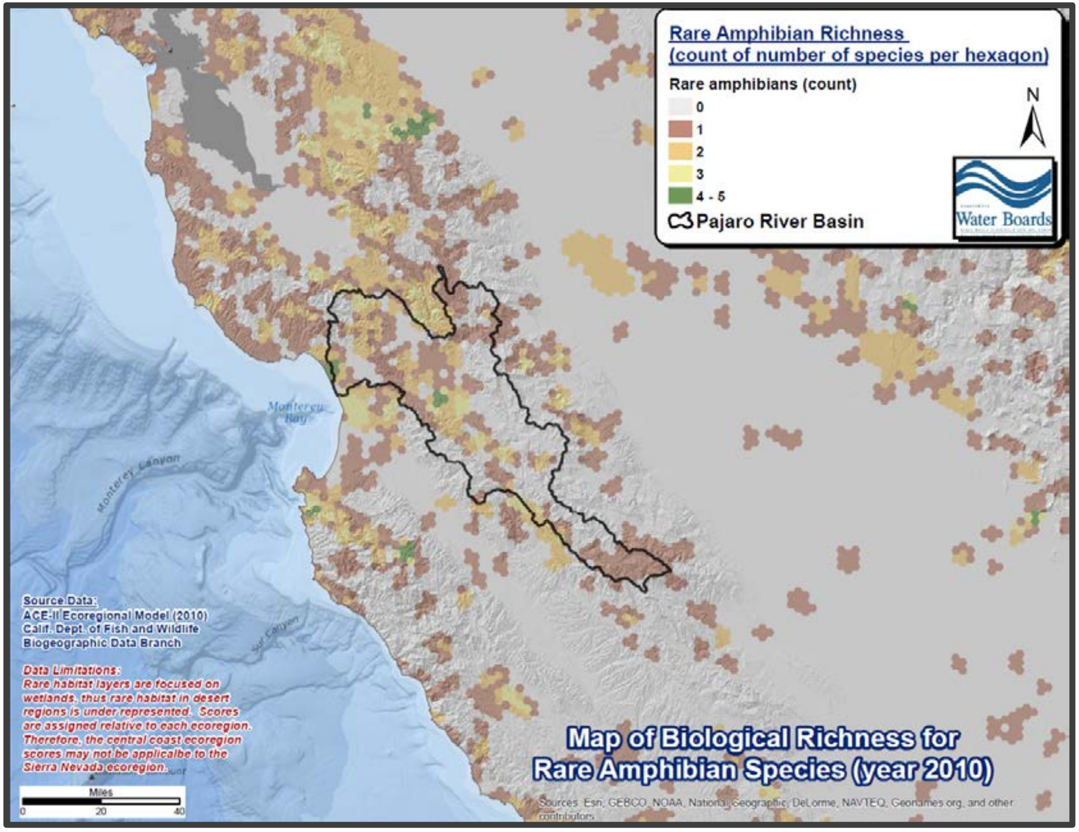
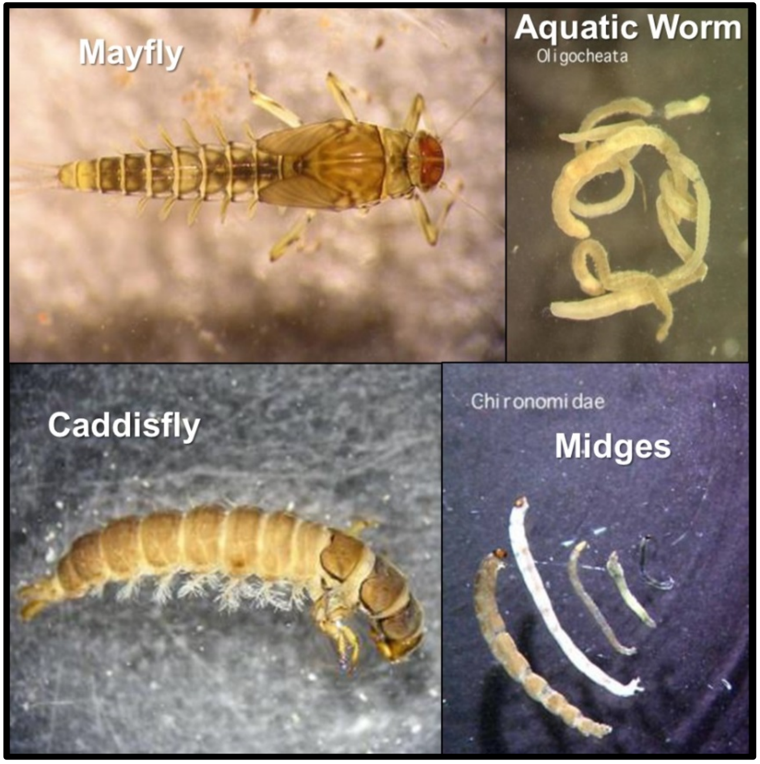


Figure 3-76. Photo reference of some aquatic macroinvertebrates which have been reported from field-surveys of streams in the Pajaro River basin[96].



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[96] Photo credits: California Digital Reference Collection, Aquatic Bioassessment Laboratory.

3.13 Coastal Receiving Waters & Downstream Impacts

Excess nutrients in inland streams which drain alluvial or headwater reaches will ultimately end up in a receiving body of water (lakes, rivers, estuaries, bays, etc.) where the nutrient concentrations and total load may degrade the water resource. Excessive nutrient inputs from human activities upstream of coastal waterbodies, even hundreds of miles inland, can degrade the health of coastal ecosystems, especially estuaries[97]. The U.S. Environmental Protection Agency (USEPA) Scientific Advisory Board has stressed the importance of recognizing downstream impacts associated with excessive nutrients with respect to developing numeric nutrient concentration criteria for inland streams (USEPA, 2010, Worcester et al., 2010) – furthermore, downstream water quality must be protected in accordance with federal water quality standards regulations[98]. Numeric targets developed for inland surface streams should generally be applied to also minimize downstream impacts of nutrients in receiving waterbodies, which are exhibiting signs of eutrophication. In other words, tributary streams themselves may not exhibit detrimental water quality impacts associated with biostimulation, but because they may drain into a receiving waterbody that *is* showing signs of excessive biostimulation, the downstream effects of the tributaries should be considered. For example, Furlong Creek, located in the Llagas Creek Watershed, does not appear to be currently exhibiting biostimulatory impacts despite the fact that water column nutrient concentrations are quite high; for example dissolved oxygen balance in the creek are generally within acceptable ranges. However Furlong is discharging its nutrient loads to receiving waters in Llagas Creek and the Pajaro River – some reaches of these downstream receiving waters do indeed show biostimulatory problems.

The Monterey Bay watersheds, which include the Pajaro River basin, are noteworthy, in part, for being an area of California that drains directly to estuaries and ecologically sensitive coastal bay receiving waters (see Figure 3-77). Coastal estuaries, lagoons, and bays are ecologically sensitive areas that are especially prone to nutrient pollution loading from land activities and freshwater stream inputs. Pajaro River basin streams ultimately drain into the Pajaro River-Watsonville Slough Estuary, and also periodically into Monterey Bay when the Pajaro River Estuary is open to ocean waters. As such, the Pajaro River-Watsonville Slough Estuary and Monterey Bay coastal waters represent the coastal confluence receiving waters for Pajaro River basin streams. It is important to recognize that some of these downstream receiving waters are managed as sensitive ecological areas and accordingly have been designated as National Marine Protection Areas – specifically, the Monterey Bay National Marine Sanctuary (see Figure 3-78). The Monterey Bay National Marine Sanctuary has legally established goals and conservation objectives[99]. The Monterey Bay National Marine Sanctuary was established and is managed in part to sustain, conserve, and restore the protected area's natural biodiversity, populations, habitats, fisheries, and ecosystems. Local resource professionals and local agencies have indicated that the Pajaro River's water quality is critical to the protection and sustainability of this offshore marine environment (Pajaro River Watershed Integrated Regional Water Management Plan, 2014).

Also worth noting: the California Coastal Commission has identified the Pajaro River and Watsonville Slough coastal area as Critical Coastal Areas (CCA)[100]. CCAs are an administrative, non-regulatory designation for coastal waterbodies that need protection from polluted runoff.

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[97] National Oceanic and Atmospheric Administration, "State of the Coast" webpage. Online linkage: http://stateofthecoast.noaa.gov/hypoxia/welcome.html

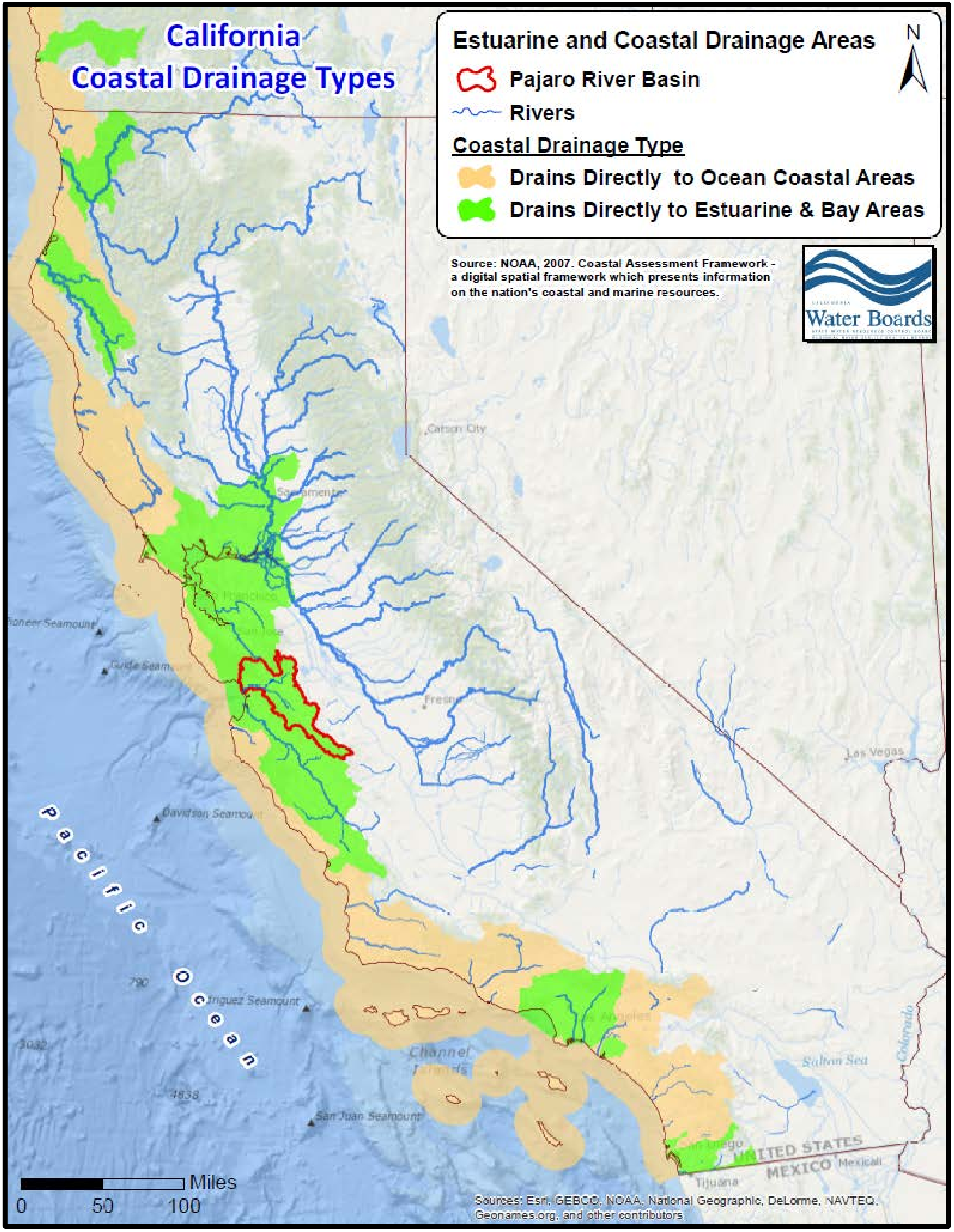
[98] 40 C.F.R. 131.10(b) states: *"In designating uses of a water body and the appropriate criteria for those uses, the state shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters."*

[99] See National Oceanic and Atmospheric Administration – National Marine Protected Areas website. Online linkage: http://marineprotectedareas.noaa.gov/

[100] Pursuant to the federal Coastal Zone Act Reauthorization Amendments of 1990, the state's Critical Coastal Areas (CCA) Program is a program to foster collaboration among local stakeholders and government agencies, to better coordinate resources and focus efforts on coastal waters in critical need of protection from polluted runoff.

As noted previously in Section 2.2 , algal toxins resulting, in part, from nutrient-enriched inland streams of the Pajaro River basin have resulted in deaths of the endangered California southern sea otters, according to recent findings by researchers. This further highlights the importance of recognizing that pollutant loads from freshwater sources within the Pajaro River basin can discharge into coastal waterbodies which are formally recognized and managed as sensitive ecological receiving waters.

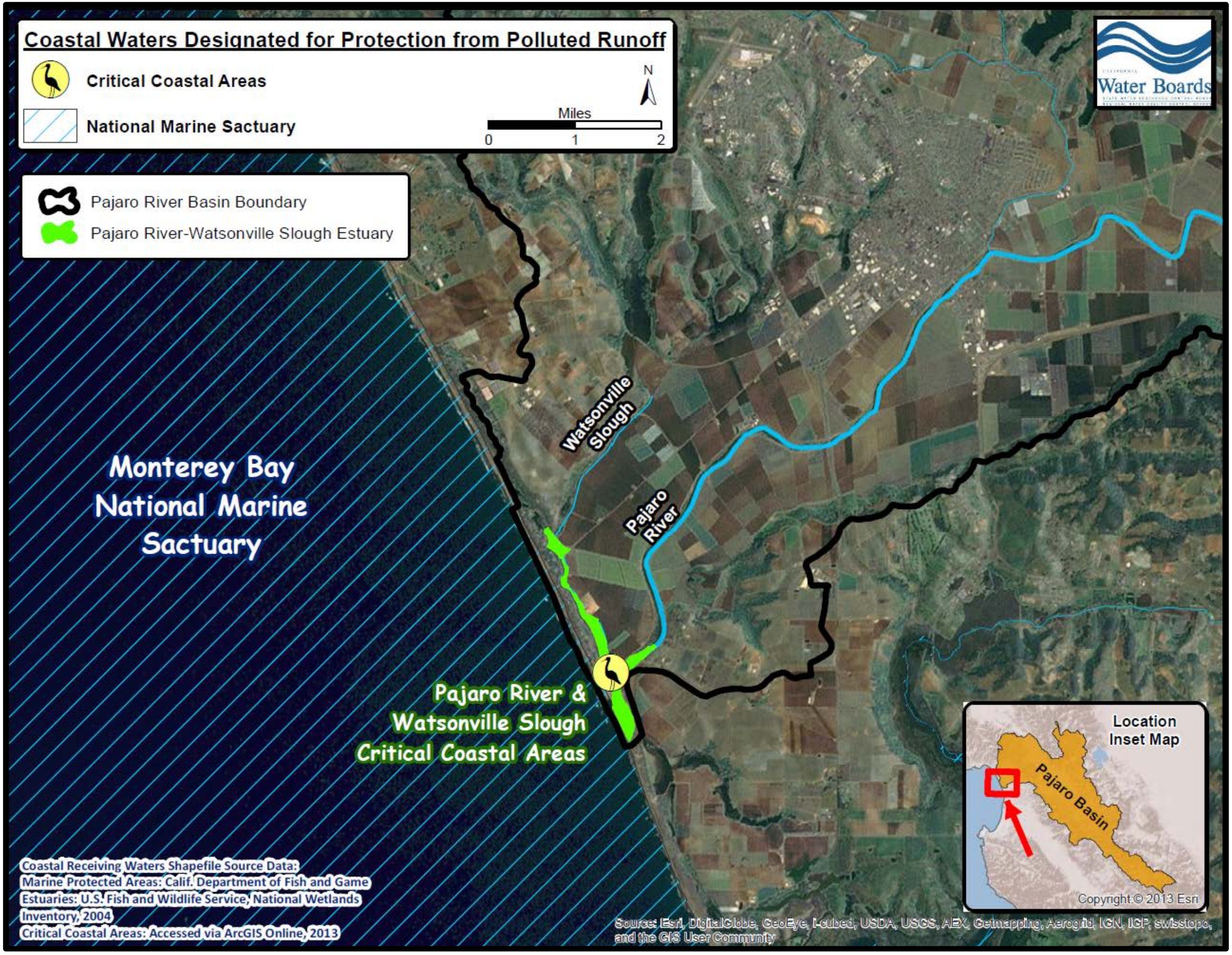
Figure 3-77. Hydrologic areas of California that drain directly to major coastal estuaries and bays.



Source: NOAA, 2007. Coastal Assessment Framework - a digital spatial framework which presents information on the nation's coastal and marine resources.

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

Figure 3-78. Coastal confluence receiving waters of the Pajaro River basin: Monterey Bay National Marine Sanctuary and the Pajaro River-Watsonville Slough Estuary Critical Coastal Areas (CCAs).



Nutrient impacts to coastal waters have been recognized as a significant national environmental problem. According to the U.S. Environmental Protection Agency, 78% of assessed coastal waters in the nation exhibit eutrophication[101]. However, according to data published by Green et al. (2004), it should be noted that at regional-scales, California's offshore marine coastal waters are relatively unimpacted by land-based nitrogen discharges as compared to other coastal areas of the United States (see Figure 3-79). For example, California coastal waters do not have nutrient-related problems even approaching the scale and severity of the Gulf of Mexico hypoxia zone (also known as the Gulf of Mexico "dead zone") which is caused by nutrient enrichment originating from the Mississippi River Basin[102].

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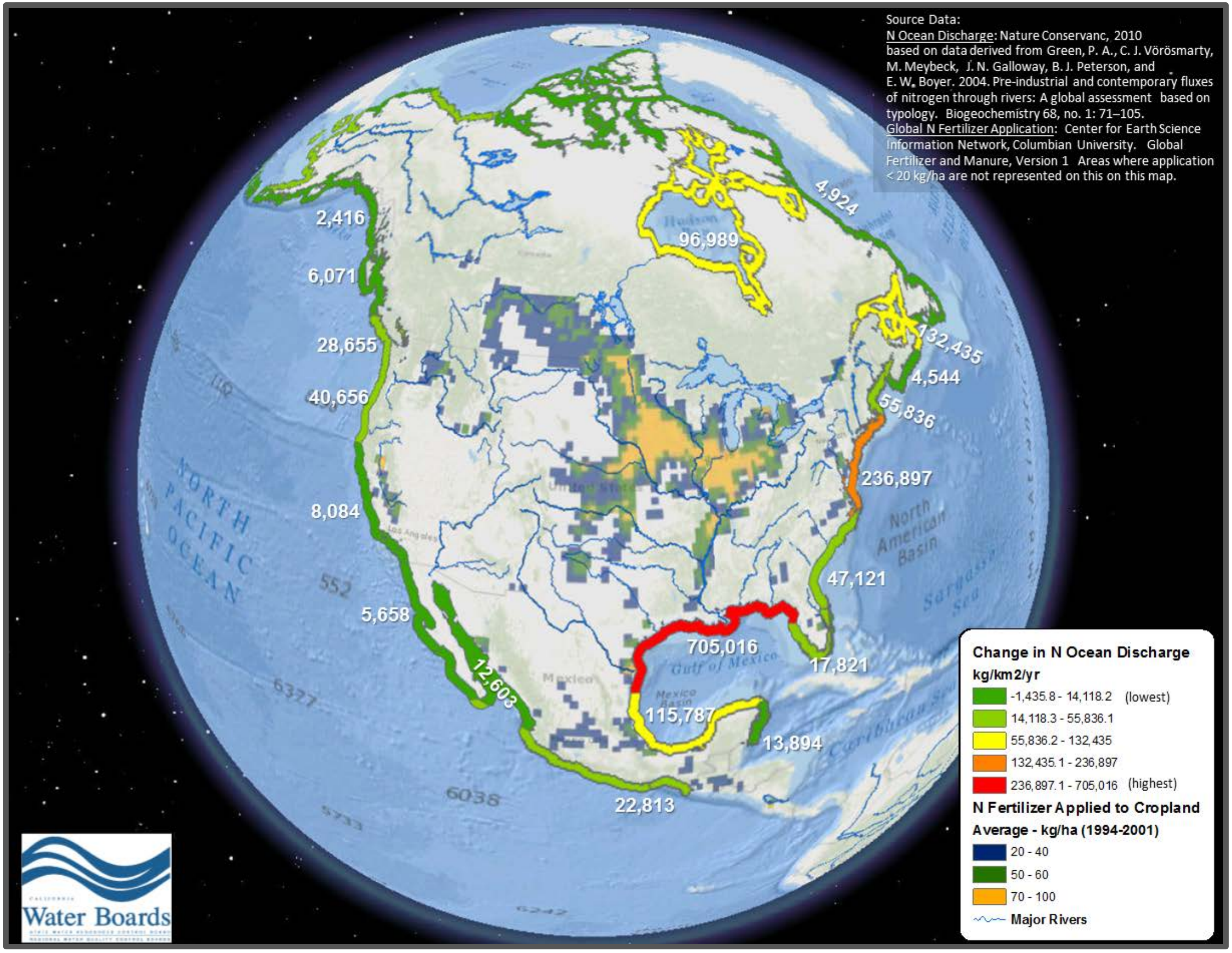
[101] U.S. Environmental Protection Agency: Memorandum from Acting Assistant Administrator Nancy K. Stoner. March 16, 2011. Subject: "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions".

[102] "Dead zones" are a common symptom of nutrient pollution. According to Dr. Bob Diaz of the Virginia Institute of Marine Science, the number of "dead zones"—areas of seafloor with too little oxygen for most marine life—has increased by a third between 1995 and 2007. Dead zones are now a key stressor of marine ecosystems and rank with over-fishing, habitat loss, and harmful algal blooms as global environmental problems. See http://www.vims.edu/research/topics/dead_zones/

Figure 3-79. Globe view showing 1) estimated increase in discharges of nitrogen to coastal waters between pre-industrial times and contemporary times by marine ecoregion (units = kg nitrogen/km^2/year); and 2) estimated nitrogen fertilizer applied to cropland (where application >20 kg/ha), by grid cell (years 1994-2001, units = kg/ha).



Source Data:
N Ocean Discharge: Nature Conservanc, 2010 based on data derived from Green, P. A., C. J. Vörösmarty, M. Meybeck, J. N. Galloway, B. J. Peterson, and E. W. Boyer. 2004. Pre-industrial and contemporary fluxes of nitrogen through rivers: A global assessment based on typology. Biogeochemistry 68, no. 1: 71–105.
Global N Fertilizer Application: Center for Earth Science Information Network, Columbian University. Global Fertilizer and Manure, Version 1 Areas where application < 20 kg/ha are not represented on this on this map.

While California offshore coastal waters – at marine ecoregional scales – are generally in relatively good condition with respect to nutrient pollution, at more localized scales researchers have reported a number of problems in some near-shore coastal areas in the Monterey Bay National Marine Sanctuary. Some of these near shore coastal areas are characterized by elevated levels of nitrates, sediment, pesticides, and fecal bacteria which originate, in part, from freshwater sources such as runoff and inland streams of Monterey Bay watersheds (Monterey Bay National Marine Estuary–Sanctuary Integrated Monitoring Network website, accessed March, 2014). In addition, Lane et al. (2009) provided evidence that algal blooms in Monterey Bay may periodically result from sources of nitrogen associated with Pajaro River discharges. It should be noted however, that algal blooms in Monterey Bay may also be periodically caused by ocean basin upwelling processes which are unrelated to human activities.

Chlorophyll-a is a water quality parameter that is a proxy for measuring biomass and algae. Spatial data compiled and reported by the Goddard Space Flight Center and the Center for International Earth Science Information Network - CIESIN - Columbia University[103] illustrate trends of chlorophyll-a

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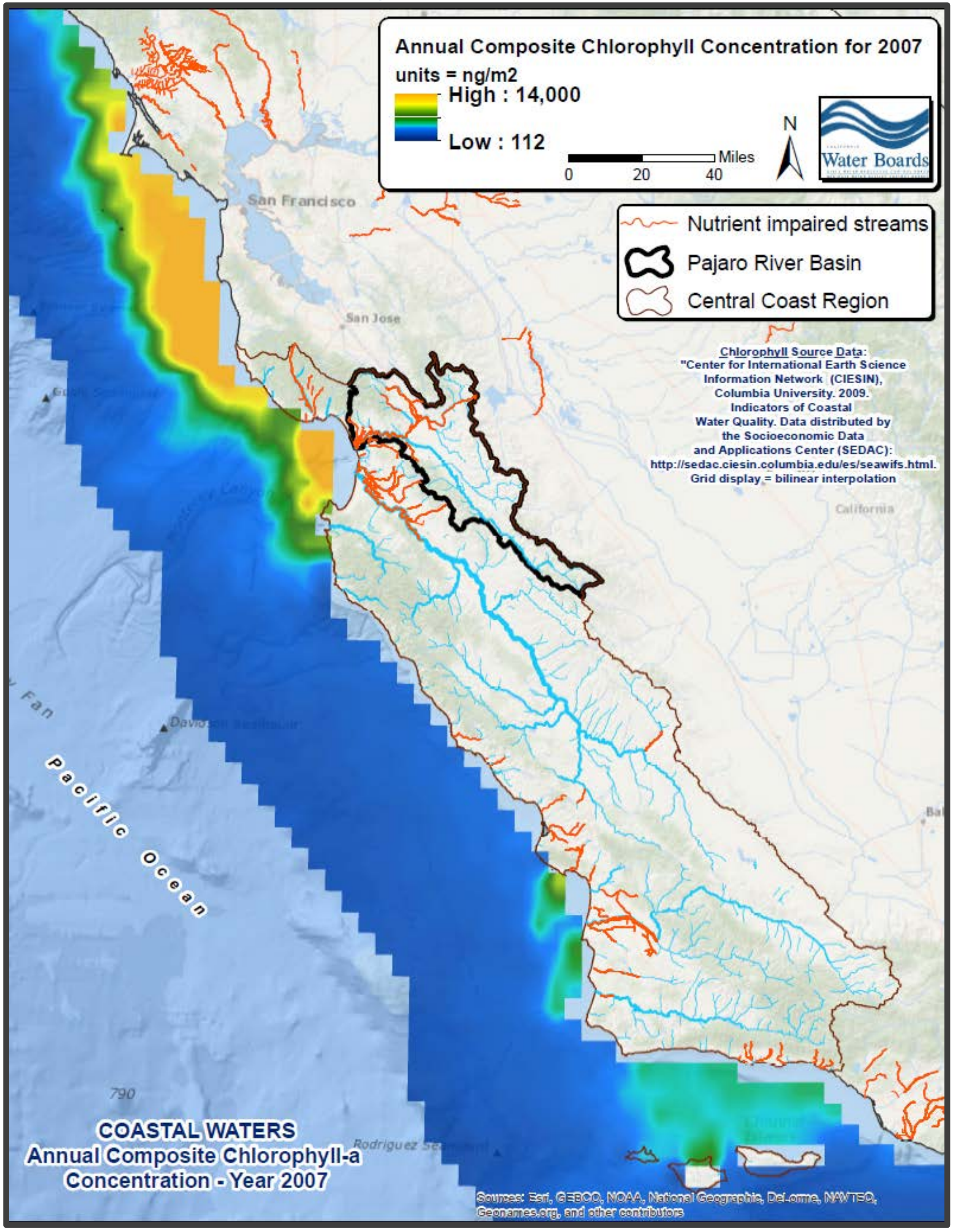
[103] Goddard Space Flight Center - GSFC, and Center for International Earth Science Information Network - CIESIN - Columbia University. 2009. Indicators of Coastal Water Quality: Change in Chlorophyll-a Concentration 1998-2007. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://sedac.ciesin.columbia.edu/data/set/icwq-change-in-chlorophyll-a-concentration-1998-2007.

concentrations on a pixel-by-pixel basis. Annual composite chlorophyll-a concentrations in California central coastal waters for 2007 are shown in Figure 3-80. Trends in changing concentrations from 1999-2007 are shown in Figure 3-81; these data suggest statistically significant increases in chlorophyll-a concentrations from 1998-2007 locally in coastal waters of Monterey Bay and in the southern California coastal waters. It is important to recognize that statistical significance is a measure of the association between two variables, but does not prove causation. Chlorophyll-*a* concentration can be related to many factors besides nutrient loads; for example, the extent and persistence of cloud cover and solar radiation, or ocean upwelling processes which are not anthropogenic in nature.

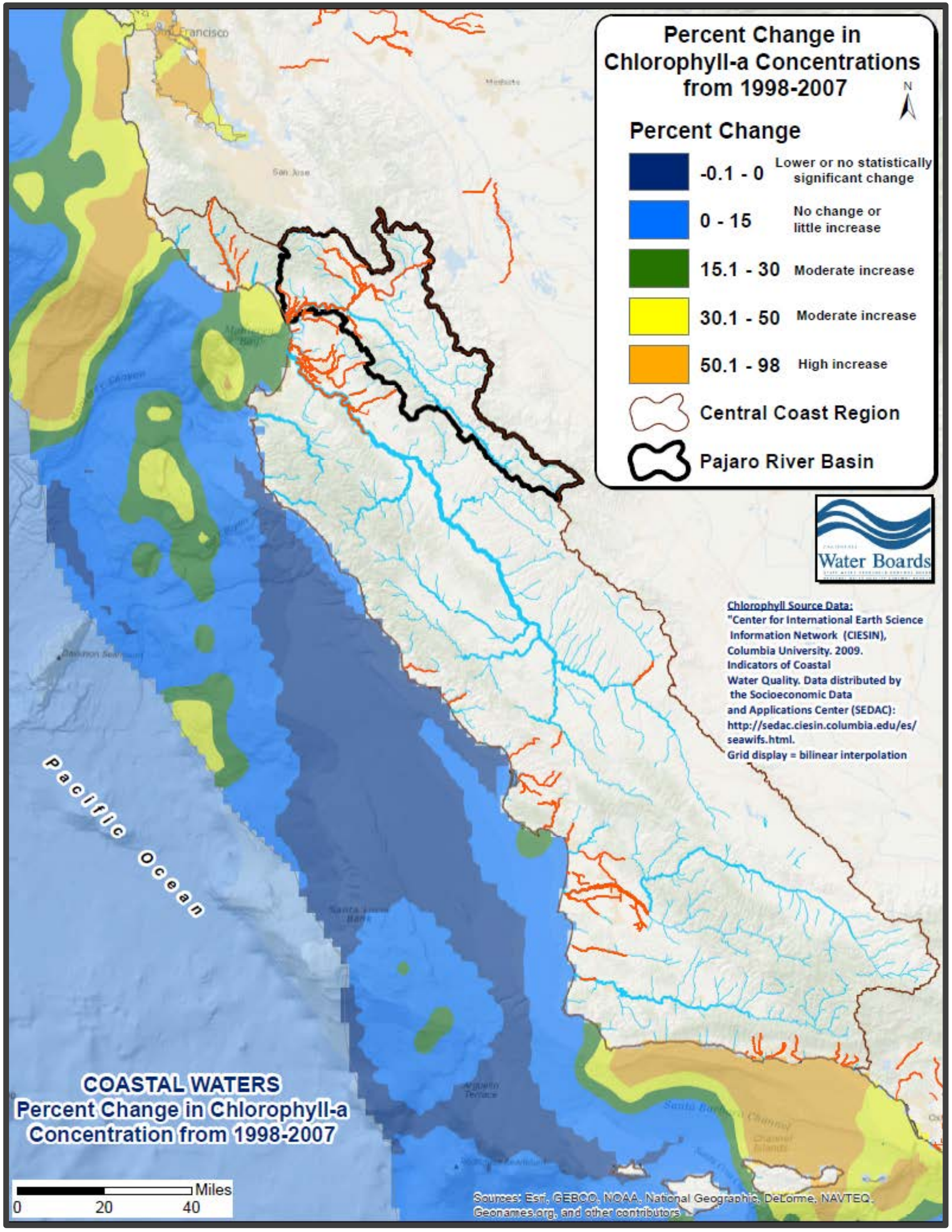
Figure 3-80. Map illustrating estimated annual composite chlorophyll-a concetrations for the year 2007, in the California central coast region.



Chlorophyll Source Data:
"Center for International Earth Science Information Network (CIESIN), Columbia University. 2009. Indicators of Coastal Water Quality. Data distributed by the Socioeconomic Data and Applications Center (SEDAC): http://sedac.ciesin.columbia.edu/es/seawifs.html.
Grid display = bilinear interpolation

Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and other contributors

Figure 3-81. Map highlighing coastal waters characterized by statistically significant change (% increase) in chlorophyll-a concentrations (green-yellow-orange shades), and coastal waters characterized by no statistically significant increases or little change (blue shades) between 1998 and 2007, California central coast region.



In summary, due to reported river-based nutrient related water quality impacts in near-shore coastal areas of Monterey Bay, due to the administrative designations of the Pajaro River Estuary and Watsonville Slough as Critical Coastal Areas (CCAs), and due to reported nutrient-related adverse impacts to the threatened southern sea otter originating from the Pajaro River basin, this TMDL does consider and take into account biostimulatory impairments and downstream impacts to receiving coastal marine and estuarine waters.

4 WATER QUALITY STANDARDS

TMDLs are requirements pursuant to the federal Clean Water Act. The broad objective of the federal Clean Water Act is to "restore and maintain the chemical, physical and biological integrity of the Nation's waters[104]." Water quality standards are provisions of state and federal law intended to implement the federal Clean Water Act. In accordance with state and federal law, California's water quality standards consist of:

- Beneficial uses, which refer to legally-designated uses of waters of the state that may be protected against water quality degradation (e.g., drinking water supply, recreation, aquatic habitat, agricultural supply, etc.)
- Water quality objectives, which refer to limits or levels (numeric or narrative) of water quality constituents or characteristics that provide for the reasonable protection of beneficial uses of waters of the state.
- Anti-degradation policies, which are implemented to maintain and protect existing water quality, and high quality waters.

Therefore, beneficial uses, water quality objectives, and anti-degradation policies collectively constitute water quality standards[105]. Beneficial uses, relevant water quality objectives, and anti-degradation requirements that pertain to this TMDL are presented below in Section 4.1, Section 4.2, and Section 4.3 respectively. For a detailed discussion of anti-degradation policies, please refer to Section 9.2.3.

4.1 Beneficial Uses

California's water quality standards designate beneficial uses for each waterbody (e.g., drinking water supply, aquatic life support, recreation, etc.) and the scientific criteria to support that use. The California Central Coast Water Board is required under both State and Federal Law to protect and regulate beneficial uses of waters of the state.

The Basin Plan identifies beneficial uses for waterbodies of California's central coast region. Beneficial uses for surface waters in the Pajaro River basin are presented in Table 4-1. The Basin Plan also states that surface water bodies within the region that do not have beneficial uses specifically designated for them are assigned the beneficial uses of "municipal and domestic water supply" and "protection of both recreation and aquatic life." The Central Coast Water Board has interpreted this general statement of beneficial uses to encompass the beneficial uses of REC-1, REC-2, and MUN, along with all beneficial uses associated with aquatic life. The finding comports with the Clean Water Act's national interim goal of water quality [CWA Section 101(a)(2)] which provides for the protection and propagation of fish, shellfish and wildlife. As such, consistent with the Basin Plan the Central Coast Water Board has interpreted "aquatic life" as WARM, COLD, and SPWN for the 2008 impaired waterbody Clean Water Act 303(d) list. It should be noted that the COLD beneficial use may not be appropriate for all inland waterbodies which are not currently listed in the Basin Plan's Table 2-1. However, staff does not have the authority to unilaterally designate or de-designate beneficial uses within the context of a permit or in a project report. The State Water Resources Control Board (State Water Board) has indeed upheld that a basin plan amendment is the appropriate vehicle to de-designate beneficial uses(s) on a case-by-case basis (see for example, State Water Board, Order WQO 2002-0015). The Central Coast Water Board could in the future conclude on a case-by-case basis that (for example) the COLD beneficial use does not apply to specific stream reaches that are not currently listed in Basin Plan Table 2-1 if stakeholders, resource professionals, and/or staff present evidence that the uses do not exist and are highly-improbable. Alternatively, changes to beneficial uses designations in the Basin Plan can occur during the triennial Basin Plan review process; stakeholders, interested parties, and the general public may participate and submit data for the triennial review.

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[104] Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.) Title 1, Section 101(a)
[105] See 40 CFR Ch. 1 §131

Table 4-1. Central Coastal Basin Plan (June 2011 edition) designated beneficial uses for Pajaro River basin surface water bodies.

Waterbody Names	MUN	AGR	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	COMM	SHELL
Corralitos Lagoon					X	X	X	X									X	
Palm Beach Pond	X				X	X	X		X				X				X	
Pinto Lake	X	X		X	X	X	X		X		X						X	
Kelley Lake	X	X		X	X	X	X		X		X						X	
Drew Lake	X	X		X	X	X	X		X		X						X	
Tynan Lake	X	X		X	X	X	X		X		X						X	
Warner Lake	X	X		X		X	X										X	
Pajaro River Estuary					X	X	X	X	X	X	X	X	X	X			X	X
Pajaro River	X	X	X	X	X	X	X	X	X	X	X				X		X	
San Benito River	X	X	X	X	X	X	X		X		X				X		X	
Bird Creek	X	X		X	X	X	X		X			X					X	
Pescadero Creek (S. Benito)	X	X		X	X	X	X	X	X	X	X						X	
Tres Pinos Creek	X	X	X	X	X	X	X		X		X						X	
Hernandez Reservoir	X	X		X	X	X	X		X		X				X	X	X	
Tequisquita Slough				X	X	X	X		X		X						X	
San Felipe Lake	X	X		X	X	X	X	X	X	X					X	X	X	
Pacheco Creek	X	X		X	X	X	X	X	X	X	X	X	X		X		X	
Pacheco Lake	X	X		X	X	X	X	X	X		X		X		X	X	X	
Llagas Creek (above Chesbro Res.)	X	X		X	X	X	X	X	X				X		X		X	
Chesbro Reservoir	X	X		X	X	X	X		X	X	X		X		X	X	X	
Llagas Creek (below Chesbro Res.)	X	X	X	X	X	X	X	X	X	X	X		X				X	
Alamias Creek	X	X		X	X	X	X	X	X	X	X						X	
Live Oak Creek	X	X		X	X	X	X	X	X	X							X	
Little Llagas Creek	X	X		X	X	X	X		X								X	
Carnadero Creek	X			X	X	X	X	X	X	X			X				X	
Uvas Creek, downstream	X	X	X	X	X	X	X	X	X	X	X		X				X	
Uvas Res.	X	X		X	X	X	X		X		X		X		X	X	X	
Little Arthur Creek	X	X		X	X	X	X	X	X	X	X						X	
Bodfish Creek	X	X		X	X	X	X	X	X	X	X		X				X	
Black Hawk Canyon Creek	X				X	X	X		X	X	X		X				X	
Uvas Creek, upstream	X			X	X	X	X	X		X	X		X		X		X	
Little Uvas Creek	X	X		X	X	X	X		X								X	
Swanson Canyon Creek	X			X	X	X	X										X	
Alec Canyon Creek	X			X	X	X	X	X		X	X						X	
Croy Creek	X			X	X	X	X		X				X				X	
Eastman Canyon Creek	X	X		X	X	X	X		X								X	
Pescadero Creek	X	X		X	X	X	X	X		X	X	X					X	
Soda Lake						X	X		X				X				X	
Salsipuedes Creek	X	X		X	X	X	X	X		X	X						X	
Corralitos Creek	X	X	X	X	X	X	X	X	X	X	X						X	

Waterbody Names	MUN	AGR	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	NAV	COMM	SHELL
Browns Creek	X	X	X	X	X	X	X	X	X	X	X						X	
Gamecock Creek	X			X	X	X	X	X		X	X						X	
Ramsey Gulch	X			X	X	X	X	X		X	X						X	
Redwood Creek	X				X	X	X	X		X	X						X	
Mormon Gulch	X			X	X	X	X	X									X	
Clipper Gulch	X			X	X	X	X	X									X	
Cookhouse Gulch	X			X	X	X	X	X									X	
Shingle Mill Gulch	X			X	X	X	X	X		X	X						X	
Rattlesnake Gulch	X			X	X	X	X	X									X	
Diablo Gulch Creek	X			X	X	X	X	X									X	
Eureka Gulch	X			X	X	X	X	X									X	
Rider Gulch Creek	X			X	X	X	X	X		X	X						X	
Watsonville Slough					X	X	X		X		X	X	X	X			X	
Struve Slough					X	X	X		X		X	X	X	X			X	
Hanson Slough					X	X	X		X		X	X	X	X			X	
Harkins Slough					X	X	X		X		X	X	X	X			X	
Galligan Slough					X	X	X		X		X		X	X			X	

MUN: Municipal and domestic water supply.
AGR: Agricultural supply.
IND: Industrial service supply
GWR: Ground water recharge.
REC1: Water contact recreation.
REC2: Non-Contact water recreation.
WILD: Wildlife habitat.
COLD: Cold Fresh water habitat
WARM: Warm fresh water habitat
MIGR: Migration of aquatic organisms.
SPWN: Spawning, reproduction, and/or early development
BIOL: Preservation of biological habitats of special significance.
RARE: Rare, threatened, or endangered species
EST: Estuarine habitat
FRESH: Freshwater replenishment.
COMM: Commercial and sport fishing.
SHELL: Shellfish harvesting..

A narrative description of the designated beneficial uses of Pajaro River basin surface waters which are most likely to be potentially at risk of impairment by water column nutrients are presented below.

4.1.1 Municipal & Domestic Water Supply (MUN)

> *Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply. According to State Board Resolution No. 88- 63, "Sources of Drinking Water Policy" all surface waters are considered suitable, or potentially suitable, for municipal or domestic water supply except under certain conditions (see Basin Plan, Chapter 2, Section II.)*

The nitrate numeric water quality objective protective of the MUN beneficial use is legally established as 10 mg/L[106] nitrate as nitrogen (see Basin Plan, Table 3-2). This level is established to protect public health (refer back to Section 0 for a description of health risks related to nitrate).

4.1.2 Ground Water Recharge (GWR)

> *Uses of water for natural or artificial recharge of ground water for purposes of future extraction, **maintenance of water quality**, or halting of saltwater intrusion into freshwater aquifers. Ground water recharge includes recharge of surface water underflow (emphasis added) - (see Basin Plan, Chapter 2, Section II).*

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[106] This value is equivalent to, and may be expressed as, 45 mg/L nitrate as NO3.

The groundwater recharge (GWR) beneficial use is recognition by the state of the fundamental nature of the hydrologic cycle, and that surface waters and ground water are not closed systems that act independently from each other. Underlying groundwaters are, in effect, receiving waters for stream waters that infiltrate and recharge the subsurface water resource. Most surface waters and ground waters of the central coast region are both designated with the MUN (drinking water) and AGR (agricultural supply) beneficial uses. The MUN nitrate water quality objective (10 mg/L) therefore applies to *both* the stream waters, and to the underlying groundwater. This numeric water quality objective and the MUN and AGR designations of underlying groundwater are relevant to the extent that portions of Pajaro River basin streams recharge the underlying groundwater resource.

The Basin Plan GWR beneficial use explicitly states that the designated groundwater recharge use of surface waters are to be protected to maintain groundwater quality. Note that surface waters and ground waters are often in direct or indirect hydrologic communication. As such, where necessary, the GWR beneficial uses of the surface waters need to be protected so as to support and maintain the MUN or AGR beneficial use of the underlying ground water resource. Indeed, protection of the groundwater recharge beneficial use of surface waters has been recognized in State Water Board–approved California TMDLs[107]. The U.S. Environmental Protection Agency also recognizes the appropriateness of protecting designated groundwater recharge beneficial uses in the context of California TMDLs (USEPA 2002, USEPA 2003). The Basin Plan does not specifically identify numeric water quality objectives to implement the GWR beneficial use, however a situation-specific weight of evidence approach can be used to assess if GWR is being supported, consistent with Section 3.11 of the California Listing Policy (State Water Board, 2004). Section 5.10 of this project report presents data, lines of evidence, and assessments regarding whether or not designated GWR beneficial uses are currently being supported in streams of the Pajaro River basin.

4.1.3 Agricultural Supply (AGR)

> *Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing (see Basin Plan, Chapter 2, Section II).*

In accordance with the Basin Plan, interpretation of the amount of nitrate which adversely effects the agricultural supply beneficial use of waters of the State shall be derived from the University of California Agricultural Extension Service guidelines, which are found in Basin Plan Table 3-3. Accordingly, severe problems for sensitive crops could occur for irrigation water exceeding 30 mg/L[108]. It should be noted that the University of California Agricultural Extension Service guideline values are flexible, and may not necessarily be appropriate due to local conditions or special conditions of crop, soil, and method of irrigation.

High concentrations of nitrates in irrigation water can potentially create problems for sensitive crops (e.g., grapes, avocado, citrus, sugar beets, apricots, almonds, cotton) by detrimentally impacting crop yield or quality. Nitrogen in the irrigation water acts the same as fertilizer nitrogen and excesses may cause problems just as fertilizer excesses cause problems[109]. For example, according to Ayers and Westcot

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[107] For example, RWQCB-Los Angeles Region, Calluguas Creek Nitrogen Compounds TMDL, 2002. Resolution No. 02-017, and approved by the California Office of Administrative Law, OAL File No. 03-0519-02 SR; and RWQCB-Central Coast Region, TMDLs for Nitrogen Compounds and Orthophosphate in the Lower Salinas River and Reclamation Canal Basin and the Moro Cojo Slough Subwatershed, Resolution No. R3-2013-0008 and approved by the California Office of Administrative Law, OAL File No. 2014-0325-01S.

[108] The University of California Agricultural Extension Service guideline values are flexible, and may not necessarily be appropriate due to local conditions or special conditions of crop, soil, and method of irrigation. 30 mg/L nitrate-N is the recommended uppermost threshold concentration for nitrate in irrigation supply water as identified by the University of Californnia Agricultural Extension Service which potentially cause severe problems for sensitive crops (see Table 3-3 in the Basin Plan). Selecting the least stringent threshold (30 mg/L) therefore conservatively identifies exceedances which could detrimentally impact the AGR beneficial uses for irrigation water.

[109] 1 mg/L nitrate-N in irrigation water = 2.72 pounds of nitrogen per acre foot of applied water.

(1985)[110] grapes are sensitive to high nitrate in irrigation water and may continue to grow late into the season at the expense of fruit production; yields are often reduced and grapes may be late in maturing and have a lower sugar content. Maturity of fruit such as apricot, citrus and avocado may also be delayed and the fruit may be poorer in quality, thus affecting the marketability and storage life. Excessive nitrogen can also trigger and favor the production of green tissue (leaves) over vegetative tissue in sensitive crops. In many grain crops, excess nitrogen may promote excessive vegetative growth producing weak stalks that cannot support the grain weight. According to the *Draft Conclusions of the Agricultural Expert Panel* (State Water Board, 2014), the yield and quality of cotton and almonds will suffer from excess nitrogen. These problems can usually be overcome by good fertilizer and irrigation management. However, regardless of the type of crop many resource professionals recommend that nitrate in the irrigation water should be credited toward the fertilizer rate[111] especially when the concentration exceeds 10 mg/L nitrate as N[112]. Should this be ignored, the resulting excess input of nitrogen could cause problems such as excessive vegetative growth and contamination of groundwater[113]. It should be noted that irrigation water that is high in nitrate does not necessarily mean that in contains enough nitrate to eliminate the need for additional nitrogen fertilizer; however, the grower may be able to reduce and replace the amount of fertilizer normally applied with the nitrate present in the irrigation water[114].

Further, the Basin Plan provides water quality objectives for nitrate which are protective of the AGR beneficial uses for livestock watering. While nitrate (NO_3) itself is relatively non-toxic to livestock, ingested nitrate is broken down to nitrite (NO_2); subsequently nitrite enters the bloodstream where it converts blood hemoglobin to methemoglobin. This greatly reduces the oxygen-carrying capacity of the blood, and the animal suffers from oxygen starvation of the tissues[115]. Death can occur when blood hemoglobin has fallen to one-third normal levels. Resource professionals[116] report that nitrate can reach dangerous levels for livestock in streams, ponds, or shallow wells that collect drainage from highly fertilized fields. Accordingly, the Basin Plan identifies the safe threshold of nitrate as N for purposes of livestock watering at 100 mg/L[117].

Also noteworthy is that the AGR beneficial use of surface water not only applies to a number of stream reaches in the Pajaro River basin, but also apply to the groundwater resources underlying those stream reaches. The groundwater in some of these reaches is recharged by stream infiltration. Therefore, the groundwater recharge (GWR) beneficial use of stream reaches provides the nexus between protection of designated AGR beneficial uses of both the surface waters and the underlying groundwater resource (refer back to Section 4.1.2).

4.1.4 Aquatic Habitat (WARM, COLD, MIGR, SPWN, WILD, BIOL, RARE, EST)

> *WARM: Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.*

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[110] R.S. Ayers (Soil and Water Specialist, University of California-Davis) and D.W. Westcot (Senior Land and Water Resources Specialist – California Central Valley Regional Water Quality Control Board) published in UN-FAO Irrigation and Drainage Paper 29 Rev.1

[111] Crediting of irrigation source-water nitrogen may not be a 1:1 relationship as some irrigation water may not be retained entirely within the cropped area.

[112] Colorado State University Extension - Irrigation Water Quality Criteria. Authors: T.A. Bauder, Colorado State University Extension water quality specialist; R.M. Waskom, director, Colorado Water Institute; P.L. Sutherland, USDA/NRCS area resource conservationist; and J.G. Davis, Extension soils specialist and professor, soil and crop sciences

[113] University of California-Davis, Farm Water Quality Planning Reference Sheet 9.10. Publication 8066. Author: S. R. Grattan, Plant-Water Relations Specialist, UC-Davis.

[114] Monterey County Water Resources Agency – Santa Clara Valley Water District, Fact Sheet 4. *Using the Nitrate Present in Soil and Water in Your Fertilizer Calculations.*

[115] New Mexico State University, Cooperative Extension Service. Nitrate Poisoning of Livestock. Guide B-807.

[116] University of Arkansas, Division of Agriculture - Cooperative Extension. “Nitrate Poisoning in Cattle”. Publication FSA3024.

[117] 100 mg/L nitrate-N is the Basin Plan’s water quality objective protective of livestock watering, and is based on National Academy of Sciences-National Academy of Engineering guidelines (see Table 3-3 in the Basin Plan).

> *COLD: Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.*
>
> *MIGR: Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.*
>
> *SPWN: Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.*
>
> *WILD: Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.*
>
> *BIOL: Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.*
>
> *RARE: Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.*
>
> *EST: Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds). An estuary is generally described as a semi-enclosed body of water having a free connection with the open sea, at least part of the year and within which the seawater is diluted at least seasonally with fresh water drained from the land. Included are water bodies which would naturally fit the definition if not controlled by tidegates or other such devices.*

The Basin Plan water quality objectives protective of aquatic habitat beneficial uses and which are most relevant to nutrient pollution[118] is the biostimulatory substances objective and dissolved oxygen objectives for aquatic habitat. The biostimulatory substances objective is a narrative water quality objective that states "*Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses*."

The Basin Plan also requires that in waterbodies designated for WARM habitat dissolved oxygen concentrations shall not be depressed below 5 mg/L and that in waterbodies designated for COLD and SPWN dissolved oxygen shall not be depressed below 7 mg/L. Further, since unionized ammonia is highly toxic to aquatic species, the Basin Plan requires that the discharge of waste shall not cause concentrations of unionized ammonia (NH3) to exceed 0.025 mg/L (as N) in receiving waters.

4.1.5 Water Contact Recreation (REC-1)

> *REC-1: Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs. (see Basin Plan, Chapter 2, Section II).*

The Basin Plan water quality objective protective of water contact recreation beneficial uses and which is most relevant to nutrient pollution is the general toxicity objective for all inland surface water, enclosed bays, and estuaries (Basin Plan Chapter 3, section II.A.2.a). The general toxicity objective is a narrative water quality objective that states:

"All waters shall be maintained free of toxic substances in concentrations which are toxic to, or which produce detrimental physiological responses in, human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, toxicity bioassays of appropriate duration, or other appropriate methods as specified by the Regional Board."

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[118] Nutrients, such as nitrate, do not by themselves necessarily directly impair aquatic habitat beneficial uses. Rather, they cause indirect impacts by promoting algal growth and low dissolved oxygen that impair aquatic habitat uses.

Because illnesses are considered detrimental physiological responses in humans, the narrative toxicity objective applies to algal toxins. Possible health effects of exposure to blue-green algae blooms and their toxins can include rashes, skin and eye irritation, allergic reactions, gastrointestinal upset, and other effects including poisoning (refer back to Section 2.2) Note that microcystins are toxins produced by cyanobacteria (blue-green algae) and are associated with algal blooms, elevated nutrients, and biostimulation in surface waterbodies. The State of California Office of Environmental Health Hazard Assessment (OEHHA) has published peer-reviewed public health action-level guidelines for algal cyanotoxins (microcystins) in recreational water uses; this public health action-level for microcystins is 0.8 μg/L[119] (OEHHA, 2012). This public health action level can therefore be used to assess attainment or non-attainment of the Basin Plan's general toxicity objective and to ensure that REC-1 designated beneficial uses are being protected and supported.

The Pajaro River in modern times has not typically been thought of in terms of water recreation, however, citizens and local agencies have been working to preserve the riparian habitat of the Pajaro River and enhance opportunities for kayaking and canoeing. Kayaking and canoeing are types of REC-1 (water contact) recreation, thus highlighting the importance of minimizing nuisance algae blooms and minimizing the current or future risk of algal cyanobacteria toxins. An example of some recreational and boating opportunities on the Pajaro River is articulated by the City of Watsonville Department of Public Works below:

> ***The Pajaro River Community Access and Recreation Project***
>
> *This project located behind the Water Resources Center at 500 Clearwater Lane, Watsonville has created new walking and boating opportunities along the Pajaro River. The Pajaro River is a great place to explore the natural beauty of our valley. Whether you want to go for a leisurely stroll, take a jog away from the busy streets or go for a bike ride, the trail offers incredible views and peace and quiet. This project also includes a river access point that allows visitors to get to the river for wildlife viewing and a kayak and canoe river entry for those folks that want to explore the river from the water. After you launch your kayak or canoe, if you paddle east several hundred yards you will end at the highway one bridge, if you paddle west about 3.5 miles, it will take you to the mouth of the Pajaro River that flows into the Monterey Bay.*
>
> *The Pajaro River is a rich riparian corridor that is home to a variety of plants and animals. It is home to trout, different species of frogs and western pond turtles. The river is lined by mostly cottonwood, alder and willow which provide critical habitat for small mammals such a brush rabbit, fox squirrels and hundreds of different types of birds.*
>
> *Some of the bird species you might see when visiting this area are the Red tailed hawk, red shouldered hawk, double crested cormorants, great blue heron, and great egret. There are also huge populations of song birds that flock to the riparian vegetation for food, shelter and nesting. Birds like warblers, sparrows, woodpeckers, and flycatchers just to name a few will also be found here.*
>
> *From: City of Watsonville Public Works* http://cityofwatsonville.org/public-works-utilities/projects/projects/pajaro-river-care-project

4.2 Water Quality Objectives & Criteria

The Basin Plan contains specific water quality objectives that apply to nutrients and nutrient-related parameters. In addition, the Central Coast Water Board uses established, scientifically-defensible numeric criteria to implement narrative water quality objectives, and for use in Clean Water Act Section 303(d) Listing assessments. These water quality objectives and numeric criteria are established to protect beneficial uses and are compiled in Table 4-2.

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[119] Includes microcystins LR, RR, YR, and LA.

4.3 Anti-degradation Policy

In accordance with Section II.A of the Basin Plan, wherever the existing quality of water is better than the quality of water established in the Basin Plan as objectives, **such existing quality shall be maintained** unless otherwise provided by provisions of the state anti-degradation policy. Practically speaking, this means that where water quality is *better* than necessary to support designated beneficial uses, such existing high water quality shall be maintained and further lowering of water quality is not allowed except under conditions provided for in the anti-degradation policy. See report section 9.2.3 for a full description of anti-degradation requirements.

The U.S. Environmental Protection Agency has also issued detailed guidelines for implementation of federal anti-degradation regulations for surface waters (40 CFR 131.12). The State Water Resources Control Board has interpreted Resolution No. 68-16 (i.e., the state anti-degradation policy) to incorporate the federal anti-degradation policy to ensure consistency. It is important to note that federal policy only applies to surface waters, while state policy applies to both surface and ground waters.

Indeed, the U.S. Environmental Protection Agency recognizes the validity of using TMDLs as a tool for implementing anti-degradation goals:

> *"Identifying opportunities to protect waters that are not yet impaired: TMDLs are typically written for restoring impaired waters; however, states can prepare TMDLs geared towards maintaining a "better than water quality standard" condition for a given waterbody-pollutant combination, and they can be a useful tool for high quality waters."*
>
> From: USEPA, 2014a. Opportunities to Protect Drinking Water Sources and Advance Watershed Goals Through the Clean Water Act: A Toolkit for State, Interstate, Tribal and Federal Water Program Managers. November 2014.

Table 4-2. Compilation of Basin Plan water quality objectives and numeric criteria for nutrients and nutrient-related parameters.

Constituent Parameter	Source of Water Quality Objective/Criteria	Numeric Target	Primary Use Protected
Unionized Ammonia as N	Basin Plan numeric objective	0.025 mg/L	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries *(toxicity objective)*
Nitrate as N	Basin Plan numeric objective	10 mg/L	MUN, GWR (Municipal/Domestic Supply; Groundwater Recharge)
Nitrate as N	Basin Plan numeric criteria (Table 3-3 in Basin Plan)	5 – 30 mg/L *California Agricultural Extension Service guidelines*	AGR (Agricultural Supply – irrigation water) *“Severe” problems for sensitive crops at greater than 30 mg/L* *“Increasing problems” for sensitive crops at 5 to 30 mg/L*
Nitrate (NO3-N) plus Nitrite (NO2-N)	Basin Plan numeric objective (Table 3-4 in Basin Plan)	100 mg/L *National Academy of Sciences-National Academy of Engineers guidelines*	AGR (Agricultural Supply - livestock watering)
Nitrite (NO2–N)	Basin Plan numeric objective (Table 3-4 in Basin Plan)	10 mg/L *National Academy of Sciences-National Academy of Engineers guidelines*	AGR (Agricultural Supply - livestock watering)
Dissolved Oxygen	General Inland Surface Waters numeric objectives	For waters not mentioned by a specific beneficial use, dissolved oxygen shall not be depressed below 5.0 mg/L Median values should not fall below 85% saturation.	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries.
	Basin Plan numeric objective WARM, COLD, SPWN	Dissolved Oxygen shall not be depressed below 5.0 mg/L (WARM) Dissolved Oxygen shall not be depressed below 7.0 mg/L (COLD, SPWN)	Cold Freshwater Habitat, Warm Freshwater Habitat, Fish Spawning
	Basin Plan numeric objective AGR	Dissolved Oxygen shall not be depressed below 2.0 mg/L	AGR (Agricultural Supply)
pH	General Inland Surface Waters numeric objective	pH value shall not be depressed below 7.0 or raised above 8.5.	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries.
	Basin Plan numeric objective MUN, AGR, REC1, REC-2	The pH value shall neither be depressed below 6.5 nor raised above 8.3.	Municipal/Domestic Supply, Agricultural Supply, Water Recreation
	Basin Plan numeric objective WARM, COLD	pH value shall not be depressed below 7.0 or raised above 8.5	Cold Freshwater Habitat, Warm freshwater habitat
Biostimulatory Substances	Basin Plan narrative objective[A]	see report Section 6.3	General Objective for all Inland Surface Waters, Enclosed Bays, and Estuaries *(biostimulatory substances objective)* -- (e.g., WARM, COLD, REC, WILD, EST)
Chlorophyll *a*	Basin Plan narrative objective[A]	40 µg/L *Source: North Carolina Administrative Code, Title 151, Subchapter 2B, Rule 0211*	Numeric listing criteria to implement the Basin Plan biostimulatory substances objective for purposes of Clean Water Act Section 303(d) Listing assessments.
Microcystins *(includes Microcytins LA, LR, RR, and YR)*	Basin Plan narrative objective[B]	0.8 µg/L *Calif. Office of Environmental Health Hazard Assessment Suggested Public Health Action Level*	REC-1 (water contact recreation)

[A] The Basin Plan biostimulatory substances narrative objective states: “Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.” (Biostimulatory Substances Objective, Basin Plan, Chapter 3)

[B] The Basin Plan toxicity narrative objective states: “All waters shall be maintained free of toxic substances in concentrations which are toxic to, or which produce detrimental physiological responses in, human, plant, animal, or aquatic life..” (Toxicity Objective, Basin Plan, Chapter 3)

4.4 California Clean Water Act Section 303(d) Listing Policy

Water quality standards, such as those discussed previously, play a central role in federally-mandated statewide assessments of impaired waterbodies. The Central Coast Water Board assesses water quality monitoring data for surface waters every two years to determine if they contain pollutants at levels that exceed water quality standards. In accordance with the Water Quality Control Policy for developing California's Clean Water Act (CWA) Section 303(d) List (State Water Board, 2004) – hereafter referred to as the California Listing Policy – water body and pollutants that exceed water quality standards are placed on the State's 303(d) List of impaired waters. The California Listing Policy also defines the minimum number of measured exceedances needed to place a water segment on the 303(d) list for toxicants (Listing Policy, Table 3.1) and for conventional or other pollutants (California Listing Policy, Table 3.2). The minimum number of measured exceedances for toxicants is displayed in Table 4-3 and for conventional and other pollutants in Table 4-4.

With regard to the water quality constituents addressed in this TMDL, it is important to note that nitrate and unionized ammonia are considered toxicants[120] in accordance with the California Listing Policy, while low dissolved oxygen, chlorophyll *a* and pH, are conventional pollutants. Thus, impairments by nitrate and unionized ammonia are assessed on the basis of Table 4-3, while impairments by dissolved oxygen and chlorophyll a are assessed on the basis of Table 4-4.

Table 4-3. . Minimum number of measured exceedances needed to place a water segment on the 303(d) list for toxicants.

Sample Size	Number of Exceedances needed to assert impairment
2 – 24	2
25 – 36	3
37 – 47	4
48 – 59	5
60 – 71	6
72 – 82	7
83 – 94	8
95 – 106	9
107 – 117	10
118 – 129	11
For sample sizes greater than 129, the minimum number of measured exceedances is established where α and $\beta < 0.2$ and where $\lvert\alpha - \beta\rvert$ is minimized. α = Excel® Function BINOMDIST(n-k, n, 1 – 0.03, TRUE) β = Excel® Function BINOMDIST(k-1, n, 0.18, TRUE) where n = the number of samples, k = minimum number of measured exceedances to place a water on the section 303(d) list,	

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[120] See Section 7 Definitions-Toxicants in *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List*, State Water Board (2004).

Table 4-4. Minimum number of measured exceedances needed to place a water segment on the 303(d) list for conventional and other pollutants.

Sample Size	Number of Exceedances needed to assert impairment
5-30	5
31-36	6
37-42	7
43-48	8
49-54	9
55-60	10
61-66	11
67-72	12
73-78	13
79-84	14
85-91	15
92-97	16
98-103	17
104-109	18
110-115	19
116-121	20

For sample sizes greater than 121, the minimum number of measured exceedances is established where α and $\beta < 0.2$ and where $|\alpha - \beta|$ is minimized.
α = Excel® Function BINOMDIST(n-k, n, 1 – 0.10, TRUE)
β = Excel® Function BINOMDIST(k-1, n, 0.25, TRUE)
where n = the number of samples,
k = minimum number of measured exceedances to place a water segment on section 303(d) list

4.4.1 Clean Water Act Section 303(d) Listings in Pajaro River Basin

The final 2010 303(d) List for the Central Coast region listing waterbodies with nutrient or potential nutrient-related impairments in the Pajaro River basin are presented in Table 4-5. It is important to note that the 2010 303(d) List was based on what would now be considered "older vintage" data, from the year 2008 and earlier. This TMDL report compiles and assesses water quality data up through the year 2013, and thus new water quality problems could potentially be identified, or water quality improvements may be recognized.

Table 4-5. Year 2010 303(d) List of nutrient or nutrient-related impairments in the Pajaro River basin.

WATER BODY NAME	WBID	ESTIMATED SIZE AFFECTED	UNIT	POLLUTANT
Beach Road Ditch	CAR3051003020080603123839	0.8	Miles	Low Dissolved Oxygen
Beach Road Ditch	CAR3051003020080603123839	0.8	Miles	Nitrate
Carnadero Creek	CAR3053002019990223155037	1.8	Miles	Low Dissolved Oxygen
Carnadero Creek	CAR3053002019990223155037	1.8	Miles	Nitrate
Furlong Creek	CAR3053002019990222111932	8.5	Miles	Nitrate
Harkins Slough	CAR3051001320080603122917	7.3	Miles	Chlorophyll-a
Harkins Slough	CAR3051001320080603122917	7.3	Miles	Low Dissolved Oxygen
Llagas Creek (below Chesbro Reservoir)	CAR3053002020020319075726	16	Miles	Low Dissolved Oxygen
Llagas Creek (below Chesbro Reservoir)	CAR3053002020020319075726	16	Miles	Nutrients
McGowan Ditch	CAR3051003020100620223644	2.6	Miles	Nitrate
Millers Canal	CAR3053002020080603171000	2.1	Miles	Chlorophyll-a
Millers Canal	CAR3053002020080603171000	2.1	Miles	Low Dissolved Oxygen
Pacheco Creek	CAR3053002020020103133745	25	Miles	Low Dissolved Oxygen

WATER BODY NAME	WBID	ESTIMATED SIZE AFFECTED	UNIT	POLLUTANT
Pajaro River	CAR3051003019980826115152	32	Miles	Low Dissolved Oxygen
Pajaro River	CAR3051003019980826115152	32	Miles	Nitrate
Pajaro River	CAR3051003019980826115152	32	Miles	Nutrients
Pinto Lake	CAL3051003020020124122807	115	Acres	Chlorophyll-a
Pinto Lake	CAL3051003020020124122807	115	Acres	Low Dissolved Oxygen
Salsipuedes Creek (Santa Cruz County)	CAR3051003020080603123522	2.6	Miles	Low Dissolved Oxygen
San Juan Creek (San Benito County)	CAR3052005020090204001958	7.3	Miles	Low Dissolved Oxygen
San Juan Creek (San Benito County)	CAR3052005020090204001958	7.3	Miles	Nitrate
Struve Slough	CAR3051003020080603125227	2.8	Miles	Low Dissolved Oxygen
Tequisquita Slough	CAR3053002020011121091332	7.2	Miles	Low Dissolved Oxygen
Uvas Creek (below Uvas Reservoir)	CAR3052002120080603163208	7.8	Miles	Low Dissolved Oxygen
Watsonville Slough	CAR3051003019981209150043	6.2	Miles	Low Dissolved Oxygen

➢ pH 303(d) Listings

303(d)-listed pH impairments have been identified for some streams of the Pajaro River basin. It should be noted that while water column pH impairments can sometimes result from biostimulation in any given watershed, staff are not addressing the pH 303(d) listings for streams in the Pajaro River basin in this TMDL. Our reasoning is as follows:

1) The California Nutrient Numeric Endpoints (NNE) approach recommends that a pH value of greater than 9.0 (for cold water aquatic habitat beneficial uses) or a pH of greater than 9.5 (for warm water aquatic habitat beneficial uses) represent the pH numeric endpoints which are indicative of a presumptive photosynthesis-driven pH impairment[121]. Only 1.27% of stream pH samples in the Pajaro River basin exceeded 9 pH units (sample size = 9,198), and only 0.2% exceeded 9.5 pH units. As such, based on California NNE guidance the current pH-based impairments in the Pajaro River basin cannot credibly be attributed to biostimulatory impairments.
2) In some areas of the Pajaro River basin, ambient soil conditions are quite alkaline. Locally, some soils range up to 9.3 pH units. A soil pH map of the Pajaro River basin is presented in Figure 4-1. Climatic conditions, geology, plants, and physical surroundings can influence soil pH. In temperate climates that support dense forests, soils tend to be acidic, with pH ranging between 4.0 and 5.5. North American Midwest grasslands tend to have slightly acidic soils (pH 6.0 to 6.5), while in contrast alkaline soils (pH greater than 7.0) are often associated with arid regions characterized by high water evaporation rates (Pleasant, 2014). Local geologic conditions can also influence soil pH independent of climate; for example, alkaline soils are known to develop on limestone bedrock, irrespective of climatic conditions. Climatically, the Pajaro River basin is an arid Mediterranean climate and locally the river basin has relatively high rates of evapotranspiration[122], thus these climatic conditions locally can promote formation of alkaline soils. Also worth noting, historic natural alkali meadows existed in the southern Santa Clara Valley (refer back to Figure 3-6), therefore high pH water quality may have naturally prevailed in some waterbodies of this river basin. In addition, 303(d) pH listings on upper Uvas and upper Llagas creeks occur in upland areas of the river basin which are relatively lightly-disturbed by humans, suggesting a natural cause for these pH

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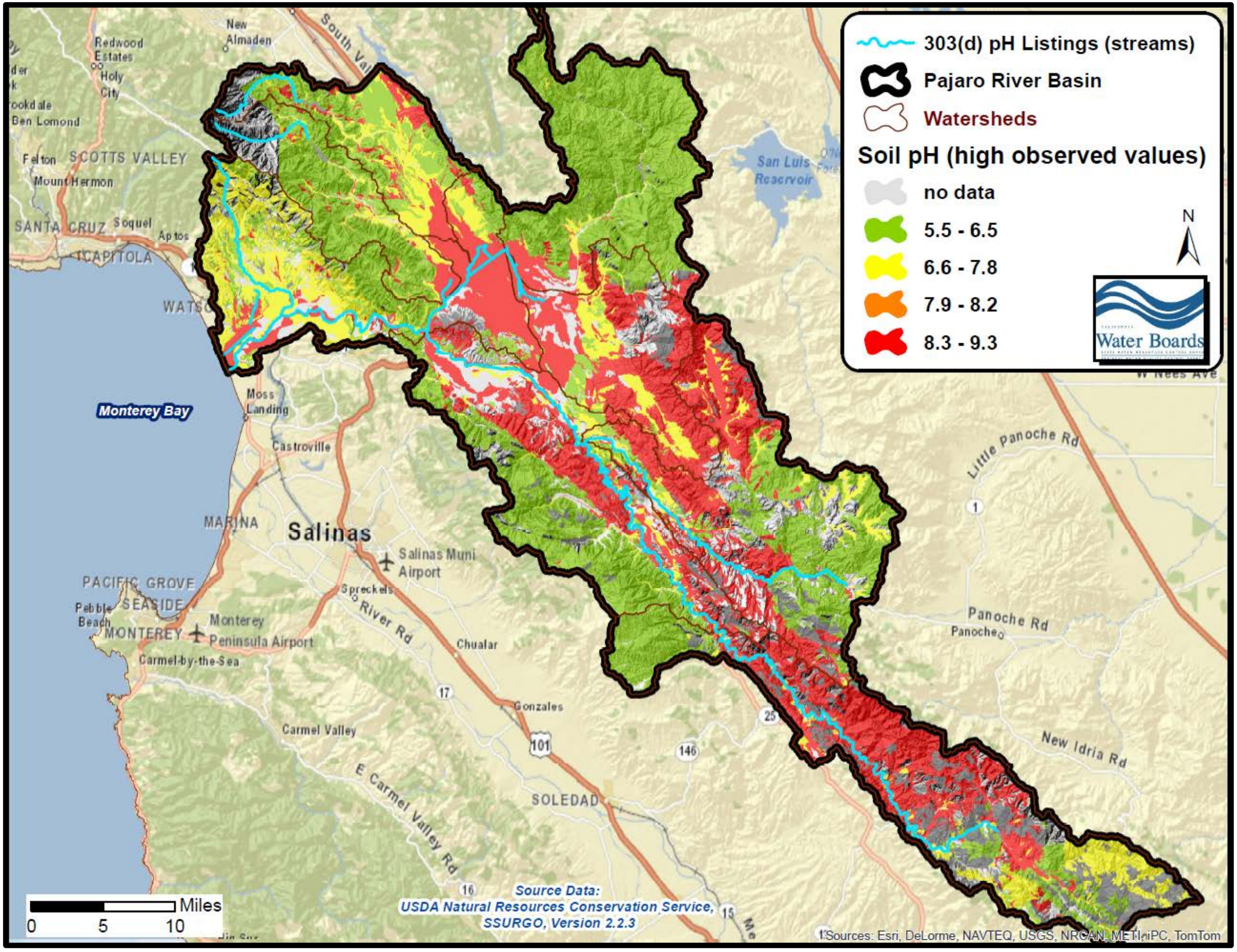
[121] See Table 3-2 in Tetra Tech (2006): Technical Approach to Develop Nutrient Numeric Endpoints for California (July 2006, prepared for USEPA Region IX, Contract No. 68-C-02-108-To-111).

[122] Data source: Trabucco, A., and Zomer, R.J. 2009. *Global Aridity Index (Global-Aridity) and Global Potential Evapo-Transpiration (Global-PET) Geospatial Database*. CGIAR Consortium for Spatial Information. Published online, available from the CGIAR-CSI Geoportal.

> impairments. It should be recognized that the upper Uvas Creek and upper Llagas Creek subwatersheds[123] are characterized in large part by mafic to ultramafic rocks (basalt, peridotite, serpentinite) – refer back to the geologic map in Figure 3-48; these rock types are known to promote the formation of high pH (alkaline) soils[124].

On the basis of the aforementioned information, staff hypothesizes that natural conditions – such as alkaline soils, geology, and/or climatic conditions – cause or contribute to 303(d)-listed pH stream impairments in the Pajaro River basin. These conditions would thus be unrelated to water column photosynthesis and biostimulation. Therefore, at this time staff recommends that Pajaro River basin stream pH 303(d)- listings be addressed through a separate TMDL process or a future water quality standards action.

Figure 4-1. Soil pH conditions and pH 303(d) listed streams, Pajaro River basin.



Source Data:
USDA Natural Resources Conservation Service,
SSURGO, Version 2.2.3

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

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[123] A map of subwatersheds was previously presented in Figure 3-4.

[124] For example: Stanford University Department of Geology, Geology 299 field class, field blog entitled *"Ultramafics in the Field".* Ultramafic rocks, such as peridotite, are noted to be associated with highly alkaline soils. Online linkage: http://web.stanford.edu/group/warrenlab/cgi-bin/wordpress/

5 WATER QUALITY DATA ANALYSIS

The data used for this Project included water quality data from the Central Coast Ambient Monitoring Program (CCAMP) and several other entities shown below. CCAMP is the Central Coast Water Board's regionally-scaled water quality monitoring and assessment program. The Water Board's CCAMP data is collected by the Board's in-house staff consisting of trained field scientists and technicians who adhere to the sampling and reporting protocols consistent with the State's Surface Water Ambient Monitoring Program (SWAMP). SWAMP is a state framework for coordinating consistent and scientifically defensible methods and strategies for water quality monitoring, assessment, and reporting. Substantial amounts of water quality data for the Pajaro River basin are also available from the Cooperative Monitoring Program of Central Coast Water Quality Preservation, Inc. (CCWQP). CCWQP also periodically publishes reports with information that pertains to nutrient pollution (for example, CCWQP, 2010).

During TMDL development, staff conducted further data quality control and data filtering. This quality control included 1) filtering the data to extract only grab samples and field measurements (thus excluding field blanks and duplicates); 2) converting nutrient data reported in compound molecular reporting conventions to the elemental reporting convention (e.g., converting nitrate molecular (NO_3) concentration values to nitrate as elemental nitrogen (N) values); 3) quantifying censored data[125] by using a simple substitution method and setting the censored data equal to half the method detection limit (MDL)[126]. For samples where an MDL was not reported, staff set the non-detects equal to half the median MDL that was reported for that constituent.. For this TMDL report, the water quality parameters under consideration had very low ratios of non-detects; 4) eliminating suspicious or low-quality data (data having inadequate, dubious or indeterminate documentation or reporting) and when we could not make clarifications to said data with the assistance of the data provider, we eliminated them so as not to introduce suspect data into our final dataset; 5) combining and averaging the water quality data from monitoring sites which were in close proximity to each other (<200 meters), on the same stream reach, and when there was no compelling reason to treat them, for TMDL purposes, as individual, discrete monitoring sites[127]; consistent with guidance published in the *California Listing Policy* (State Water Board, 2004); and 6) combining sample results collected on the same date and from the same monitoring site[128], and representing these results with a single resultant value consistent with guidance published in the *California Listing Policy* (State Water Board 2004).

5.1 Nitrogen & Phosphorus Analytical Reporting Convention

Water quality data using different analytical reporting conventions can result in confusion, and even scientists and regulators have to practice diligence to avoid mixing-up and conflating nitrate

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[125] Censored data are non-quantified measurements of constituents that are reported as less than the detection limit, because the sample constituent exists in a concentration lower than can reliably be detected and reported by the laboratory.

[126] Simple substitution methods, such as setting censored data equal to half the method detection limit for the constituent, is a method widely used in the environmental sciences (see, for example: U.S. Geological Survey, Data Series 152, *Water-Quality, Streamflow, and Ancillary Data for Nutrients in Streams and Rivers Across the Nation, 1992-2001;* also see *Alley (editor), 1993, Regional Water Quality Data).* It should be noted that for datasets characterized by large amounts or ratios of censored data, simplistic substitution methods introduce bias to statistical procedures. Large ratios of censored data (non-detects) are particularly common during water quality investigations involving trace elements and synthetic organic compounds.

[127] The California Listing Policy section 6.1.5.2 states: *"Samples collected within 200 meters of each other should be considered samples from the same station or location."* It should be recognized that TMDLs are watershed studies which endeavor to identify waterbody impairments at the stream reach scale. Typically, a monitoring program consisting of high-resolution, fine-scale monitoring – such as discrete monitoring locations upgradient and downgradient of a pipe or culvert – is more appropriate for field-scale or implementation studies.

[128] The California Listing Policy section 6.1.5.6 states: *"for data that is not temporally independent (e.g., when multiple samples are collected at a single location on the same day), the measurements shall be combined and represented by a single resultant value*." In these cases, Central Coast Water Board staff used an arithmetic mean of the sample results to represent a single resultant value; however, for dissolved oxygen the minimum value reported was used to represent a single resultant value consistent with the guidance in California Listing Policy section 6.1.5.6.

concentrations which are reported in different conventions. Mixing up and conflating analytical nitrate reporting conventions can result in apples-to-oranges comparisons. Nitrate concentration values are commonly reported as either molecular nitrate (NO_3), or as nitrate as elemental nitrogen (i.e., NO_3-N or nitrate as N). Note that the maximum contaminant level (MCL) in drinking water as molecular nitrate (NO_3) is 45 mg/L, whereas this MCL when reported as elemental nitrogen (NO_3-N) is 10 mg/L. While these two nitrate numeric values would appear to represent different concentrations, these concentration values are in fact actually equivalent to each other − the only difference being whether or not the molecular weight of the oxygen atoms in the nitrate molecule is included in the analytical reporting. Table 5-1 illustrates the difference between the two analytical reporting conventions.

National and USEPA water quality standards, water quality modeling tools, most scientific literature, and most TMDLs use the elemental nitrogen reporting convention (i.e., written as either nitrate as nitrogen; NO_3-N; or nitrate as N). Likewise, this TMDL Report uses the elemental nitrogen convention (i.e., nitrate as N).

Table 5-1. Illustration of EQUIVALENT nitrate concentrations in two different analytical reporting conventions.

Nitrate reporting convention used by most California Public Water Supply Districts & Agencies	multiply nitrate as NO_3 by: $\left(\frac{14 \text{ gram/mole N}}{62 \text{ gram/mole } NO_3}\right)$ to convert to nitrate as N	Nitrate reporting convention used by U.S. Environmental Protection Agency, U.S. Geological Survey, in most scientific literature, and in this TMDL report
Nitrate as NO_3 (mg/L)	**Reporting Equivalent as nitrogen (N) >>>>**	**Nitrate as N (mg/L)**
44.3*	☞	10
22.1	☞	5
11.1	☞	2.5
4.4	☞	1
2.2	☞	0.5

* In California, the drinking water standard for nitrate as NO_3 is established to two significant figures, and is 45 mg/l

Similarly, in this TMDL project ammonia is reported as elemental nitrogen (e.g., un-ionized ammonia as nitrogen – NH_3-N), and phosphate is reported as elemental phosphorus (e.g., orthophosphate as phosphorus – PO_4-P).

Also worth noting, is that most nitrogen analytical measurements include and report nitrate (NO_3) plus nitrite (NO_2), but because concentrations of nitrite (NO_2) are typically insignificant relative to nitrate, this mixture is simply called “nitrate” in this TMDL report, and in most regulatory contexts.

5.2 Water Quality Data Sources & Monitoring Sites

The water quality data used for this TMDL project included data from several sources are presented in Table 5-2. Many sources of stream quality data are available for the Pajaro River basin; Central Coast Water Board staff also invited interested parties to voluntarily submit their water quality data, should they choose to do so in support of TMDL development. Consequently, additional water quality data was kindly provided to Central Coast Water Board staff by the Pajaro Valley Water Management Agency and the City of Watsonville.

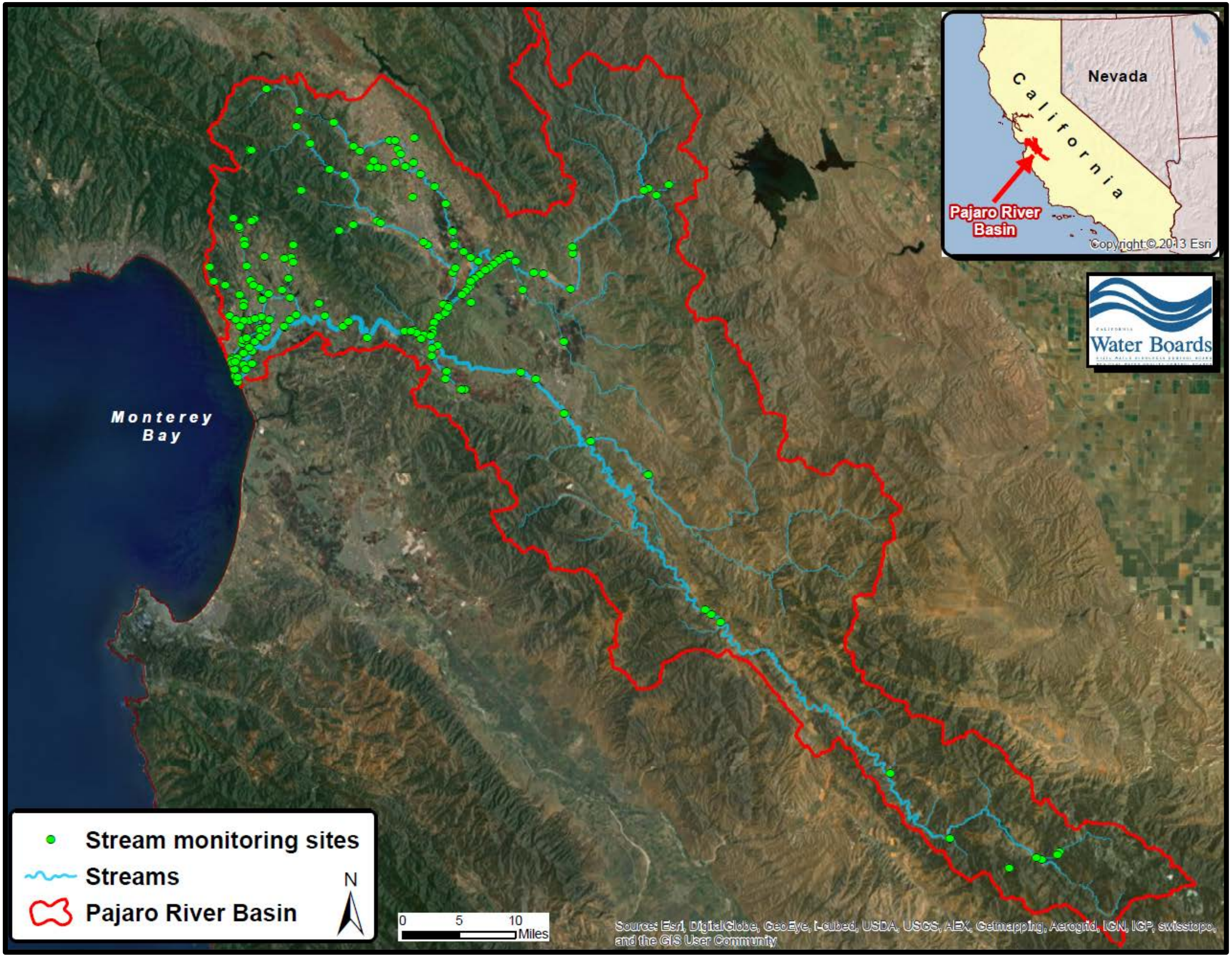
Table 5-2. Stream and river water quality monitoring data used in this TMDL report.

Monitoring Entity/Program	Number of Monitoring Sites	Temporal Representation	Geographic Range of Stream Water Quality Monitoring
Central Coast Water Board – Central Coast Ambient Monitoring Program (CCAMP)	41	Dec. 1997 to Sept. 2013	Pajaro River basin (Basin-wide)
Central Coast Water Quality Preservation, Inc. – Cooperative Monitoring Program	18	Jan. 2006 to Dec. 2013	Focusing on agricultural valley floor reaches of the Pajaro Valley, southern Santa Clara Valley and the San Juan Valley
City of Watsonville	2	May 2009 to July 2013	Pajaro River @ Watsonville
U.S. Environmental Protection Agency – Environmental Monitoring & Assessment Program	5	June 2001 to June 2003	Uvas Creek Watershed, Pacheco Creek Watershed, and Salsipuedes Creek Subwatershed, with a primary focus on upland reaches and headwater tributary reaches
Monterey Bay National Marine Sanctuary Monitoring Programs	19	Jan. 2002 to May 2006	Lower Pajaro River Subwatershed, Watsonville Slough Subwatershed, and Corralitos Creek Subwatershed
University of California, Davis Marine Pollution Studies Laboratory at Granite Canyon	5	Jan. 2008 to Oct. 2009	Lower Pajaro River Valley with a focus on estuarine reaches of the lower Pajaro River-Watsonville Slough area
Pajaro Valley Water Management Agency	22	Dec. 2002 to Dec. 2013	Pajaro Valley, including lower Pajaro River, Watsonville Slough, Corralitos Creek, and Salsipuedes Creek subwatersheds.
University of California Santa Cruz Grant Study and Dr. Marc Los Huertos monitoring data	62	Oct. 2000 to March 2007	Pajaro River basin (Basin-wide)
County of Santa Cruz Environmental Health Services	4	March 1999 to May 2006	Corralitos Creek and the lower Pajaro River
Lion's Gate Limited Partnership – Cordevalle Golf Club	4	April 1997 to June 2013	West Branch, Llagas Creek focusing on creek water quality within a golf course.
U.S. Environmental Protection Agency Storage and Retrieval (STORET) Dataset	49	Dec. 1951 to Dec. 1994	Pajaro River basin (Basin-wide, older legacy data)
State Water Resources Control Board, Surface Water Ambient Monitoring Program – data from the Perennial Stream Survey & the Statewide Reference Condition Management Plan	8	June 2008 to June 2010	Pajaro River, Llagas Creek, and headwater tributary reaches of the Uvas Creek Subwatershed and the Upper San Benito River Watershed
U.S. Geological Survey – National Water Information System data	16	May 1952 to July 2011	Pajaro River basin (Basin-wide with a primary focus on legacy data)

Monitoring Entity/Program	Number of Monitoring Sites	Temporal Representation	Geographic Range of Stream Water Quality Monitoring
Coastal Watershed Council	15	May 2001 to May 2010	Surface waters of the Watsonville Slough Subwatershed and Corralitos Creek
Williamson et al. San Jose State University and Merrit Smith Consulting Grant Data – Contract Number 0-212-253-0	7	June 1992 to July 1993	Llagas Creek Watershed and the upper Pajaro River legacy data
Julie Renee Casagrande Master's Theses –San Jose State Univ. *"Aquatic Ecology of San Felipe Lake, San Benito County, CA" (2010)*	2 *stream sites*	May 2005 to Nov. 2006	Pacheco Creek and Tequisquita Slough at confluence with San Felipe Lake

Figure 5-1 illustrates the location of the Pajaro River basin stream water quality monitoring sites used in this report. Due to the size of the river basin, and the large number of stream monitoring sites, more-legible and higher resolution illustrations of the stream monitoring sites are presented in Figure 5-2, Figure 5-3 and Figure 5-4.

Figure 5-1. Pajaro River basin stream water quality monitoring locations used in this TMDL report.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 5-2. Stream water quality monitoring locations in the Pajaro Valley area, including sites in the lower Pajaro River Subwatershed, the Watsonville Slough Subwatershed, the Corralitos Creek Subwatershed, and the Salsipuedes Creek Subwatershed – Santa Cruz and Monterey counties.

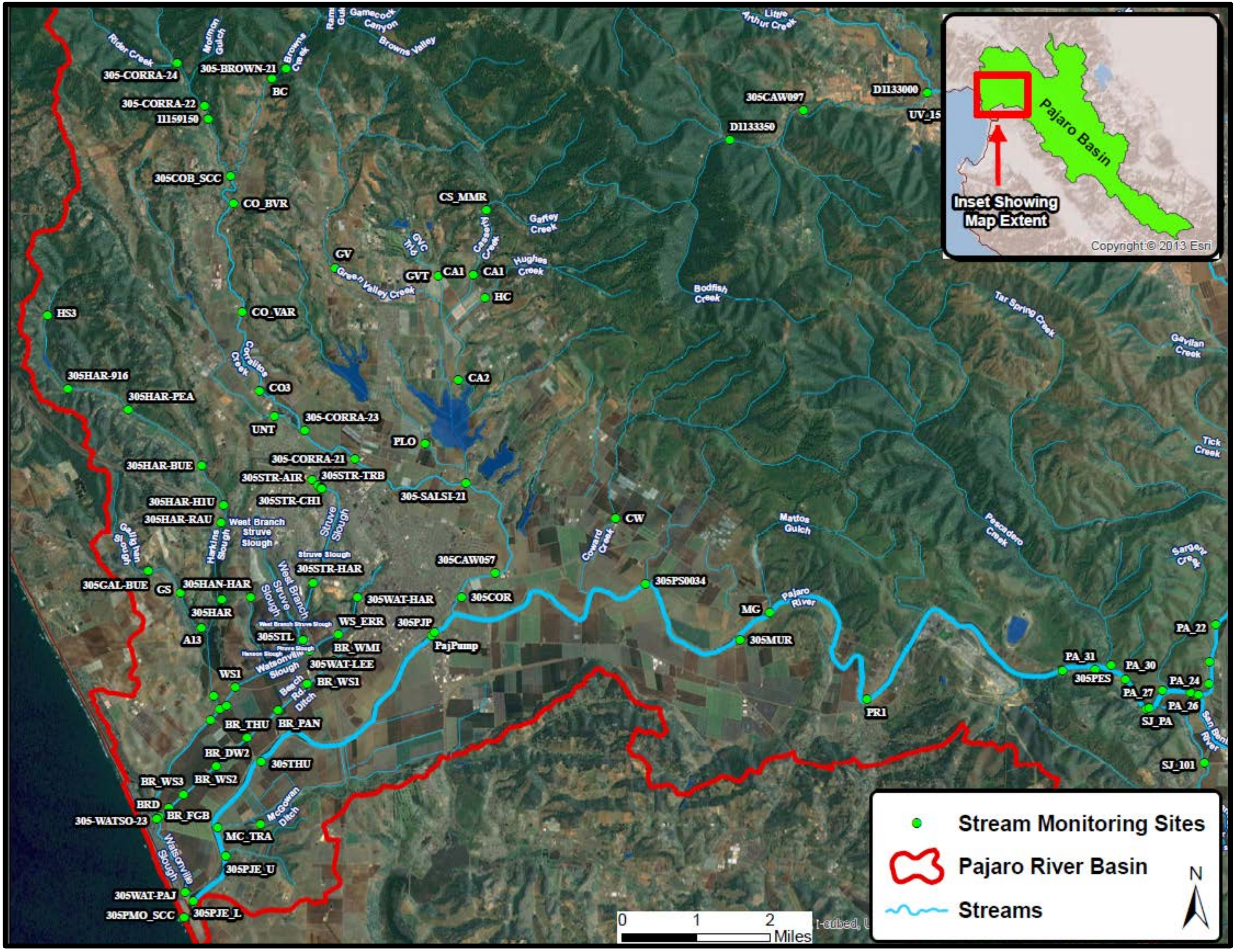
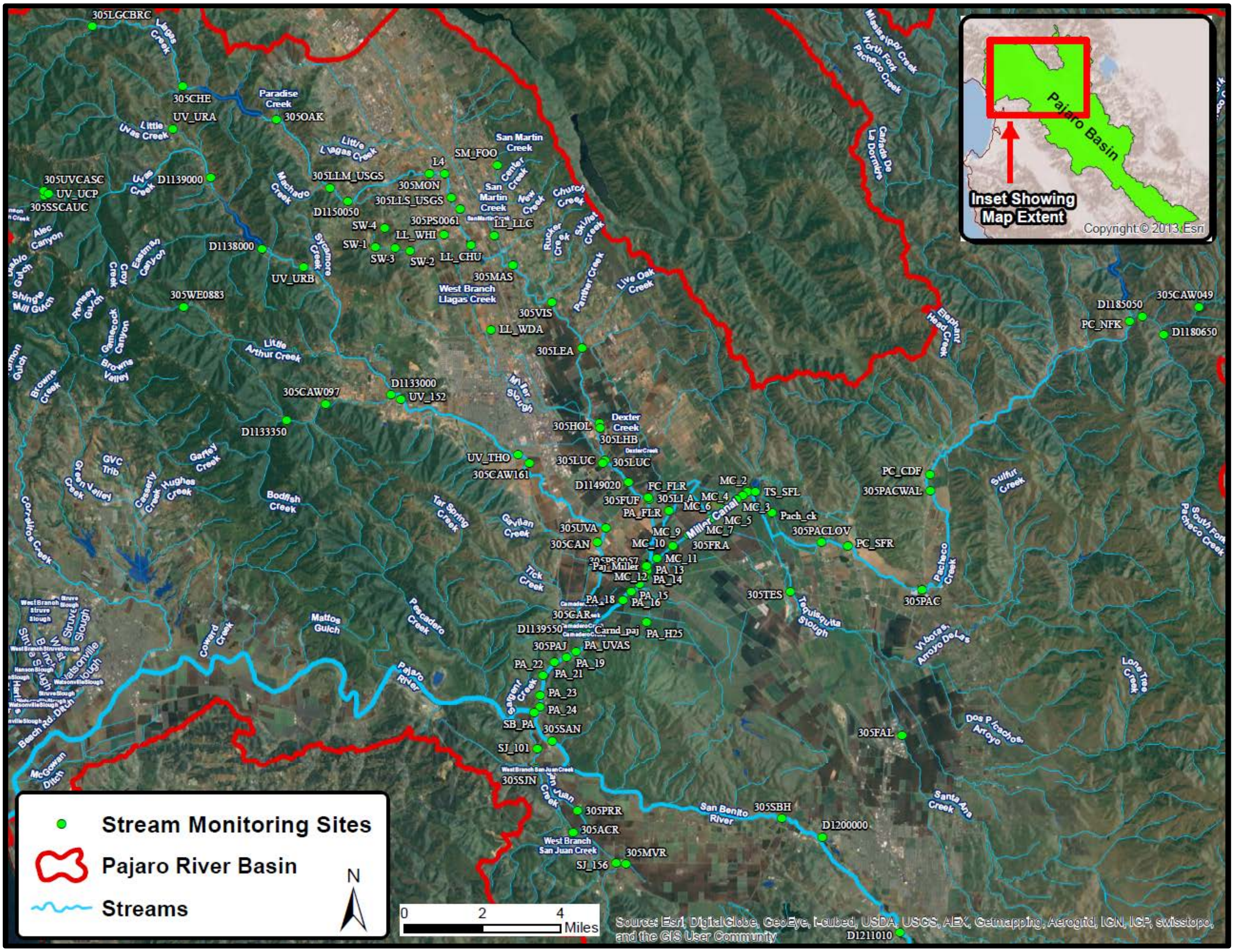
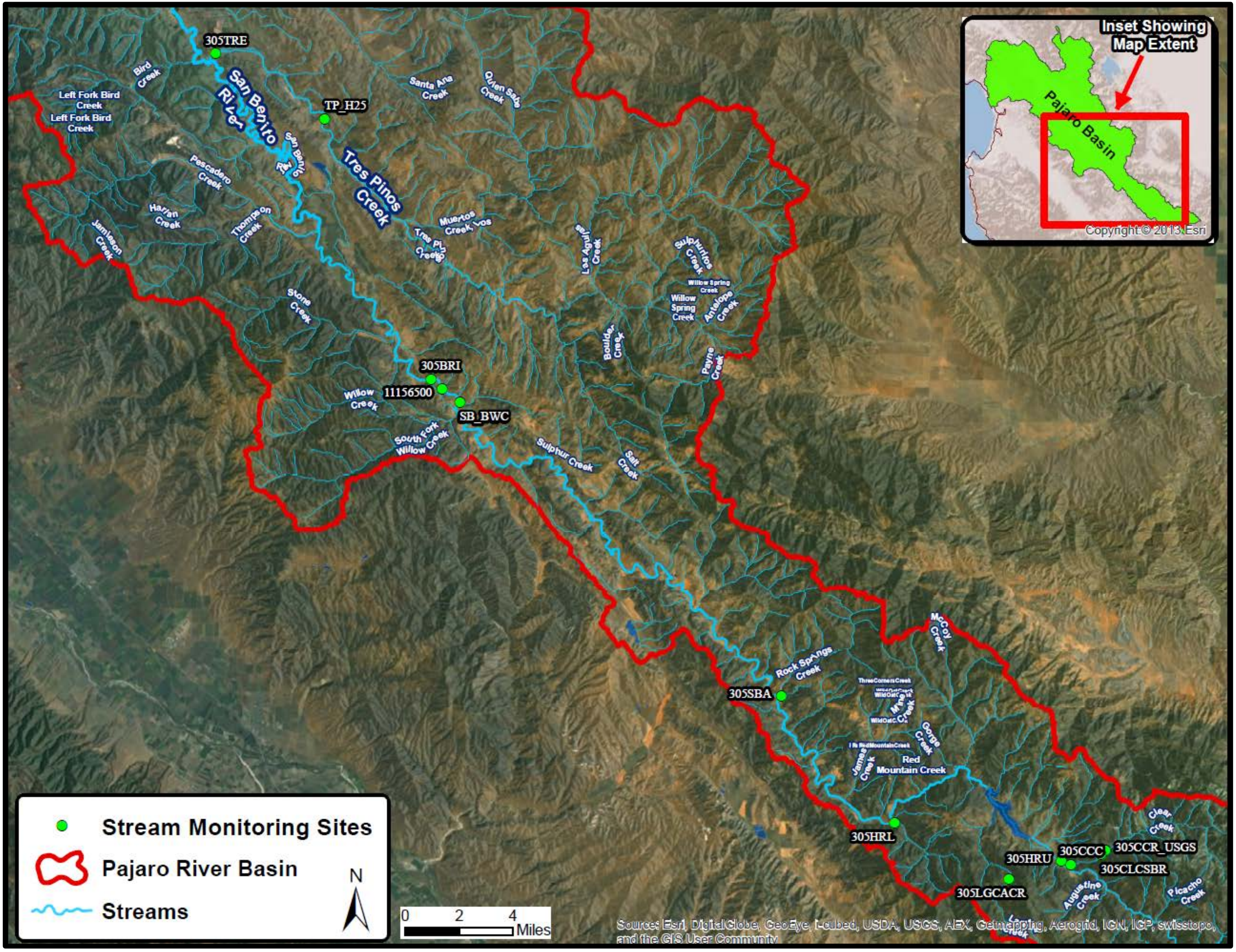


Figure 5-3. Stream water quality monitoring locations in the southern Santa Clara Valley area and San Juan Valley area, including sites in the upper Pajaro River Watershed, the Llagas Creek Watershed, the Uvas Creek Watershed, the Pacheco Creek Watershed, and the Lower San Benito River Watershed – Santa Clara and San Benito counties.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

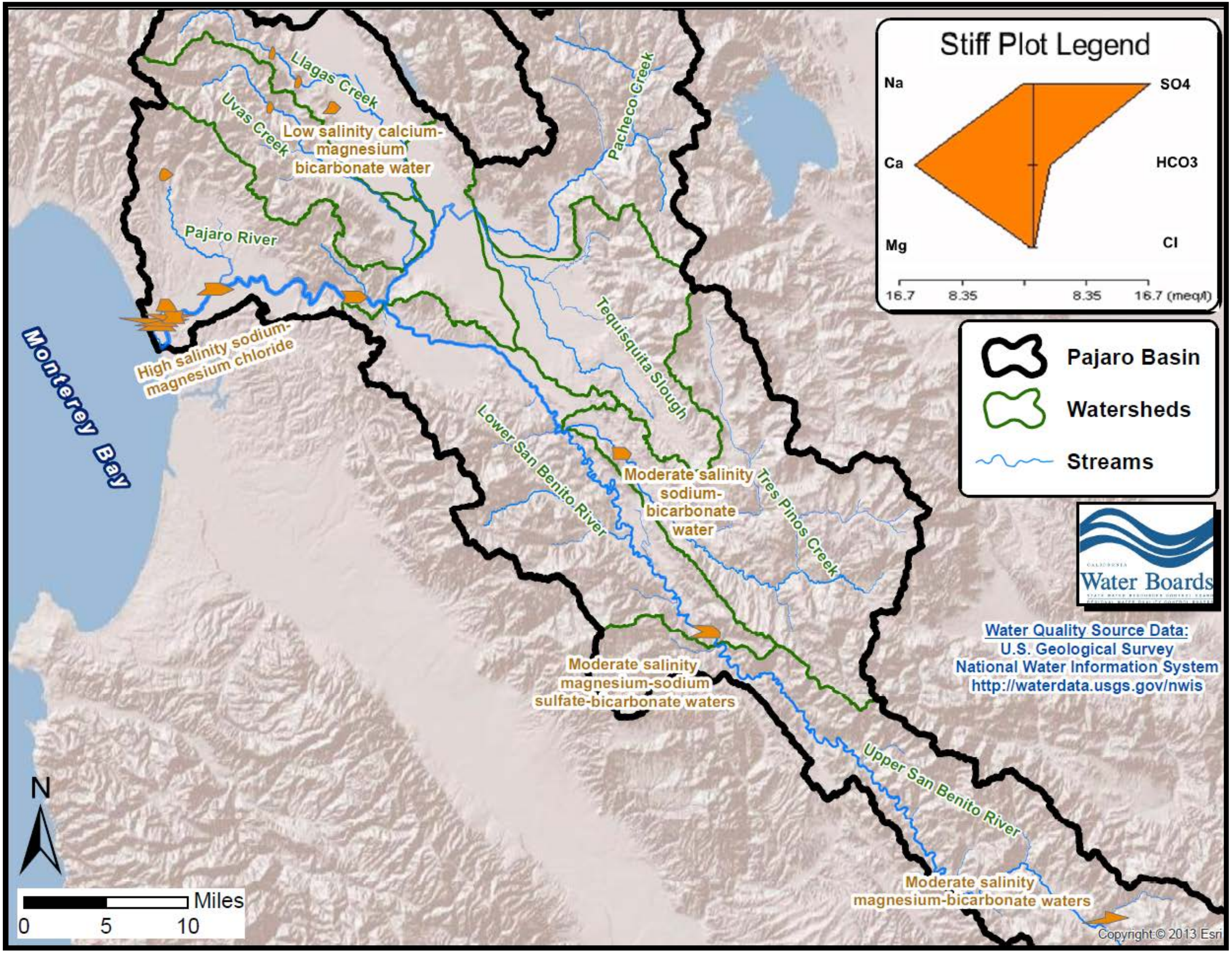
Figure 5-4. Stream and river water quality monitoring locations from the middle and upper reaches of the San Benito River Watershed and the Tres Pinos Creek Watershed – San Benito County.



5.3 General Water Quality Types in Streams of the Pajaro River Basin

U.S. Environmental Protection Agency guidance on development of water quality criteria for biostimulatory substances, such as nitrate, recommend that these criteria be developed taking into account spatial, physical, hydraulic, and chemical variation in streams within any given region or basin. Figure 5-5 illustrates generalized variations in water quality types in streams of the Pajaro River basin on the basis of general minerals and Stiff diagrams. Stiff diagrams are a representation of general minerals and electrical conductivity. Much of the data represented here are from pre-1990 sampling events, so these should be considered historical, or baseline conditions in the river basin.

Figure 5-5. General water quality types in streams of the Pajaro River basin on the basis of Stiff plots.



Surface water quality in the upper San Benito and Tres Pinos watersheds can be characterized as moderate salinity, magnesium bicarbonate waters ($Mg\text{-}HCO_3$), sodium bicarbonate ($Na\text{-}HCO_3$), or sodium bicarbonate–sulfate ($Na\text{-}HCO_3\text{-}SO_4$) waters. Surface water quality in the Llagas, Uvas, and Upper Corralitos Creek watersheds, draining the Santa Cruz Mountains, can be generally characterized as lower salinity, magnesium bicarbonate ($Mg\text{-}HCO_3$) or calcium bicarbonate ($Ca\text{-}HCO_3$) waters. The lower reaches of the river basin, which includes the Pajaro River, can be generally characterized as higher salinity sodium and magnesium bicarbonate–sulfate waters ($Na\text{-}Mg\text{-}\ HCO_3\text{-}SO_4$). Limited data from agricultural ditches in the lowermost reaches of the river basin, near Watsonville, were characterized by higher salinity sodium chloride waters (Na-Cl).

5.4 Water Quality Spatial Trends

Figure 5-6 through Figure 5-19 illustrate spatial variations[129] and statistical distributions (box and whisker plots)[130] of nitrate (as N), orthophosphate (as P) concentrations at stream monitoring sites throughout the Pajaro River basin. Box and whisker plots are a graphical way of representing data dispersion. Note that occasionally on some box and whisker plot figures, a few monitoring sites have insufficient data to construct a proper box and whiskers. The data representing these sites may lack "whiskers" or other box plot components. However, we include these in the box and whisker figures in this report for completeness.

As indicated by the spatial and statistical distributions shown in the figures, elevated nutrient concentrations are most characteristic of the valley-floor areas of the northern Pajaro River basin – specifically in stream reaches associated with the lower Pajaro River subwatershed, the Watsonville Slough subwatershed, the Upper Pajaro River subwatershed, the lower Llagas Creek subwatershed, and the San Juan Canyon subwatershed. Additionally, as shown in Figure 5-6 and Figure 5-7, lowlands of the valley floor reaches of the Pajaro Valley and Santa Clara Valley are expected to have a higher intensity of nitrogen and phosphorus inputs from human activities (primarily fertilizer inputs) relative to the rest of the river basin more broadly.

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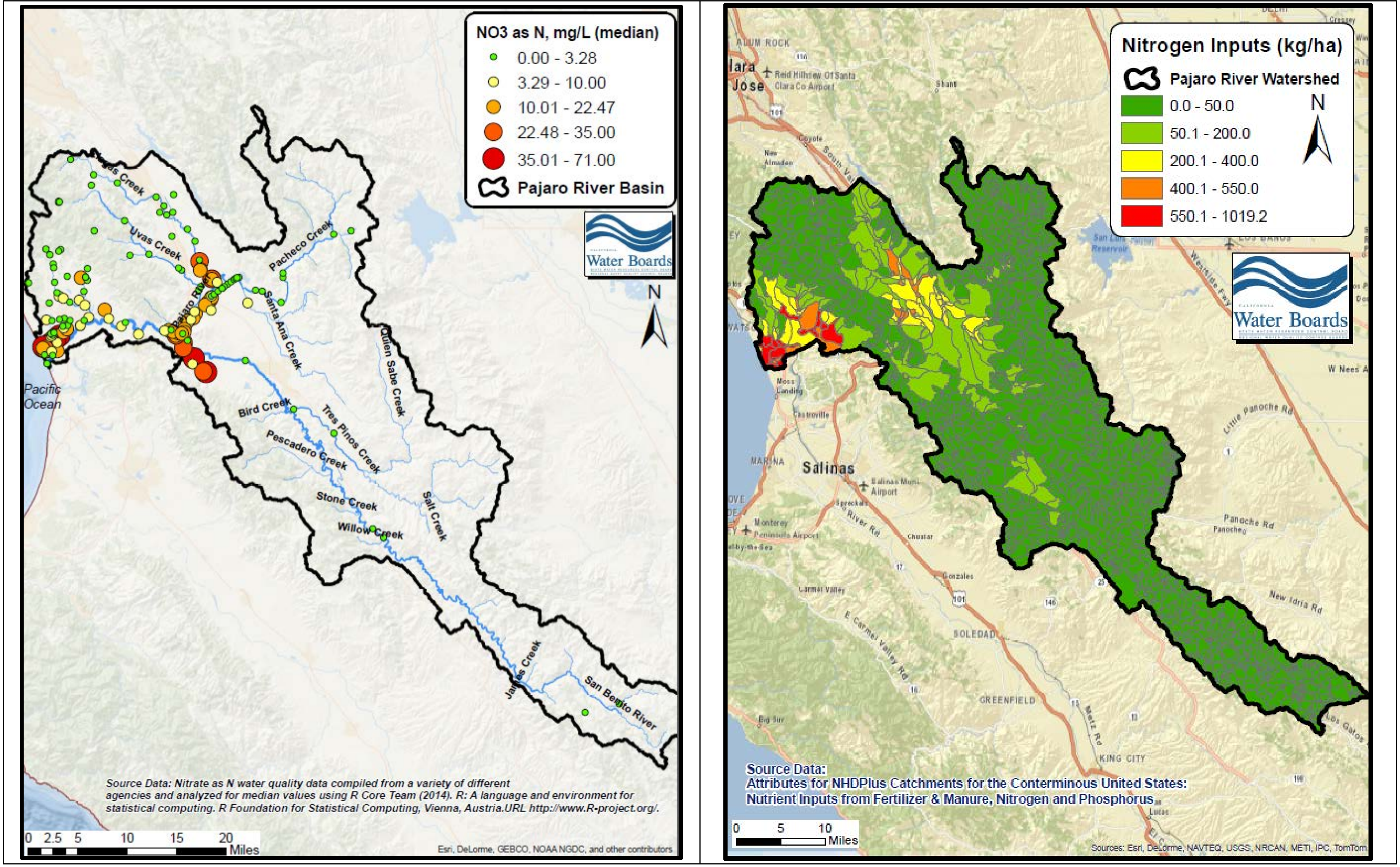
[129] The spatial datasets illustrating estimated nitrogen and phosphorus land inputs of fertilizer and mansure were created and used by the U.S. Geological Survey (U.S. GEOLOGICAL SURVEY) specifically to estimate nitrogen and phosphorus inputs from manure and fertilizer per watershed segment in the application of the national SPAtially Referenced Regression On Watershed attributes (SPARROW) model. Citation: *Attributes for NHDPlus Catchments (Version 1.1) for the Conterminous United States: Nutrient Inputs from Fertilizer and Manure, Nitrogen and Phosphorus (N&P) 2002. U.S. Geological Survey.*

[130] Statistical distributions can be represented as box plots, as illustrated in this section of the report. For those unfamiliar with the nature and utility of box plots please refer to: http://en.wikipedia.org/wiki/Box_plot

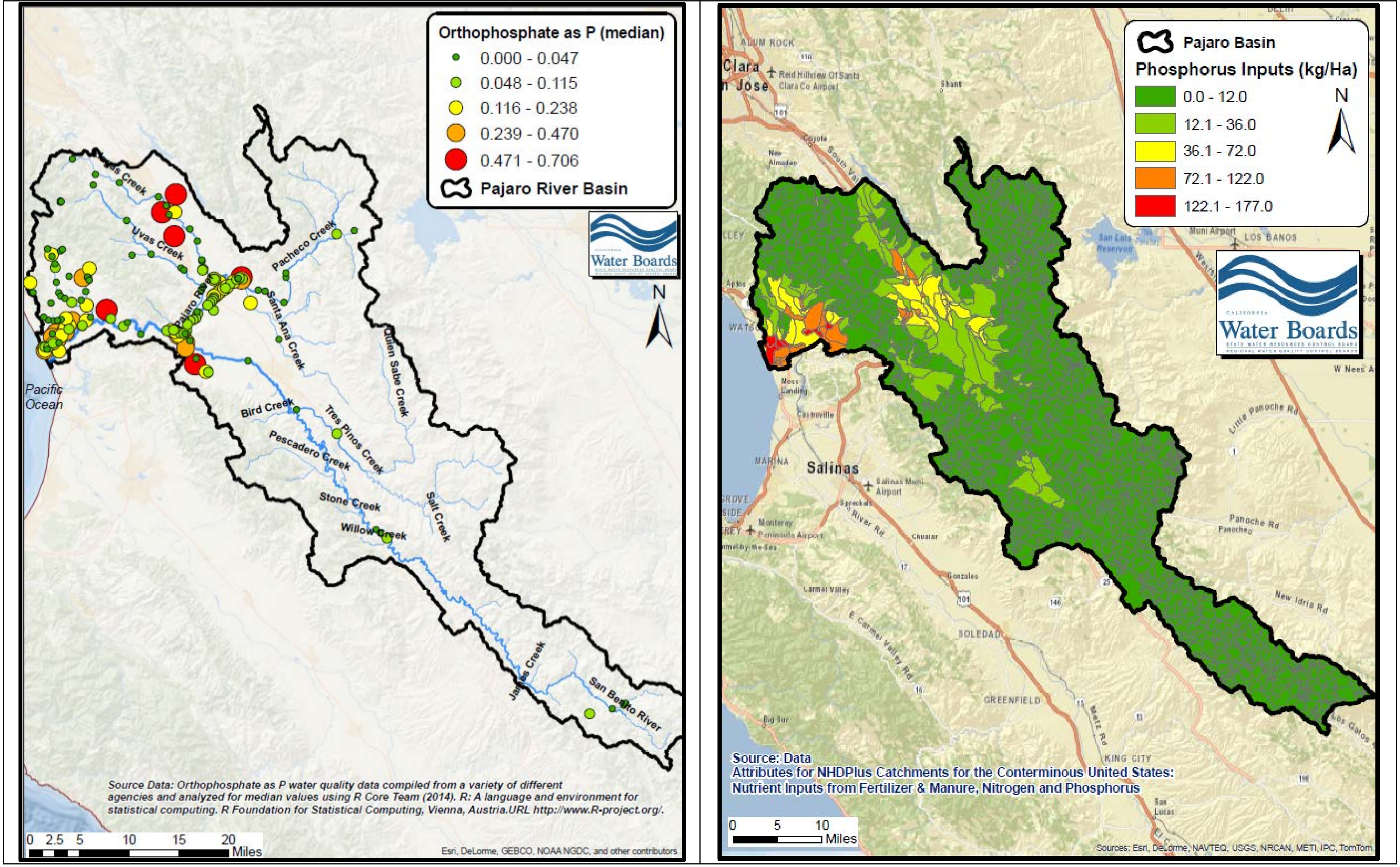
Figure 5-6. (A) Surface water nitrate as N (median concentration values – mg/L); and (B) estimated total nitrogen inputs (kg/hectare - year 2002) from fertilizer and compost, Pajaro River basin.



Source Data: Nitrate as N water quality data compiled from a variety of different agencies and analyzed for median values using R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.URL http://www.R-project.org/.

Source Data:
Attributes for NHDPlus Catchments for the Conterminous United States:
Nutrient Inputs from Fertilizer & Manure, Nitrogen and Phosphorus

Figure 5-7. (A) Surface water orthophosphate as P (median concentration values – mg/L); and (B) estimated total phosphorus inputs (kg/hectare - year 2002) from fertilizer and compost, Pajaro River basin.



Source Data: Orthophosphate as P water quality data compiled from a variety of different agencies and analyzed for median values using R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.URL http://www.R-project.org/.

Source: Data
Attributes for NHDPlus Catchments for the Conterminous United States:
Nutrient Inputs from Fertilizer & Manure, Nitrogen and Phosphorus

Figure 5-8. Surface water nitrate as N concentrations (median value), TMDL project area, northern section.

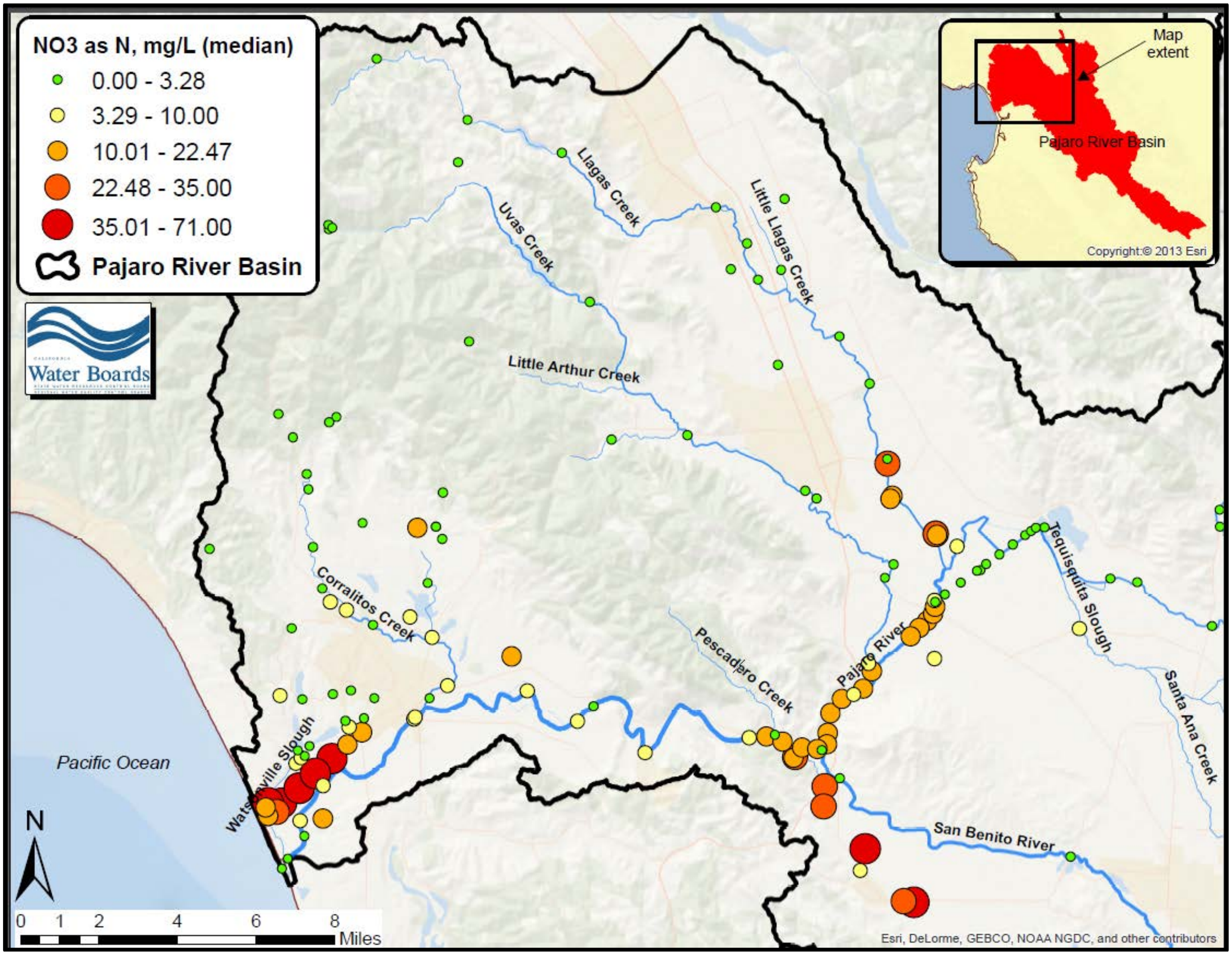
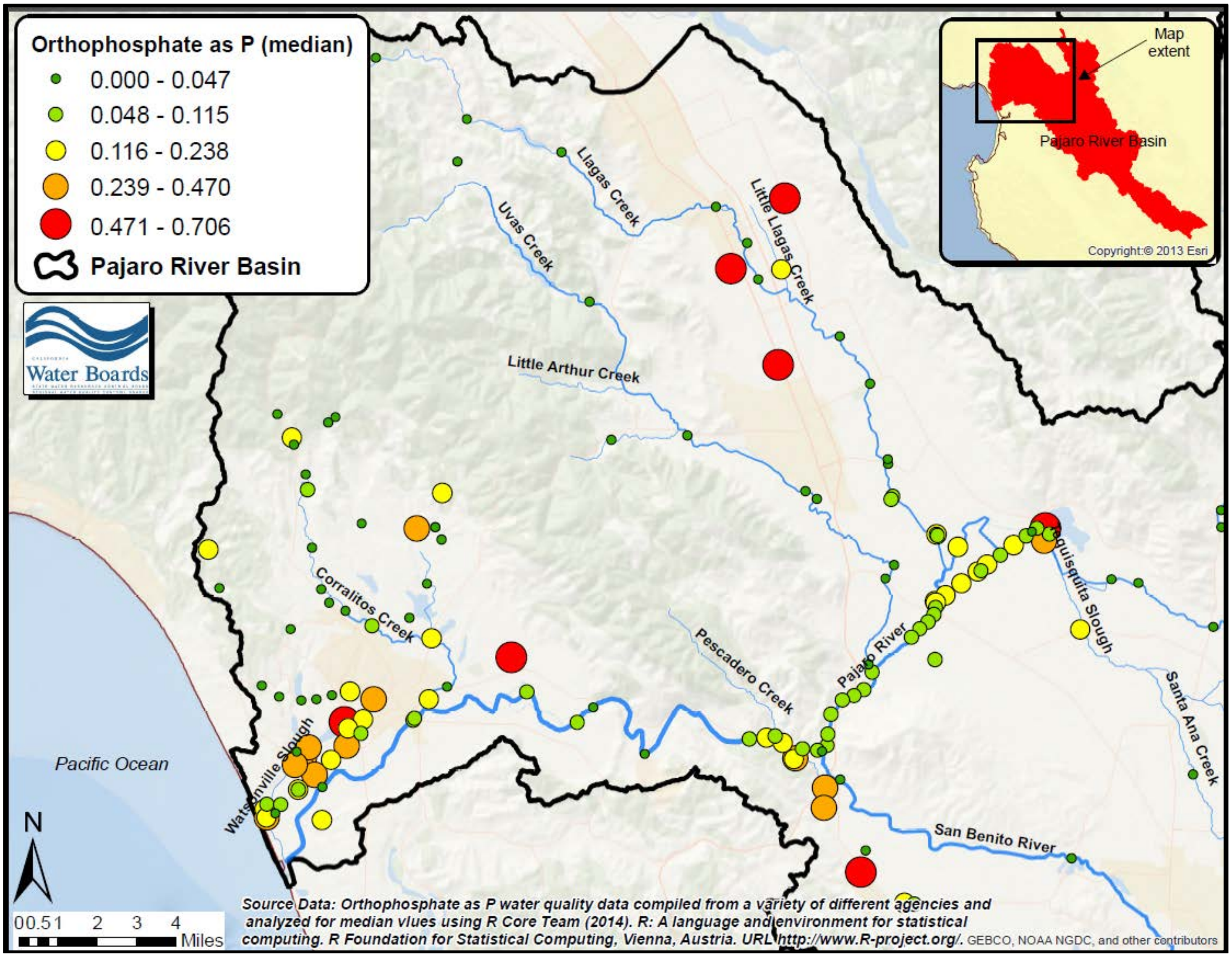


Figure 5-9. Surface water orthophosphate as P concentrations (median value), TMDL project area, northern section.



Source Data: Orthophosphate as P water quality data compiled from a variety of different agencies and analyzed for median vlues using R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/. GEBCO, NOAA NGDC, and other contributors

Figure 5-10. Box and whiskers plot, nitrate as N water quality data for all waterbodies within the Pajaro River basin, ordered alphabetically. For reference, the nitrate as N water quality standard for drinking water is 10 mg/L.

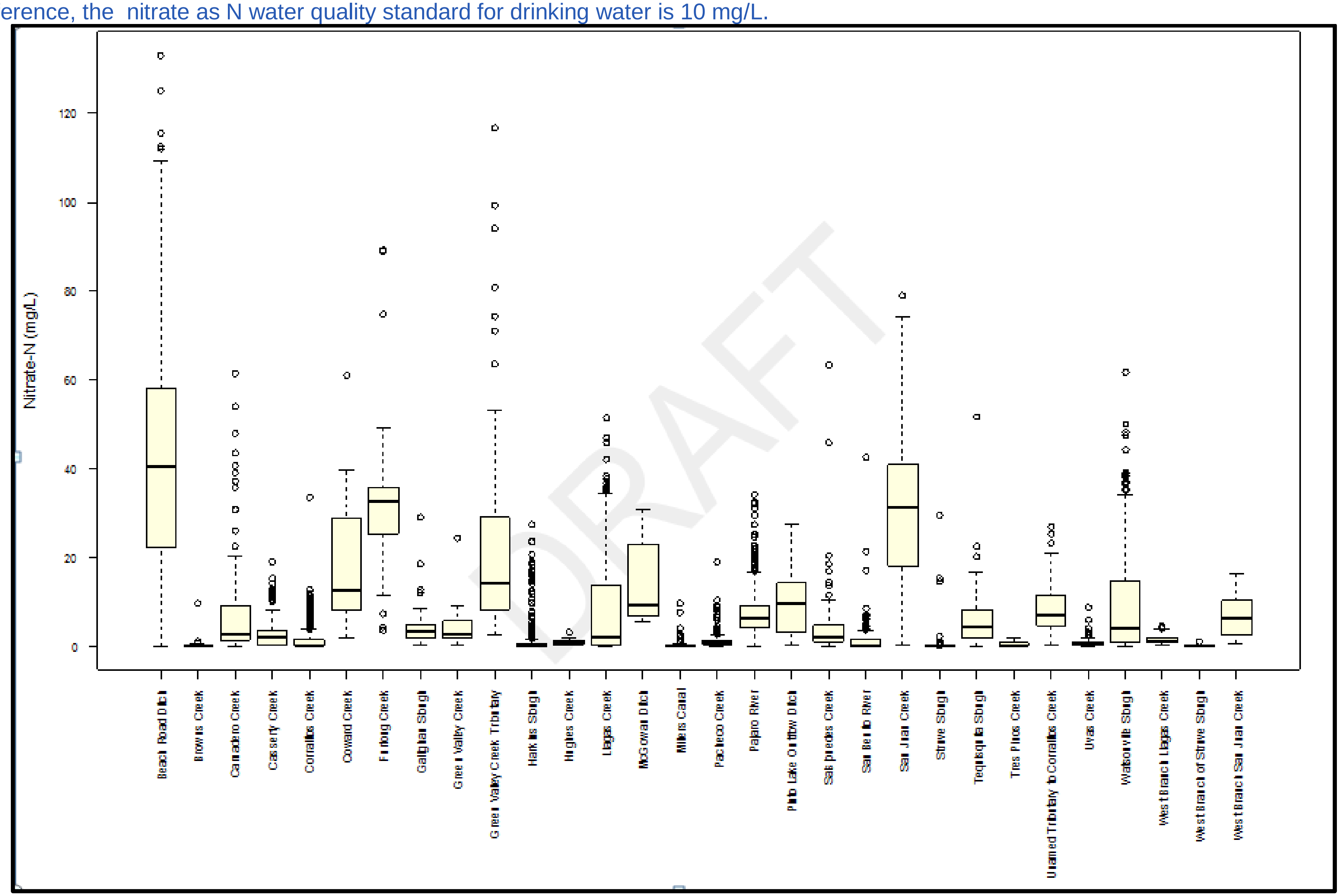


Figure 5-11. Box and whiskers plot, nitrate as N water quality data, Pajaro River. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the nitrate as N water quality standard for drinking water is 10 mg/L.

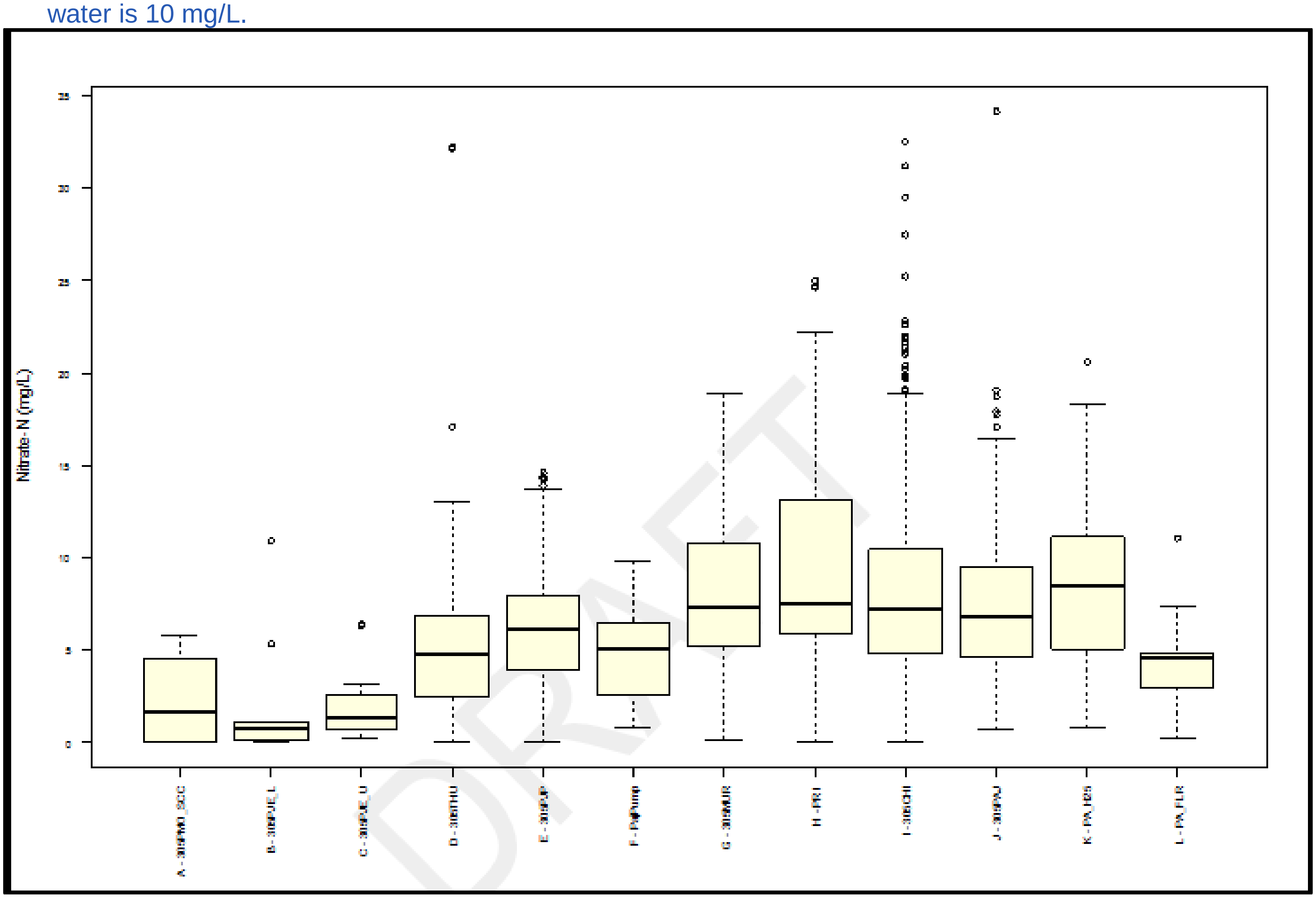


Figure 5-12. Box and whiskers plot, nitrate as N water quality data, Llagas Creek. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the nitrate as N water quality standard for drinking water is 10 mg/L.

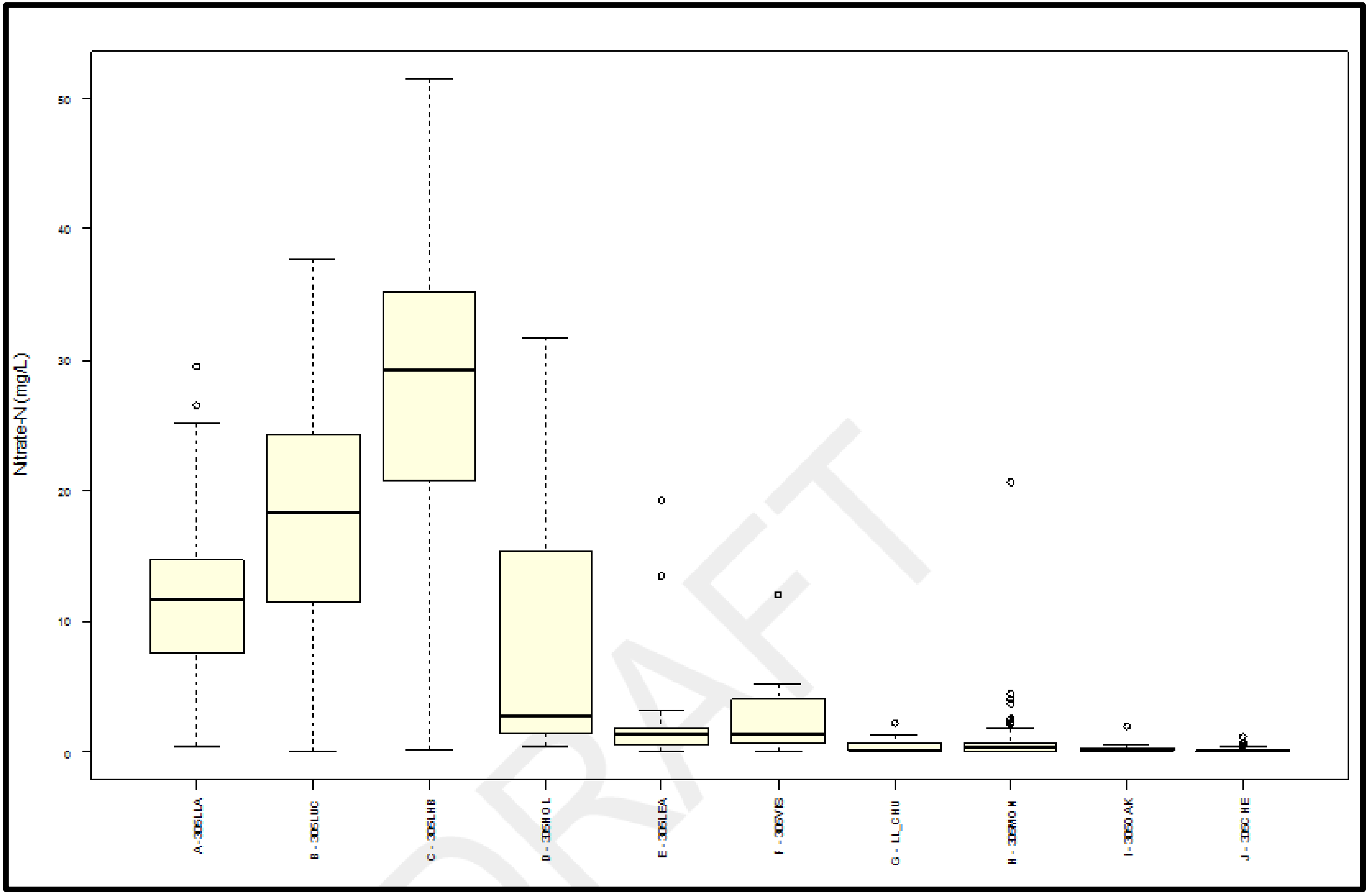


Figure 5-13. Box and whiskers plot, nitrate as N water quality data, Watsonville Slough. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the nitrate as N water quality standard for drinking water is 10 mg/L.

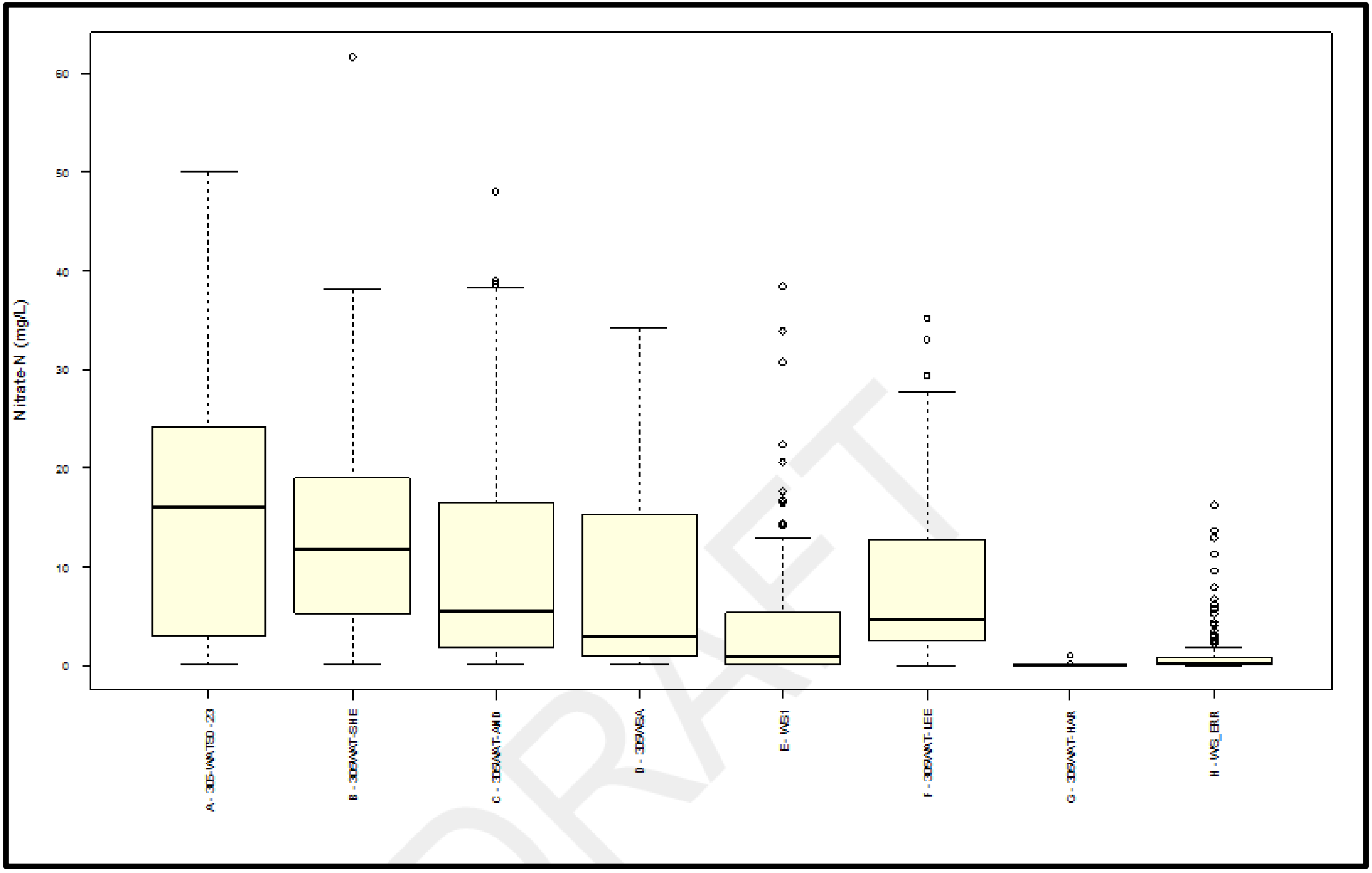


Figure 5-14. Box and whiskers plot, nitrate as N water quality data, San Juan Creek. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the nitrate as N water quality standard for drinking water is 10 mg/.

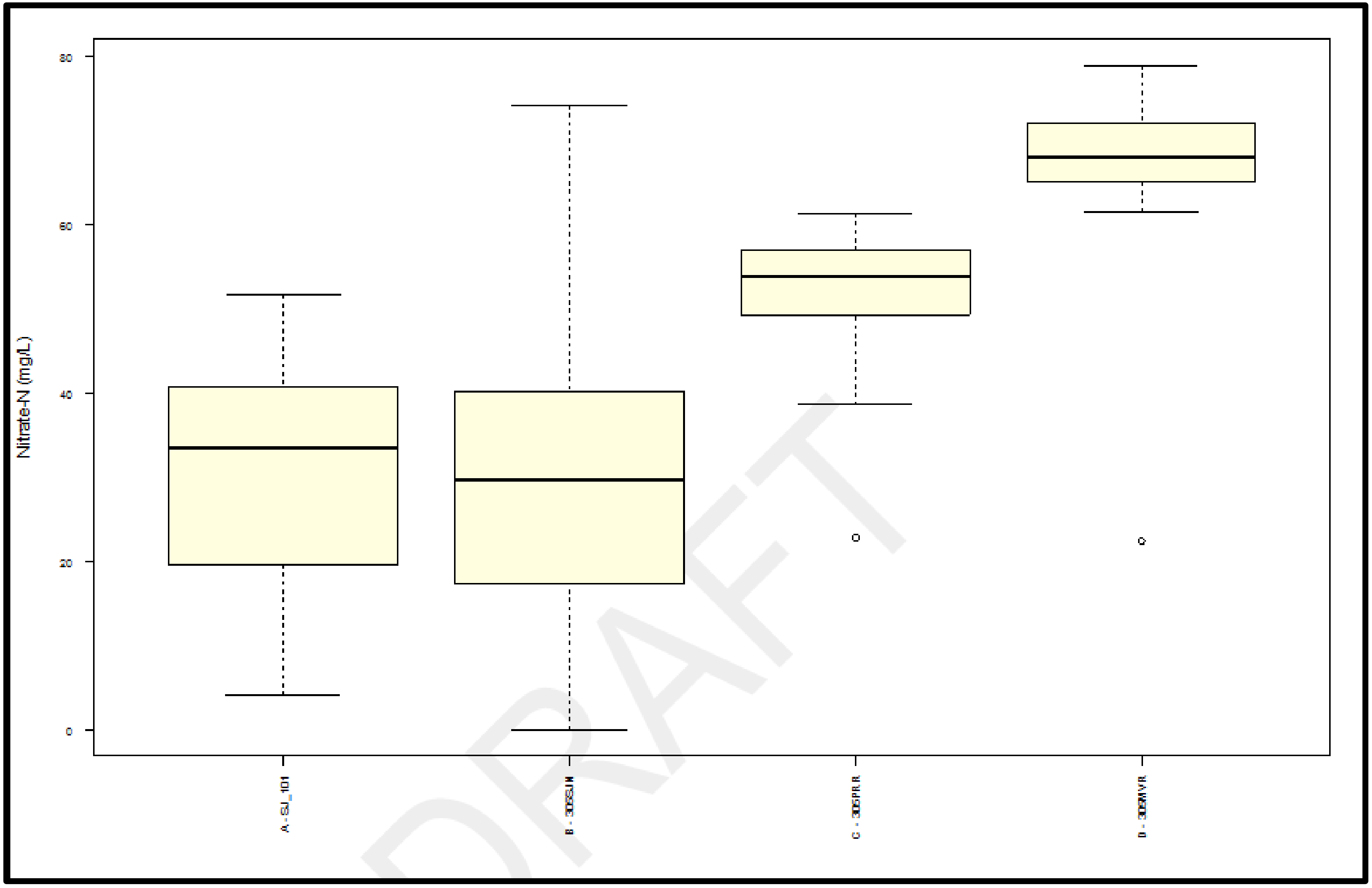


Figure 5-15. Box and whiskers plot, orthophosphate as P water quality data for all waterbodies within the Pajaro River basin, ordered alphabetically. For reference, the orthophosphate as P guideline is 0.3 mg/L (State of Nevada criteria for Class B and most Class A streams). Note that Green Valley Creek Tributary had multiple values above 5 mg/L that are not shown here so as not to skew the overall scale of the graph.

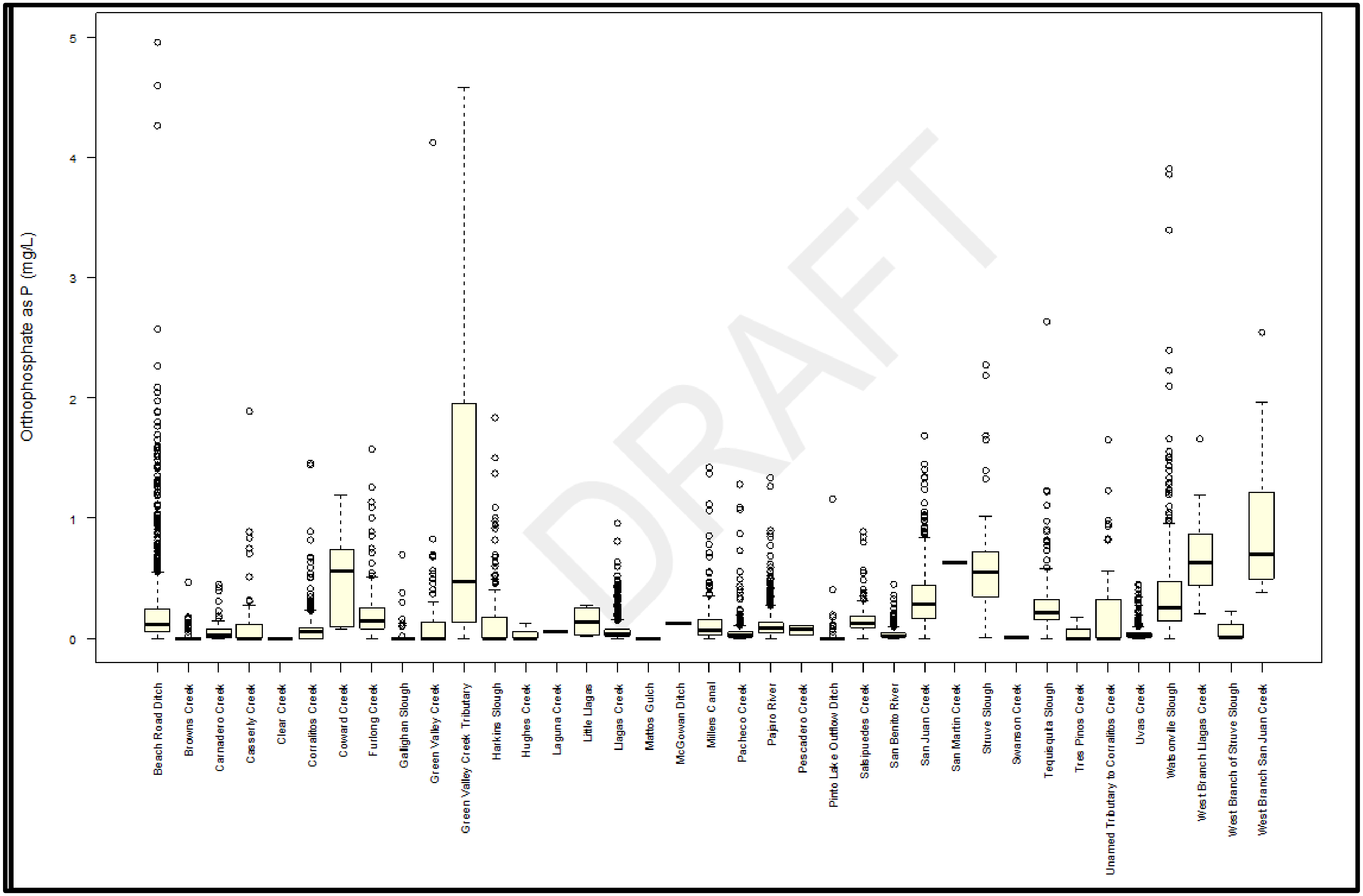


Figure 5-16. Box and whiskers plot, orthophosphate as P water quality data, Pajaro River. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the orthophosphate as P guideline is 0.3 mg/L.

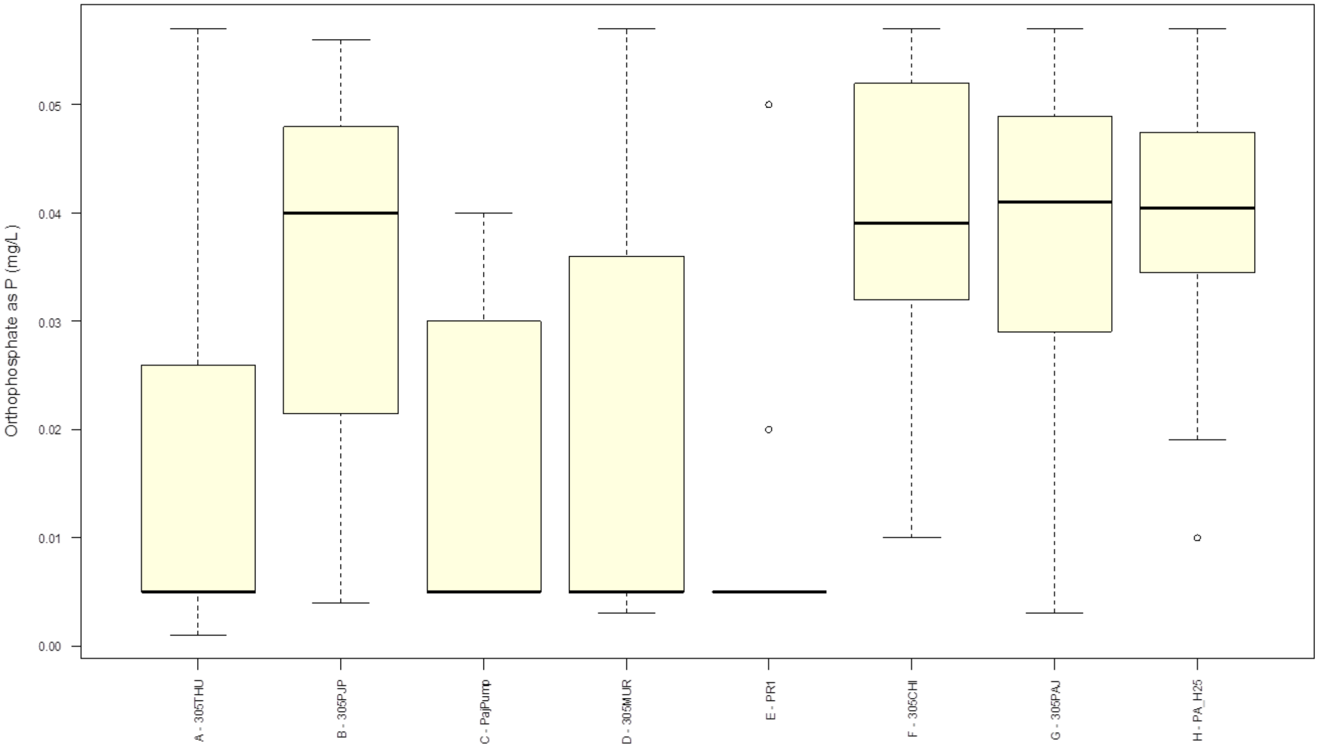


Figure 5-17. Box and whiskers plot, orthophosphate as P water quality data, Llagas Creek. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the orthophosphate as P guideline is 0.3 mg/L.

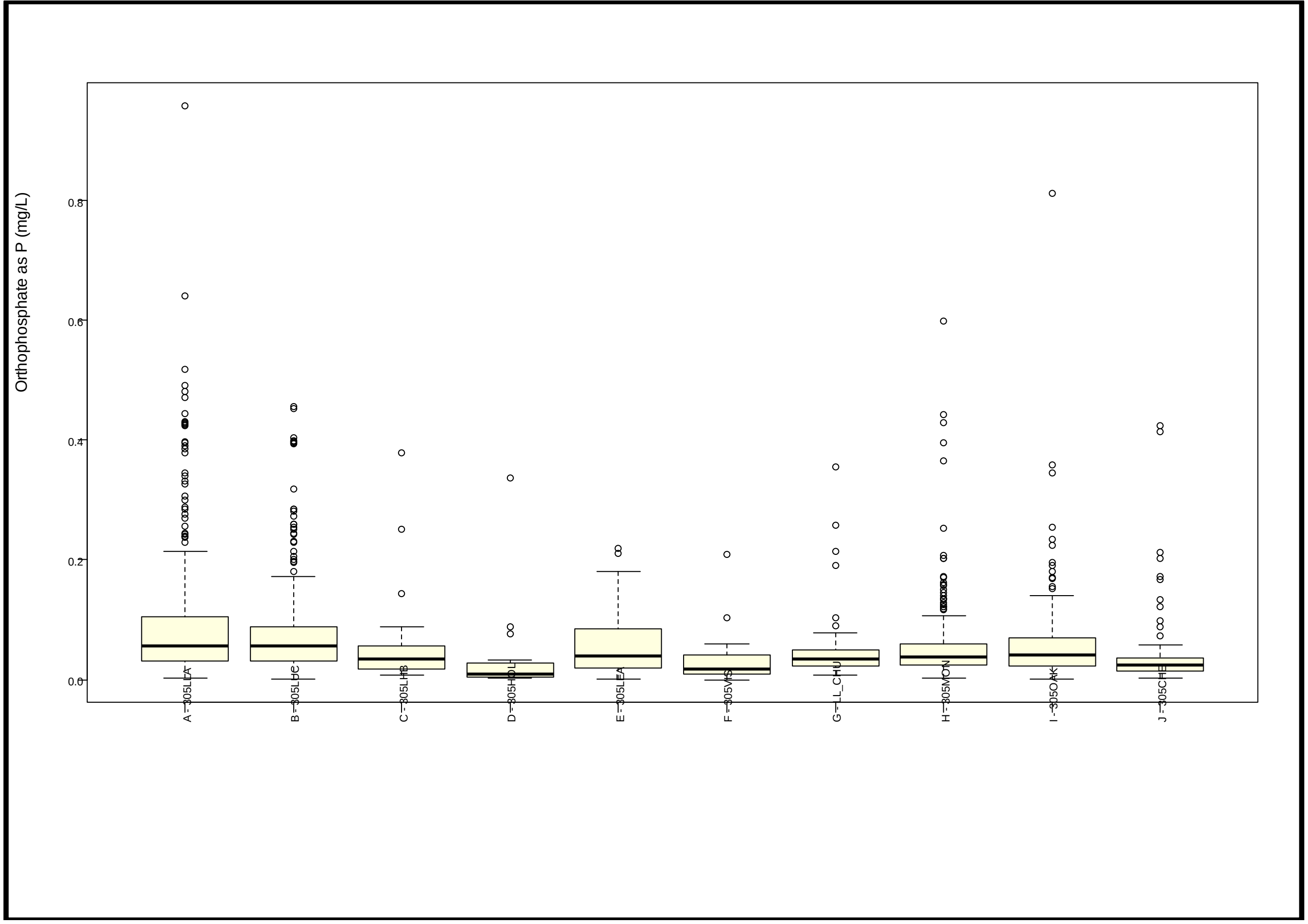


Figure 5-18. Box and whiskers plot, orthophosphate as P water quality data, Watsonville Slough. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the orthophosphate as P guideline is 0.3 mg/L.

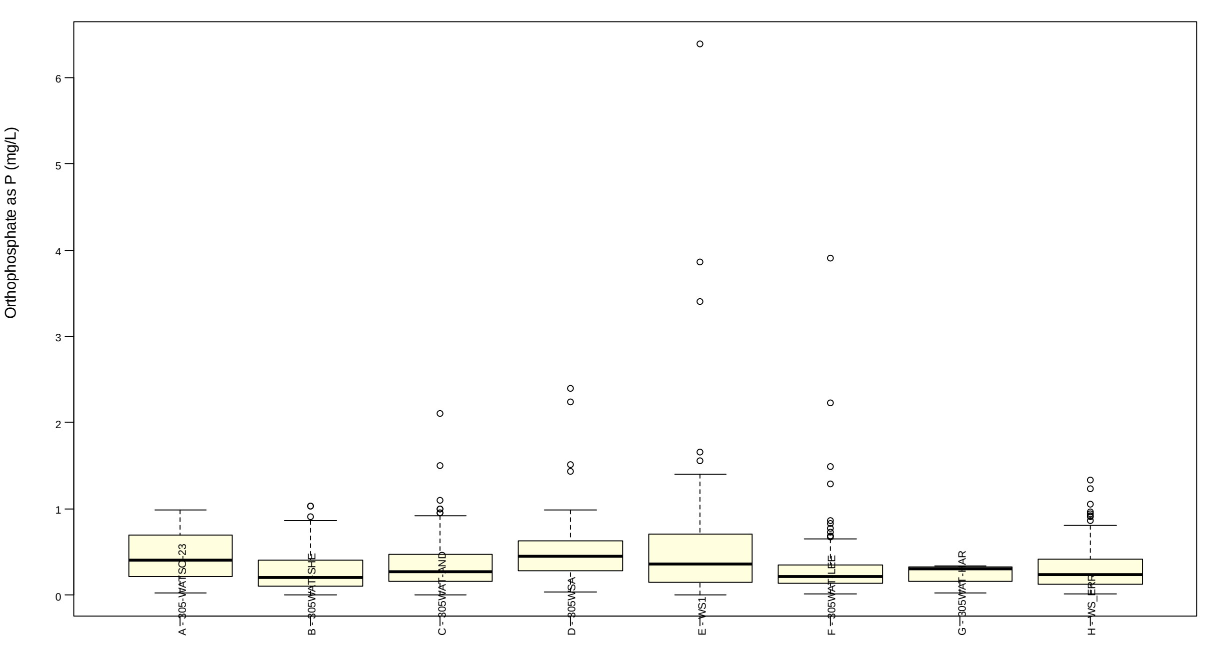
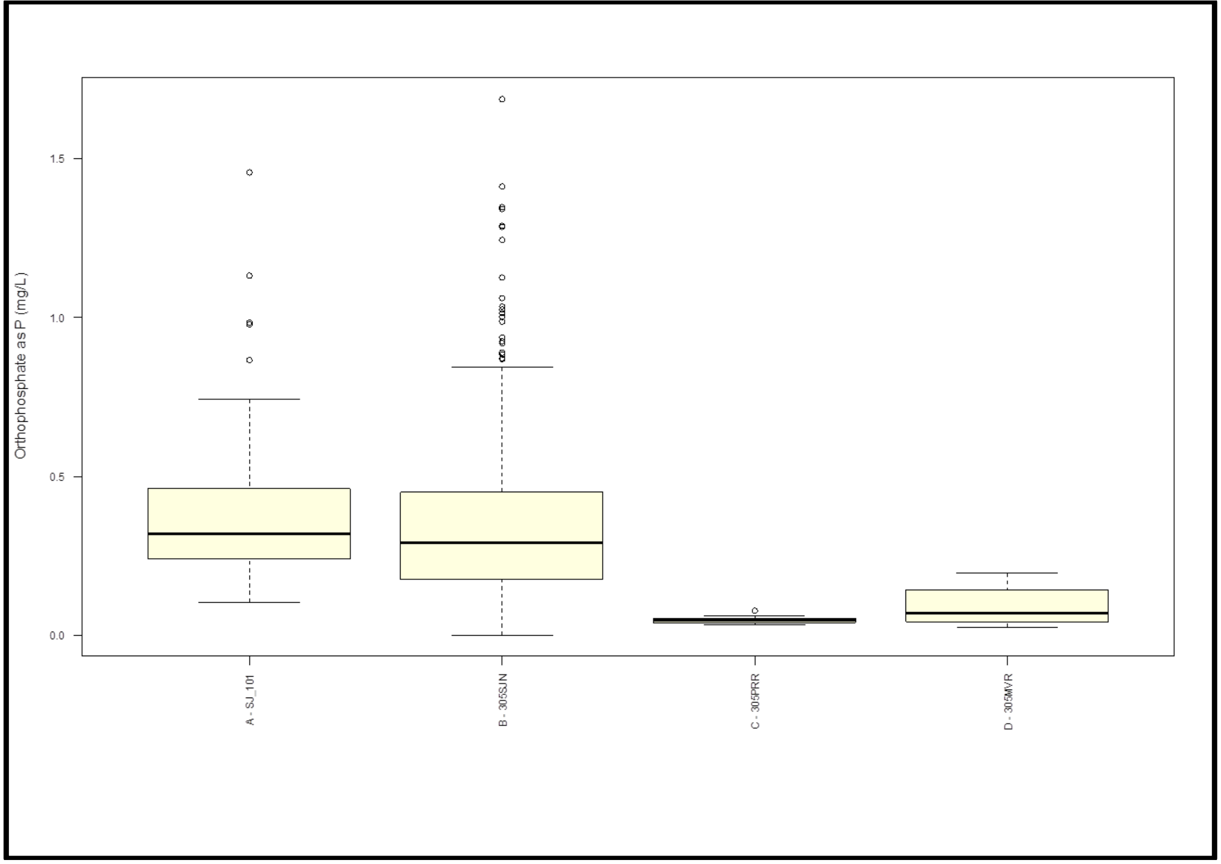


Figure 5-19. Box and whiskers plot, orthophosphate as P water quality data, San Juan Creek. Sites are shown from most downstream site to the most upstream site. The most downstream site is on the far left and the most upstream site is on the far right. For reference, the orthophosphate as P guideline is 0.3 mg/L.



5.5 Water Quality Temporal Trends

Figure 5-20 through Figure 5-26 illustrate time series plots of nitrate as N concentrations several key points in the Pajaro River basin, where stream nitrate concentrations are known to be highly elevated above natural background conditions. In addition, Central Coast Water Board staff performed Kendall's tau[131] nonparametric correlation tests using R[132] on these time series datasets shown, and the results of the Kendall's tau tests are presented in Table 5-3. The correlation tests indicate that nitrate concentrations in the Pajaro River monitoring sites, and at the Llagas Creek monitoring site, have a positive (increasing) trend over the periods of record (tau ranging from 0.084 to 0.296) and these correlations are both statistically significant (p-value < 2.2 e-16).

Practically speaking, this means there is a trend of increasing nitrate as N concentrations over the periods of record at these monitoring sites and there is a very low probability that it could be due to random chance. Also noteworthy is that nitrate as N concentrations have been decreasing at the Watsonville Slough monitoring site over the period of record, and this decreasing trend is statistically significant.

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[131] As described by the U.S. Geological Survey (U.S. Geological Survey, 2002b), the Kendall's tau test statistic is a nonparametric measure of the monotonic correlation between the variables. By convention, Kendall's tau correlation coefficients are considered statistically significant when probabilities (p-values) are less than 0.05.

[132] R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Table 5-3. Tabular summary of nitrate as N concentrations temporal trends and significance at several key stream monitoring sites in the Pajaro River basin. Graphs illustrating the time series data summarized herein are presented in Figure 5-20 through Figure 5-26

Stream Monitoring Site	Associated Watershed & Subwatershed	No. of Samples	Temporal Representation	tau	p-value	Interpretation of Nitrate-N Concentration Temporal Trends and Significance
Pajaro River @ Thurwatcher Bridge	Pajaro River Watershed Lower Pajaro River Subwatershed	442	1997–2013	0.084	0.00857	Increasing Trend and Statistically Significant
Pajaro River @ Porter	Pajaro River Watershed Lower Pajaro River Subwatershed	395	2000–2013	0.152	7.016E-6	Increasing Trend and Statistically Significant
Pajaro River @ Murphy's Crossing	Pajaro River Watershed Lower Pajaro River Subwatershed	337	1998–2013	0.142	0.000113	Increasing Trend and Statistically Significant
Pajaro River @ Chittenden Gap	Pajaro River Watershed Lower Pajaro River Subwatershed	755	1952–2013	0.296	<2.2E-16	Increasing Trend and Statistically Significant
Llagas Creek @ Bloomfield Ave.	Llagas Creek Watershed Lower Llagas Creek Subwatershed	343	1992–2011	0.182	4.68E-7	Increasing Trend and Statistically Significant
Watsonville Slough @ Shell Rd.	Pajaro River Watershed Watsonville Slough Subwatershed	130	1994–2013	-0.205	4.504E-7	Decreasing trend and Statistically Significant
San Juan Creek @ Anzar Rd.	Lower San Benito River Watershed San Juan Canyon Subwatershed	227	2003–2011	-0.068	0.1254	Decreasing Trend and Not Statistically Significant

Figure 5-20. Time series (1997-2013), nitrate as N – lower Pajaro River at Thuwatcher Bridge.

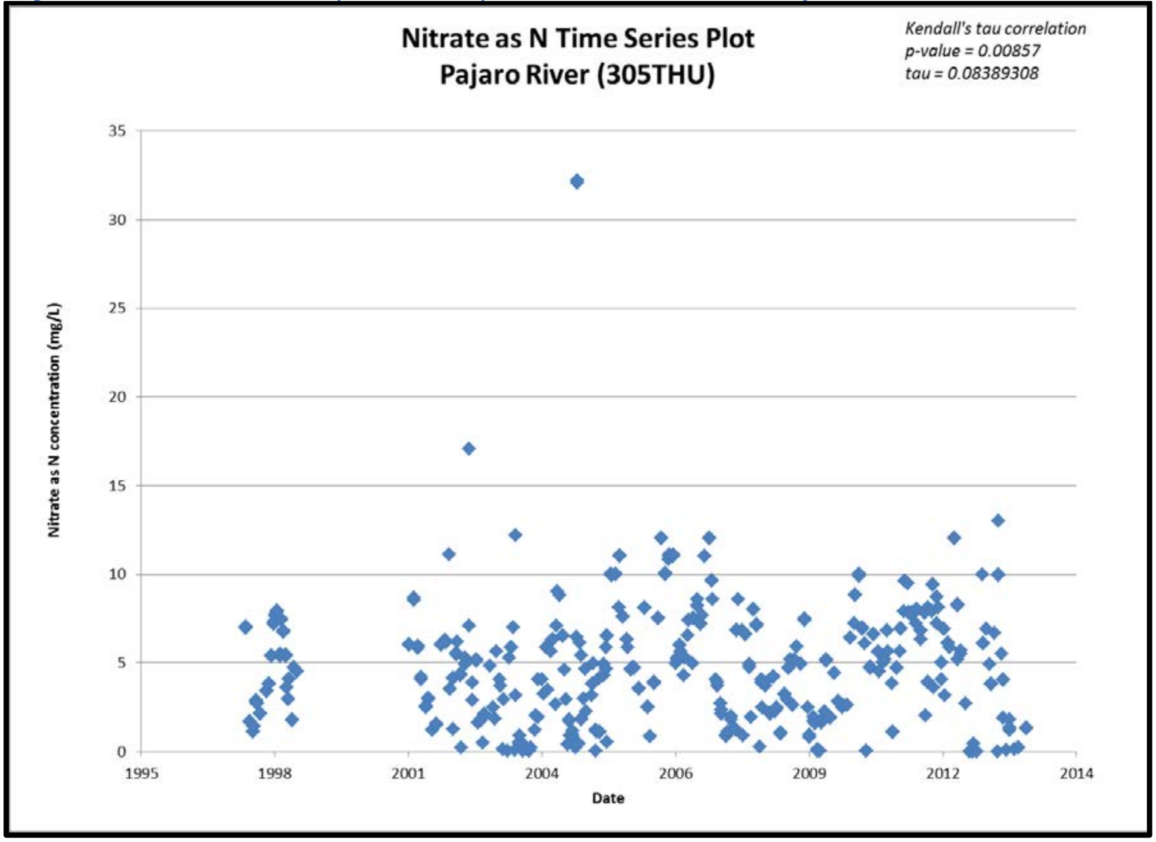


Figure 5-21. Time series (2000-2013), nitrate as N – Pajaro River at Porter.

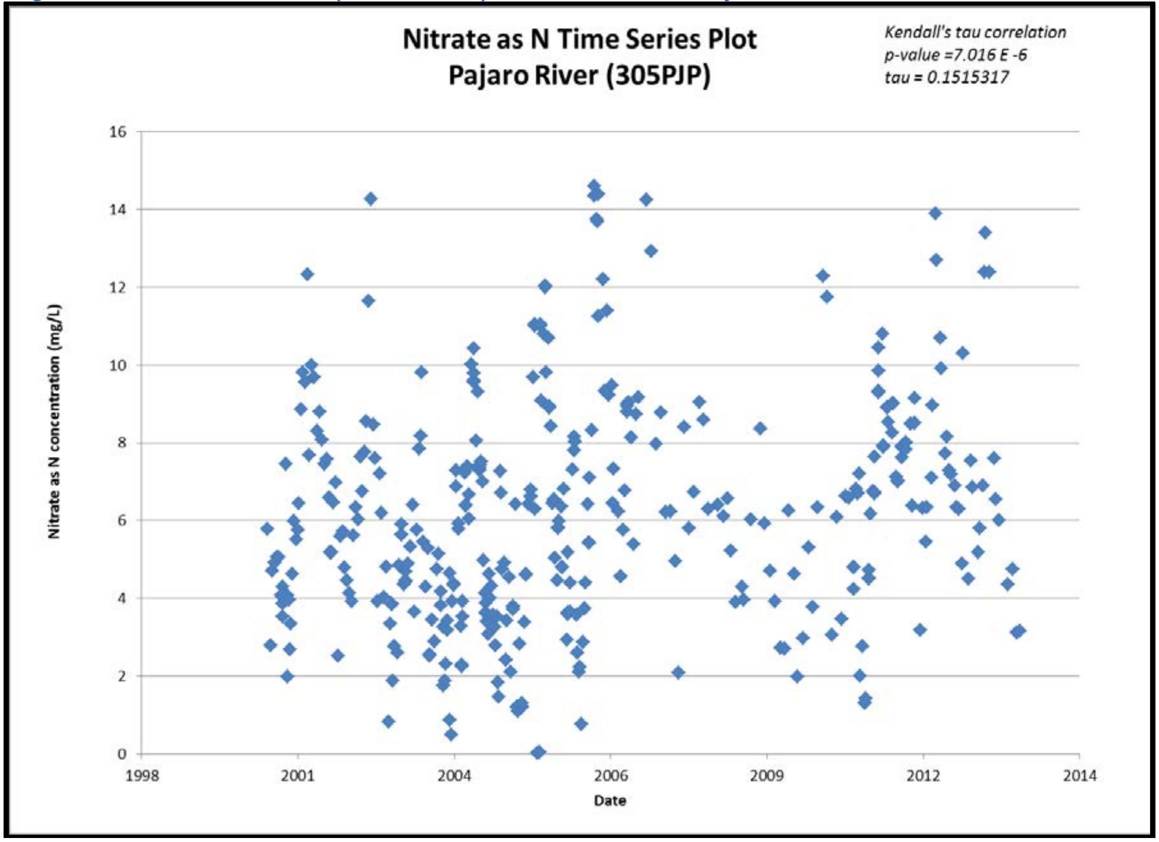


Figure 5-22. Time series (1998-2013), nitrate as N – Pajaro River at Murphy's Crossing.

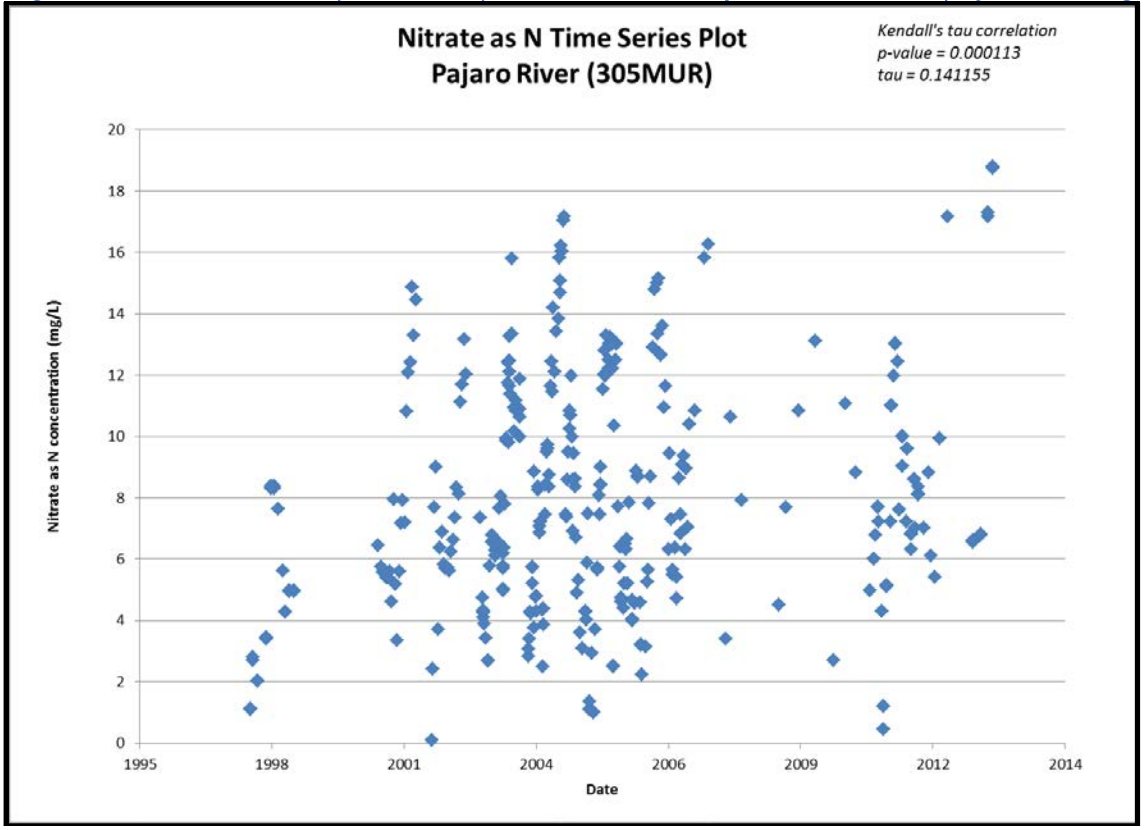


Figure 5-23. Time series (1952-2013), nitrate as N – Pajaro River at Chittenden Gap.

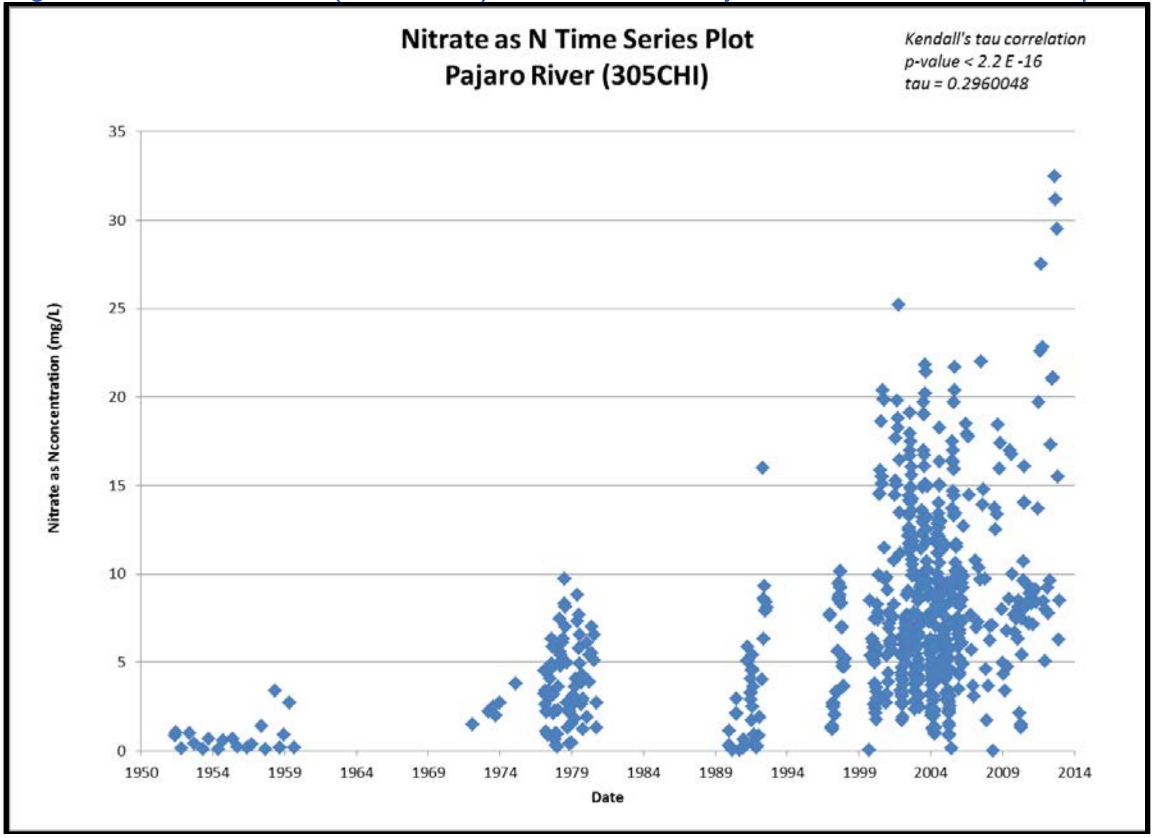


Figure 5-24. Time series (1992-2011), nitrate as N – Llagas Creek at Bloomfield Avenue.

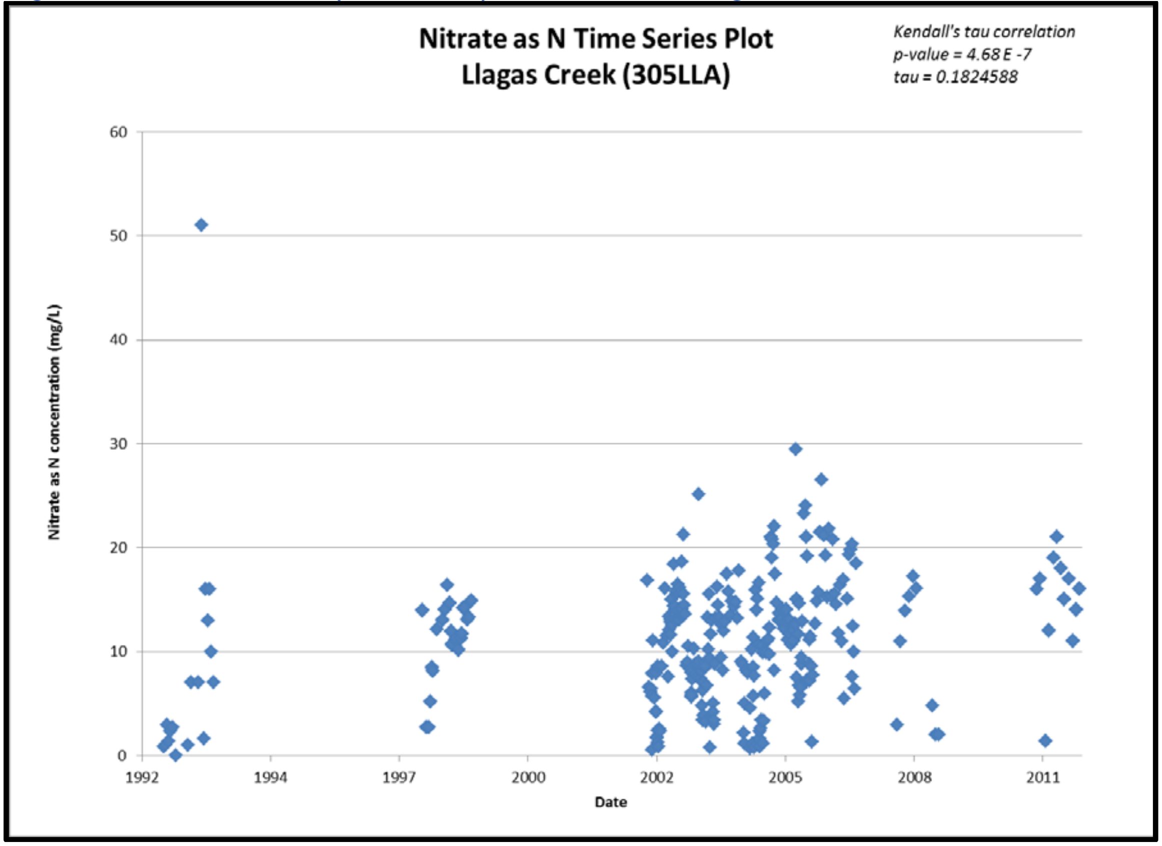


Figure 5-25. Time series (1994-2013), nitrate as N – Watsonville Slough at Shell Road.

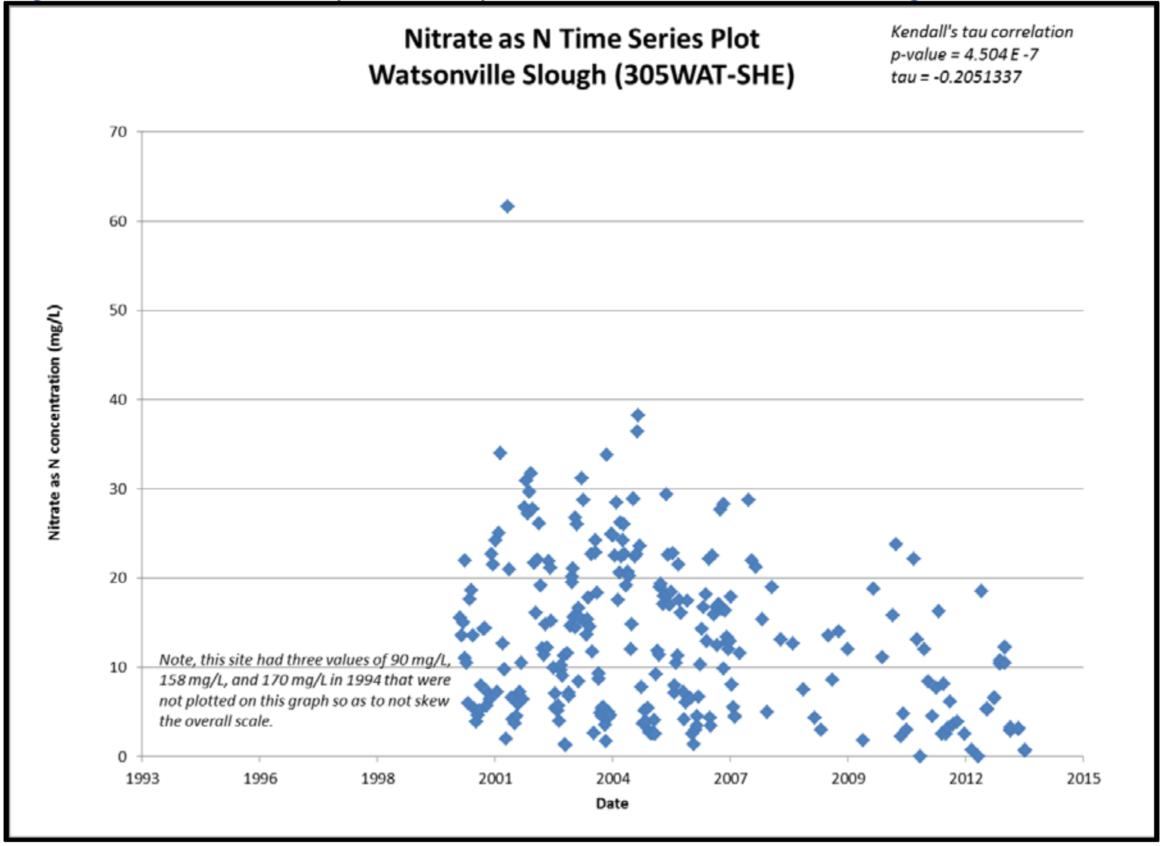


Figure 5-26. Time series (2003-2011), nitrate as N – Lower San Juan Creek at Anzar Road.

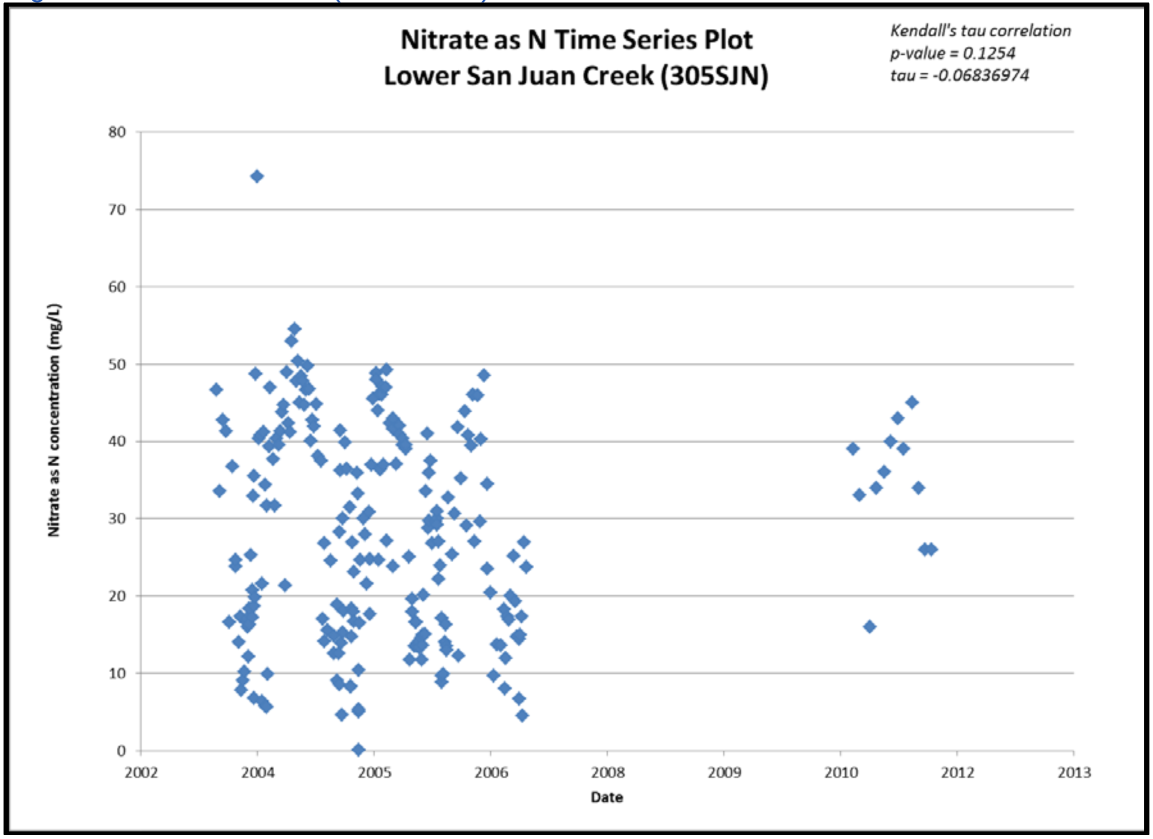


Figure 5-27 through Figure 5-33 illustrate time series plots of orthophosphate as P concentrations at several key stream monitoring sites in the Pajaro River basin, where stream nitrate concentrations are known to be highly elevated about natural background conditions. In addition, Central Coast Water Board staff performed Kendall's tau nonparametric correlation tests using R on these time series datasets shown, and the results of the Kendall's tau tests are presented in Table 5-4. The correlation tests indicate that orthophosphate concentration trends in the Pajaro River monitoring sites, and at the Llagas Creek monitoring site are generally not significant. Practically speaking, this means the associations between time and orthophosphate concentrations are not statistically significant at these stream monitoring sites and there is an unacceptably high probability that these two variables are not strongly associated. It should be noted that nitrate concentration reductions at Murphy's Crossing on the Pajaro River was statistically significant for the period of record 1998 to 2013.

However, noteworthy is that orthophosphate as P concentrations have been decreasing at the Watsonville Slough monitoring site over the period of record, and this decreasing trend is statistically significant, meaning it is highly unlikely this is due to random chance.

It should be noted that the periods of record used for these data trends are quite long, with data extending back a decade or even several decades. More recent trends in improving water quality (recent trends seen at temporal scales less than a decade) have been compiled by the Central Coast Ambient Monitoring Program, and may show some improvements in water quality at some stream reaches over the last few years.

Table 5-4. Tabular summary of orthophosphate as P concentrations temporal trends and significance at several key stream monitoring sites in the Pajaro River basin. Graphs illustrating the time series data summarized herein are presented in Figure 5-27 through Figure 5-33.

Stream Monitoring Site	**Associated Watershed & Subwatershed**	**No. of Samples**	**Temporal Representation**	**tau**	**p-value**	**Interpretation of Orthophosphate-P Concentration Temporal Trends and Significance**
Pajaro River @ Thurwatcher Bridge	Pajaro River Watershed Lower Pajaro River Subwatershed	273	1972–2013	0.0446	0.293	Increasing Trend and Not Statistically Significant
Pajaro River @ Porter	Pajaro River Watershed Lower Pajaro River Subwatershed	360	2000–2013	0.0539	0.128	Increasing Trend and Not Statistically Significant
Pajaro River @ Murphy's Crossing	Pajaro River Watershed Lower Pajaro River Subwatershed	291	1998–2013	-0.102	0.0110	Decreasing Trend and Statistically Significant
Pajaro River @ Chittenden Gap	Pajaro River Watershed Lower Pajaro River Subwatershed	629	1976–2013	-0.0337	0.208	Decreasing Trend and Not Statistically Significant
Llagas Creek @ Bloomfiled Ave.	Llagas Creek Watershed Lower Llagas Creek Subwatershed	290	1992–2011	-0.00321	0.935	Decreasing Trend and Not Statistically Significant
Watsonville Slough @ Shell Rd.	Pajaro River Watershed Watsonville Slough Subwatershed	255	2000–2013	-0.200	3.16 E -6	Decreasing trend and Statistically Significant
San Juan Creek @ Anzar Rd.	Lower San Benito River Watershed San Juan Canyon Subwatershed	318	2003–2013	-0.0845	0.0248	Decreasing Trend and Statistically Significant

Figure 5-27. Time series (1972 – 2013), orthophosphate as P – Pajaro River at Thuwatcher Bridge.

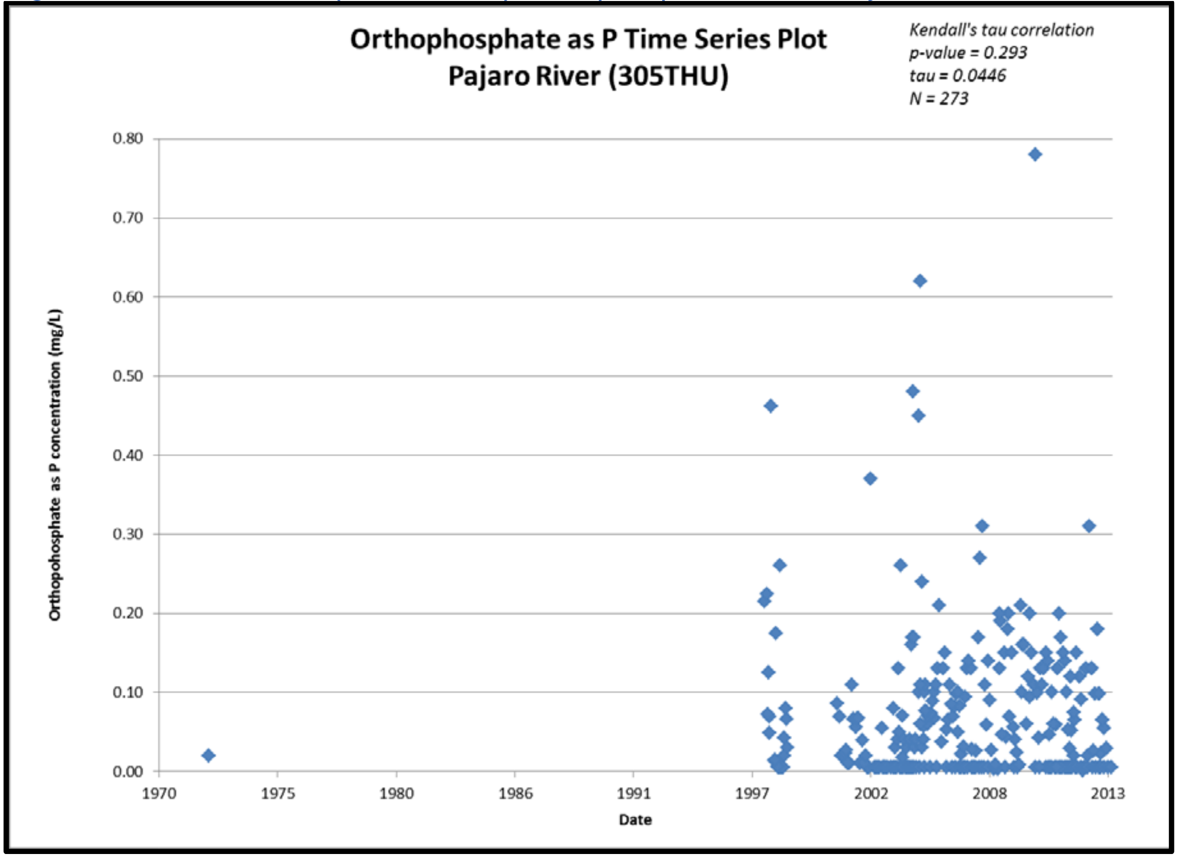


Figure 5-28. Time series (2000 – 2013), orthophosphate as P - Pajaro River at Porter.

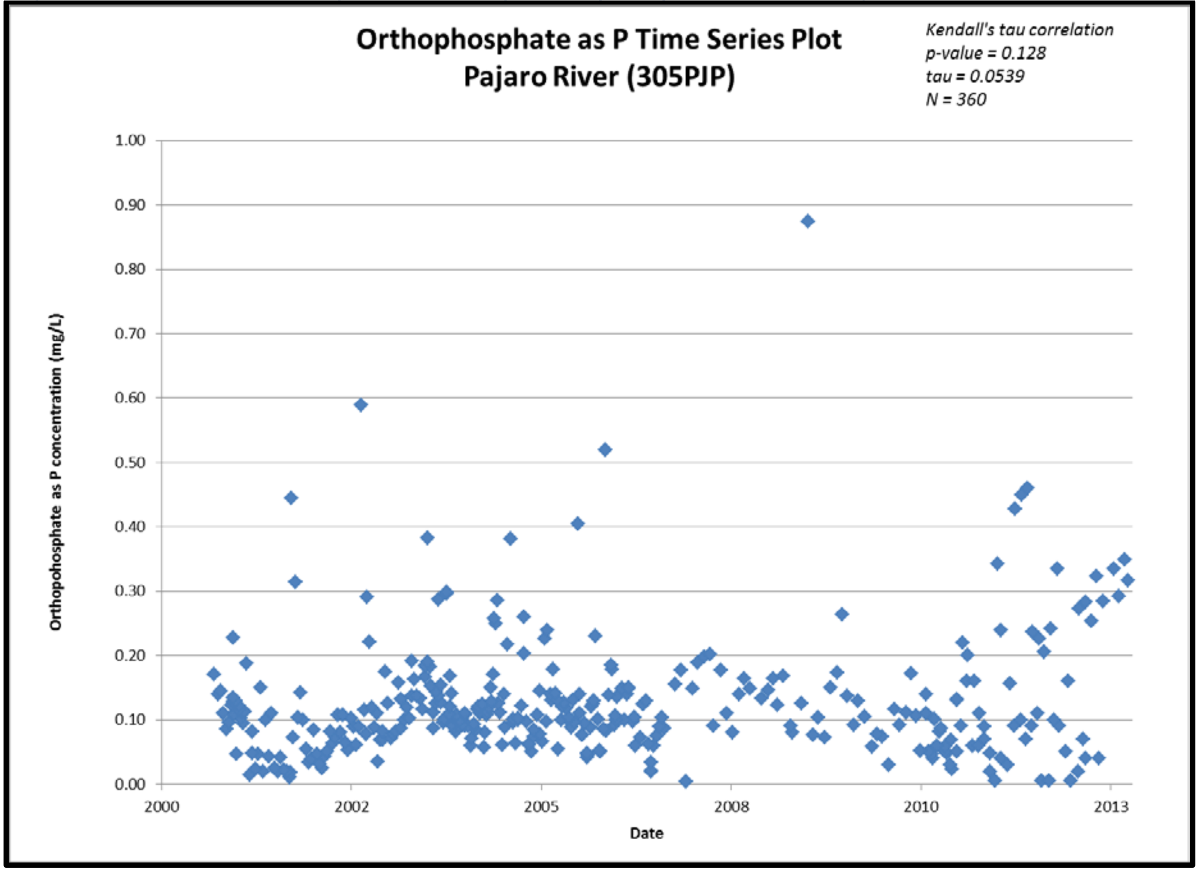


Figure 5-29. Time series (1998-2013), orthophosphate as P – Pajaro River at Murphy's Crossing.

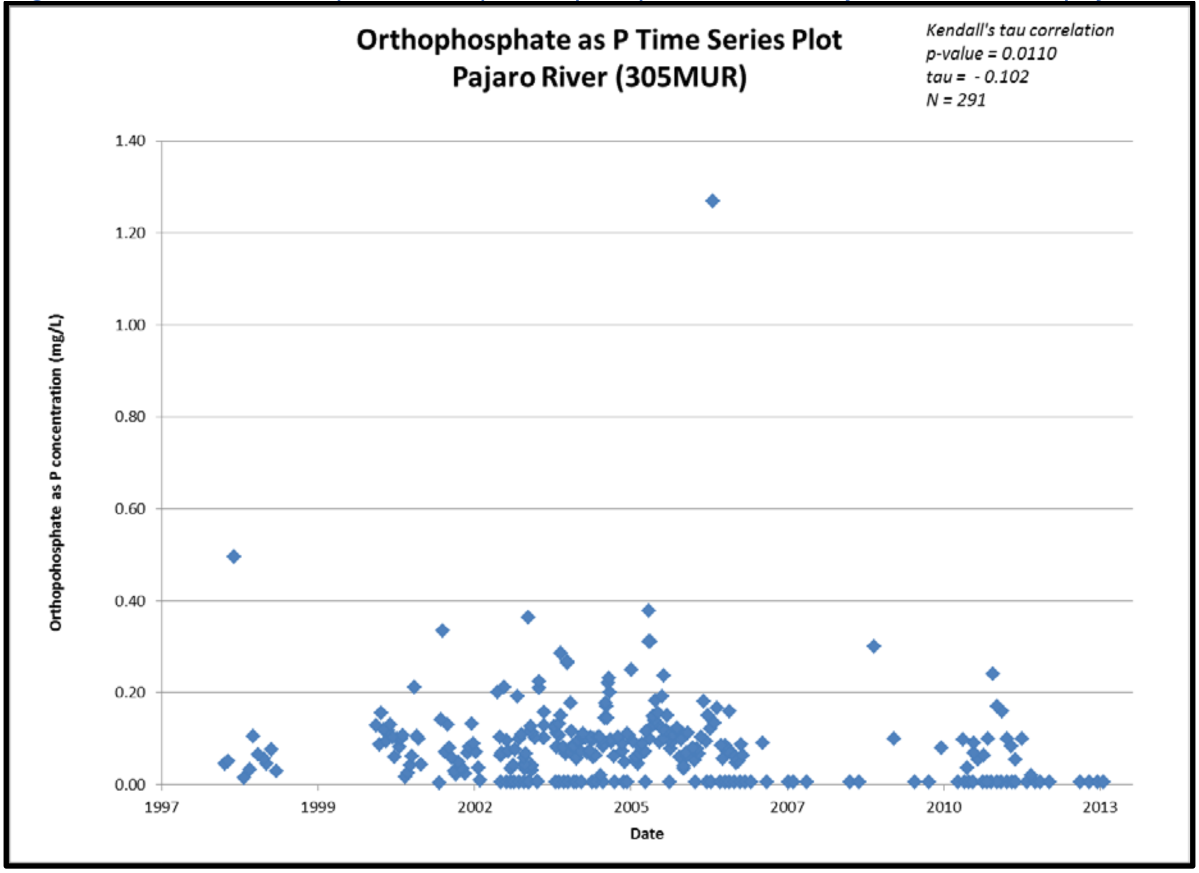


Figure 5-30. Time series (1976 – 2013), orthophosphate as P – Pajaro River at Chittenden Gap.

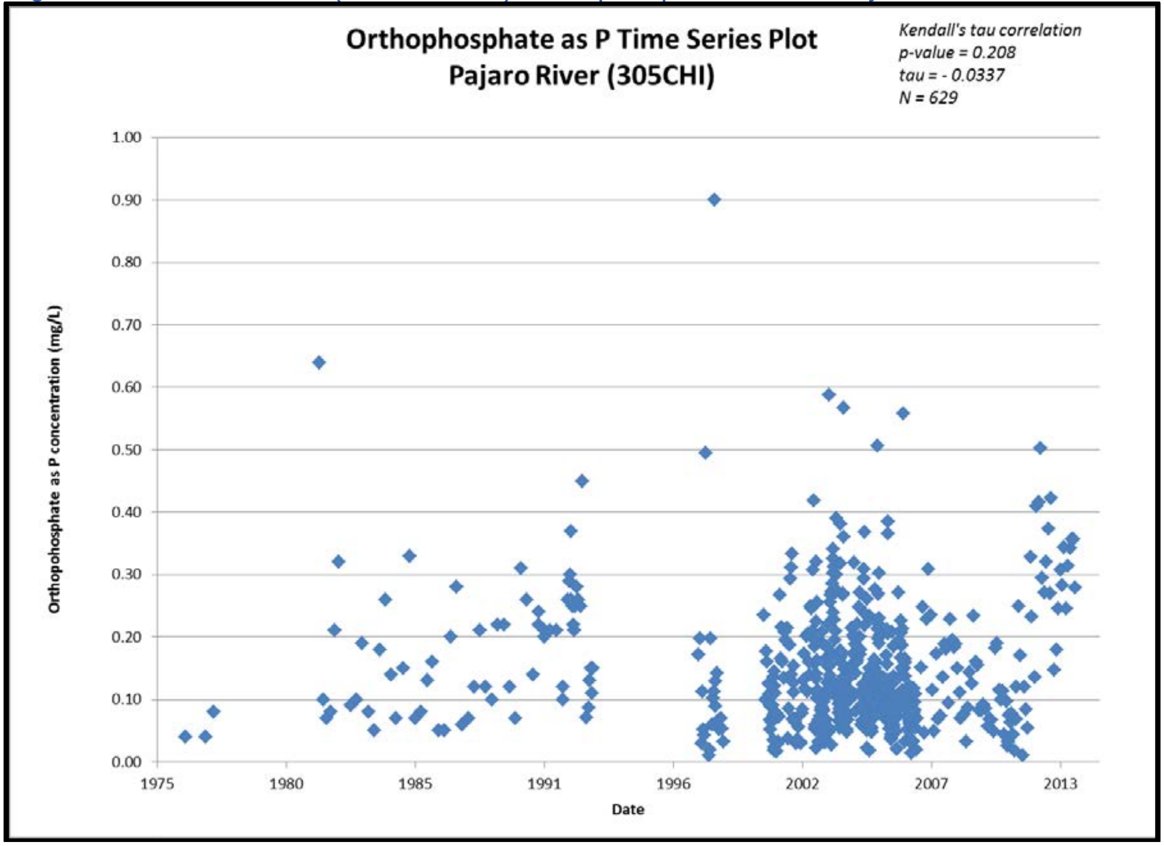


Figure 5-31. Time series (1992 – 2011), orthophosphate as P – Llagas Creek at Bloomfield Avenue.

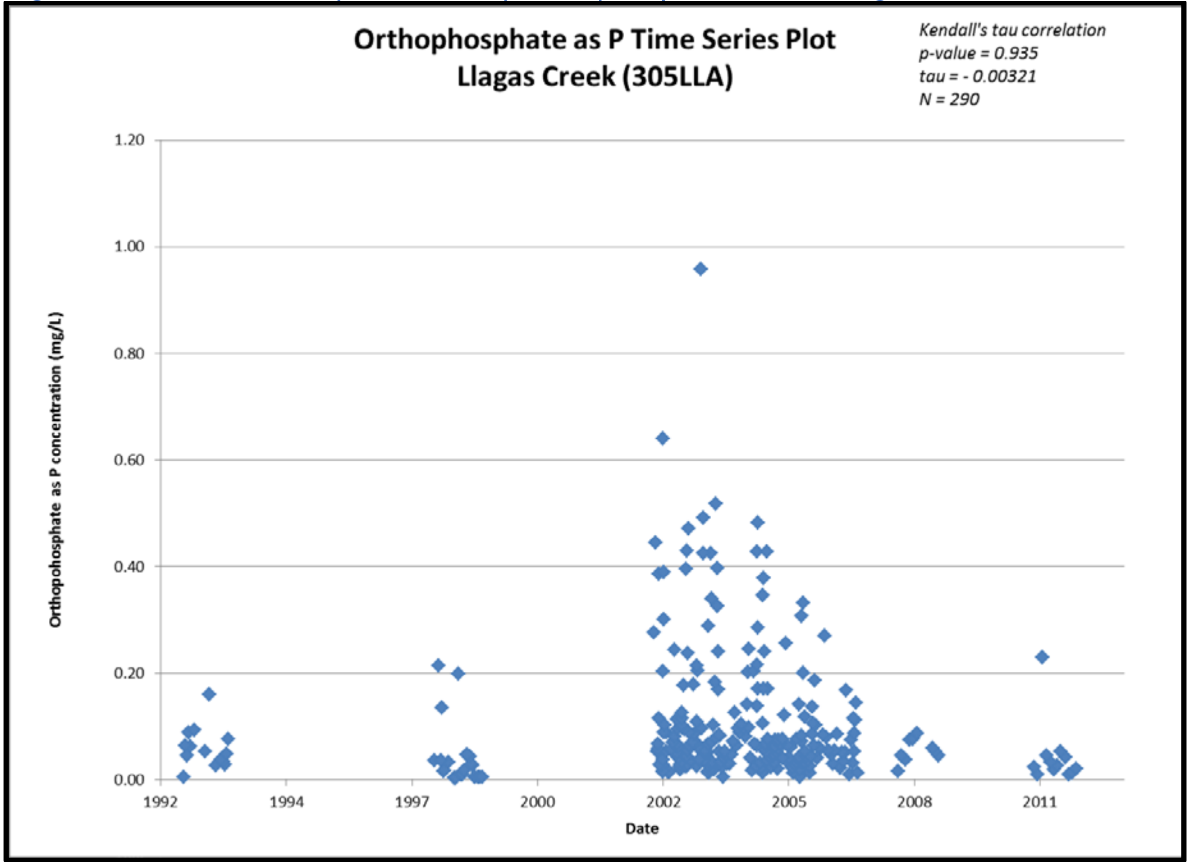


Figure 5-32. Time series (2000 – 2013), orthophosphate as P – Watsonville Slough at Shell Road.

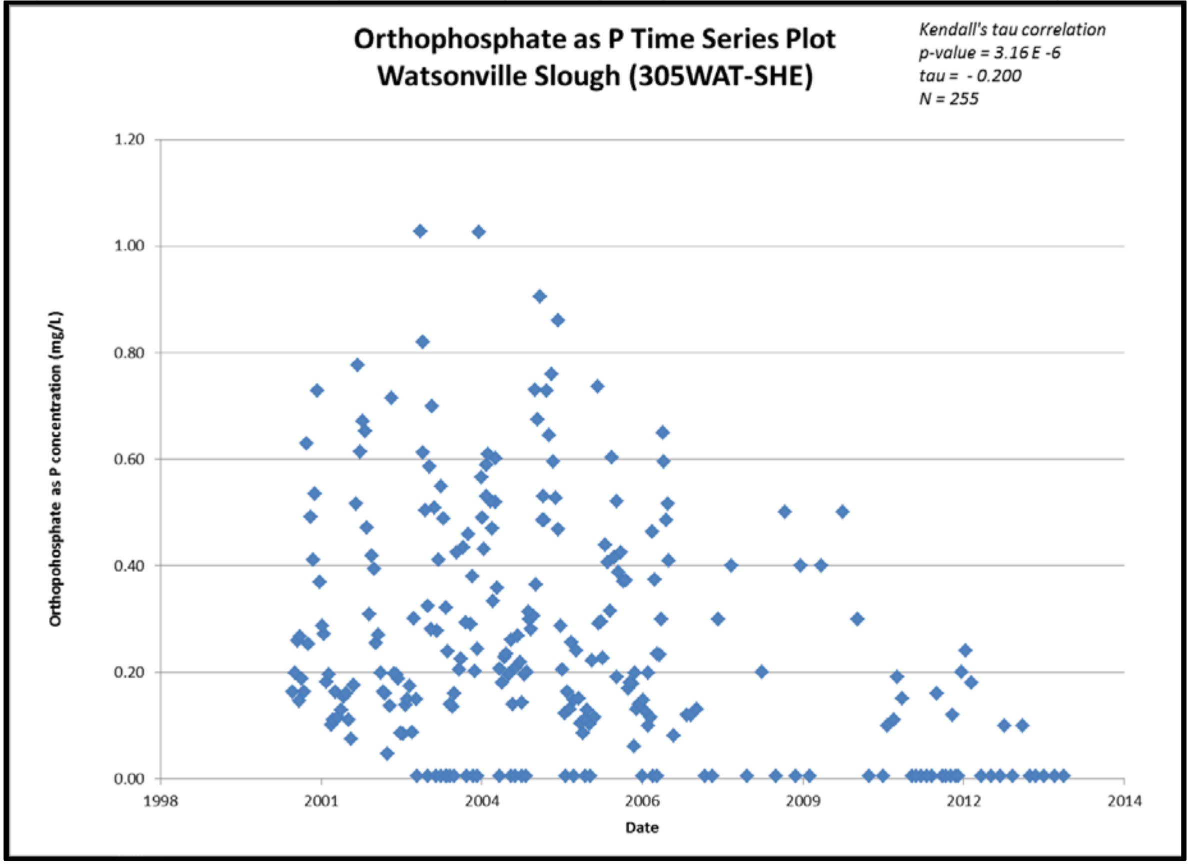
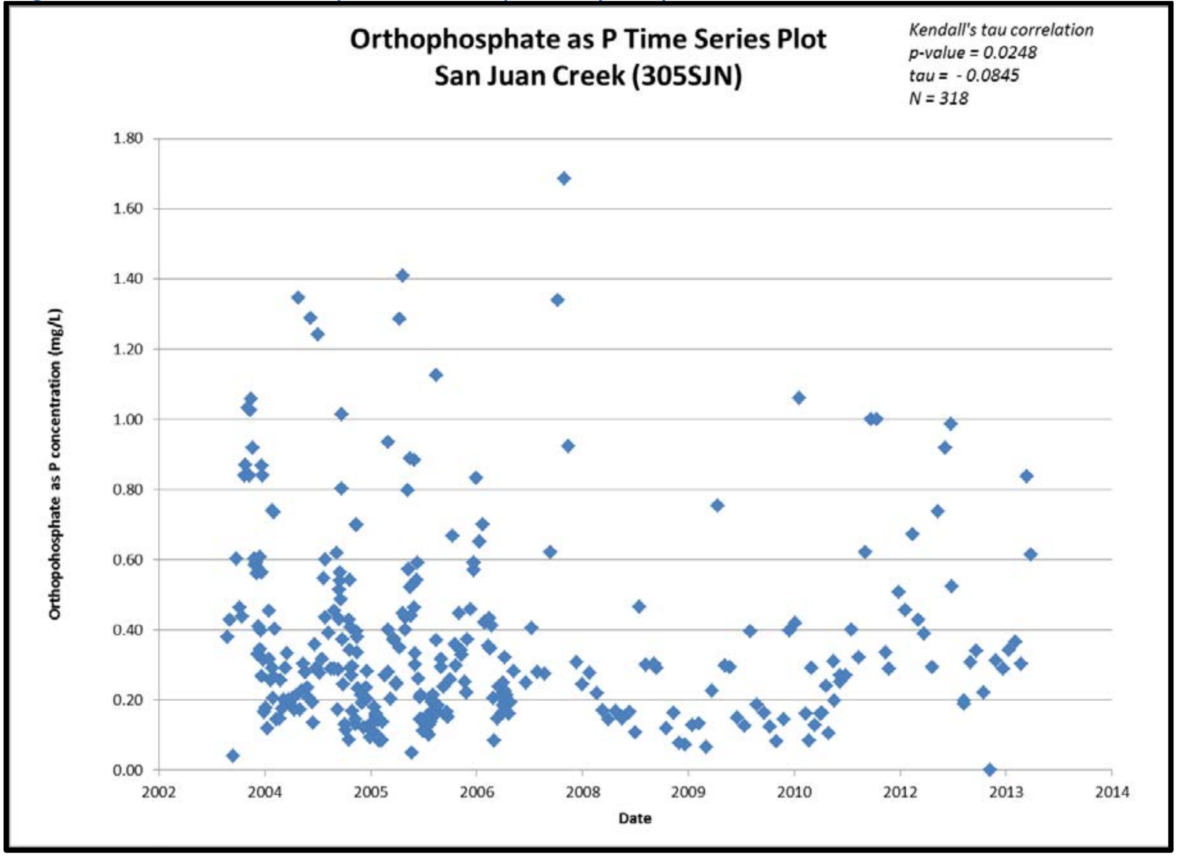


Figure 5-33. Time series (2003 – 2013), orthophosphate as P, San Juan Creek at Anzar Road.



5.6 Water Quality Seasonal Trends

Seasonal trends in nutrient water quality data are presented in Figure 5-34 through Figure 5-48. While there is substantial variability between different stream reaches and subwatersheds of the Pajaro River basin, often nitrate concentrations appear to spike during the summer, or low-flow, months.

Figure 5-34. Box and whisker plot of nitrate as N (mg/L) values on the Pajaro River at 305THU. Values plotted per month to show seasonal difference in nitrate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

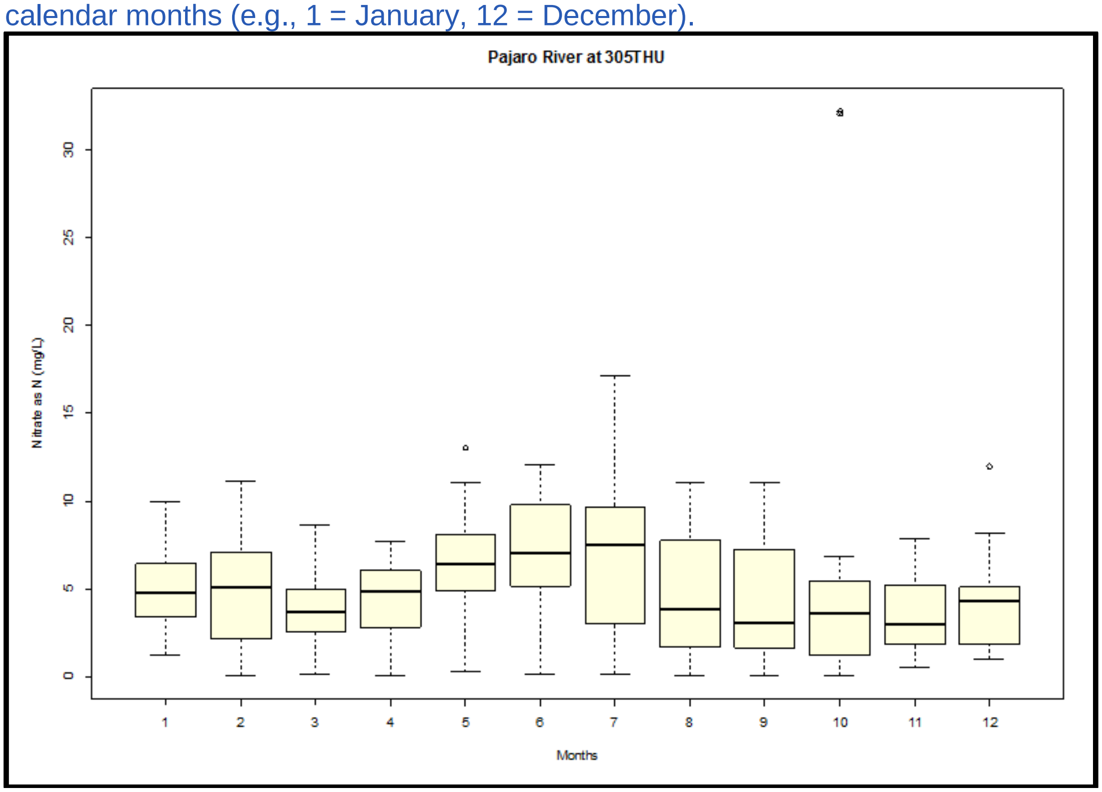


Figure 5-35. Box and whisker plot of nitrate as N (mg/L) values on the Pajaro River at 305CHI. Values plotted per month to show seasonal difference in nitrate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

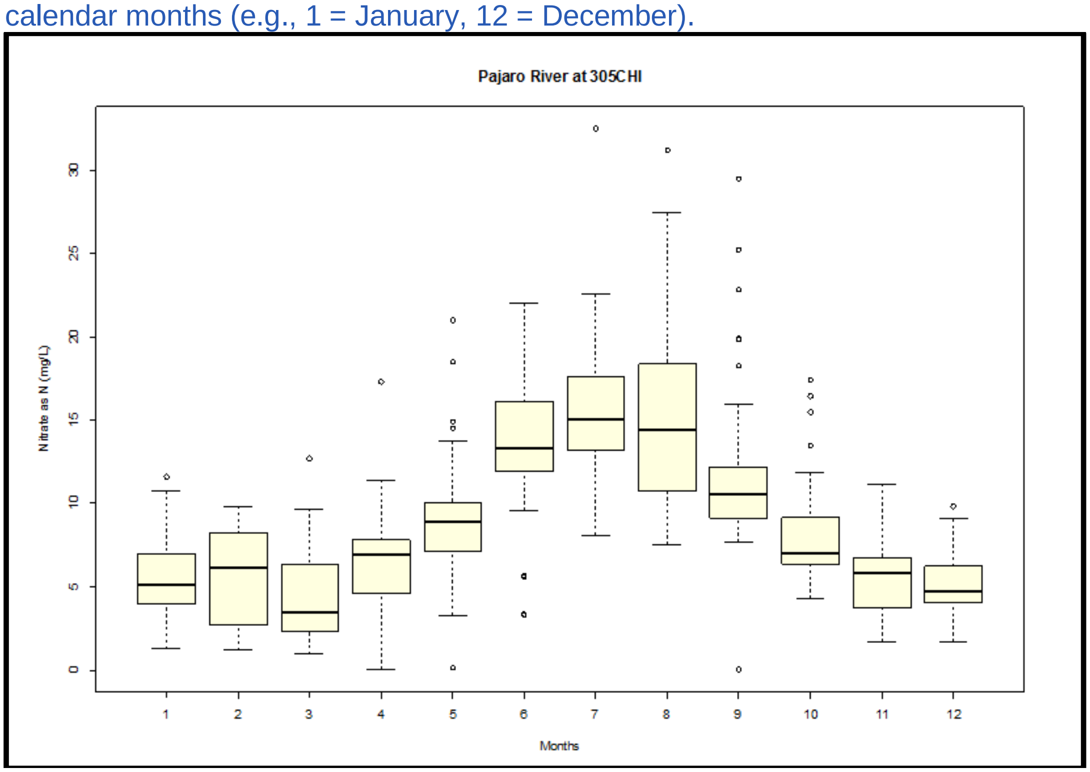


Figure 5-36. Box and whisker plot of nitrate as N (mg/L) values on Llagas Creek at 305LLA. Values plotted per month to show seasonal difference in nitrate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

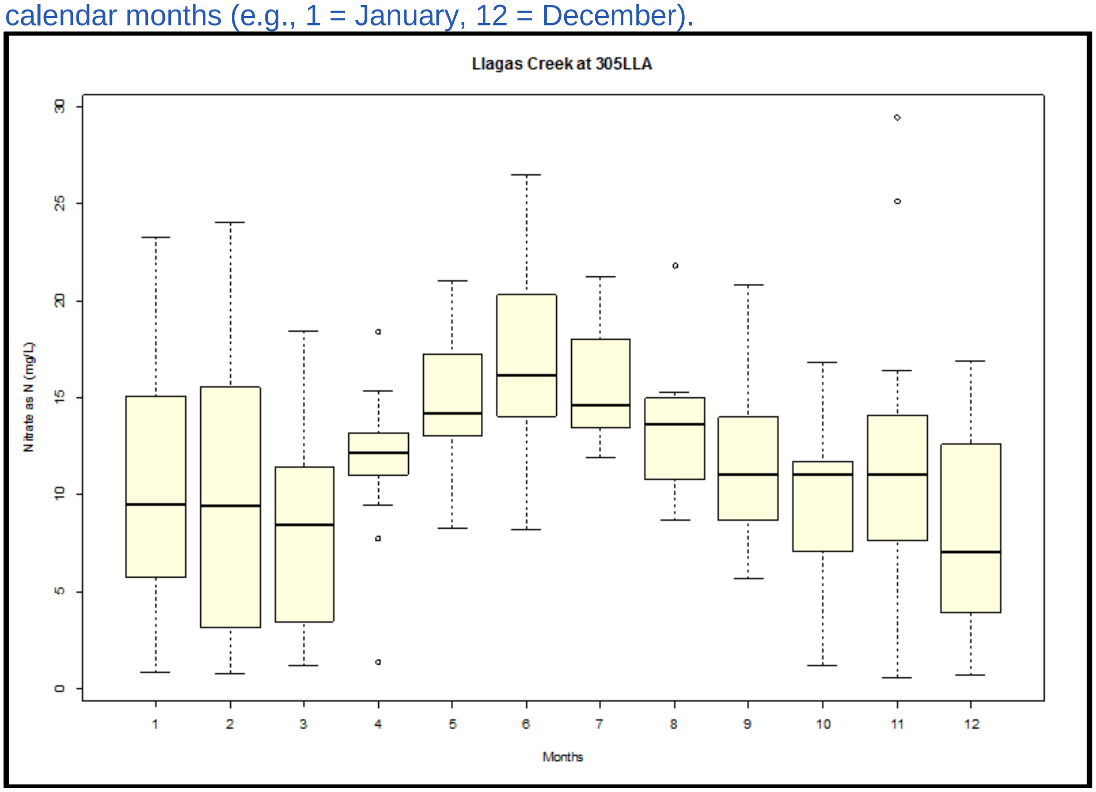


Figure 5-37. Box and whisker plot of nitrate as N (mg/L) values on San Juan Creek at 305SJN. Values plotted per month to show seasonal difference in nitrate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

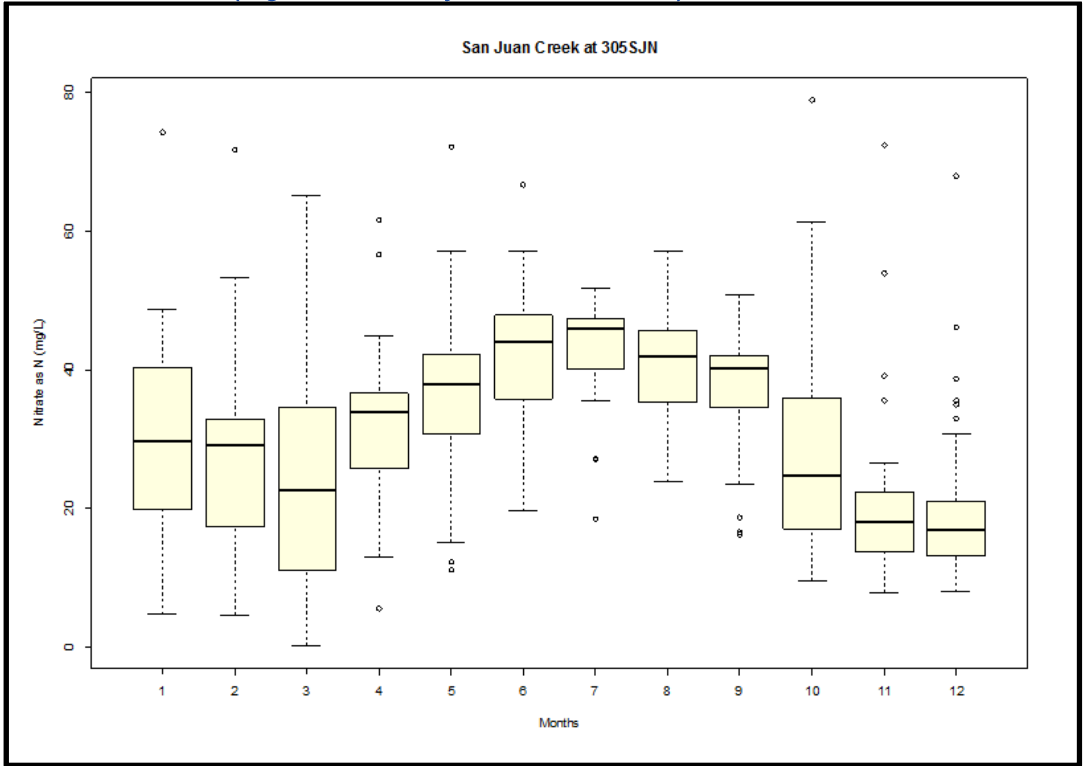


Figure 5-38. Box and whisker plot of nitrate as N (mg/L) values on Beach Road Ditch at BRD. Values plotted per month to show seasonal difference in nitrate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

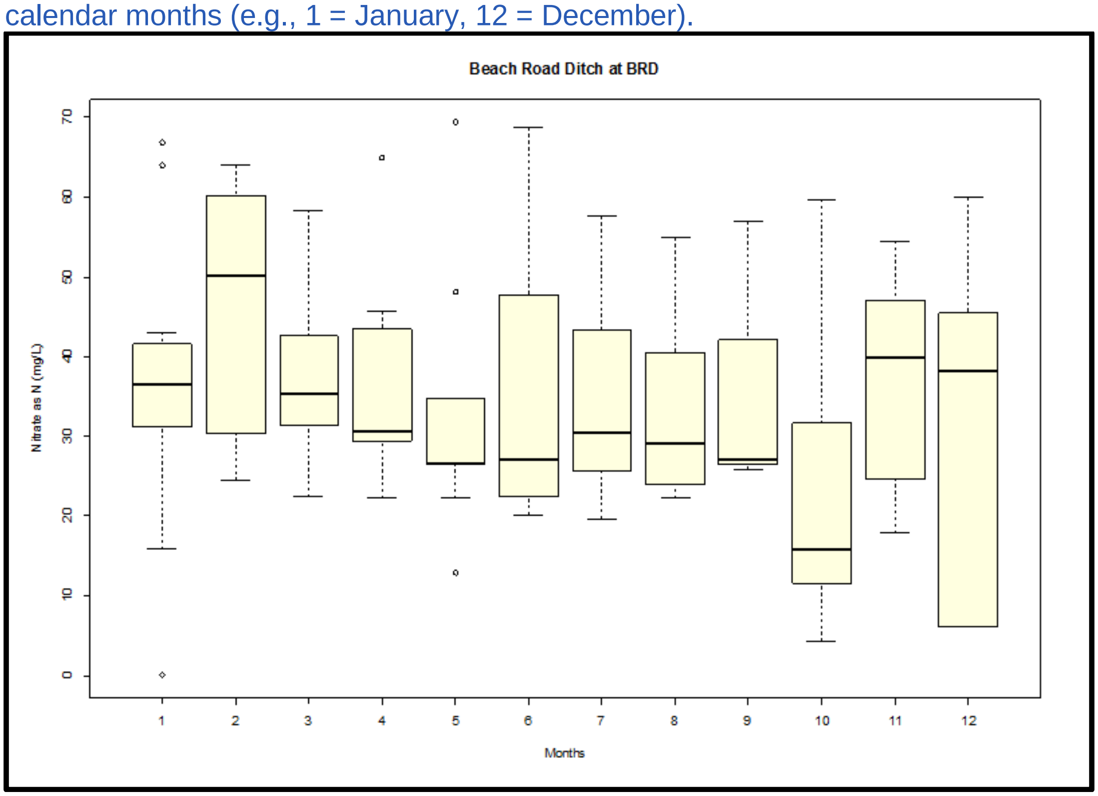


Figure 5-39. Box and whisker plot of orthophosphate as P (mg/L) values on the Pajaro River at 305THU. Values plotted per month to show seasonal difference in orthophosphate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

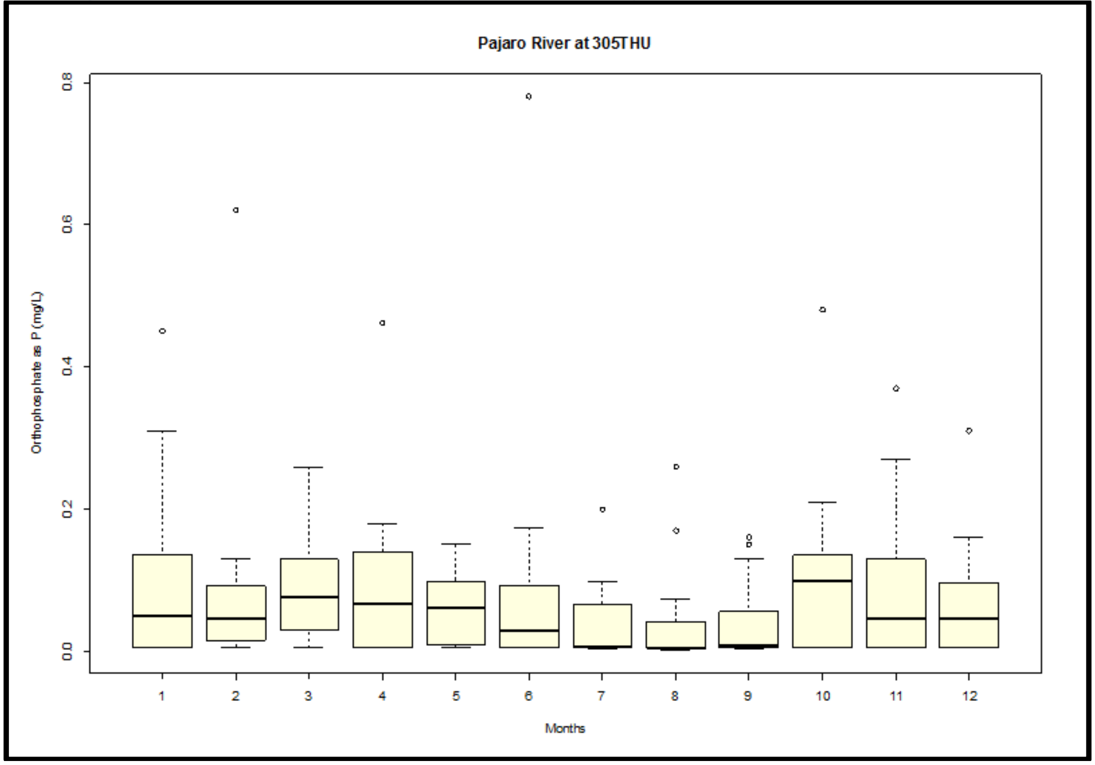


Figure 5-40. Box and whisker plot of orthophosphate as P (mg/L) values on the Pajaro River at 305CHI. Values plotted per month to show seasonal difference in orthophosphate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

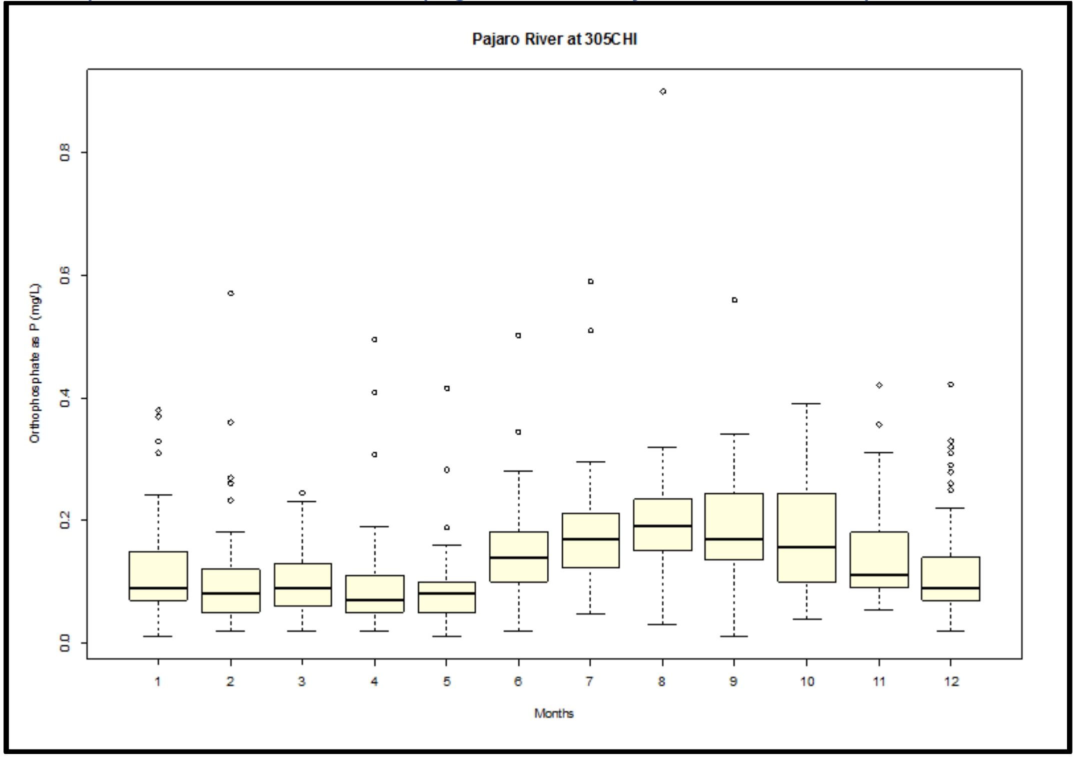


Figure 5-41. Box and whisker plot of orthophosphate as P (mg/L) values on Llagas Creek at 305LLA. Values plotted per month to show seasonal difference in orthophosphate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

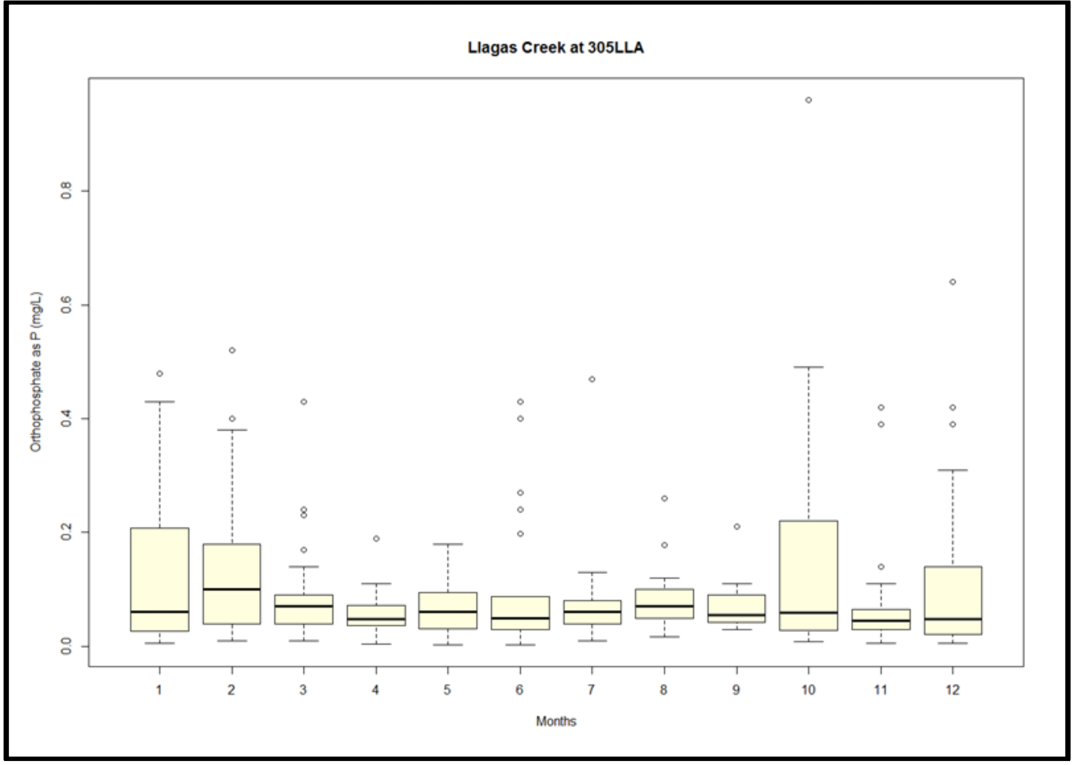


Figure 5-42. Box and whisker plot of orthophosphate as P (mg/L) values on Watsonville Slough at 305WAT-SHE. Values plotted per month to show seasonal difference in orthophosphate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

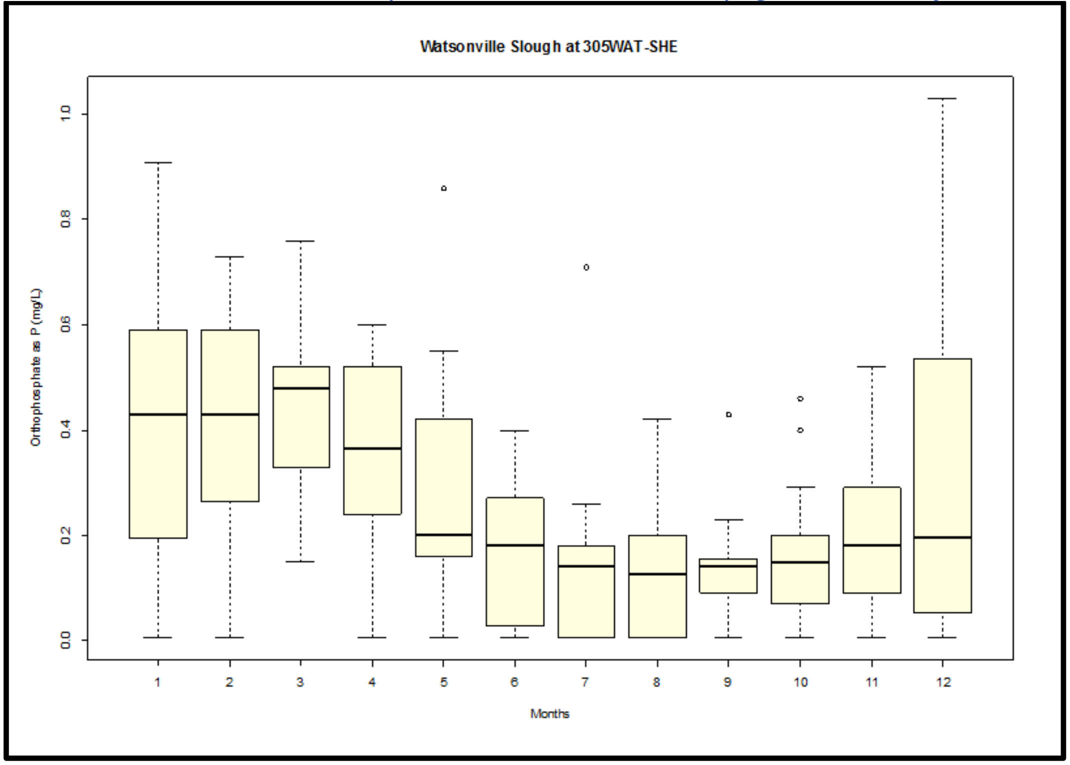


Figure 5-43. Box and whisker plot of orthophosphate as P (mg/L) values on Beach Road Ditch at BRD. Values plotted per month to show seasonal difference in orthophosphate values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

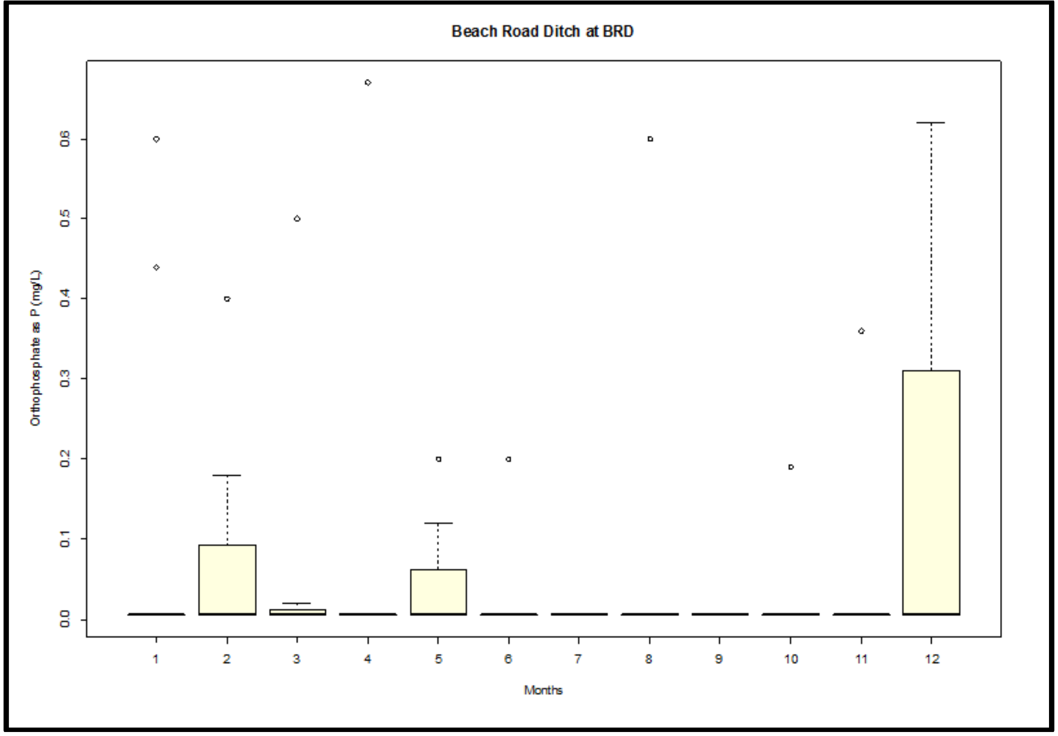


Figure 5-44. Box and whisker plot of chlorophyll-a (µg/L) values on the Pajaro River at 305THU. Values plotted per month to show seasonal difference in chlorophyll-a values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

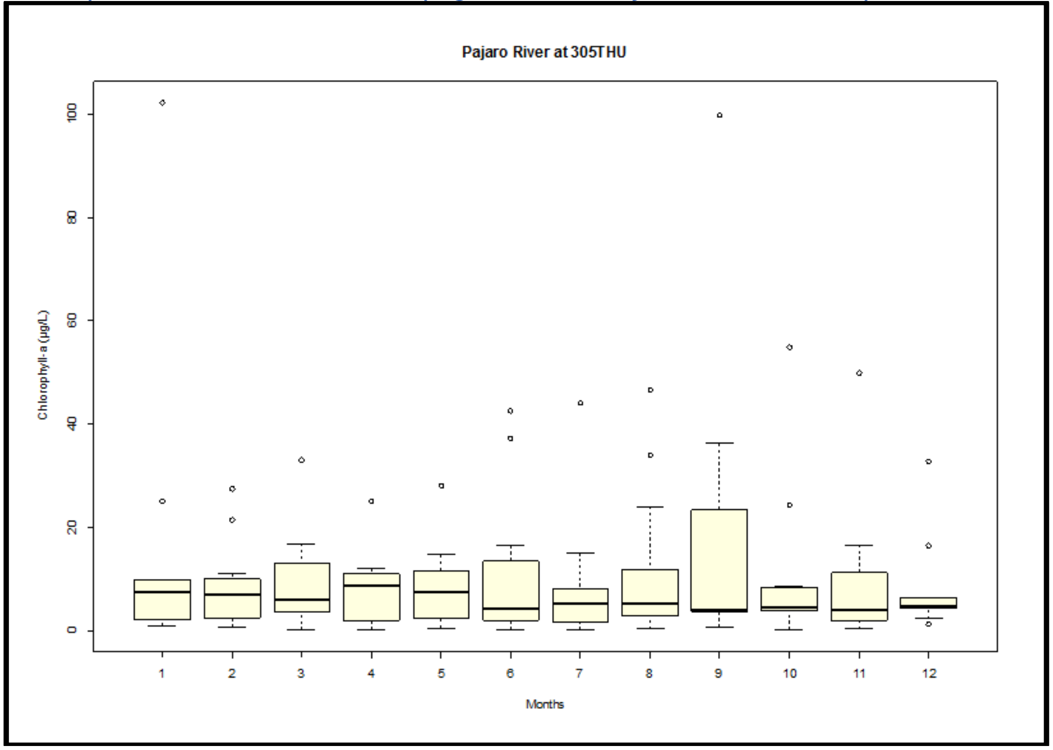


Figure 5-45. Box and whisker plot of chlorophyll-a (µg/L) values on the Pajaro River at 305CHI. Values plotted per month to show seasonal difference in chlorophyll-a values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December). *Note: this boxplot omited two samples (305.6 µg/L taken 7/28/2004 and 106.9 µg/L taken 2/6/2009) so the y-axis is a smaller scale in order to better view the dataset.*

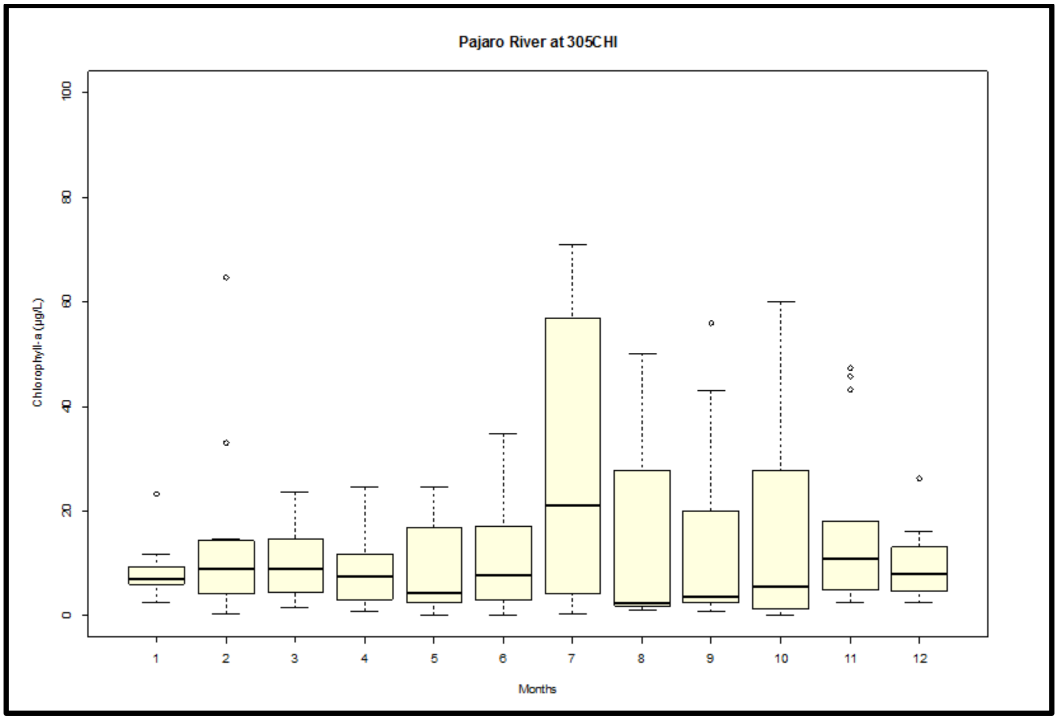


Figure 5-46. Box and whisker plot of chlorophyll-a (µg/L) values on Llagas Creek at 305LLA. Values plotted per month to show seasonal difference in chlorophyll-a values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

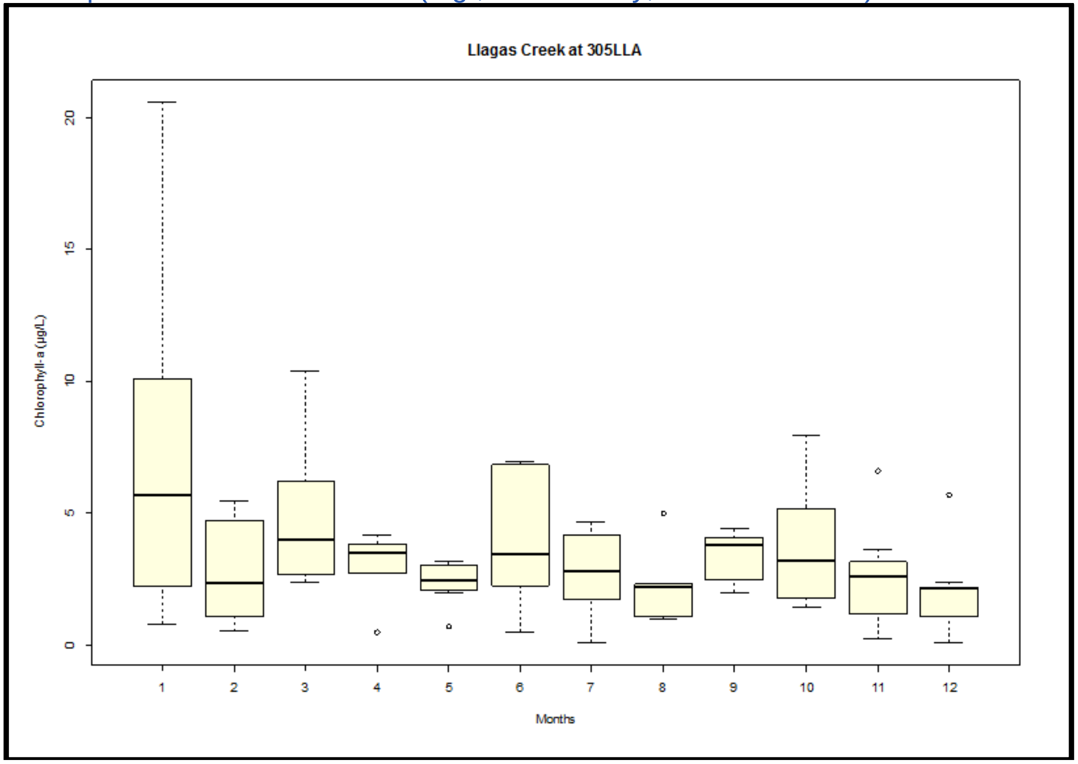


Figure 5-47. Box and whisker plot of chlorophyll-a (µg/L) values on Watsonville Slough at 305WSA. Values plotted per month to show seasonal difference in chlorophyll-a values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).

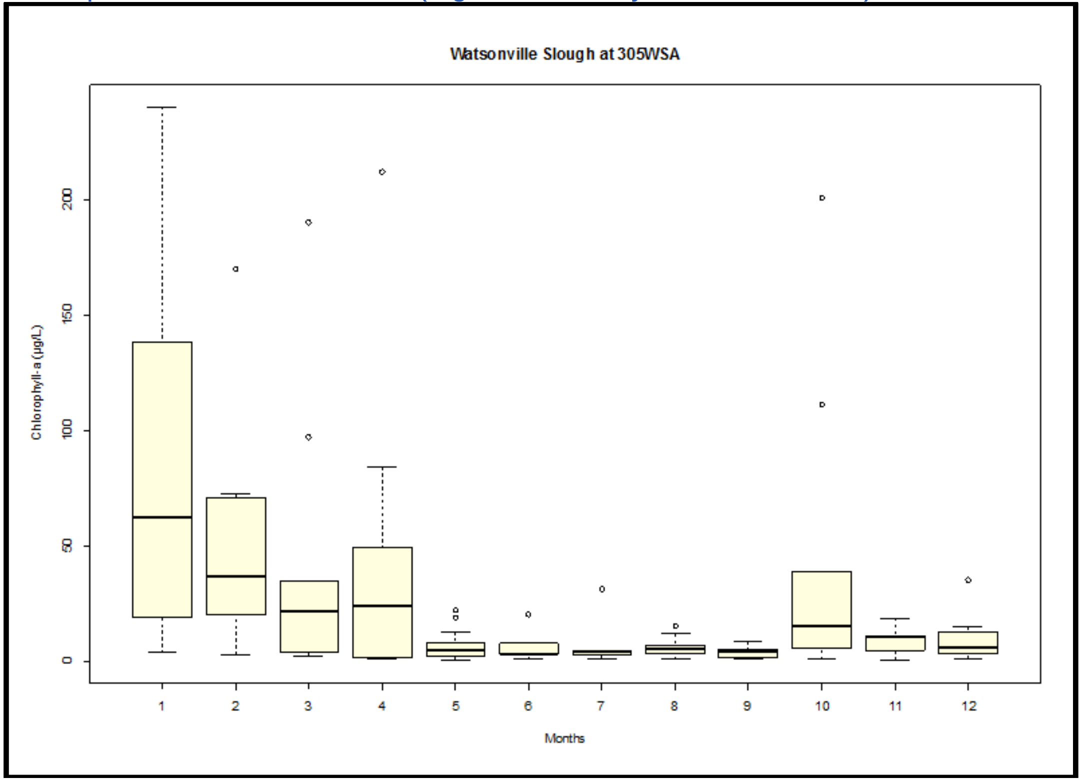
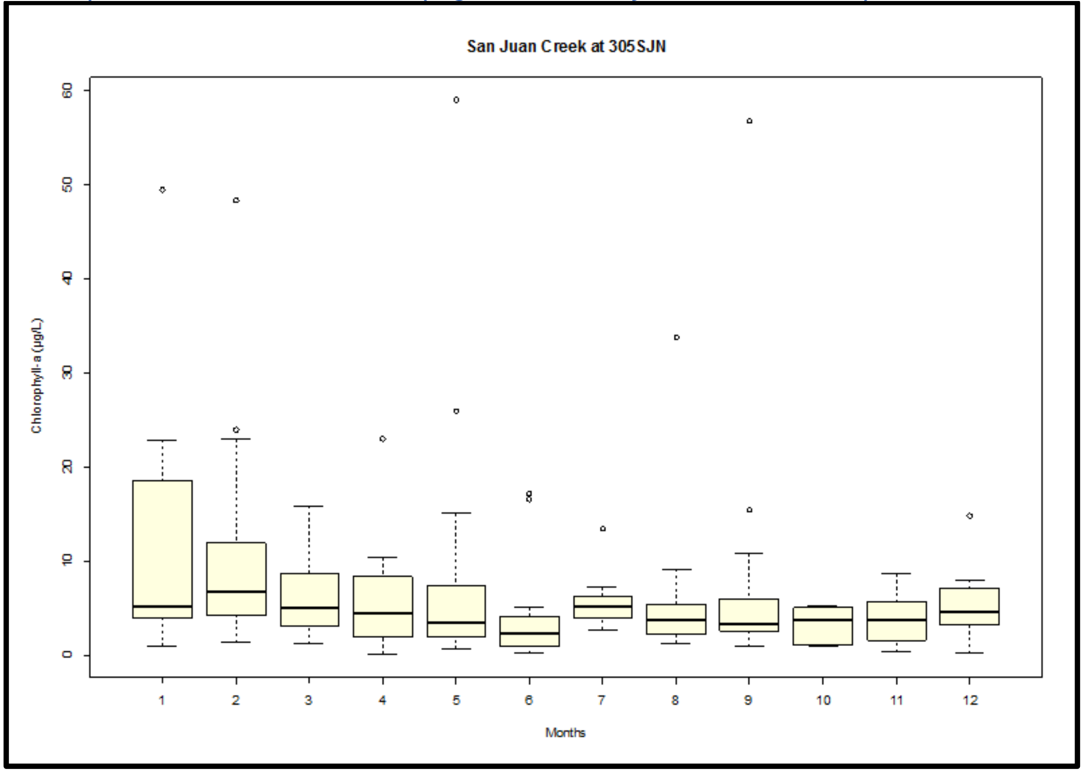


Figure 5-48. Box and whisker plot of chlorophyll-a (µg/L) values on San Juan Creek at 305SJN. Values plotted per month to show seasonal difference in chlorophyll-a values. Numbers on the x-axis correspond to calendar months (e.g., 1 = January, 12 = December).



5.7 Water Quality Flow-based Trends

Analysis of seasonal trends is not always appropriate as a surrogate for flow-based trends because of the California central coast's Mediterranean climate and flashy flow conditions. While precipitation-driven high flow conditions are typically limited to the wet season months, the flashy, event-driven nature of regional hydrologic flow patterns, as well as persistent drought conditions also means that there can be substantial and sustained periods of low flow and base flow conditions in the wet season. As such, it is relevant to assess possible flow-based patterns of nitrate-loading to representative Pajaro River basin stream reaches. Flow-based pollutant loading variation can be assessed using load duration curves. Load duration curves provide a graphical context for looking at monitoring data and can also potentially be used to focus and inform implementation decisions (Stiles and Cleland, 2003). A load duration curve is the allowable loading capacity of a pollutant, as a function of flow.

Load duration curves for the Pajaro River at Chittenden, the Pajaro River at Watsonville, and for Llagas Creek at Gilroy are presented in Figure 5-49 through Figure 5-54. The target loads shown in these load duration curves are based on regulatory standards or published water quality guidelines, but do not necessarily represent the TMDLs themselves. Rather, the target loads in this context are for informational purposes, providing a uniform reference to assess pollutant loads as a function of flow. Summary observations of flow-based trends are presented in Table 5-5.

Table 5-5. Summary of flow-based trends in pollutant loads.

		Critical Flow Conditions *The Flow Regime Exhibiting Highest Frequency (%) of Observed Daily Loads Exceeding the Reference Target Loads*	
Subwatershed	**Stream Reach**	**Nitrate as N** [A]	**Orthophosphate** [B]
Lower Pajaro River Subwatershed	Pajaro River @ Chittenden	**Low flow conditions** Strong flow-based trend observed	**No obvious flow-based trends** Exceedances of target load slightly more common (9% of samples) during low flow conditions
Lower Pajaro River Subwatershed	Pajaro River @ Watsonville	**Low flow conditions** Strong flow-based trend observed	**No obvious flow-based trends** Very infrequent and episodic exceedances of target load occur over a range of flow conditions
Lower Llagas Creek Subwatershed	Llagas Creek @ Gilroy	**Low-Moderate flow conditions** Flow-based trends are observed *Note that at very high flows (>50cfs) and at very low flows (<1 cfs) the exceedance frequency or exceedance magnitude relative to the target load is substantially less.*	**No obvious flow-based trends** Infrequent and episodic exceedances of target load occur during low flow conditions
Corrilitos Creek Subwatershed	Corrilitos Creek @ Freedom	**No obvious flow-based trends** Nitrate loads are consistently lower than the target load during all flow regimes.	**Weak flow-based trends** Episodic exceedances of target load occur during higher flow conditions, generally at stream flows exceeding 20 cfs.

[A] Reference target load based on Basin Plan MUN standard for nitrate as N (10 mg/L)
[B] Reference target load based on State of Nevada phosphate criteria for Class B streams (0.3 mg/L as P)

Figure 5-49. Nitrate as N load duration curve for the Pajaro River at Chittenden.

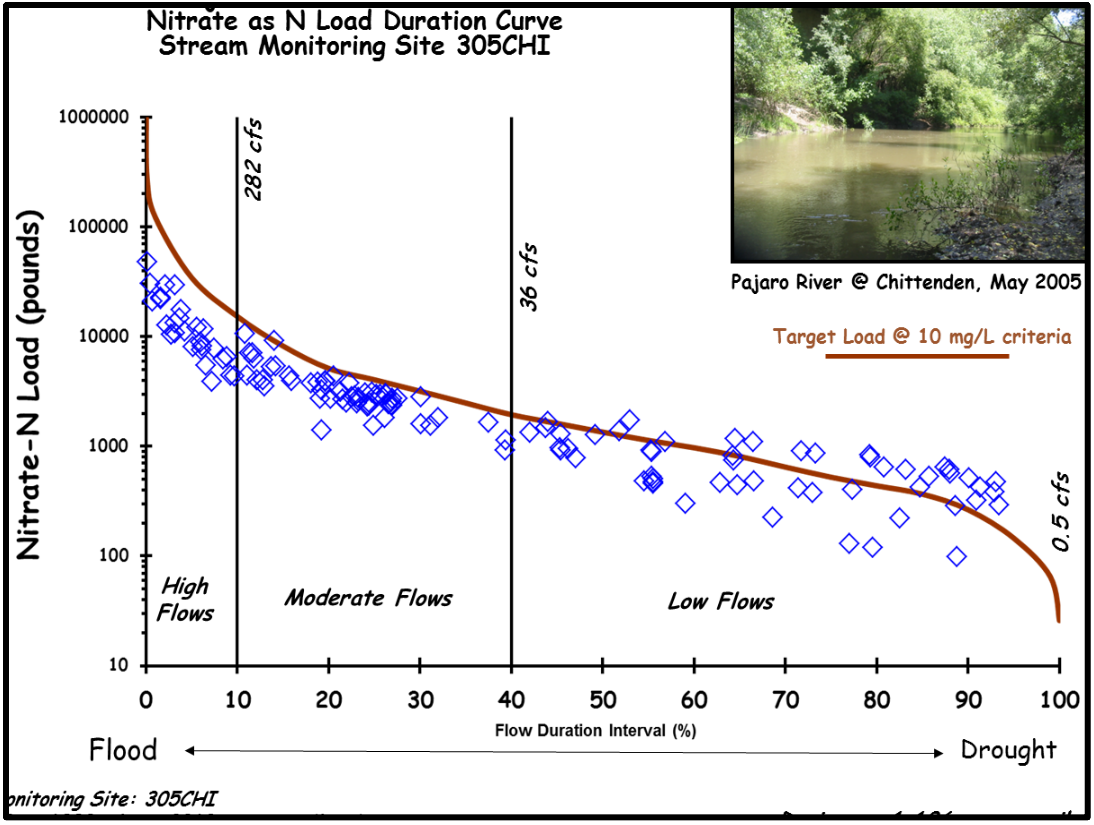


Figure 5-50. Orthophosphate as P load duration curve for the Pajaro River at Chittenden.

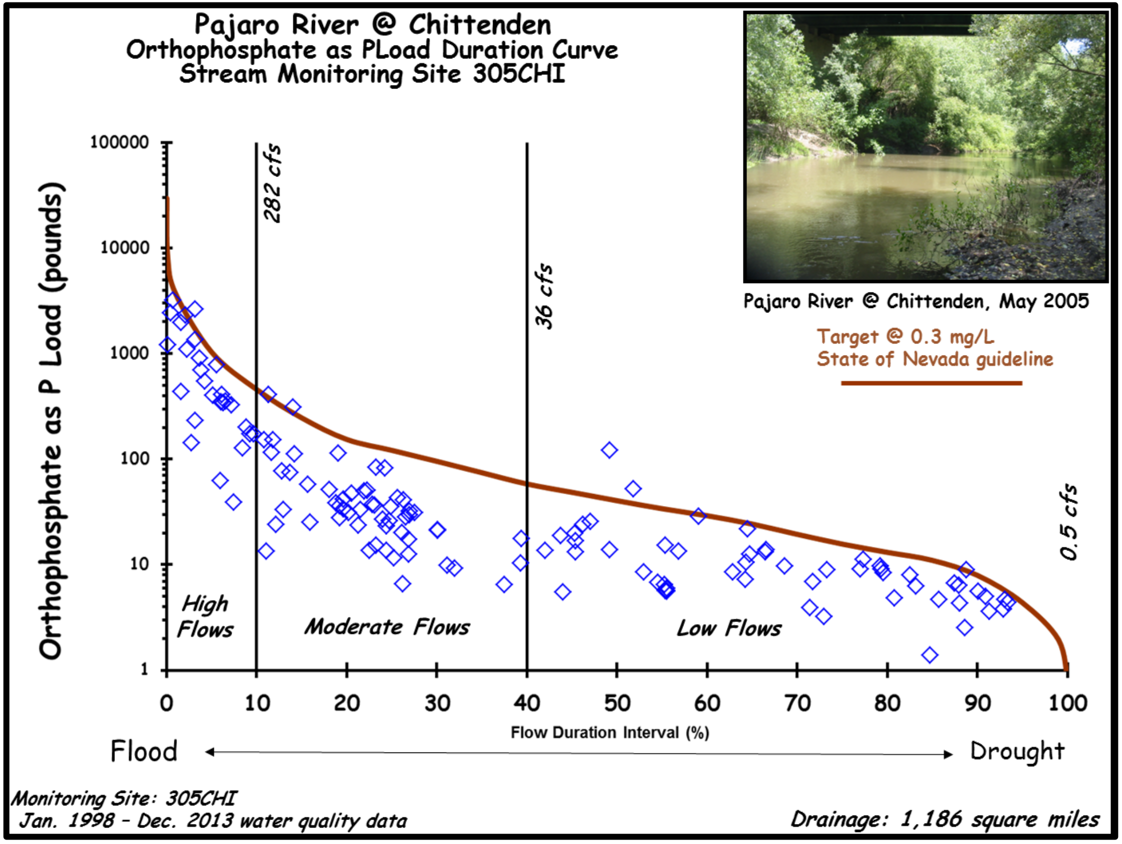


Figure 5-51. Nitrate as N load duration curve for the Pajaro River at Watsonville.

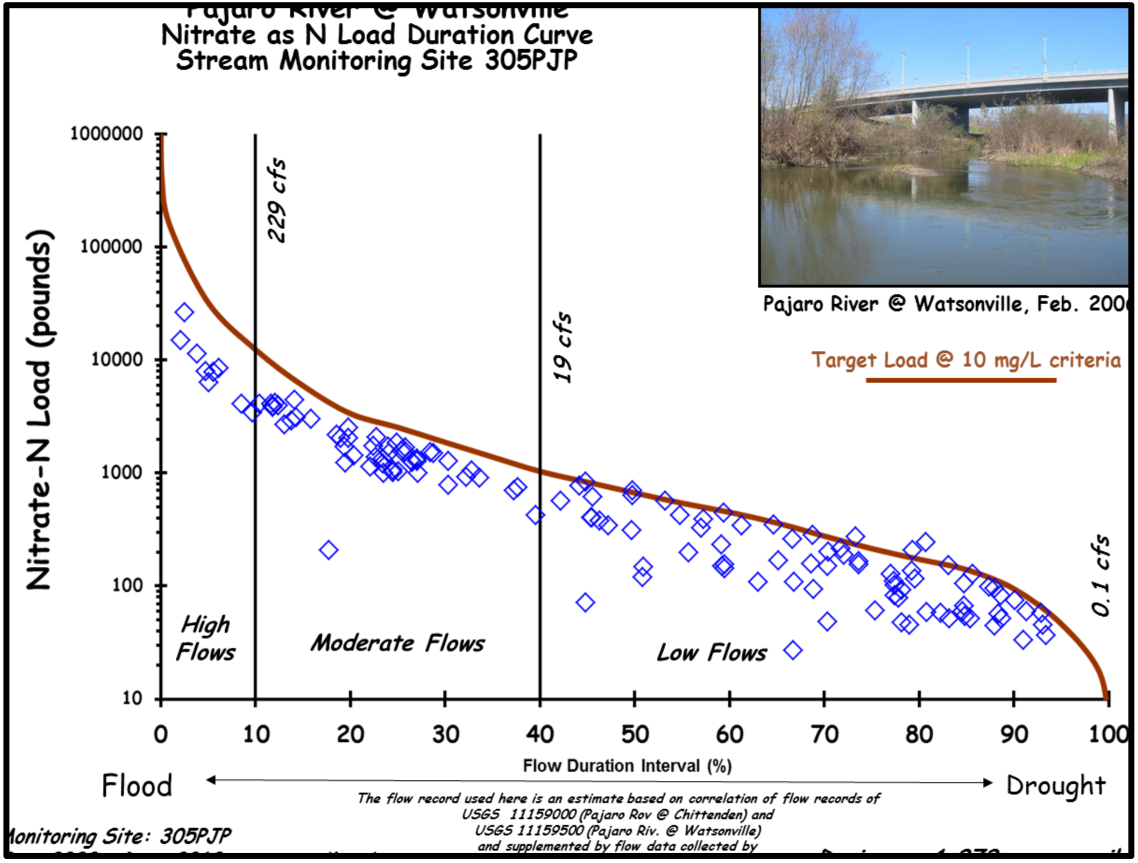


Figure 5-52. Orthophosphate as P load duration curve for the Pajaro River at Watsonville.

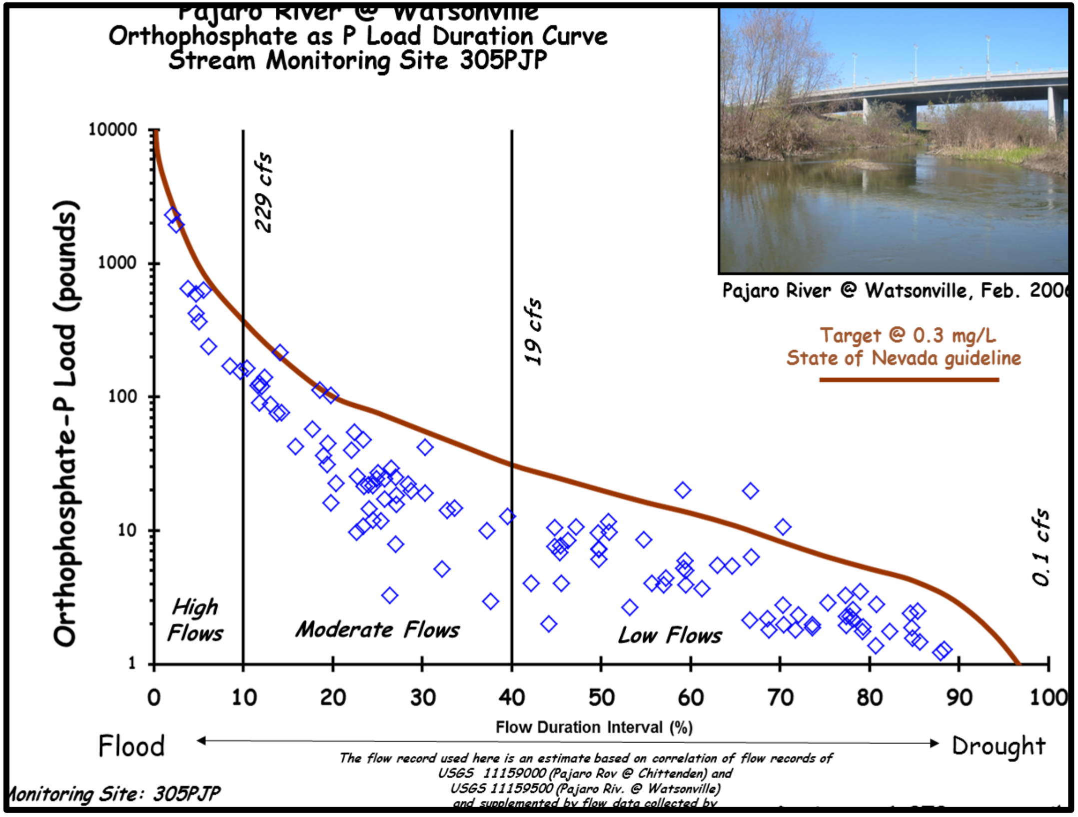


Figure 5-53. Nitrate as N load duration curve for Llagas Creek near Gilroy

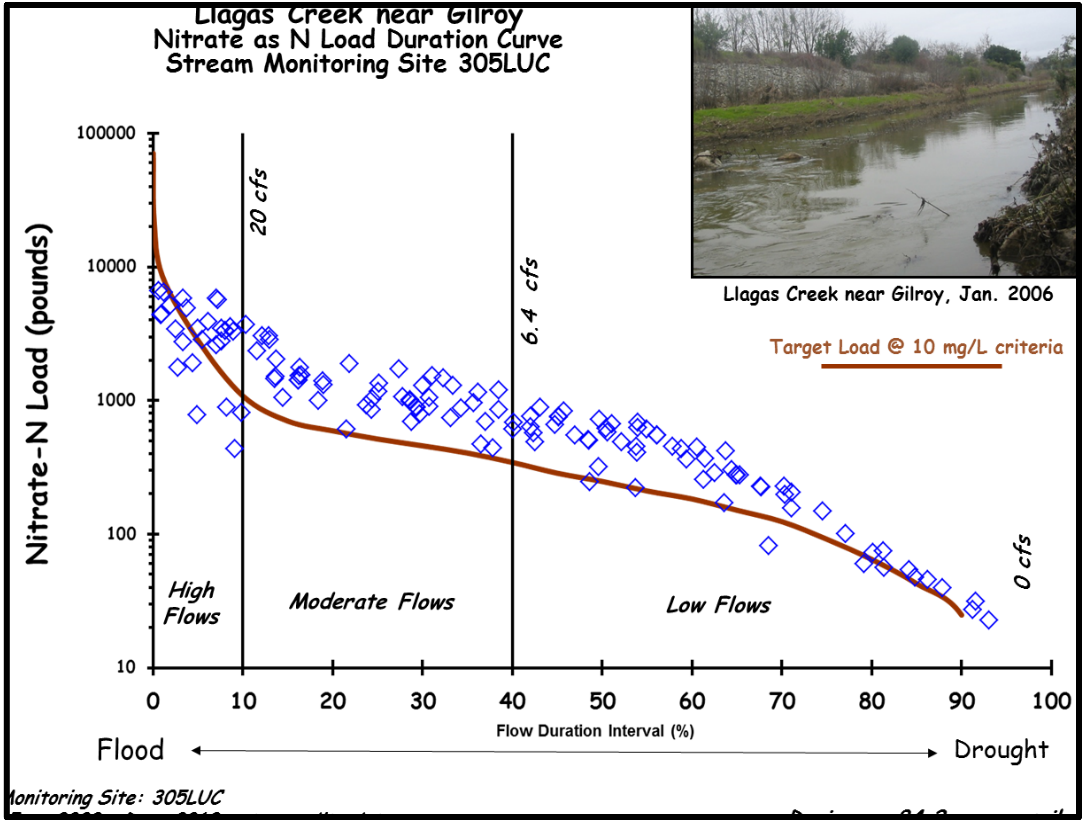


Figure 5-54. Orthophosphate a P load duration curve for Llagas Creek near Gilroy

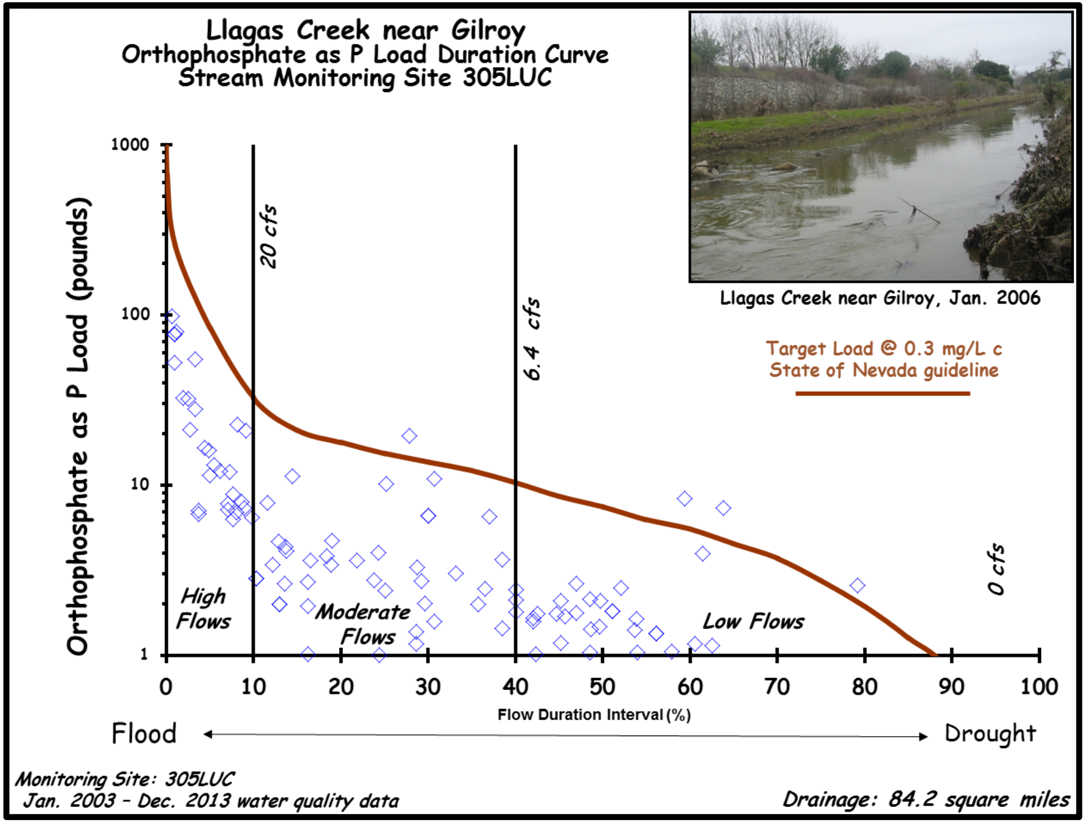


Figure 5-55. Nitrate as N load duration curve for Corralitos Creek at Freedom.

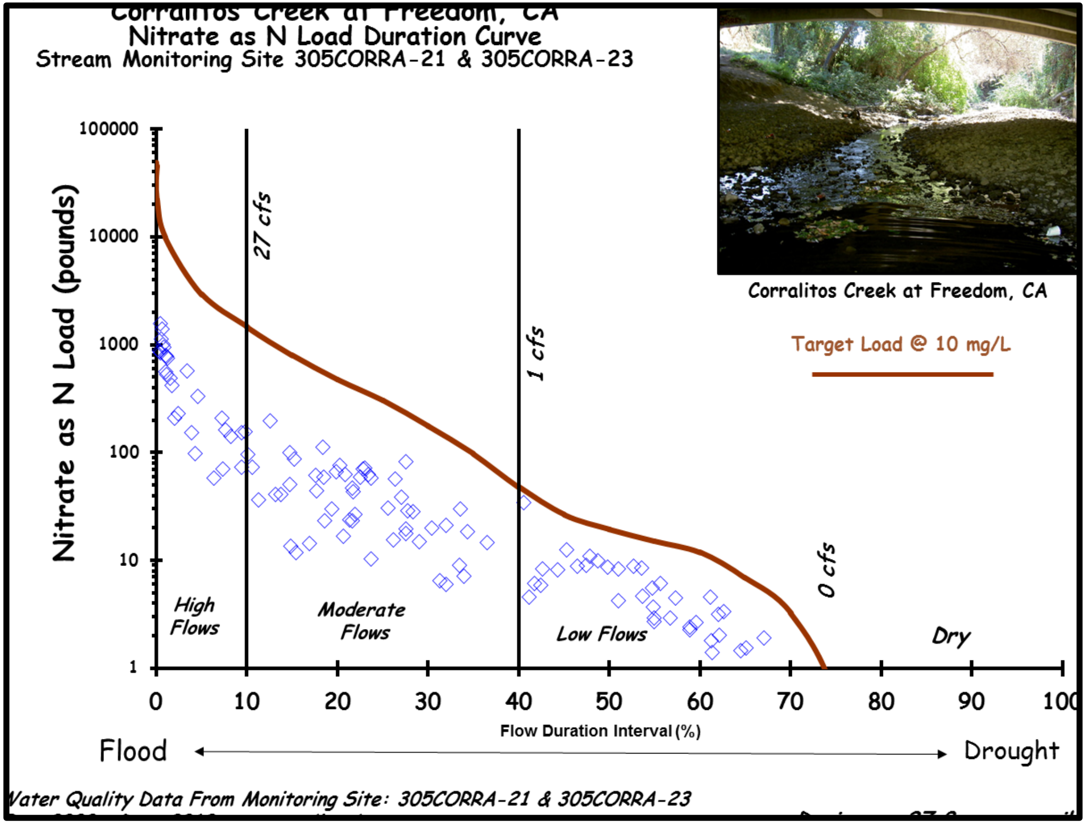
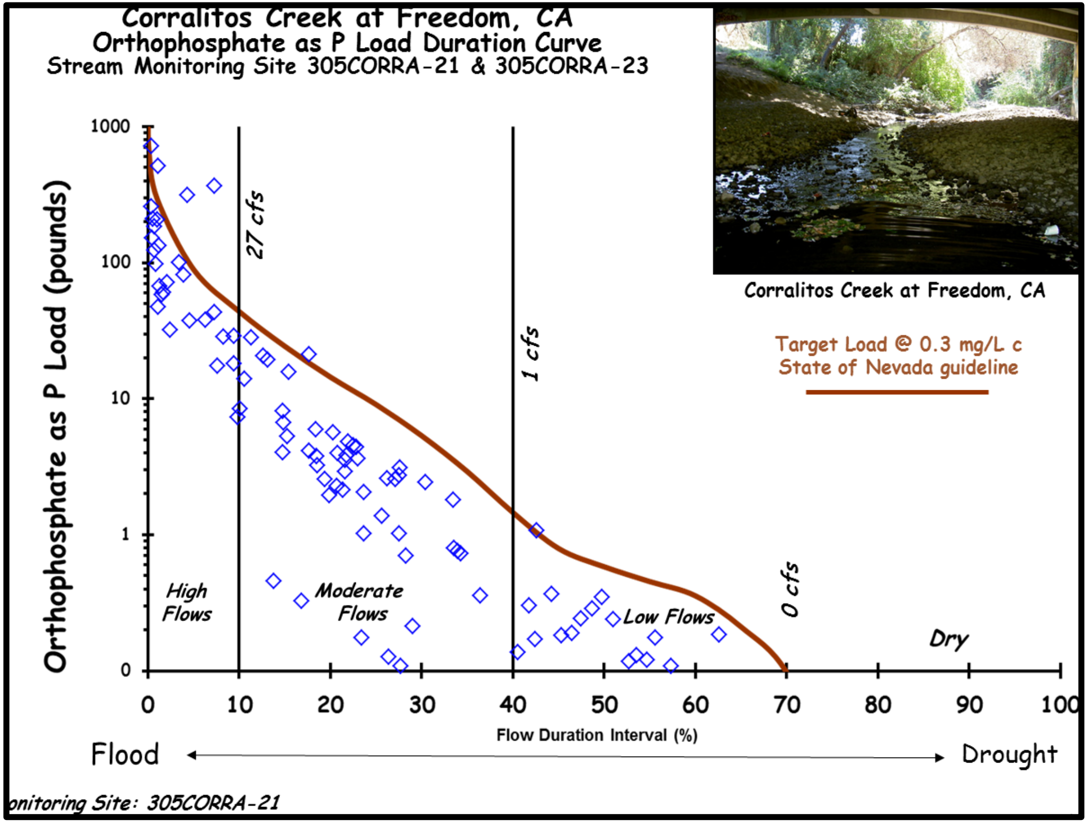


Figure 5-56. Orthophosphate as P load duration curve for Corralitos Creek at Freedom.



5.8 Diel Water Quality Data

Diel water quality data is used to assess diel (24-hour period) fluctuations of dissolved oxygen and pH and other parameters; this data can provide insight into the scope of primary production and respiration rates of algal biomass in a waterbody. The California 303(d) Listing Policy (State Water Board, 2004) indicates that if measurements of dissolved oxygen taken over the day (diel) show low concentrations in the morning and sufficient concentrations in the afternoon, then it shall be assumed that nutrients are responsible for the observed dissolved oxygen concentrations

During the daytime, algal populations generate oxygen through photosynthesis resulting in high, and sometimes supersaturated, dissolved oxygen (DO) concentrations. In contrast, metabolism by algae during nighttime to early-morning hours consumes oxygen and may result in low oxygen levels that are stressful for fish, and may cause fish kills and harm to other aquatic life (Worcester et al., 2010). In addition, prolonged, long-term nutrient enrichment (of streams) may lead to long term declines in average DO concentrations (Vagnetti et al. 2003, Parr and Mason 2003, 2004 – as reported in Zheng and Paul, 2006). With regard to pH, during daytime photosynthesis, carbon dioxide (CO2) and water are converted by sunlight into oxygen and carbohydrate. Hydroxyl ions (OH-) are produced, raising the water column pH. In contrast, at night increased algal respiration increases the release of CO2 into the water, boosting the production of carbonic acid and hydroxyl ions, which, in turn, decreases the pH. Extremely high or low pH values in streams are harmful to aquatic organisms. High pH also increases the toxicity of some substances, such as ammonia (Zheng and Paul, 2006).

Consequently, waters that contain excessive algal growth are characterized by wide swings in dissolved oxygen concentrations, and pH swings. It is important to recognize that there are other factors that affect the concentration of dissolved oxygen in a waterbody. Oxygen can be introduced by aeration of the water column (winds, hydraulic velocity and turbulence); additions of higher DO water (e.g., from tributaries); additions of lower DO water (groundwater baseflow) temperature (warm water holds less oxygen than cold water), and reductions in oxygen due to organic decomposition. However, wide swings in pH and DO over a 24 hour period (diel data) in nutrient-enriched streams are widely reported

(Zheng and Paul, 2006), particularly in lowland, slow moving streams, and tend to be evidence of the presence of excessive amounts of algal biomass and aquatic plants.

Limited amounts of diel DO water quality data are available for streams of the Pajaro River basin. Sweeping inferences and generalizations cannot be drawn from these limited amounts of diel data; however, this diel dissolved oxygen data can be useful when combined with other data in a “weight of evidence” approach in assessing biostimulation.

Figure 5-57 (Pajaro River at Chittenden), Figure 5-58 (San Benito River at Y Rd.), and Figure 5-59 (Corralitos Creek at Browns Valley Rd.) illustrate diel DO data reference conditions. In this context, “reference conditions” are water quality conditions that do not show wide and unusual diel DO fluctuations (swings). The diel swings in DO measured at these reference conditions sites were very subdued, with DO concentrations only fluctuating over a range of less than 2 mg/L during the daily cycle (Figure 5-57, Figure 5-58 and Figure 5-59). In contrast, Figure 5-60 (Pajaro River at Thurwatcher Rd.)

Figure 5-61 (Pajaro River at Murphy’s Crossing) and Figure 5-62 (San Juan Creek at Anzar Rd.) illustrates wide or unusual swings in DO during the daily cycle, relative to the reference conditions. The nature of these daily cycle DO swings would be an expected stream response to excessive algal biomass and aquatic plants in these stream reaches during the diel 24-hour sampling event. Other stream monitoring sites did not show unusual diel DO fluctuations during the 24 period of the sampling event (see Figure 5-63 through Figure 5-66).

Collectively, the aforementioned diel DO data were used as one line of evidence in a weight of evidence approach in the assessment of biostimulatory conditions in streams of the river basin (see Section 5.15, Table 5-20 and Table 5-21).

Figure 5-57. Diel dissolved oxygen (DO) data for Pajaro River at Chittenden Gap.

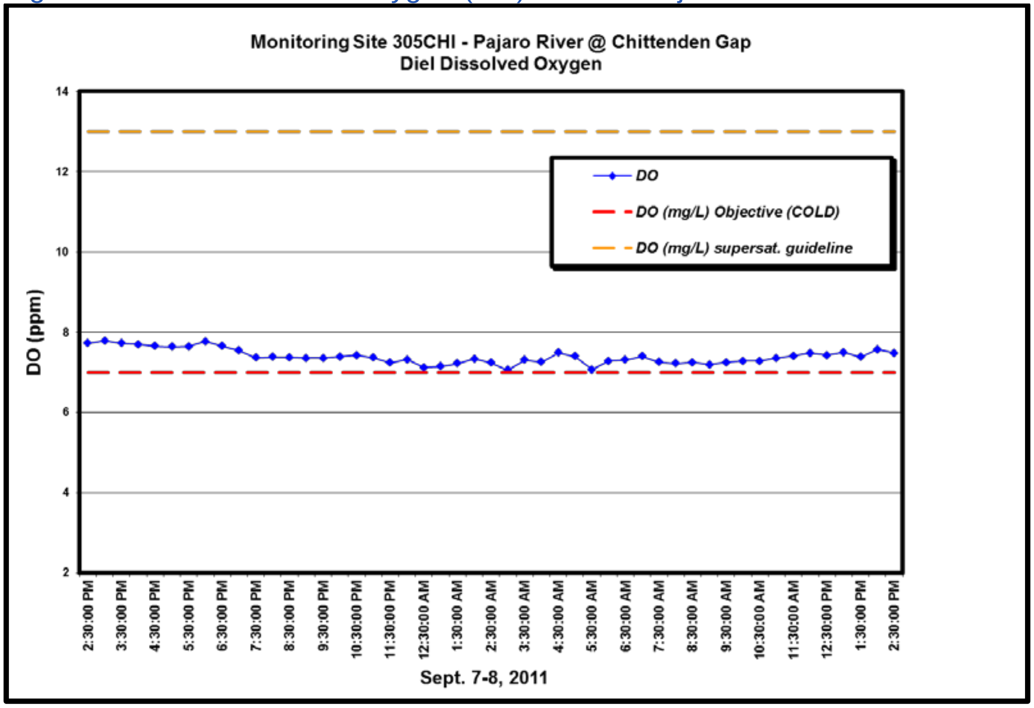


Figure 5-58. Diel dissolved oxygen (DO) data for San Benito River at Y Road.

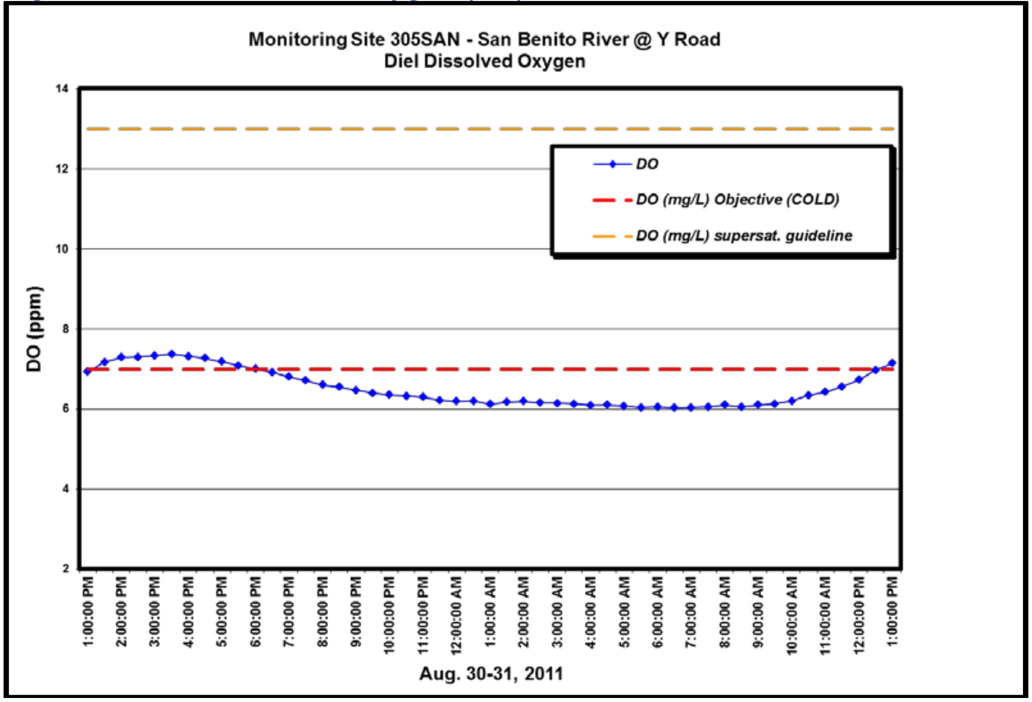


Figure 5-59. Diel dissolved oxygen (DO) data for Corralitos Creek at Brown Valley Road.

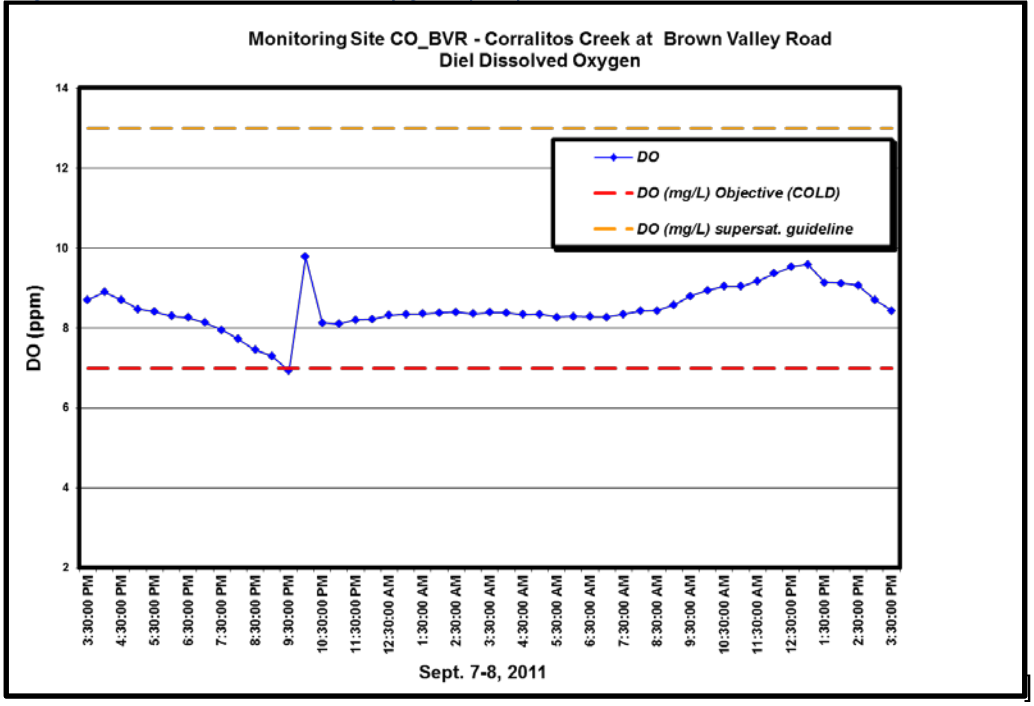


Figure 5-60. Diel dissolved oxygen (DO) data for Pajaro River at Thurwatcher Road.

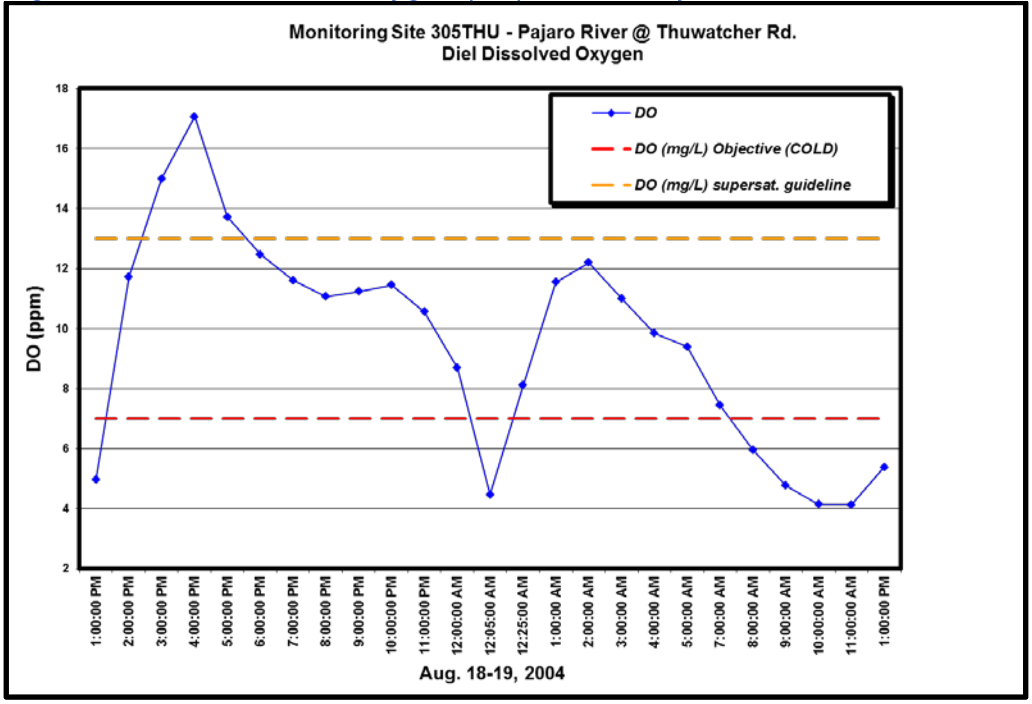


Figure 5-61. Diel dissolved oxygen (DO) data for Pajaro River at Murphy's Crossing.

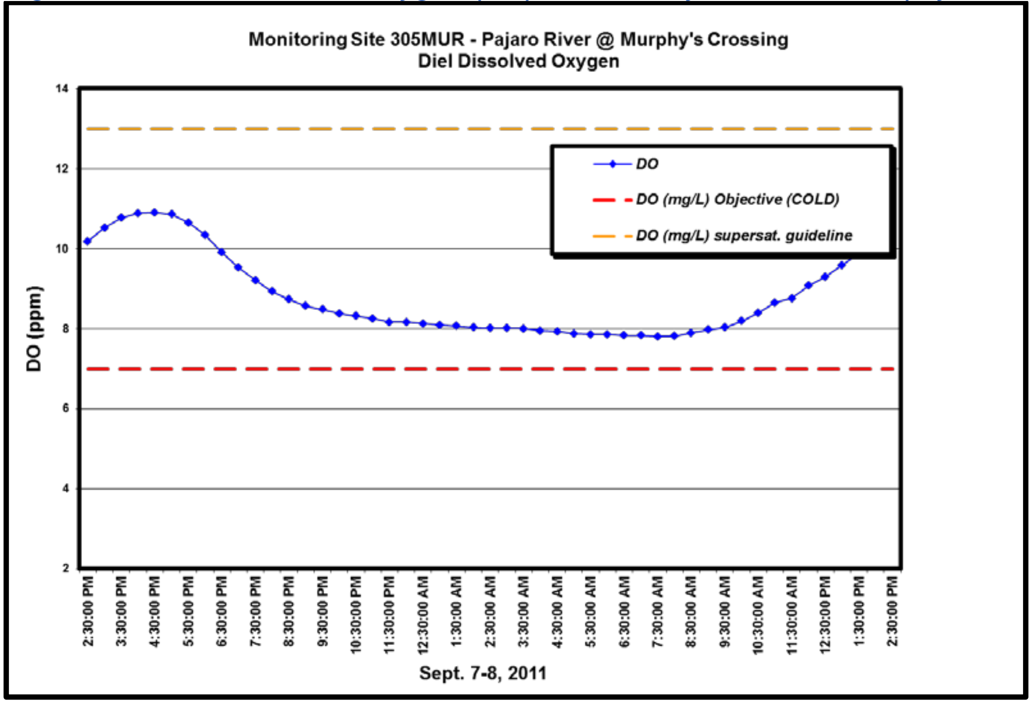


Figure 5-62. Diel dissolved oxygen (DO) data for San Juan Creek at Anzar Road.

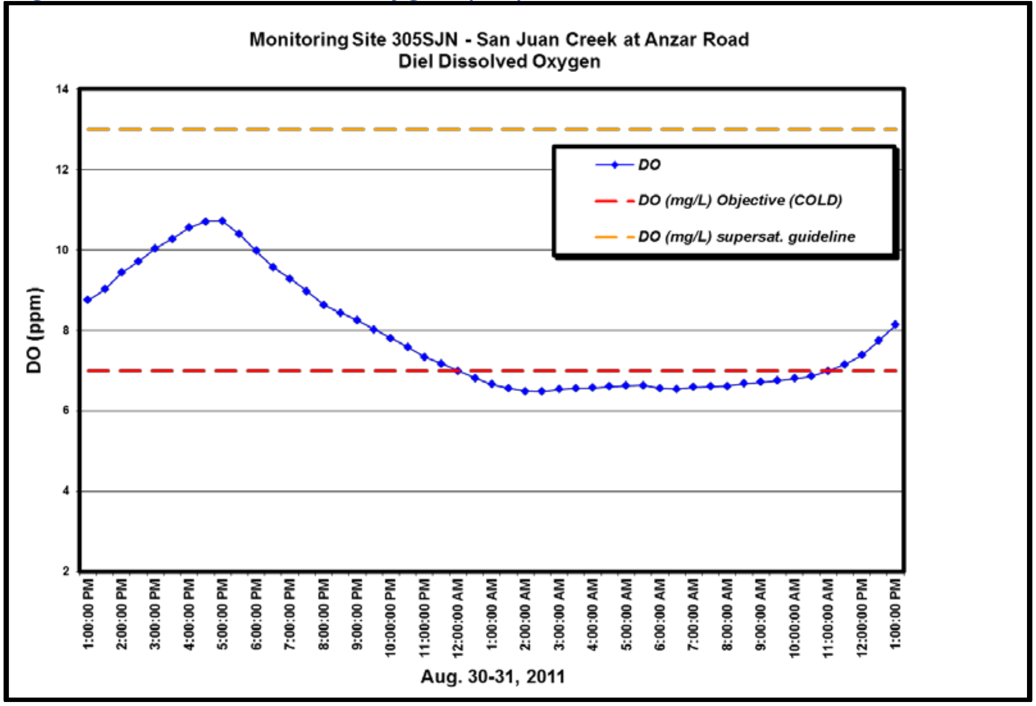


Figure 5-63. Diel dissolved oxygen (DO) data for Pajaro River at Highway 156.

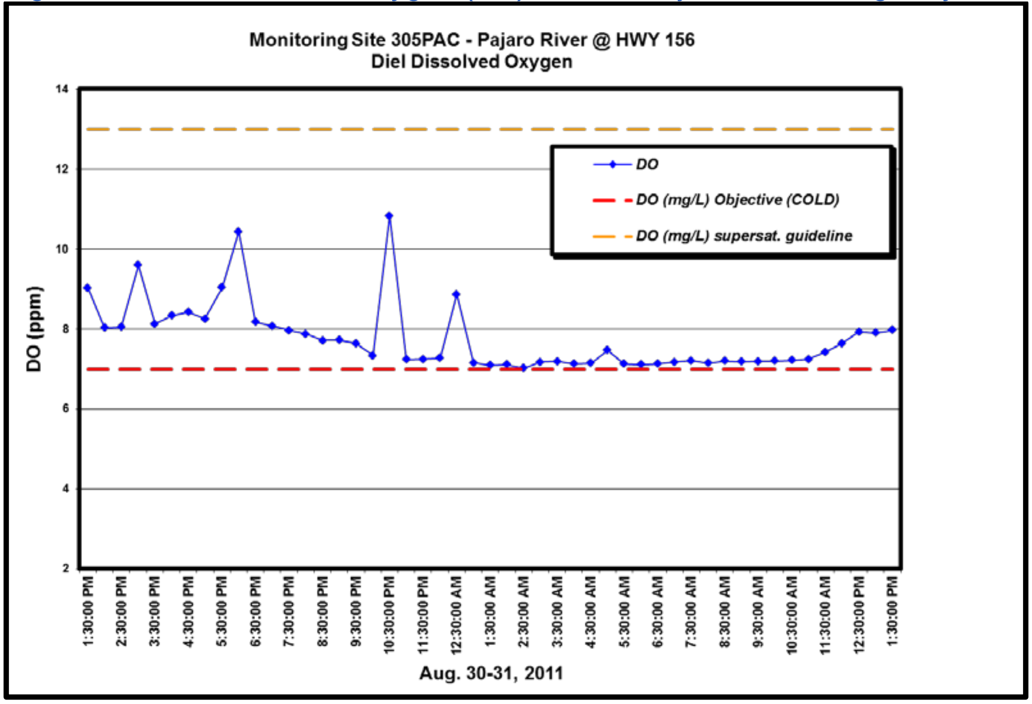


Figure 5-64. Diel dissolved oxygen (DO) data for Llagas Creek at Bloomfiled Avenue.

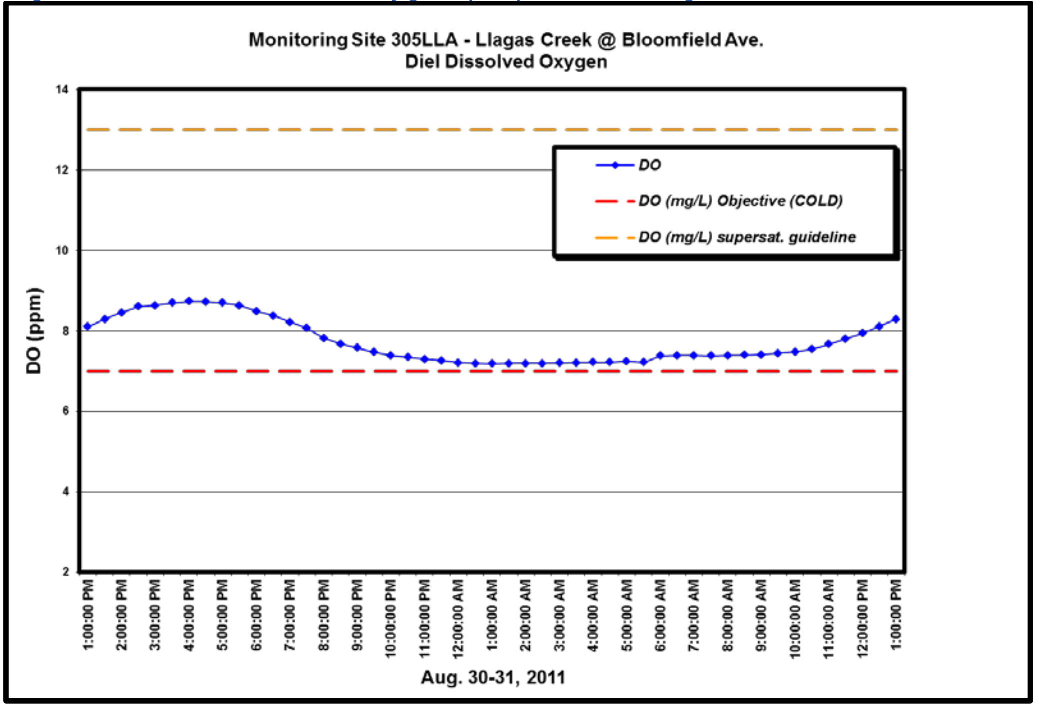


Figure 5-65. Diel dissolved oxygen (DO) data for Miller's Canal at Frazier Lake.

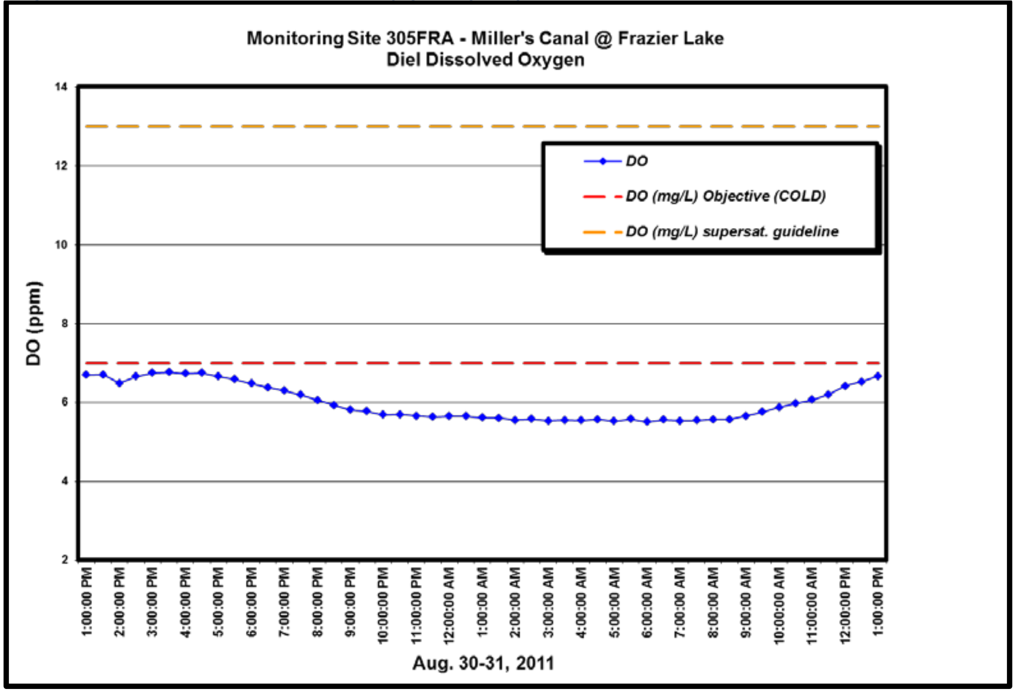
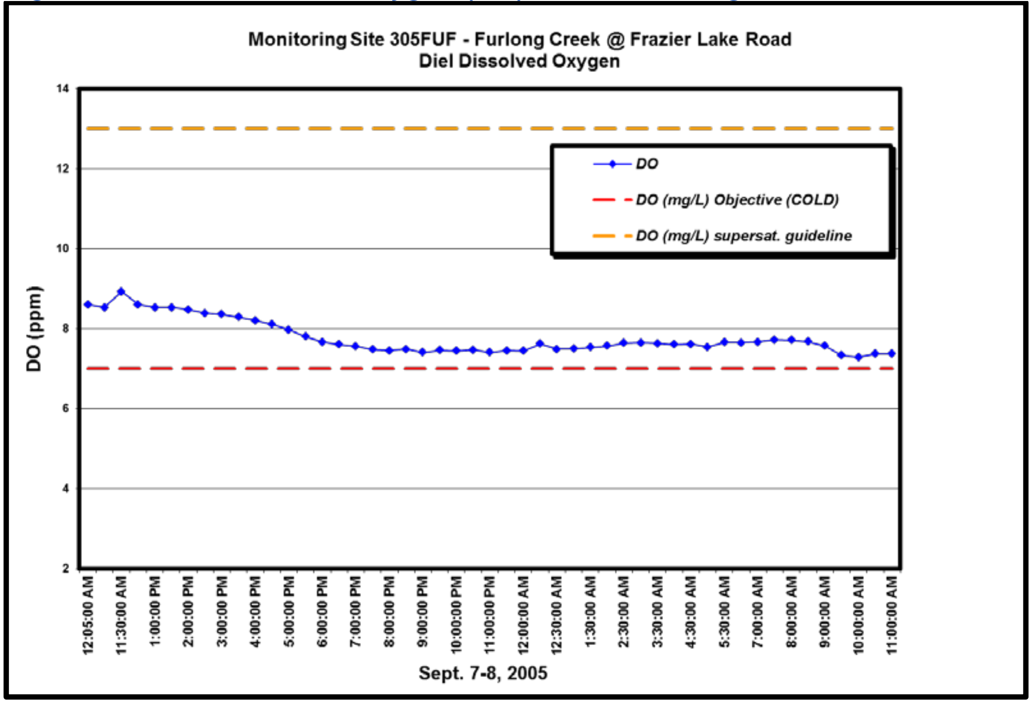


Figure 5-66. Diel dissolved oxygen (DO) data for Furlong Creek at Frazier Lake Road.



5.9 Microcystin Water Quality Data

Microcystins are toxins produced by cyanobacteria (blue-green algae) and are associated with algal blooms, nutrients, and biostimulation in surface waterbodies[133]. Due to biostimulation of surface waters in the Pajaro River basin, it is relevant to consider available microcystin data. Cyanobacterial blooms can persist with adequate levels of phosphorous and nitrogen, temperatures in the 15 to 30° C range and pH in the 6 to 9 range, with most blooms occurring in late summer and early fall (WHO, 2003). Scientists conducting research at Pinto Lake (near the City of Watsonville) report that microcystins are significantly correlated to chlorophyll and total dissolved nitrogen (Kudela, in press, 2011).

Microcystins can be toxic for animals, including humans. The health risks to humans, their pets and to livestock from cyanobacteria were previously outlined in Section 2.2. Microcystin-LR was the first strain identified and is the most commonly studied. Other common microcystin strains are RR, YR and LA (USEPA, 2006). There currently are no regulatory water quality standards for microcystins, but the State of California Office of Environmental Health Hazard Assessment (OEHHA) has published peer-reviewed public health action-level guidelines for microcystins in recreational water uses; this public health action-level is 0.8 μg/L[134] (OEHHA, 2012).

The Water Board contracted with the University of California-Santa Cruz to initiate a microcystin sampling program in 2011. The goal of the contract was to begin collection of regional baseline data at coastal confluence sites. Figure 5-67 illustrates the location of microcystin monitoring sites that were sampled in Sept. 2011 to Aug. 2012 in the central coast region

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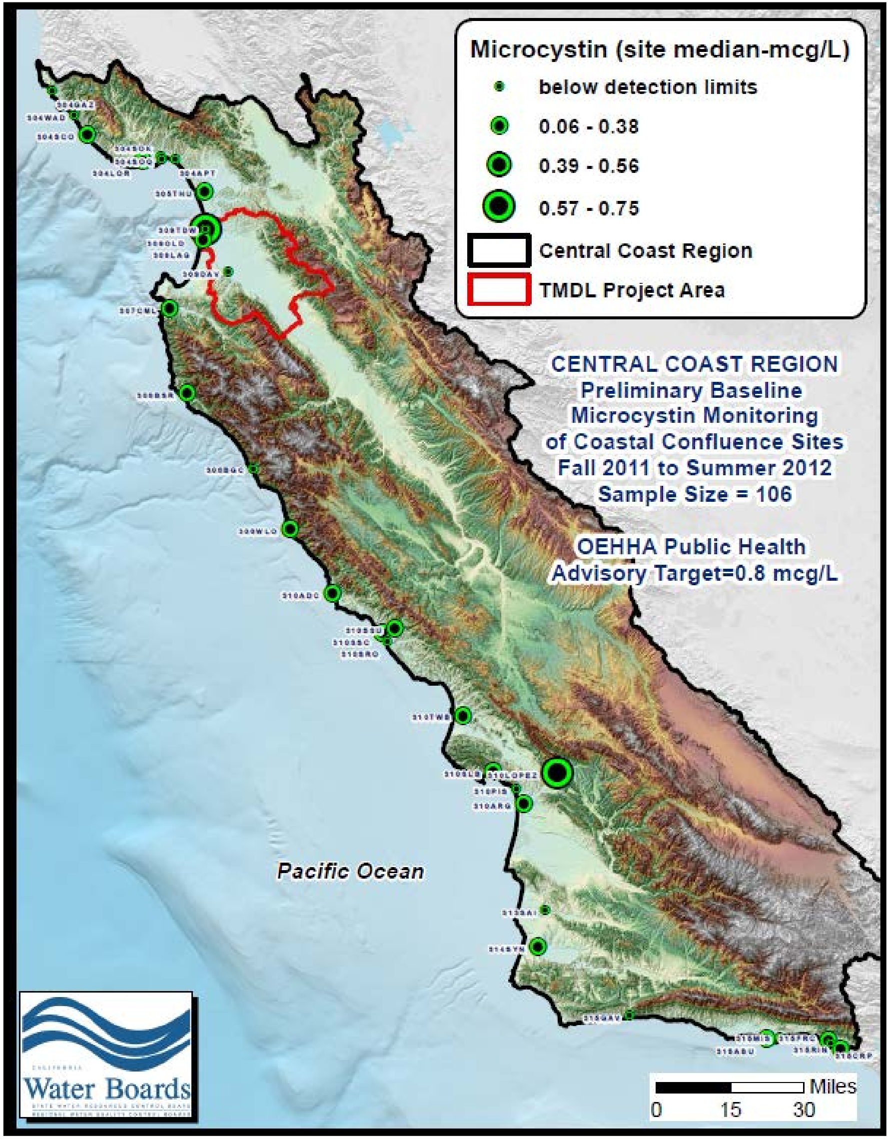
[133] U.S. Environmental Protection Agency. Drinking Water Treatability Database.

Online linkage: http://iaspub.epa.gov/tdb/pages/contaminant/contaminantOverview.do?contaminantId=-1336577584

[134] Includes microcystins LR, RR, YR, and LA.

Figure 5-67. Microcystin monitoring program sites central coast region, 2011.



Initial results available to staff (consisting of 106 samples) are incorporated into this TMDL report. Initial results of this program from Sept. and October of 2011 indicate that of most coastal confluence sites sampled in the central coast region had very low levels of microcystins, commonly below detection levels. In addition, 75 percent of all samples were below 0.1 μg/L. The available data suggests that low levels of microcystins near or below detection levels constitute a natural, ambient condition for coastal confluence waterbodies in the central coast region – see Table 5-6.

Table 5-6. California central coast microcystin summary statistics (units = μg/L), Sept. 2011-Aug. 2012.

No. of Samples	Temporal Representation	Min	25th percentile	Median	Arithmetic Mean	75th percentile	Max
108	Sept. 2011-Nov. 2012	N.D.	N.D.	N.D.	0.12	0.11	1.92

N.D. = not detected

One sample collected from the Pajaro River at Thurwatcher Road had an elevated microcystin level in comparison to regional ambient conditions for coastal confluence sites (see Table 5-7) ; however reported microcystin level was well below the OEHAA public health action level of 0.8 μg/L (Table 5-7). Clearly, one sample is inadequate to draw inferences and conclusions from. It should be noted that there are well known freshwater sources of microcystins in the Pajaro River basin at Pinto Lake. Pinto Lake is anticipated to be the subject of a separate lake TMDL, or water quality standards action, in the near future. There also is some anecdotal photographic reporting of episodic blue-green algae blooms in Tequisquita Slough (refer to Figure 5-72).

Table 5-7. Pajaro River at Thurwatcher Rd. microcystin sampling event (units = μg/L), November 2011.

No. of Samples	Sample Location	Sample Date	Concentration Reported	OEHAA[A] Recommended Public Health Threshold
1	Pajaro River @ Thurwatcher Rd.	November 15, 2011	0.24	0.8

[A] OEHAA = Office of Environmental Health Hazard Assessment

Also noteworthy, in 2007 "super blooms" of microcystins were observed in the Pajaro River and in Pinto Lake (Miller et al. 2010). These toxic super blooms originated from fresh water sources in Monterey Bay watersheds and in addition to killing water fowl, toxins from these blooms have been implicated in the death of sea otters near the mouth of the Pajaro River estuary, the Elkhorn Slough estuary, as well as other coastal areas around Monterey Bay (Miller et al. 2010), as reported below:

> *Freshwater blue green algae toxins caused the deaths of over 31 endangered southern sea otters in Monterey Bay. In 2012 a blue green algal bloom at Pinto Lake, just 4 miles from the Monterey Bay, resulted in the death of countless waterfowl. "The birds were convulsing on the ground and flying into buildings and cars all across town" states Robert Ketley, Water Quality Program Manager for Watsonville.*
>
> From: Press Release dated February 12, 2015 from California Assembly Member Luis A. Alejo

Text Box 5-1 presents of summary of information developed in this section of the report.

Text Box 5-1. Microcystin data summary.

At this time, there is insufficient data to determine whether or not there are any impairments of beneficial uses in streams of the Pajaro River basin on the basis of microcystins.

One microcystin sample from the Pajaro River at Thurwatcher Road in 2011 indicated a microcystin concentration elevated above ambient natural background conditions. However, this sample was well below a public health guideline recommended by the State of California for microcystins in surface waters. It should be noted that there are well known fresh water sources of microcystins within the river basin at Pinto Lake. Pinto Lake is anticipated to be the subject of a separate lake TMDL, or water quality standards action, in the future.

5.10 Data Assessment of Potential for GWR Impairments

As noted previously, the groundwater recharge (GWR) beneficial use is a recognition of the fundamental nature of the hydrologic cycle, and that surface waters and groundwaters are not closed systems that act independently from each other. Most surface waters and groundwaters of the central coast region are both designated with the public health (MUN) drinking water beneficial use. The MUN nitrate as N water quality objective (10 mg/L) therefore applies to *both* stream water, and to the underlying groundwater. This numeric water quality objective and the MUN designation of underlying groundwater is relevant to the extent that surface water in some reaches of Pajaro River basin streams recharge the underlying groundwater resource. It is well known that groundwater recharge from streams locally can play a significant role in the quantity and quality of groundwater in the Pajaro River basin (refer back to Section 3.9).

The Basin Plan groundwater recharge (GWR) beneficial use explicitly states that the designated groundwater recharge use of surface waters are to be protected to maintain and support groundwater quality. The Basin Plan does not specifically identify numeric water quality objectives to implement the GWR beneficial use, however a situation-specific weight of evidence approach can be used to assess if GWR is being supported, consistent with Section 3.11 of the California Listing Policy (State Water Board, 2004).

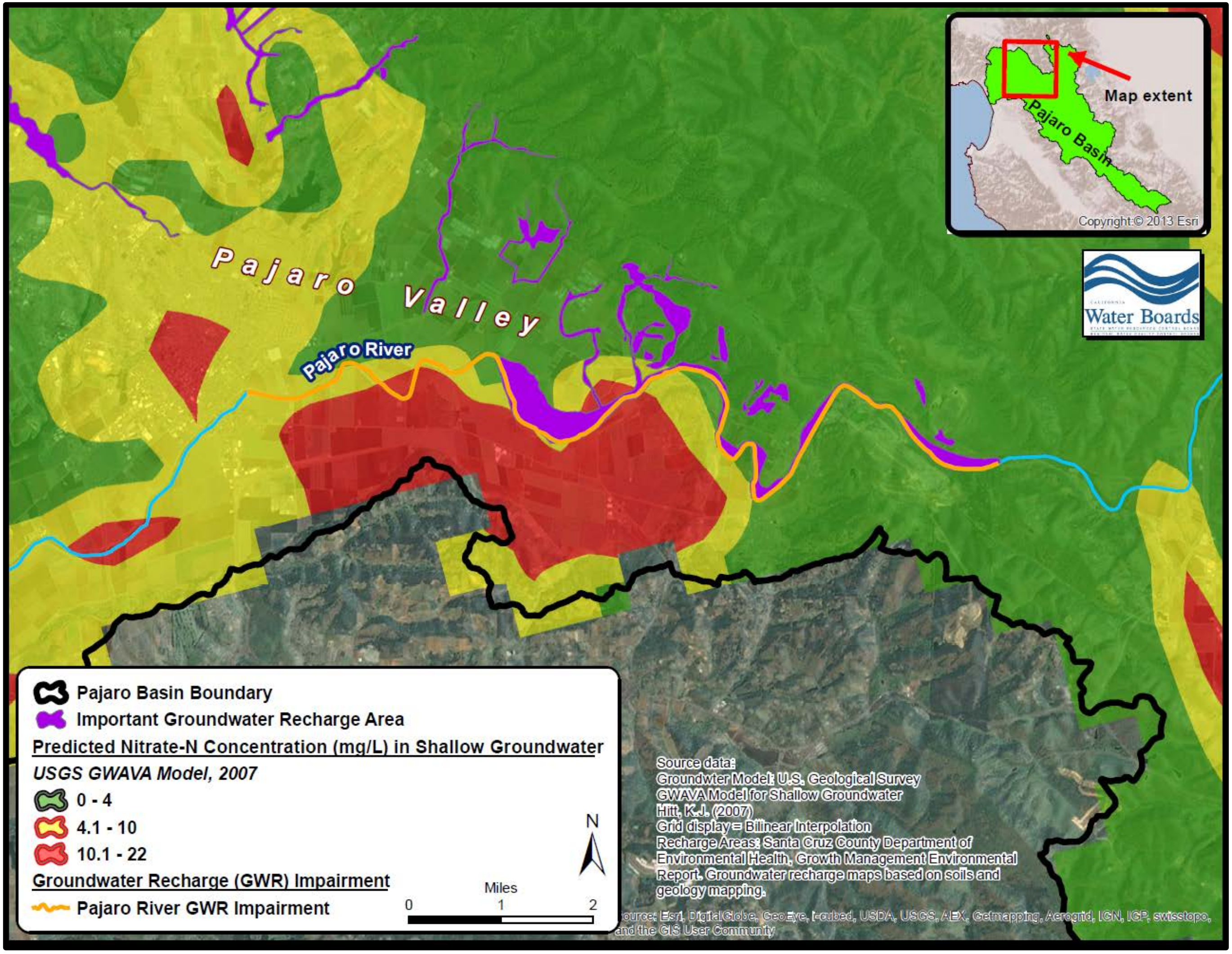
In terms of assessing whether or not designated GWR beneficial uses are being supported, it is important to consider water quality of the surface waters and also the underlying local groundwater, as well as the scope and importance of stream infiltration to the groundwater resource. Stream reaches designated in the Basin Plan for GWR in the Pajaro River basin were previously identified in Table 4-1.

The Pajaro River is designated for GWR beneficial uses, and as highlighted previously (report Section 3.9), the subsurface infiltration by waters of the Pajaro River is important for groundwater recharge in the Pajaro Valley (see report Section 3.9 and Figure 3-31). Parts of the Pajaro River that recharge the underlying aquifer are known to be having adverse impact on nitrate groundwater quality:

> *"Groundwater quality within…the Pajaro Valley is influenced by factors related to hydrology, geochemistry, well construction, groundwater pumping, and land use….**Nitrate contamination has been identified as a problem** in areas of high residential septic tank density and **in some areas that are recharged by the Pajaro River*.***
>
> *From: Pajaro Valley Water Management Agency, 2012 Basin Management Plan Update, January 2013 draft.*
>
> *emphasis added by Central Coast Water Board staff*

In some places where the Pajaro River recharges the underlying aquifer, the groundwater is so polluted with nitrate it has no further assimilative capacity to receive any more nitrate pollution from polluted river waters percolating into the subsurface (see Figure 5-68). On the basis of the information outlined above, and on the basis of nitrate water quality in surface waters and in the underlying groundwaters, the designated GWR beneficial use of the Pajaro River is not being supported in a reach of the river from downstream of Chittenden Gap to upstream of the Main Street bridge at Porter Drive (see Figure 5-68).

Figure 5-68. Map of Pajaro Valley downstream of Chittenden Gap, showing important groundwater recharge areas, and estimated nitrate as N concentrations in shallow, recently recharged groundwaters. Groundwater recharge beneficial uses of the river are not being supported in a reach of the Pajaro River downstream of Chittenden Gap, to upstream of the Main Street bridge at Porter Drive.



Source data:
Groundwter Model: U.S. Geological Survey
GWAVA Model for Shallow Groundwater
Hitt, K.J. (2007)
Grid display = Bilinear Interpolation
Recharge Areas: Santa Cruz County Department of Environmental Health, Growth Management Environmental Report. Groundwater recharge maps based on soils and geology mapping.

ource: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Llagas Creek is also designated for GWR beneficial uses. Stream infiltration[135] and groundwater recharge is indicated by observations of flow loss[136] in lower Llagas Creek between Llagas Avenue near San Martin and Highway 152 (located 9 creek miles downstream from Llagas Creek at Llagas Avenue in San Martin). During seven sampling events between June 1992 and December 1992 when there was zero flow at the Llagas Creek at Highway 152 monitoring site, and there was measurable flow on the same day at the upstream Llagas Creek at Llagas Avenue site, average stream flow loss in a downstream direction between the two sites was 17.6 cfs. One daily observation indicated a downstream flow loss of 24.2 cfs between the two locations.

According to eWRIMS[137] data, there are no point of diversion water rights on Llagas Creek between the Llagas Avenue and the Highway 152 monitoring sites; therefore the flow differences between the two creek locations are presumed to be largely due to surface water percolating through the creek bed to the underlying aquifer (see Figure 5-69). These data show that locally, this reach of lower Llagas Creek is a losing stream reach. The aforementioned flow-losses between these two sites on Llagas Creek could

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[135] Stream infiltration is the volume of water that percolates through a streambed into the aquifer.

[136] On the basis of 1990s vintage flow data, William et al. 1994

[137] eWRIMS = Electronic Water Rights Information Management System (State Water Resources Control Board)

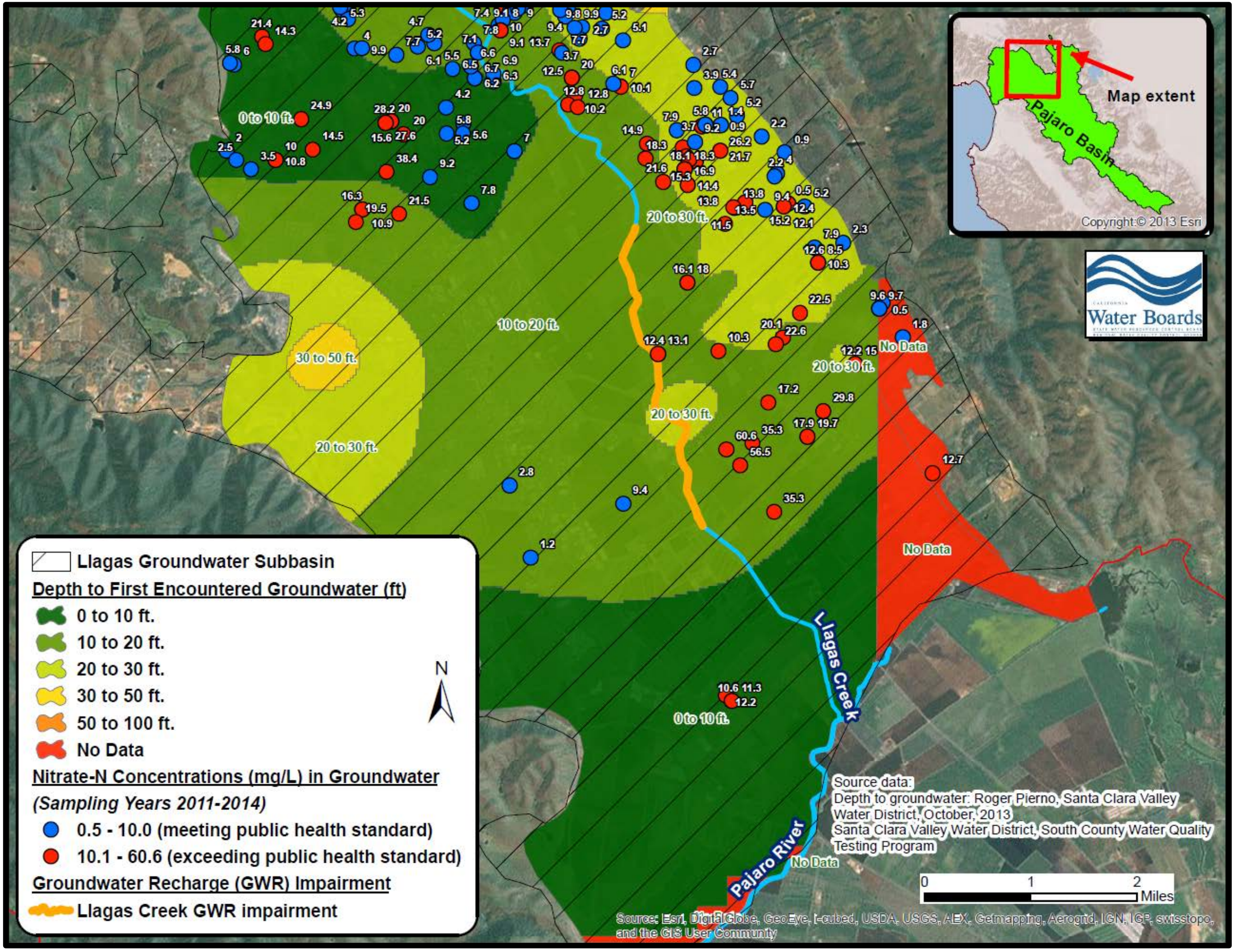
potentially represent thousands of acre-feet of groundwater recharge annually over a long term basis within this nine-mile reach of Llagas Creek.

It should be noted that a cursory review of limited, available flow data suggests that the reach of lowermost Llagas Creek between Luchessa Road and the confluence with the Pajaro River is generally a gaining reach of creek, with creek flows marginally increasing as one moves downstream from the intermittently dry creek reach at Highway 152. This indicates this lowermost reach of Llagas Creek receives contributions of subsurface flows, and thus is a gaining reach of stream that generally would not be expected to recharge the underlying groundwater.

Figure 5-69. Llagas Creek at Holsclaw Road below Leavesly Road, showing evidence of strongly "losing" hyraulic conditions as indicated by the intermittent nature of flow and on the basis of recorded flow data, in which creek waters percolate through the creek bed to the underlying groundwater resource. The course-grained, high-permeability sand and gravel creek substrate would be expected to locally promote rapid infiltration of creek waters into the subsurface.

In the lower Llagas Creek subwatershed, both the creek waters, and underlying groundwater frequently exceed the public health (MUN) drinking water beneficial use objective of 10 mg/L nitrate as N. Therefore, these groundwaters have no further assimilative capacity to absorb any nitrate pollution from polluted creek waters in losing reaches of the creek (see Figure 5-70). In addition, first encountered groundwater is generally quite shallow in the lower Llagas Creek subwatershed – often less than 10 or 15 feet below the elevation of the creek bed (see Figure 5-70) – thus there is little vertical separation of the water table and the creek bed, and little opportunity for distance attenuation of nitrate-polluted water percolating downward through the creek bed. The losing reach of Llagas Creek where nitrate pollutions has been observed is approximately from Llagas Creek upstream of Luchessa Road to Llagas Creek downstream of Leavesley Road (see Figure 5-70); this creek reach is not supporting it's designated GWR beneficial uses.

Figure 5-70. Depth to first encountered groundwater and nitrate concentations in groundwater in the Llagas Groundwater subbasin. Lower reaches of Llagas Creek – which are designated for groundwater recharge beneficial uses – convey nitrate-polluted creek waters which locally percolate through the creek bed to the underlying groundwater resource.



Source data:
Depth to groundwater: Roger Pierno, Santa Clara Valley Water District, October, 2013
Santa Clara Valley Water District, South County Water Quality Testing Program

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Based on all of the aforementioned information, the designated groundwater recharge (GWR) beneficial uses locally in reaches of the Pajaro River (upstream of Watsonville and downstream of Chittenden Gap at Chittenden Road) and lower Llagas Creek (upstream of Southside Drive and downstream of Leavesley Road) are not being supported for the following reasons:

- *Available data show that both the stream waters and the underlying local groundwater frequently exceed the drinking water objective of 10 mg/L nitrate-N. Therefore, since groundwater underlying and proximal to the parts of the Pajaro River and to lower Llagas creek are currently exceeding the drinking water standard, these groundwaters have no further assimilative capacity to absorb nitrate polluted stream waters percolating downward and recharging to the groundwater resource.*
- *Available information indicates that stream infiltration in these creeks and their designated groundwater recharge beneficial uses are locally an important hydrologic process pertaining to the supply and maintenance of local groundwater resources;*
- *Transmission through the streambed of nitrate-impaired creek surface waters recharging to the shallow saturated zone of groundwater could locally happen quite rapidly, with presumably little opportunity for attenuation of pollutants.*

It should be noted that nitrate pollution of shallow groundwater from these stream reaches may locally be mitigated to some extent by denitrification. Denitrification, which converts nitrate to nitrogen or nitrous oxide gas, can reduce nitrate loading to groundwaters, and denitrification reportedly can locally be an important process in hyporheic zones of streams (i.e., regions beneath and alongside a stream bed) - (Moran et al., 2011). It should be noted that some researchers have cautioned against drawing sweeping generalities about specific hyporheic zone processes (Edwardson et al. 2003 as reported in Bencala, 2005). While hyporheic zone denitrification can reportedly be an important process locally and where geochemical conditions are conducive, there is uncertainty about how significant the process is at the basin-scale or subwatershed-scale in terms of mitigating nitrate loading to groundwaters. During TMDL implementation, staff anticipates the future research and more information will ultimately become available to make better assessments and address uncertainties regarding the nexus between denitrification, polluted groundwater, and nitrate-polluted streams in the Pajaro River basin.

5.11 Summary Water Quality Statistics

5.11.1 Statistical Summary of 1998–2013 Monitoring Data

While some legacy water quality data was used for informational purposes in this TMDL report, for the purposes of regulatory compliance it is important to only look at more recent data, since water quality and land use activities from decades ago have generally no bearing on more current regulatory compliance. According to Central Coast Water Board staff, the next Clean Water Act 303(d) assessment in the Pajaro River basin will likely use data from 1998 and onward (personal communication, Mary Hamilton, Central Coast Water Board staff environmental scientist). Therefore, for the sake of consistency, impairment status of stream waters in this TMDL report will be assessed on the basis of 1998-2013 water quality data. Data older than 1998 will not be used in assessing impairment status of streams in the Pajaro River basin.

Table 5-8 through Table 5-19 present summary statistics for stream water quality data in the Pajaro River basin. Summary statistics were calculated using R[138]. As noted above, these water quality data represent the suite of samples that are used in this TMDL to assess water quality status and impairments. Impairments are determined on the basis of methodologies presented in the California 303(d) Listing Policy and the Water Quality Control Plan for the Central Coast Region (refer back to Section 4 and to Section 4.4).

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[138] R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org

Table 5-8. Summary statistics for nitrate as N (units=mg/L) and exceedances of drinking water standard in streams of the Pajaro River basin.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 10mg/L (MUN Standard)	% Exceeding 10 mg/L
Beach Road Ditch	**All sites**	1,140	10/4/2000	12/17/2013	40.55	0.00	22.30	40.46	57.94	133.00	1,020	89%
	BRD	103	12/10/2002	12/17/2013	34.63	0.02	24.86	30.74	45.31	69.38	98	95%
	305-BEACH-21	181	10/4/2000	5/2/2009	43.05	0.02	31.22	44.85	57.94	115.50	162	90%
	BR_WMI	164	10/4/2000	3/20/2007	21.49	0.00	17.13	21.15	26.50	85.80	138	84%
	BR_WS3	177	10/25/2000	3/20/2007	53.87	2.99	41.85	56.54	67.06	125.00	170	96%
	BR_WS1	29	1/16/2001	12/12/2006	35.28	0.30	5.23	22.47	60.61	112.49	20	69%
	BR_WS2	162	11/22/2000	3/20/2007	49.76	0.67	37.30	48.30	63.44	112.00	160	99%
	BR_FGB	165	10/4/2000	3/20/2007	24.09	0.70	8.78	19.98	34.57	133.00	118	72%
	BR_DW2	49	2/13/2001	12/29/2002	71.69	55.64	66.42	71.00	76.49	88.79	49	100%
	BR_PAN	54	1/30/2001	9/21/2004	50.37	0.69	38.38	54.64	62.01	84.69	52	96%
	BR_THU	56	12/5/2000	9/21/2004	44.90	0.20	31.42	48.20	57.33	97.38	53	95%
Bodfish Creek	305CAW097	1	5/27/2003	5/27/2003	0.09	0.09	0.09	0.09	0.09	0.09	0	0%
Browns Creek	**All sites**	125	12/10/2002	12/17/2013	0.19	0.02	0.02	0.02	0.23	9.72	0	0%
	BC	100	12/10/2002	12/17/2013	0.24	0.02	0.02	0.02	0.23	9.72	0	0%
	305-BROWN-21	25	5/8/2004	11/20/2004	0.03	0.02	0.02	0.02	0.02	0.12	0	0%
Carnadero Creek	**All sites**	157	1/25/2005	12/10/2013	7.77	0.01	1.40	2.70	9.12	61.55	39	25%
	305CAN	101	1/24/2006	12/10/2013	7.22	0.01	1.20	1.84	4.67	61.55	19	19%
	305CAR	56	1/25/2005	12/13/2011	8.78	0.58	2.48	4.96	13.01	39.12	20	36%
Casserly Creek	**All sites**	163	12/10/2002	12/17/2013	3.21	0.02	0.45	2.26	3.73	18.98	19	12%
	CA1	63	1/21/2003	4/1/2013	0.36	0.02	0.02	0.23	0.55	1.58	0	0%
	CC_CAS	1	3/11/2003	3/11/2003	7.42	7.42	7.42	7.42	7.42	7.42	0	0%
	CA2	98	12/10/2002	12/17/2013	5.03	0.02	2.55	3.28	6.81	18.98	19	19%
	CS_MMR	1	8/17/2006	8/17/2006	0.33	0.33	0.33	0.33	0.33	0.33	0	0%
Clear Creek	305CLCSBR	1	6/11/2008	6/11/2008	0.14	0.14	0.14	0.14	0.14	0.14	0	0%
Corralitos Creek	**All sites**	961	7/11/2000	12/17/2013	1.40	0.00	0.02	0.23	1.59	33.51	12	1%
	305COB_SCC	8	7/11/2000	5/8/2006	0.10	0.02	0.06	0.08	0.14	0.24	0	0%
	305-CORRA-21	342	10/4/2000	5/21/2013	2.23	0.02	0.67	1.25	2.94	33.51	4	1%
	CO_BVR	225	10/4/2000	12/17/2013	0.10	0.01	0.02	0.05	0.11	4.07	0	0%
	305-SALSI-21	31	5/1/2004	11/20/2004	5.31	0.02	3.50	5.00	6.61	12.82	3	10%
	305-CORRA-24	134	7/11/2000	12/17/2013	0.11	0.01	0.02	0.02	0.05	4.97	0	0%
	305-CORRA-22	10	5/17/2003	5/1/2010	0.27	0.04	0.05	0.07	0.43	1.03	0	0%
	CO3	96	12/12/2002	12/17/2013	2.43	0.02	0.23	0.79	3.73	11.75	3	3%
	CO_VAR	85	1/16/2001	4/1/2013	0.09	0.00	0.02	0.02	0.05	2.94	0	0%
	305-CORRA-23	30	5/8/2004	11/20/2004	4.55	1.00	3.00	4.00	5.00	10.86	2	7%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 10mg/L (MUN Standard)	% Exceeding 10 mg/L
Unnamed tributary to Corralitos Creek	UNT	93	12/12/2002	12/17/2013	8.93	0.02	4.60	7.23	11.53	26.89	31	33%
Coward Creek	CW	9	4/3/2003	1/23/2012	20.04	1.81	8.36	12.43	28.70	61.02	6	67%
Furlong Creek	**All sites**	159	3/11/2003	12/13/2011	31.12	3.58	25.30	32.59	35.83	89.12	155	97%
	305FUF	54	1/25/2005	12/13/2011	34.13	4.40	29.64	35.00	38.55	89.12	52	96%
	FC_FLR	105	3/11/2003	3/13/2007	29.56	3.58	23.82	31.15	34.80	74.70	103	98%
Gallighan Slough	GS	76	12/12/2002	12/17/2013	4.35	0.40	2.03	3.50	4.80	29.15	4	5%
Green Valley Creek	GV	99	12/10/2002	12/17/2013	3.84	0.40	1.80	2.71	5.65	24.41	1	1%
Tributary to Green Valley Creek	GVT	99	12/10/2002	12/17/2013	21.48	2.49	8.36	14.24	29.14	116.62	67	68%
Harkins Slough	**All sites**	300	12/12/2002	12/17/2013	2.08	0.01	0.02	0.02	0.68	27.35	27	9%
	305HAR-BUE	3	5/17/2003	5/7/2005	0.14	0.05	0.06	0.07	0.19	0.31	0	0%
	305HAR	168	12/12/2002	12/17/2013	0.15	0.01	0.02	0.02	0.02	4.10	0	0%
	305-HARKI-22	4	5/17/2003	5/7/2005	4.93	0.02	0.19	3.94	8.67	11.83	1	25%
	HS1	105	12/12/2002	12/17/2013	5.39	0.02	0.02	1.13	9.94	27.35	26	25%
	HS3	20	1/16/2003	4/16/2012	0.59	0.02	0.17	0.36	0.57	3.39	0	0%
Hughes Creek	HC	23	1/21/2003	1/31/2013	0.95	0.20	0.45	0.90	1.24	3.16	0	0%
Laguna Creek	305LGCACR	1	7/16/2008	7/16/2008	0.00	0.00	0.00	0.00	0.00	0.00	0	0%
Little Arthur Creek	305WE0883	1	6/28/2001	6/28/2001	0.17	0.17	0.17	0.17	0.17	0.17	0	0%
Llagas Creek	**All sites**	1,290	1/19/1998	12/10/2013	7.75	0.00	0.20	1.92	13.97	51.50	454	35%
	305OAK	146	2/10/1998	3/13/2007	0.20	0.01	0.07	0.15	0.30	1.96	0	0%
	305LGCBRC	2	7/11/2006	6/30/2010	0.00	0.00	0.00	0.00	0.00	0.00	0	0%
	305VIS	20	2/10/1998	5/25/2004	2.52	0.01	0.68	1.32	4.03	12.10	1	5%
	305CHE	109	2/10/1998	3/13/2007	0.15	0.00	0.03	0.07	0.17	1.19	0	0%
	LL_CHU	51	10/1/2002	12/17/2004	0.42	0.00	0.07	0.20	0.79	2.21	0	0%
	305LHB	42	6/9/2004	3/26/2008	26.90	0.20	21.16	29.24	34.74	51.50	36	86%
	305HOL	33	2/10/1998	1/25/2008	10.81	0.46	1.50	2.82	15.33	31.72	14	42%
	305LEA	58	12/15/2002	5/25/2011	1.78	0.01	0.63	1.29	1.77	19.21	2	3%
	305MON	252	2/10/1998	3/13/2007	0.60	0.00	0.07	0.30	0.78	20.60	1	0%
	305LUC	252	2/10/1998	12/10/2013	17.80	0.02	11.54	18.36	24.23	37.70	200	79%
	305PS0061	1	6/17/2009	6/17/2009	0.01	0.01	0.01	0.01	0.01	0.01	0	0%
	305LLA	324	1/19/1998	12/13/2011	11.27	0.52	7.57	11.71	14.70	29.45	200	62%
West Branch	**All sites**	52	2/12/1998	7/18/2013	1.50	0.02	0.74	1.10	2.00	4.46	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 10mg/L (MUN Standard)	% Exceeding 10 mg/L
Llagas Creek	SW2	17	2/12/1998	7/18/2013	1.34	0.32	0.79	1.00	2.00	3.00	0	0%
	SW1	17	5/14/1998	4/25/2013	1.00	0.02	0.45	1.00	1.00	3.00	0	0%
	SW3	6	12/16/2003	7/22/2005	2.32	1.20	1.81	2.00	2.75	4.00	0	0%
	LL_WDA	5	12/15/2002	3/15/2003	2.26	0.70	1.44	2.09	2.69	4.37	0	0%
	LL_WHI	7	12/15/2002	5/2/2003	1.91	0.36	0.73	1.56	2.75	4.46	0	0%
West Branch Llagas Creek Tributary	SW4	3	10/19/2004	7/25/2005	1.38	0.02	1.01	2.00	2.06	2.12	0	0%
Little Llagas	LL_LLC	4	12/23/2002	5/11/2004	1.67	0.01	0.87	1.77	2.57	3.11	0	0%
Mattos Gulch	MG	1	4/20/2006	4/20/2006	0.23	0.23	0.23	0.23	0.23	0.23	0	0%
McGowan Ditch	**All sites**	7	11/14/2006	9/22/2009	15.04	5.49	6.91	9.13	22.93	31.00	3	43%
	305MDD	6	1/6/2008	9/22/2009	13.84	5.49	6.83	8.09	19.98	31.00	2	33%
	MC_TRA	1	11/14/2006	11/14/2006	22.25	22.25	22.25	22.25	22.25	22.25	1	100%
Miller's Canal	**All sites**	401	2/10/1998	5/30/2013	0.31	0.00	0.03	0.09	0.30	9.58	0	0%
	305FRA	391	2/10/1998	5/30/2013	0.32	0.00	0.03	0.09	0.31	9.58	0	0%
	MC_4	1	7/12/2006	7/12/2006	0.04	0.04	0.04	0.04	0.04	0.04	0	0%
	MC_5	1	7/12/2006	7/12/2006	0.08	0.08	0.08	0.08	0.08	0.08	0	0%
	MC_6	1	7/12/2006	7/12/2006	0.11	0.11	0.11	0.11	0.11	0.11	0	0%
	MC_7	1	7/12/2006	7/12/2006	0.09	0.09	0.09	0.09	0.09	0.09	0	0%
	MC_9	1	7/12/2006	7/12/2006	0.07	0.07	0.07	0.07	0.07	0.07	0	0%
	MC_10	1	7/12/2006	7/12/2006	0.21	0.21	0.21	0.21	0.21	0.21	0	0%
	MC_11	1	7/12/2006	7/12/2006	0.22	0.22	0.22	0.22	0.22	0.22	0	0%
	MC_12	1	7/12/2006	7/12/2006	0.25	0.25	0.25	0.25	0.25	0.25	0	0%
	MC_2	1	7/12/2006	7/12/2006	0.01	0.01	0.01	0.01	0.01	0.01	0	0%
	MC_3	1	7/12/2006	7/12/2006	0.02	0.02	0.02	0.02	0.02	0.02	0	0%
Pacheco Creek	**All sites**	489	1/19/1998	12/13/2011	1.14	0.01	0.34	0.64	1.26	18.95	2	0%
	305CAW049	1	5/29/2003	5/29/2003	0.04	0.04	0.04	0.04	0.04	0.04	0	0%
	PC_CDF	1	9/2/2003	9/2/2003	0.01	0.01	0.01	0.01	0.01	0.01	0	0%
	305PAC	252	1/19/1998	12/13/2011	1.68	0.01	0.44	1.16	1.99	18.95	2	1%
	305PACLOV	87	11/11/2003	3/13/2007	0.66	0.02	0.29	0.54	0.85	7.04	0	0%
	PC_NFK	1	7/17/2006	7/17/2006	0.44	0.44	0.44	0.44	0.44	0.44	0	0%
	PC_SFR	105	10/1/2002	8/29/2006	0.63	0.17	0.38	0.56	0.73	2.14	0	0%
	305PACWAL	42	9/2/2003	10/24/2006	0.27	0.02	0.05	0.13	0.42	1.82	0	0%
Pajaro River	**All sites**	2,347	1/19/1998	12/17/2013	7.20	0.00	4.24	6.50	9.25	34.14	481	20%
	305PMO_SCC	4	12/11/2001	4/3/2003	2.26	0.00	0.00	1.62	3.88	5.81	0	0%
	PR1	99	12/12/2002	12/17/2013	9.58	0.02	5.88	7.46	13.11	25.00	37	37%
	PajPump	20	5/15/2009	12/7/2010	4.72	0.79	2.75	5.07	6.45	9.81	0	0%
	305PS0057	1	6/16/2009	6/16/2009	7.78	7.78	7.78	7.78	7.78	7.78	0	0%

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	305PAJ	319	1/19/1998	12/13/2011	7.51	0.72	4.68	6.77	9.48	34.14	71	22%
	305CHI	611	1/19/1998	12/10/2013	8.27	0.01	4.74	7.15	10.45	32.50	164	27%
	PA_H25	87	7/8/2003	3/13/2007	8.67	0.76	5.05	8.45	11.09	20.60	29	33%
	305PJP	395	10/4/2000	12/10/2013	6.17	0.01	3.96	6.05	7.93	14.60	37	9%
	305MUR	337	2/10/1998	6/26/2013	7.97	0.10	5.20	7.35	10.81	18.80	94	28%
	305THU	440	1/19/1998	12/17/2013	5.01	0.02	2.49	4.77	6.90	32.22	32	7%
	PA_UVAS	1	7/13/2006	7/13/2006	16.20	16.20	16.20	16.20	16.20	16.20	1	100%
	305PS0034	1	6/17/2008	6/17/2008	8.95	8.95	8.95	8.95	8.95	8.95	0	0%
	PA_FLR	17	12/23/2002	5/25/2004	4.17	0.18	2.93	4.54	4.79	11.03	1	6%
	PA_13	1	7/12/2006	7/12/2006	11.85	11.85	11.85	11.85	11.85	11.85	1	100%
	PA_14	1	7/12/2006	7/12/2006	11.90	11.90	11.90	11.90	11.90	11.90	1	100%
	PA_15	1	7/12/2006	7/12/2006	12.00	12.00	12.00	12.00	12.00	12.00	1	100%
	PA_16	1	7/12/2006	7/12/2006	11.90	11.90	11.90	11.90	11.90	11.90	1	100%
	PA_18	1	7/12/2006	7/12/2006	11.85	11.85	11.85	11.85	11.85	11.85	1	100%
	PA_19	1	7/13/2006	7/13/2006	15.60	15.60	15.60	15.60	15.60	15.60	1	100%
	PA_21	1	7/13/2006	7/13/2006	15.40	15.40	15.40	15.40	15.40	15.40	1	100%
	PA_22	1	7/13/2006	7/13/2006	15.50	15.50	15.50	15.50	15.50	15.50	1	100%
	PA_23	1	7/13/2006	7/13/2006	15.40	15.40	15.40	15.40	15.40	15.40	1	100%
	PA_24	1	7/13/2006	7/13/2006	14.95	14.95	14.95	14.95	14.95	14.95	1	100%
	PA_26	1	7/13/2006	7/13/2006	13.50	13.50	13.50	13.50	13.50	13.50	1	100%
	PA_27	1	7/13/2006	7/13/2006	17.20	17.20	17.20	17.20	17.20	17.20	1	100%
	PA_29	1	7/13/2006	7/13/2006	21.05	21.05	21.05	21.05	21.05	21.05	1	100%
	PA_30	1	7/13/2006	7/13/2006	15.25	15.25	15.25	15.25	15.25	15.25	1	100%
	PA_31	1	7/13/2006	7/13/2006	16.65	16.65	16.65	16.65	16.65	16.65	1	100%
Pajaro River Estuary	**All sites**	24	1/6/2008	9/22/2009	1.96	0.02	0.45	0.99	1.84	10.90	1	4%
	305PJE_L	12	1/6/2008	9/22/2009	1.77	0.02	0.11	0.69	1.09	10.90	1	8%
	305PJE_U	12	1/6/2008	9/22/2009	2.15	0.20	0.74	1.38	2.26	6.42	0	0%
Pescadero Creek	305PES	4	2/10/1998	2/19/1998	1.30	1.19	1.21	1.30	1.40	1.41	0	0%
Pinto Lake Outflow Ditch	PLO	92	12/12/2002	8/15/2013	9.62	0.23	3.43	9.61	13.90	27.57	44	48%
Salsipuedes Creek	**All sites**	363	1/19/1998	11/21/2013	3.55	0.01	1.14	1.90	4.85	63.42	12	3%
	305CAW057	1	6/24/2003	6/24/2003	6.71	6.71	6.71	6.71	6.71	6.71	0	0%
	305COR	362	1/19/1998	11/21/2013	3.54	0.01	1.13	1.88	4.82	63.42	12	3%
San Benito River	**All sites**	451	1/19/1998	12/12/2011	1.29	0.00	0.02	0.20	1.50	42.60	3	1%
	305SBH	2	1/24/2008	2/22/2008	0.29	0.20	0.24	0.29	0.33	0.37	0	0%
	SB_BWC	1	6/19/2006	6/19/2006	0.01	0.01	0.01	0.01	0.01	0.01	0	0%
	SB_PA	1	7/13/2006	7/13/2006	0.10	0.10	0.10	0.10	0.10	0.10	0	0%
	305SAN	395	1/19/1998	12/12/2011	1.46	0.00	0.03	0.40	1.91	42.60	3	1%

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	305BRI	52	1/24/2005	12/12/2011	0.05	0.01	0.01	0.02	0.12	0.19	0	0%
San Juan Creek	**All sites**	419	11/6/2002	12/10/2013	30.59	0.13	18.08	31.10	41.02	78.90	390	93%
	305SJN	345	7/22/2003	12/10/2012	29.13	0.13	17.30	29.65	40.25	74.31	317	92%
	SJ_101	53	11/6/2002	9/29/2004	30.97	4.17	19.57	33.41	40.82	51.66	52	98%
	SJ_156	2	8/4/2003	3/29/2005	34.52	22.00	28.26	34.52	40.79	47.05	2	100%
	305MVR	9	1/24/2008	12/17/2008	64.36	22.50	65.20	68.05	72.14	78.90	9	100%
	SJ_PA	1	7/13/2006	7/13/2006	27.00	27.00	27.00	27.00	27.00	27.00	1	100%
	305PRR	9	1/24/2008	12/17/2008	50.05	22.90	49.32	53.90	57.12	61.40	9	100%
West Branch San Juan Creek	305ACR	9	1/24/2008	12/17/2008	6.62	0.51	2.40	6.24	10.30	16.46	3	33%
San Martin Creek	SM_FOO	1	2/25/2004	2/25/2004	1.20	1.20	1.20	1.20	1.20	1.20	0	0%
Struve Slough	**All sites**	137	5/17/2003	12/12/2011	0.63	0.01	0.02	0.03	0.07	29.41	4	3%
	305STR-HAR	5	5/17/2003	5/7/2005	0.08	0.02	0.02	0.09	0.10	0.20	0	0%
	305STL	132	5/17/2003	12/12/2011	0.65	0.01	0.02	0.03	0.07	29.41	4	3%
West Branch of Struve Slough	305-WSTRU-21	7	5/17/2003	8/30/2004	0.21	0.02	0.02	0.02	0.20	1.00	0	0%
Swanson Canyon Creek	305SSCAUC	1	6/29/2010	6/29/2010	0.02	0.02	0.02	0.02	0.02	0.02	0	0%
Tequisquita Slough	**All sites**	233	1/19/1998	12/10/2013	5.53	0.01	1.81	4.36	8.29	51.75	32	14%
	TS_SFL	2	6/23/2006	7/12/2006	0.06	0.02	0.04	0.06	0.07	0.09	0	0%
	305TES	231	1/19/1998	12/10/2013	5.57	0.01	1.87	4.37	8.31	51.75	32	14%
Tres Pinos Creek	**All sites**	51	2/19/1998	10/19/2011	0.41	0.01	0.02	0.11	0.79	1.85	0	0%
	305TRE	50	2/19/1998	10/19/2011	0.42	0.01	0.02	0.10	0.80	1.85	0	0%
	TP_H25	1	6/22/2006	6/22/2006	0.27	0.27	0.27	0.27	0.27	0.27	0	0%
Uvas Creek	**All sites**	701	1/19/1998	12/13/2011	0.69	0.00	0.20	0.54	0.99	8.86	0	0%
	305CAW161	1	5/19/2003	5/19/2003	1.56	1.56	1.56	1.56	1.56	1.56	0	0%
	305UVCASC	1	6/29/2010	6/29/2010	0.02	0.02	0.02	0.02	0.02	0.02	0	0%
	UV_URA	77	1/7/2003	3/13/2007	0.32	0.00	0.03	0.09	0.30	2.64	0	0%
	305UVA	193	1/19/1998	12/13/2011	1.11	0.01	0.63	0.99	1.30	8.86	0	0%
	UV_UCP	1	7/10/2006	7/10/2006	0.01	0.01	0.01	0.01	0.01	0.01	0	0%
	UV_152	223	10/1/2002	3/13/2007	0.63	0.06	0.26	0.58	0.86	5.95	0	0%
	UV_THO	90	11/12/2002	3/13/2007	0.91	0.09	0.52	0.91	1.18	2.71	0	0%
	UV_URB	115	10/15/2002	3/13/2007	0.17	0.01	0.07	0.12	0.25	1.10	0	0%
Watsonville Slough	**All sites**	1184	2/12/1998	12/17/2013	8.41	0.00	0.87	4.18	14.48	61.64	403	34%
	305WAT-AND	292	10/4/2000	12/17/2013	9.71	0.02	1.76	5.42	16.48	48.06	119	41%
	305WAT-SHE	270	10/25/2000	12/17/2013	13.05	0.02	5.30	11.89	18.98	61.64	154	57%
	WS1	108	12/12/2002	12/17/2013	4.41	0.01	0.02	0.90	5.14	38.42	19	18%
	305-WATSO-23	25	5/17/2003	9/22/2009	19.35	0.02	3.14	16.00	24.17	50.00	16	64%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 10mg/L (MUN Standard)	% Exceeding 10 mg/L
	WS_ERR	173	10/4/2000	3/20/2007	1.17	0.00	0.09	0.24	0.80	16.26	4	2%
	305WAT-HAR	15	5/17/2003	5/7/2005	0.17	0.02	0.02	0.02	0.05	1.00	0	0%
	305WAT-LEE	171	10/4/2000	3/20/2007	8.29	0.01	2.46	4.76	12.79	35.20	54	32%
	305WSA	130	2/12/1998	7/18/2013	7.86	0.03	0.94	2.89	15.19	34.18	37	28%

Table 5-9. Pajaro River basin summary statistics for nitrate as N (units = mg/L) and exceedances of agricultural supply water quality criterion.

Waterbody[A]	Monitoring Site ID	No. of Samples	Temporal Representation		Min	50% (Median)	Mean	Max	No. Exceeding 30 mg/L[B]	% Exceeding 30 mg/L	No. Exceeding 100 mg/L[C]	% Exceeding 100 mg/L
Bodfish Creek	305CAW097	1	5/27/2003	5/27/2003	0.1	0.1	0.1	0.1	0	0%	0	0%
Browns Creek	**All sites**	125	12/10/2002	12/17/2013	0.0	0.0	0.2	9.7	0	0%	0	0%
	305-BROWN-21	25	5/8/2004	11/20/2004	0.0	0.0	0.0	0.1	0	0%	0	0%
	BC	100	12/10/2002	12/17/2013	0.0	0.0	0.2	9.7	0	0%	0	0%
Corralitos Creek	**All sites**	961	7/11/2000	12/17/2013	0.0	0.2	1.4	33.5	1	<1%	0	0%
	305COB_SCC	8	7/11/2000	5/8/2006	0.0	0.1	0.1	0.2	0	0%	0	0%
	305-CORRA-21	342	10/4/2000	5/21/2013	0.0	1.3	2.2	33.5	1	<1%	0	0%
	305-CORRA-22	10	5/17/2003	5/1/2010	0.0	0.1	0.3	1.0	0	0%	0	0%
	305-CORRA-23	30	5/8/2004	11/20/2004	1.0	4.0	4.6	10.9	0	0%	0	0%
	305-CORRA-24	134	7/11/2000	12/17/2013	0.0	0.0	0.1	5.0	0	0%	0	0%
	305-SALSI-21	31	5/1/2004	11/20/2004	0.0	5.0	5.3	12.8	0	0%	0	0%
	CO_BVR	225	10/4/2000	12/17/2013	0.0	0.1	0.1	4.1	0	0%	0	0%
	CO_VAR	85	1/16/2001	4/1/2013	0.0	0.0	0.1	2.9	0	0%	0	0%
	CO3	96	12/12/2002	12/17/2013	0.0	0.8	2.4	11.8	0	0%	0	0%
Little Arthur Creek	305WE0883	1	6/28/2001	6/28/2001	0.2	0.2	0.2	0.2	0	0%	0	0%
Llagas Creek	**All sites**	1,290	1/19/1998	12/10/2013	0.0	2.0	7.7	51.5	39	3%	0	0%
	305CHE	109	2/10/1998	3/13/2007	0.0	0.1	0.1	1.2	0	0%	0	0%
	305HOL	33	2/10/1998	1/25/2008	0.5	2.8	10.8	31.7	2	6%	0	0%
	305LEA	58	12/15/2002	5/25/2011	0.0	1.3	1.8	19.2	0	0%	0	0%
	305LGCBRC	2	7/11/2006	6/30/2010	0.0	0.0	0.0	0.0	0	0%	0	0%
	305LHB	42	6/9/2004	3/26/2008	0.2	29.3	26.9	51.5	20	48%	0	0%
	305LLA	324	1/19/1998	12/13/2011	0.5	11.7	11.3	29.5	0	0%	0	0%
	305LUC	252	2/10/1998	12/10/2013	0.0	18.4	17.8	37.7	17	7%	0	0%
	305MON	252	2/10/1998	3/13/2007	0.0	0.3	0.6	20.6	0	0%	0	0%
	305OAK	146	2/10/1998	3/13/2007	0.0	0.1	0.2	2.0	0	0%	0	0%
	305PS0061	1	6/17/2009	6/17/2009	0.0	0.0	0.0	0.0	0	0%	0	0%

Waterbody[A]	Monitoring Site ID	No. of Samples	Temporal Representation		Min	50% (Median)	Mean	Max	No. Exceeding 30 mg/L[B]	% Exceeding 30 mg/L	No. Exceeding 100 mg/L[C]	% Exceeding 100 mg/L
	305VIS	20	2/10/1998	5/25/2004	0.0	1.3	2.5	12.1	0	0%	0	0%
	LL_CHU	51	10/1/2002	12/17/2004	0.0	0.2	0.4	2.2	0	0%	0	0%
Little Llagas	LL_LLC	4	12/23/2002	5/11/2004	0.0	1.8	1.7	3.1	0	0%	0	0%
Pacheco Creek	**All sites**	489	1/19/1998	12/13/2011	0.0	0.6	1.1	18.9	0	0%	0	0%
	305CAW049	1	5/29/2003	5/29/2003	0.0	0.0	0.0	0.0	0	0%	0	0%
	305PAC	252	1/19/1998	12/13/2011	0.0	1.2	1.7	18.9	0	0%	0	0%
	305PACLOV	87	11/11/2003	3/13/2007	0.0	0.5	0.7	7.0	0	0%	0	0%
	305PACWAL	42	9/2/2003	10/24/2006	0.0	0.1	0.3	1.8	0	0%	0	0%
	PC_CDF	1	9/2/2003	9/2/2003	0.0	0.0	0.0	0.0	0	0%	0	0%
	PC_NFK	1	7/17/2006	7/17/2006	0.4	0.4	0.4	0.4	0	0%	0	0%
	PC_SFR	105	10/1/2002	8/29/2006	0.2	0.6	0.6	2.1	0	0%	0	0%
Pajaro River	**All sites**	2,371	1/19/1998	12/17/2013	0.0	6.4	7.2	34.1	5	<1%	0	0%
	305CHI	611	1/19/1998	12/10/2013	0.0	7.2	8.3	32.5	2	<1%	0	0%
	305MUR	337	2/10/1998	6/26/2013	0.1	7.3	8.0	18.8	0	0%	0	0%
	305PAJ	319	1/19/1998	12/13/2011	0.7	6.8	7.5	34.1	1	<1%	0	0%
	305PJE_L	12	1/6/2008	9/22/2009	0.0	0.7	1.8	10.9	0	0%	0	0%
	305PJE_U	12	1/6/2008	9/22/2009	0.2	1.4	2.1	6.4	0	0%	0	0%
	305PJP	395	10/4/2000	12/10/2013	0.0	6.0	6.2	14.6	0	0%	0	0%
	305PMO_SCC	4	12/11/2001	4/3/2003	0.0	1.6	2.3	5.8	0	0%	0	0%
	305PS0034	1	6/17/2008	6/17/2008	9.0	9.0	9.0	9.0	0	0%	0	0%
	305PS0057	1	6/16/2009	6/16/2009	7.8	7.8	7.8	7.8	0	0%	0	0%
	305THU	440	1/19/1998	12/17/2013	0.0	4.8	5.0	32.2	2	<1%	0	0%
	PA_13	1	7/12/2006	7/12/2006	11.9	11.9	11.9	11.9	0	0%	0	0%
	PA_14	1	7/12/2006	7/12/2006	11.9	11.9	11.9	11.9	0	0%	0	0%
	PA_15	1	7/12/2006	7/12/2006	12.0	12.0	12.0	12.0	0	0%	0	0%
	PA_16	1	7/12/2006	7/12/2006	11.9	11.9	11.9	11.9	0	0%	0	0%
	PA_18	1	7/12/2006	7/12/2006	11.9	11.9	11.9	11.9	0	0%	0	0%
	PA_19	1	7/13/2006	7/13/2006	15.6	15.6	15.6	15.6	0	0%	0	0%
	PA_21	1	7/13/2006	7/13/2006	15.4	15.4	15.4	15.4	0	0%	0	0%
	PA_22	1	7/13/2006	7/13/2006	15.5	15.5	15.5	15.5	0	0%	0	0%
	PA_23	1	7/13/2006	7/13/2006	15.4	15.4	15.4	15.4	0	0%	0	0%
	PA_24	1	7/13/2006	7/13/2006	15.0	15.0	15.0	15.0	0	0%	0	0%
	PA_26	1	7/13/2006	7/13/2006	13.5	13.5	13.5	13.5	0	0%	0	0%
	PA_27	1	7/13/2006	7/13/2006	17.2	17.2	17.2	17.2	0	0%	0	0%
	PA_29	1	7/13/2006	7/13/2006	21.1	21.1	21.1	21.1	0	0%	0	0%
	PA_30	1	7/13/2006	7/13/2006	15.3	15.3	15.3	15.3	0	0%	0	0%
	PA_31	1	7/13/2006	7/13/2006	16.7	16.7	16.7	16.7	0	0%	0	0%
	PA_FLR	17	12/23/2002	5/25/2004	0.2	4.5	4.2	11.0	0	0%	0	0%

Waterbody[A]	Monitoring Site ID	No. of Samples	Temporal Representation		Min	50% (Median)	Mean	Max	No. Exceeding 30 mg/L[B]	% Exceeding 30 mg/L	No. Exceeding 100 mg/L[C]	% Exceeding 100 mg/L
	PA_H25	87	7/8/2003	3/13/2007	0.8	8.4	8.7	20.6	0	0%	0	0%
	PA_UVAS	1	7/13/2006	7/13/2006	16.2	16.2	16.2	16.2	0	0%	0	0%
	PajPump	20	5/15/2009	12/7/2010	0.8	5.1	4.7	9.8	0	0%	0	0%
	PR1	99	12/12/2002	12/17/2013	0.0	7.5	9.6	25.0	0	0%	0	0%
Pescadero Creek	305PES	4	2/10/1998	2/19/1998	1.2	1.3	1.3	1.4	0	0%	0	0%
Salsipuedes Creek	**All sites**	363	1/19/1998	11/21/2013	0.0	1.9	3.5	63.4	2	<1%	0	0%
	305CAW057	1	6/24/2003	6/24/2003	6.7	6.7	6.7	6.7	0	0%	0	0%
	305COR	362	1/19/1998	11/21/2013	0.0	1.9	3.5	63.4	2	<1%	0	0%
San Benito River	**All sites**	451	1/19/1998	12/12/2011	0.0	0.2	1.3	42.6	1	<1%	0	0%
	305BRI	52	1/24/2005	12/12/2011	0.0	0.0	0.0	0.2	0	0%	0	0%
	305SAN	395	1/19/1998	12/12/2011	0.0	0.4	1.5	42.6	1	<1%	0	0%
	305SBH	2	1/24/2008	2/22/2008	0.2	0.3	0.3	0.4	0	0%	0	0%
	SB_BWC	1	6/19/2006	6/19/2006	0.0	0.0	0.0	0.0	0	0%	0	0%
	SB_PA	1	7/13/2006	7/13/2006	0.1	0.1	0.1	0.1	0	0%	0	0%
Tres Pinos Creek	**All sites**	51	2/19/1998	10/19/2011	0.0	0.1	0.4	1.9	0	0%	0	0%
	305TRE	50	2/19/1998	10/19/2011	0.0	0.1	0.4	1.9	0	0%	0	0%
	TP_H25	1	6/22/2006	6/22/2006	0.3	0.3	0.3	0.3	0	0%	0	0%
Uvas Creek	**All sites**	701	1/19/1998	12/13/2011	0.0	0.5	0.7	8.9	0	0%	0	0%
	305CAW161	1	5/19/2003	5/19/2003	1.6	1.6	1.6	1.6	0	0%	0	0%
	305UVA	193	1/19/1998	12/13/2011	0.0	1.0	1.1	8.9	0	0%	0	0%
	305UVCASC	1	6/29/2010	6/29/2010	0.0	0.0	0.0	0.0	0	0%	0	0%
	UV_152	223	10/1/2002	3/13/2007	0.1	0.6	0.6	5.9	0	0%	0	0%
	UV_THO	90	11/12/2002	3/13/2007	0.1	0.9	0.9	2.7	0	0%	0	0%
	UV_UCP	1	7/10/2006	7/10/2006	0.0	0.0	0.0	0.0	0	0%	0	0%
	UV_URA	77	1/7/2003	3/13/2007	0.0	0.1	0.3	2.6	0	0%	0	0%
	UV_URB	115	10/15/2002	3/13/2007	0.0	0.1	0.2	1.1	0	0%	0	0%

[A] The stream reaches in this table are designated for agricultural supply beneficial use (AGR) in Table 2-1 of the Basin Plan.

[B] 30 mg/L nitrate as N is the recommended uppermost threshold concentration for nitrate in irrigation supply water as identified by the Univ. of California Agricultural Extension Service which potentially cause severe problems for sensitive crops (see Table 3-3 in the Basin Plan). Conservatively selecting the uppermost threshold (30 mg/L) therefore conservatively identifies exceedances which could detrimentally impact the AGR beneficial uses for irrigation water.

[C] 100 mg/L nitrate as N is the Basin Plan’s water quality objective protective of livestock watering, and is based on National Academy of Sciences-National Academy of Engineering guidelines (see Table 3-3 in the Basin Plan).

Table 5-10. Pajaro River basin summary statistics for nitrate as N (mg/L) as compared to a biostimulatory numeric criteria.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds geometric mean of 1 mg/L? (Yes/No)
Beach Road	**All sites**	1,140	10/4/2000	12/17/2013	29.9	**Yes**

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds geometric mean of 1 mg/L? (Yes/No)
Ditch	BRD	103	12/10/2002	12/17/2013	28.8	**Yes**
	305-BEACH-21	181	10/4/2000	5/2/2009	30.4	**Yes**
	BR_WMI	164	10/4/2000	3/20/2007	15.5	**Yes**
	BR_WS3	177	10/25/2000	3/20/2007	48.9	**Yes**
	BR_WS1	29	1/16/2001	12/12/2006	15.5	**Yes**
	BR_WS2	162	11/22/2000	3/20/2007	45.6	**Yes**
	BR_FGB	165	10/4/2000	3/20/2007	17.1	**Yes**
	BR_DW2	49	2/13/2001	12/29/2002	71.2	**Yes**
	BR_PAN	54	1/30/2001	9/21/2004	42.6	**Yes**
	BR_THU	56	12/5/2000	9/21/2004	34.3	**Yes**
Bodfish Creek	305CAW097	1	5/27/2003	5/27/2003	0.1	No
Browns Creek	**All sites**	125	12/10/2002	12/17/2013	0.0	No
	BC	100	12/10/2002	12/17/2013	0.1	No
	305-BROWN-21	25	5/8/2004	11/20/2004	0.0	No
Carnadero Creek	**All sites**	157	1/25/2005	12/10/2013	3.3	**Yes**
	305CAN	101	1/24/2006	12/10/2013	2.5	**Yes**
	305CAR	56	1/25/2005	12/13/2011	5.4	**Yes**
Casserly Creek	**All sites**	163	12/10/2002	12/17/2013	1.0	**Yes**
	CA1	63	1/21/2003	4/1/2013	0.1	No
	CC_CAS	1	3/11/2003	3/11/2003	7.4	**Yes**
	CA2	98	12/10/2002	12/17/2013	3.8	**Yes**
	CS_MMR	1	8/17/2006	8/17/2006	0.3	No
Clear Creek	305CLCSBR	1	6/11/2008	6/11/2008	0.1	No
Corralitos Creek	**All sites**	961	7/11/2000	12/17/2013	0.2	No
	305COB_SCC	8	7/11/2000	5/8/2006	0.1	No
	305-CORRA-21	342	10/4/2000	5/21/2013	1.2	**Yes**
	305-CORRA-22	10	5/17/2003	5/1/2010	0.1	No
	305-CORRA-23	30	5/8/2004	11/20/2004	4.0	**Yes**
	305-CORRA-24	134	7/11/2000	12/17/2013	0.0	No
	305-SALSI-21	31	5/1/2004	11/20/2004	3.9	**Yes**
	CO_BVR	225	10/4/2000	12/17/2013	0.1	No
	CO_VAR	85	1/16/2001	4/1/2013	0.0	No
	CO3	96	12/12/2002	12/17/2013	0.7	No
Unnamed tributary to Corralitos Creek	UNT	93	12/12/2002	12/17/2013	6.7	**Yes**

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds geometric mean of 1 mg/L? (Yes/No)
Coward Creek	CW	9	4/3/2003	1/23/2012	11.6	**Yes**
Furlong Creek	**All sites**	159	3/11/2003	12/13/2011	28.7	**Yes**
	305FUF	54	1/25/2005	12/13/2011	30.9	**Yes**
	FC_FLR	105	3/11/2003	3/13/2007	27.6	**Yes**
Gallighan Slough	GS	76	12/12/2002	12/17/2013	3.3	**Yes**
Green Valley Creek	GV	99	12/10/2002	12/17/2013	2.8	**Yes**
Tributary to Green Valley Creek	GVT	99	12/10/2002	12/17/2013	14.5	**Yes**
Harkins Slough	**All sites**	300	12/12/2002	12/17/2013	0.1	No
	305HAR	168	12/12/2002	12/17/2013	0.0	No
	305HAR-BUE	3	5/17/2003	5/7/2005	0.1	No
	305-HARKI-22	4	5/17/2003	5/7/2005	0.8	No
	HS1	105	12/12/2002	12/17/2013	0.6	No
	HS3	20	1/16/2003	4/16/2012	0.2	No
Hughes Creek	HC	23	1/21/2003	1/31/2013	0.7	No
Laguna Creek	305LGCACR	1	7/16/2008	7/16/2008	0.0	No
Little Arthur Creek	305WE0883	1	6/28/2001	6/28/2001	0.2	No
Llagas Creek	**All sites**	1,290	1/19/1998	12/10/2013	1.5	**Yes**
	305CHE	109	2/10/1998	3/13/2007	0.1	No
	305HOL	33	2/10/1998	1/25/2008	4.7	**Yes**
	305LEA	58	12/15/2002	5/25/2011	0.9	No
	305LGCBRC	2	7/11/2006	6/30/2010	0.0	No
	305LHB	42	6/9/2004	3/26/2008	21.6	**Yes**
	305LLA	324	1/19/1998	12/13/2011	9.3	**Yes**
	305LUC	252	2/10/1998	12/10/2013	14.3	**Yes**
	305MON	252	2/10/1998	3/13/2007	0.2	No
	305OAK	146	2/10/1998	3/13/2007	0.1	No
	305PS0061	1	6/17/2009	6/17/2009	0.0	No
	305VIS	20	2/10/1998	5/25/2004	1.1	**Yes**
	LL_CHU	51	10/1/2002	12/17/2004	0.2	No
West Branch Llagas Creek	**All sites**	52	2/12/1998	7/18/2013	1.1	**Yes**
	LL_WDA	5	12/15/2002	3/15/2003	1.9	**Yes**
	LL_WHI	7	12/15/2002	5/2/2003	1.3	**Yes**
	SW1	17	5/14/1998	4/25/2013	0.6	No

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds geometric mean of 1 mg/L? (Yes/No)
	SW2	17	2/12/1998	7/18/2013	1.1	**Yes**
	SW3	6	12/16/2003	7/22/2005	2.2	**Yes**
West Branch Llagas Creek Tributary	SW4	3	10/19/2004	7/25/2005	0.4	No
Little Llagas	LL_LLC	4	12/23/2002	5/11/2004	0.5	No
Mattos Gulch	MG	1	4/20/2006	4/20/2006	0.2	No
McGowan Ditch	**All sites**	7	11/14/2006	9/22/2009	12.1	**Yes**
	305MDD	6	1/6/2008	9/22/2009	11.0	**Yes**
	MC_TRA	1	11/14/2006	11/14/2006	22.3	**Yes**
Miller’s Canal	**All sites**	401	2/10/1998	5/30/2013	0.1	No
	305FRA	391	2/10/1998	5/30/2013	0.1	No
	MC_10	1	7/12/2006	7/12/2006	0.2	No
	MC_11	1	7/12/2006	7/12/2006	0.2	No
	MC_12	1	7/12/2006	7/12/2006	0.2	No
	MC_2	1	7/12/2006	7/12/2006	0.0	No
	MC_3	1	7/12/2006	7/12/2006	0.0	No
	MC_4	1	7/12/2006	7/12/2006	0.0	No
	MC_5	1	7/12/2006	7/12/2006	0.1	No
	MC_6	1	7/12/2006	7/12/2006	0.1	No
	MC_7	1	7/12/2006	7/12/2006	0.1	No
	MC_9	1	7/12/2006	7/12/2006	0.1	No
Pacheco Creek	**All sites**	489	1/19/1998	12/13/2011	0.6	No
	305CAW049	1	5/29/2003	5/29/2003	0.0	No
	305PAC	252	1/19/1998	12/13/2011	1.0	**Yes**
	305PACLOV	87	11/11/2003	3/13/2007	0.5	No
	305PACWAL	42	9/2/2003	10/24/2006	0.1	No
	PC_CDF	1	9/2/2003	9/2/2003	0.0	No
	PC_NFK	1	7/17/2006	7/17/2006	0.4	No
	PC_SFR	105	10/1/2002	8/29/2006	0.5	No
Pajaro River	**All sites**	2,347	1/19/1998	12/17/2013	5.6	**Yes**
	305CHI	611	1/19/1998	12/10/2013	6.6	**Yes**
	305MUR	337	2/10/1998	6/26/2013	6.9	**Yes**
	305PAJ	319	1/19/1998	12/13/2011	6.4	**Yes**
	305PJP	395	10/4/2000	12/10/2013	5.3	**Yes**
	305PMO_SCC	4	12/11/2001	4/3/2003	0.1	No
	305PS0034	1	6/17/2008	6/17/2008	9.0	**Yes**
	305PS0057	1	6/16/2009	6/16/2009	7.8	**Yes**
	305THU	440	1/19/1998	12/17/2013	3.5	**Yes**

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds geometric mean of 1 mg/L? (Yes/No)
	PA_13	1	7/12/2006	7/12/2006	11.9	**Yes**
	PA_14	1	7/12/2006	7/12/2006	11.9	**Yes**
	PA_15	1	7/12/2006	7/12/2006	12.0	**Yes**
	PA_16	1	7/12/2006	7/12/2006	11.9	**Yes**
	PA_18	1	7/12/2006	7/12/2006	11.9	**Yes**
	PA_19	1	7/13/2006	7/13/2006	15.6	**Yes**
	PA_21	1	7/13/2006	7/13/2006	15.4	**Yes**
	PA_22	1	7/13/2006	7/13/2006	15.5	**Yes**
	PA_23	1	7/13/2006	7/13/2006	15.4	**Yes**
	PA_24	1	7/13/2006	7/13/2006	15.0	**Yes**
	PA_26	1	7/13/2006	7/13/2006	13.5	**Yes**
	PA_27	1	7/13/2006	7/13/2006	17.2	**Yes**
	PA_29	1	7/13/2006	7/13/2006	21.1	**Yes**
	PA_30	1	7/13/2006	7/13/2006	15.3	**Yes**
	PA_31	1	7/13/2006	7/13/2006	16.7	**Yes**
	PA_FLR	17	12/23/2002	5/25/2004	3.2	**Yes**
	PA_H25	87	7/8/2003	3/13/2007	7.4	**Yes**
	PA_UVAS	1	7/13/2006	7/13/2006	16.2	**Yes**
	PajPump	20	5/15/2009	12/7/2010	3.9	**Yes**
	PR1	99	12/12/2002	12/17/2013	7.4	**Yes**
Pajaro River Estuary	**All sites**	24	1/6/2008	9/22/2009	0.8	No
	305PJE_L	12	1/6/2008	9/22/2009	0.4	No
	305PJE_U	12	1/6/2008	9/22/2009	1.4	**Yes**
Pescadero Creek	305PES	4	2/10/1998	2/19/1998	1.3	**Yes**
Pinto Lake Outflow Ditch	PLO	92	12/12/2002	8/15/2013	6.3	**Yes**
Salsipuedes Creek	**All sites**	363	1/19/1998	11/21/2013	2.0	**Yes**
	305CAW057	1	6/24/2003	6/24/2003	6.7	**Yes**
	305COR	362	1/19/1998	11/21/2013	2.0	**Yes**
San Benito River	**All sites**	451	1/19/1998	12/12/2011	0.2	No
	305BRI	52	1/24/2005	12/12/2011	0.0	No
	305SAN	395	1/19/1998	12/12/2011	0.3	No
	305SBH	2	1/24/2008	2/22/2008	0.3	No
	SB_BWC	1	6/19/2006	6/19/2006	0.0	No
	SB_PA	1	7/13/2006	7/13/2006	0.1	No
San Juan Creek	**All sites**	419	11/6/2002	12/10/2013	26.2	**Yes**
	305MVR	9	1/24/2008	12/17/2008	61.2	**Yes**

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds geometric mean of 1 mg/L? (Yes/No)
	305PRR	9	1/24/2008	12/17/2008	48.3	**Yes**
	305SJN	345	7/22/2003	12/10/2012	24.9	**Yes**
	SJ_101	53	11/6/2002	9/29/2004	27.8	**Yes**
	SJ_156	2	8/4/2003	3/29/2005	32.2	**Yes**
	SJ_PA	1	7/13/2006	7/13/2006	27.0	**Yes**
West Branch San Juan Creek	305ACR	9	1/24/2008	12/17/2008	4.4	**Yes**
San Martin Creek	SM_FOO	1	2/25/2004	2/25/2004	1.2	**Yes**
Struve Slough	**All sites**	137	5/17/2003	12/12/2011	0.0	No
	305STR-HAR	5	5/17/2003	5/7/2005	0.1	No
	305STL	132	5/17/2003	12/12/2011	0.0	No
West Branch of Struve Slough	305-WSTRU-21	7	5/17/2003	8/30/2004	0.1	No
Swanson Creek	305SSCAUC	1	6/29/2010	6/29/2010	0.0	No
Tequisquita Slough	**All sites**	233	1/19/1998	12/10/2013	3.1	**Yes**
	TS_SFL	2	6/23/2006	7/12/2006	3.2	**Yes**
	305TES	231	1/19/1998	12/10/2013	0.0	No
Tres Pinos Creek	**All sites**	51	2/19/1998	10/19/2011	0.1	No
	305TRE	50	2/19/1998	10/19/2011	0.1	No
	TP_H25	1	6/22/2006	6/22/2006	0.3	No
Uvas Creek	**All sites**	701	1/19/1998	12/13/2011	0.4	No
	305CAW161	1	5/19/2003	5/19/2003	1.6	**Yes**
	305UVA	193	1/19/1998	12/13/2011	0.9	No
	305UVCASC	1	6/29/2010	6/29/2010	0.0	No
	UV_152	223	10/1/2002	3/13/2007	0.5	No
	UV_THO	90	11/12/2002	3/13/2007	0.8	No
	UV_UCP	1	7/10/2006	7/10/2006	0.0	No
	UV_URA	77	1/7/2003	3/13/2007	0.1	No
	UV_URB	115	10/15/2002	3/13/2007	0.1	No
Watsonville Slough	**All sites**	1184	2/12/1998	12/17/2013	2.5	**Yes**
	305WAT-AND	292	10/4/2000	12/17/2013	3.9	**Yes**
	305WAT-HAR	15	5/17/2003	5/7/2005	0.0	No
	305WAT-LEE	171	10/4/2000	3/20/2007	3.4	**Yes**
	305WAT-SHE	270	10/25/2000	12/17/2013	9.4	**Yes**
	305-WATSO-23	25	5/17/2003	9/22/2009	6.7	**Yes**
	305WSA	130	2/12/1998	7/18/2013	2.7	**Yes**
	WS_ERR	173	10/4/2000	3/20/2007	0.3	No
	WS1	108	12/12/2002	12/17/2013	0.6	No

Table 5-11. Pajaro River basin summary statistics for unionized ammonia as N (units = mg/L).

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	50% (median)	Arithmetic Mean	Max	No. Exceeding 0.025 mg/L (toxicity standard)	% Exceeding 0.025 mg/L
Carnadero Creek	**All sites**	63	1/25/2005	12/10/2013	0.000	0.001	0.004	0.015	0	0%
	305CAN	35	1/24/2006	12/10/2013	0.000	0.001	0.005	0.015	0	0%
	305CAR	28	1/25/2005	12/13/2011	0.000	0.001	0.002	0.015	0	0%
Corralitos Creek	CO_BVR	15	1/24/2005	4/20/2011	0.001	0.010	0.008	0.015	0	0%
Furlong Creek	305FUF	27	1/25/2005	12/13/2011	0.000	0.002	0.005	0.025	0	0%
Harkins Slough	305HAR	26	1/24/2005	12/12/2011	0.000	0.001	0.001	0.007	0	0%
Llagas Creek	**All sites**	153	1/19/1998	12/10/2013	0.000	0.000	0.004	0.108	2	1%
	305CHE	10	2/10/1998	12/2/1998	0.000	0.000	0.001	0.003	0	0%
	305HOL	8	2/10/1998	12/2/1998	0.000	0.001	0.001	0.004	0	0%
	305LEA	10	2/23/2005	5/25/2011	0.001	0.001	0.019	0.108	2	20%
	305LLA	48	1/19/1998	12/13/2011	0.000	0.000	0.001	0.015	0	0%
	305LUC	56	2/10/1998	12/10/2013	0.000	0.000	0.005	0.015	0	0%
	305MON	9	2/10/1998	12/2/1998	0.000	0.001	0.002	0.005	0	0%
	305OAK	9	2/10/1998	12/2/1998	0.001	0.004	0.004	0.008	0	0%
	305VIS	3	2/10/1998	6/12/1998	0.000	0.001	0.005	0.015	0	0%
West Branch Llagas Creek	**All sites**	32	2/12/1998	7/25/2005	0.015	0.015	0.015	0.015	0	0%
	SW1	13	5/14/1998	7/25/2005	0.015	0.015	0.015	0.015	0	0%
	SW2	13	2/12/1998	7/22/2005	0.015	0.015	0.015	0.015	0	0%
	SW3	6	12/16/2003	7/22/2005	0.015	0.015	0.015	0.015	0	0%
West Branch Llagas Creek Tributary	SW4	3	10/19/2004	7/25/2005	0.015	0.015	0.157	0.440	1	33%
McGowan Ditch	305MDD	9	1/6/2008	10/28/2009	0.000	0.015	0.014	0.043	1	11%
Miller's Canal	305FRA	78	2/10/1998	5/30/2013	0.000	0.004	0.012	0.330	5	6%
Pacheco Creek	305PAC	38	1/19/1998	12/13/2011	0.000	0.001	0.003	0.015	0	0%
Pajaro River	**All sites**	420	1/19/1998	12/10/2013	0.000	0.002	0.005	0.085	13	3%
	305CHI	96	1/19/1998	12/10/2013	0.000	0.001	0.004	0.016	0	0%
	305MUR	35	2/10/1998	12/12/2011	0.000	0.001	0.003	0.032	1	3%
	305PAJ	48	1/19/1998	12/13/2011	0.000	0.001	0.002	0.015	0	0%
	305PJE_L	16	1/6/2008	10/28/2009	0.000	0.015	0.022	0.085	4	25%
	305PJE_U	15	1/6/2008	10/28/2009	0.000	0.015	0.014	0.033	3	20%
	305PJP	80	12/11/2002	12/10/2013	0.000	0.001	0.005	0.075	1	1%
	305THU	130	1/19/1998	4/20/2011	0.000	0.002	0.005	0.054	4	3%
Salsipuedes Creek	305COR	69	1/19/1998	11/21/2013	0.000	0.002	0.006	0.117	3	4%
San Benito River	**All sites**	64	1/19/1998	12/12/2011	0.000	0.002	0.004	0.016	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	50% (median)	Arithmetic Mean	Max	No. Exceeding 0.025 mg/L (toxicity standard)	% Exceeding 0.025 mg/L
	305BRI	26	1/24/2005	12/12/2011	0.000	0.003	0.006	0.016	0	0%
	305SAN	38	1/19/1998	12/12/2011	0.000	0.001	0.003	0.015	0	0%
San Juan Creek	305SJN	74	1/25/2005	12/10/2013	0.000	0.002	0.009	0.120	4	5%
Struve Slough	305STL	48	1/24/2005	12/12/2011	0.000	0.000	0.001	0.013	0	0%
Tequisquita Slough	305TES	58	1/19/1998	12/10/2013	0.000	0.005	0.008	0.072	1	2%
Tres Pinos Creek	305TRE	20	2/19/1998	4/20/2011	0.000	0.007	0.008	0.023	0	0%
Uvas Creek	305UVA	20	1/19/1998	4/21/2011	0.000	0.001	0.003	0.015	0	0%
Watsonville Slough	**All sites**	61	1/24/2005	4/30/2013	0.000	0.001	0.003	0.030	1	2%
	305-WATSO-23	9	1/6/2008	10/28/2009	0.000	0.005	0.010	0.030	1	11%
	305WSA	52	1/24/2005	4/30/2013	0.000	0.001	0.002	0.015	0	0%

Table 5-12. Pajaro River basin summary statistics for orthophosphate as P (units = mg/L).

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.3 mg/L^{A}	% Exceeding 0.3 mg/L
Beach Road Ditch	**All sites**	1,117	10/4/2000	12/17/2013	0.249	0.003	0.055	0.116	0.253	4.953	234	21%
	305-BEACH-21	169	10/4/2000	3/20/2007	0.204	0.005	0.050	0.109	0.229	1.525	29	17%
	BR_DW2	49	2/13/2001	12/29/2002	0.099	0.003	0.031	0.081	0.140	0.430	2	4%
	BR_FGB	165	10/4/2000	3/20/2007	0.279	0.015	0.110	0.198	0.396	1.440	56	34%
	BR_PAN	56	1/30/2001	9/21/2004	0.345	0.014	0.061	0.156	0.298	1.878	14	25%
	BR_THU	57	12/5/2000	9/21/2004	0.520	0.004	0.069	0.328	0.847	2.267	29	51%
	BR_WMI	165	10/4/2000	3/20/2007	0.271	0.021	0.068	0.093	0.172	4.953	20	12%
	BR_WS1	29	1/16/2001	12/12/2006	0.500	0.004	0.204	0.320	0.584	2.044	16	55%
	BR_WS2	162	11/22/2000	3/20/2007	0.247	0.008	0.076	0.125	0.218	1.976	29	18%
	BR_WS3	177	10/25/2000	3/20/2007	0.221	0.004	0.046	0.097	0.208	1.886	30	17%
	BRD	88	12/10/2002	12/17/2013	0.069	0.005	0.005	0.005	0.005	0.670	9	10%
Browns Creek	BC	85	12/10/2002	12/17/2013	0.028	0.005	0.005	0.005	0.005	0.470	1	1%
Carnadero Creek	**All sites**	128	1/25/2005	12/10/2013	0.059	0.001	0.014	0.036	0.072	0.455	5	4%
	305CAN	100	1/24/2006	12/10/2013	0.058	0.001	0.005	0.028	0.070	0.455	5	5%
	305CAR	28	1/25/2005	12/13/2011	0.060	0.016	0.036	0.046	0.085	0.170	0	0%
Casserly Creek	**All sites**	143	12/10/2002	12/17/2013	0.093	0.005	0.005	0.005	0.120	1.890	8	6%
	CA1	58	1/21/2003	4/1/2013	0.072	0.005	0.005	0.005	0.070	1.890	1	2%
	CA2	83	12/10/2002	12/17/2013	0.106	0.005	0.005	0.005	0.160	0.890	7	8%
	CC_CAS	1	3/11/2003	3/11/2003	0.146	0.146	0.146	0.146	0.146	0.146	0	0%
	CS_MMR	1	8/17/2006	8/17/2006	0.130	0.130	0.130	0.130	0.130	0.130	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.3 mg/L[A]	% Exceeding 0.3 mg/L
Clear Creek	305CLCSBR	1	6/11/2008	6/11/2008	0.004	0.004	0.004	0.004	0.004	0.004	0	0%
Corralitos Creek	**All sites**	758	10/4/2000	12/17/2013	0.073	0.005	0.005	0.054	0.096	1.459	21	3%
	305-CORRA-21	314	10/4/2000	5/21/2013	0.103	0.005	0.032	0.079	0.117	1.459	14	4%
	305-CORRA-22	6	5/17/2003	5/1/2010	0.353	0.018	0.095	0.227	0.587	0.888	3	50%
	305-CORRA-24	86	12/10/2002	12/17/2013	0.015	0.005	0.005	0.005	0.005	0.150	0	0%
	305-SALSI-21	1	5/1/2004	5/1/2004	0.136	0.136	0.136	0.136	0.136	0.136	0	0%
	CO_BVR	188	10/4/2000	12/17/2013	0.075	0.005	0.005	0.068	0.102	0.511	2	1%
	CO_VAR	80	1/16/2001	4/1/2013	0.055	0.005	0.005	0.042	0.081	0.508	1	1%
	CO3	83	12/12/2002	12/17/2013	0.014	0.005	0.005	0.005	0.005	0.670	1	1%
Unnamed tributary to Corralitos Creek	UNT	78	12/12/2002	12/17/2013	0.198	0.005	0.005	0.005	0.328	1.650	21	27%
Coward Creek	CW	9	4/3/2003	1/23/2012	0.509	0.080	0.100	0.570	0.740	1.200	6	67%
Furlong Creek	**All sites**	132	3/11/2003	12/13/2011	0.283	0.005	0.086	0.141	0.260	6.600	27	20%
	305FUF	27	1/25/2005	12/13/2011	0.478	0.005	0.054	0.098	0.380	6.600	7	26%
	FC_FLR	105	3/11/2003	3/13/2007	0.233	0.008	0.089	0.151	0.257	1.578	20	19%
Galligan Slough	GS	67	12/12/2002	12/17/2013	0.033	0.005	0.005	0.005	0.005	0.700	3	4%
Green Valley Creek	GV	84	12/10/2002	12/17/2013	0.159	0.005	0.005	0.005	0.128	4.120	14	17%
Green Valley Creek Tributary	GVT	84	12/10/2002	12/17/2013	1.880	0.005	0.138	0.470	1.940	19.600	54	64%
Harkins Slough	**All sites**	229	12/12/2002	12/17/2013	0.145	0.005	0.005	0.005	0.180	1.840		18%
	305HAR	114	12/12/2002	12/17/2013	0.069	0.005	0.005	0.005	0.025	0.980	9	8%
	305HAR-BUE	3	5/17/2003	5/7/2005	0.043	0.018	0.018	0.018	0.055	0.092	0	0%
	305-HARKI-22	3	5/17/2003	5/7/2005	0.412	0.160	0.271	0.381	0.538	0.695	2	67%
	HS1	89	12/12/2002	12/17/2013	0.221	0.005	0.005	0.005	0.340	1.840	25	28%
	HS3	20	1/16/2003	4/16/2012	0.212	0.005	0.005	0.140	0.298	1.090	5	25%
Hughes Creek	HC	20	1/21/2003	1/31/2013	0.031	0.005	0.005	0.005	0.038	0.130	0	0%
Laguna Creek	305LGCACR	1	7/16/2008	7/16/2008	0.055	0.055	0.055	0.055	0.055	0.055	0	0%
Llagas Creek	**All sites**	1,162	1/19/1998	12/10/2013	0.071	0.000	0.023	0.042	0.076	0.958	44	4%
	305CHE	98	2/10/1998	3/13/2007	0.043	0.002	0.015	0.024	0.037	0.424	2	2%
	305HOL	17	2/10/1998	1/25/2008	0.039	0.002	0.005	0.010	0.027	0.336	1	6%
	305LEA	48	12/15/2002	5/25/2011	0.062	0.001	0.020	0.039	0.082	0.220	0	0%
	305LGCBRC	2	7/11/2006	6/30/2010	0.014	0.009	0.012	0.014	0.017	0.019	0	0%
	305LHB	41	6/9/2004	3/26/2008	0.051	0.008	0.018	0.035	0.057	0.378	1	2%
	305LLA	275	1/19/1998	12/13/2011	0.102	0.003	0.032	0.056	0.105	0.958	23	8%
	305LUC	240	2/10/1998	12/10/2013	0.082	0.001	0.031	0.056	0.088	0.456	8	3%
	305MON	238	2/10/1998	3/13/2007	0.057	0.002	0.024	0.038	0.059	0.598	5	2%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.3 mg/L[A]	% Exceeding 0.3 mg/L
	305OAK	134	2/10/1998	3/13/2007	0.064	0.001	0.022	0.042	0.070	0.812	3	2%
	305PS0061	1	6/17/2009	6/17/2009	0.026	0.026	0.026	0.026	0.026	0.026	0	0%
	305VIS	17	2/10/1998	6/9/2004	0.036	0.000	0.009	0.017	0.042	0.209	0	0%
	LL_CHU	51	10/1/2002	12/17/2004	0.052	0.008	0.022	0.034	0.049	0.356	1	2%
West Branch Llagas Creek	**All sites**	12	12/15/2002	5/2/2003	0.716	0.204	0.459	0.628	0.838	1.661	11	92%
	LL_WDA	5	12/15/2002	3/15/2003	0.694	0.472	0.608	0.648	0.805	0.936	5	100%
	LL_WHI	7	12/15/2002	5/2/2003	0.731	0.204	0.417	0.494	0.963	1.661	6	86%
Little Llagas	LL_LLC	4	12/23/2002	5/11/2004	0.143	0.019	0.034	0.137	0.245	0.279	0	0%
Mattos Gulch	MG	1	4/20/2006	4/20/2006	0.005	0.005	0.005	0.005	0.005	0.005	0	0%
McGowan Ditch	MC_TRA	1	11/14/2006	11/14/2006	0.130	0.130	0.130	0.130	0.130	0.130	0	0%
Millers Canal	**All sites**	362	2/10/1998	5/30/2013	0.139	0.000	0.033	0.067	0.161	6.140	24	7%
	305FRA	352	2/10/1998	5/30/2013	0.140	0.000	0.033	0.064	0.162	6.140	24	7%
	MC_10	1	7/12/2006	7/12/2006	0.153	0.153	0.153	0.153	0.153	0.153	0	0%
	MC_11	1	7/12/2006	7/12/2006	0.147	0.147	0.147	0.147	0.147	0.147	0	0%
	MC_12	1	7/12/2006	7/12/2006	0.132	0.132	0.132	0.132	0.132	0.132	0	0%
	MC_2	1	7/12/2006	7/12/2006	0.053	0.053	0.053	0.053	0.053	0.053	0	0%
	MC_3	1	7/12/2006	7/12/2006	0.030	0.030	0.030	0.030	0.030	0.030	0	0%
	MC_4	1	7/12/2006	7/12/2006	0.096	0.096	0.096	0.096	0.096	0.096	0	0%
	MC_5	1	7/12/2006	7/12/2006	0.142	0.142	0.142	0.142	0.142	0.142	0	0%
	MC_6	1	7/12/2006	7/12/2006	0.115	0.115	0.115	0.115	0.115	0.115	0	0%
	MC_7	1	7/12/2006	7/12/2006	0.129	0.129	0.129	0.129	0.129	0.129	0	0%
	MC_9	1	7/12/2006	7/12/2006	0.142	0.142	0.142	0.142	0.142	0.142	0	0%
Pacheco Creek	**All sites**	467	1/19/1998	12/13/2011	0.061	0.002	0.018	0.029	0.056	1.288	16	3%
	305PAC	214	1/19/1998	12/13/2011	0.084	0.002	0.020	0.038	0.066	1.288	14	7%
	305PACLOV	86	11/11/2003	3/13/2007	0.036	0.005	0.018	0.026	0.034	0.343	1	1%
	305PACWAL	41	9/2/2003	10/24/2006	0.026	0.003	0.012	0.015	0.026	0.169	0	0%
	Pach_conf	19	5/31/2005	11/3/2006	0.087	0.033	0.065	0.065	0.098	0.196	0	0%
	PC_CDF	1	9/2/2003	9/2/2003	0.012	0.012	0.012	0.012	0.012	0.012	0	0%
	PC_NFK	1	7/17/2006	7/17/2006	0.103	0.103	0.103	0.103	0.103	0.103	0	0%
	PC_SFR	105	10/1/2002	8/29/2006	0.044	0.003	0.019	0.026	0.039	0.554	1	1%
Pajaro River	**All sites**	1,979	1/19/1998	12/17/2013	0.110	0.001	0.048	0.090	0.140	1.336	91	5%
	305CHI	559	1/19/1998	12/10/2013	0.138	0.010	0.070	0.110	0.182	0.900	39	7%
	305MUR	291	2/10/1998	6/26/2013	0.087	0.003	0.030	0.073	0.109	1.270	8	3%
	305PAJ	273	1/19/1998	12/13/2011	0.111	0.003	0.055	0.088	0.145	0.459	8	3%
	305PJP	360	10/4/2000	12/10/2013	0.126	0.004	0.074	0.105	0.144	0.874	18	5%
	305PS0034	1	6/17/2008	6/17/2008	0.105	0.105	0.105	0.105	0.105	0.105	0	0%
	305PS0057	1	6/16/2009	6/16/2009	0.155	0.155	0.155	0.155	0.155	0.155	0	0%
	305THU	271	1/19/1998	12/17/2013	0.071	0.001	0.005	0.040	0.100	0.780	8	3%
	PA_13	1	7/12/2006	7/12/2006	0.113	0.113	0.113	0.113	0.113	0.113	0	0%
	PA_14	1	7/12/2006	7/12/2006	0.075	0.075	0.075	0.075	0.075	0.075	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.3 mg/L^{A}	% Exceeding 0.3 mg/L
	PA_15	1	7/12/2006	7/12/2006	0.068	0.068	0.068	0.068	0.068	0.068	0	0%
	PA_16	1	7/12/2006	7/12/2006	0.068	0.068	0.068	0.068	0.068	0.068	0	0%
	PA_18	1	7/12/2006	7/12/2006	0.058	0.058	0.058	0.058	0.058	0.058	0	0%
	PA_19	1	7/13/2006	7/13/2006	0.090	0.090	0.090	0.090	0.090	0.090	0	0%
	PA_21	1	7/13/2006	7/13/2006	0.067	0.067	0.067	0.067	0.067	0.067	0	0%
	PA_22	1	7/13/2006	7/13/2006	0.067	0.067	0.067	0.067	0.067	0.067	0	0%
	PA_23	1	7/13/2006	7/13/2006	0.089	0.089	0.089	0.089	0.089	0.089	0	0%
	PA_24	1	7/13/2006	7/13/2006	0.091	0.091	0.091	0.091	0.091	0.091	0	0%
	PA_26	1	7/13/2006	7/13/2006	0.089	0.089	0.089	0.089	0.089	0.089	0	0%
	PA_27	1	7/13/2006	7/13/2006	0.104	0.104	0.104	0.104	0.104	0.104	0	0%
	PA_29	1	7/13/2006	7/13/2006	0.147	0.147	0.147	0.147	0.147	0.147	0	0%
	PA_30	1	7/13/2006	7/13/2006	0.123	0.123	0.123	0.123	0.123	0.123	0	0%
	PA_31	1	7/13/2006	7/13/2006	0.130	0.130	0.130	0.130	0.130	0.130	0	0%
	PA_FLR	17	12/23/2002	5/25/2004	0.325	0.083	0.126	0.176	0.314	1.336	5	29%
	PA_H25	86	7/8/2003	3/13/2007	0.109	0.010	0.051	0.073	0.138	0.686	3	3%
	PA_UVAS	1	7/13/2006	7/13/2006	0.092	0.092	0.092	0.092	0.092	0.092	0	0%
	PajPump	20	5/15/2009	12/7/2010	0.062	0.005	0.016	0.060	0.093	0.170	0	0%
	PR1	84	12/12/2002	12/17/2013	0.032	0.005	0.005	0.005	0.005	0.320	2	2%
Pescadero Creek	305PES	2	2/10/1998	2/19/1998	0.071	0.030	0.051	0.071	0.092	0.112	0	0%
Pinto Lake Outflow Ditch	PLO	81	12/12/2002	8/15/2013	0.046	0.005	0.005	0.005	0.005	1.160	2	2%
Salsipuedes Creek	305COR	326	12/18/1997	11/21/2013	0.152	0.006	0.092	0.130	0.186	0.887	17	5%
San Benito River	**All sites**	386	1/19/1998	12/12/2011	0.039	0.000	0.011	0.022	0.046	0.454	3	1%
	305BRI	26	1/24/2005	12/12/2011	0.008	0.002	0.005	0.005	0.011	0.028	0	0%
	305SAN	355	1/19/1998	12/12/2011	0.042	0.000	0.012	0.023	0.049	0.454	3	1%
	305SBH	3	1/24/2008	2/22/2008	0.029	0.024	0.026	0.028	0.032	0.036	0	0%
	SB_BWC	1	6/19/2006	6/19/2006	0.085	0.085	0.085	0.085	0.085	0.085	0	0%
	SB_PA	1	7/13/2006	7/13/2006	0.022	0.022	0.022	0.022	0.022	0.022	0	0%
San Juan Creek	**All sites**	392	11/6/2002	12/10/2013	0.359	0.001	0.169	0.289	0.440	1.685	181	46%
	305MVR	9	1/24/2008	12/17/2008	0.093	0.022	0.041	0.067	0.143	0.196	0	0%
	305PRR	9	1/24/2008	12/17/2008	0.048	0.031	0.039	0.047	0.054	0.078	0	0%
	305SJN	318	1/29/2013	12/10/2013	0.370	0.001	0.175	0.290	0.450	1.685	149	47%
	SJ_101	53	11/6/2002	9/29/2004	0.399	0.104	0.238	0.318	0.462	1.455	31	58%
	SJ_156	2	8/4/2003	3/29/2005	0.182	0.078	0.130	0.182	0.234	0.286	0	0%
	SJ_PA	1	7/13/2006	7/13/2006	0.385	0.385	0.385	0.385	0.385	0.385	1	100%
West Branch of San Juan Creek	305ACR	9	1/24/2008	12/17/2008	1.049	0.384	0.493	0.706	1.215	2.545	9	100%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceeding 0.3 mg/L[A]	% Exceeding 0.3 mg/L
San Martin Creek	SM_FOO	1	2/25/2004	2/25/2004	0.630	0.630	0.630	0.630	0.630	0.630	1	100%
Struve Slough	**All sites**	107	5/17/2003	12/12/2011	0.581	0.018	0.347	0.551	0.724	2.275	84	79%
	305STL	104	5/17/2003	12/12/2011	0.592	0.029	0.350	0.565	0.740	2.275	83	80%
	305STR-HAR	3	5/17/2003	5/7/2005	0.193	0.018	0.074	0.130	0.280	0.430	1	33%
West Branch of Struve Slough	305-WSTRU-21	3	5/17/2003	5/7/2005	0.085	0.018	0.018	0.018	0.119	0.220	0	0%
Swanson Canyon Creek	305SSCAUC	1	6/29/2010	6/29/2010	0.015	0.015	0.015	0.015	0.015	0.015	0	0%
Tequisquita Slough	**All sites**	244	1/19/1998	12/10/2013	0.282	0.001	0.154	0.216	0.326	2.635	70	29%
	305TES	223	1/19/1998	12/10/2013	0.265	0.001	0.148	0.206	0.307	2.635	57	26%
	Teq_conf	19	6/17/2005	11/3/2006	0.449	0.130	0.245	0.326	0.652	0.978	11	58%
	TS_SFL	2	6/23/2006	7/12/2006	0.615	0.577	0.596	0.615	0.634	0.653	2	100%
Tres Pinos Creek	**All sites**	26	2/19/1998	10/19/2011	0.040	0.001	0.005	0.009	0.072	0.178	0	
	305TRE	25	2/19/1998	10/19/2011	0.037	0.001	0.005	0.007	0.059	0.178	0	0%
	TP_H25	1	6/22/2006	6/22/2006	0.106	0.106	0.106	0.106	0.106	0.106	0	0%
Uvas Creek	**All sites**	673	1/19/1998	12/13/2011	0.049	0.001	0.017	0.030	0.049	0.456	13	
	305UVA	169	1/19/1998	12/13/2011	0.058	0.002	0.018	0.035	0.073	0.456	3	2%
	305UVCASC	1	6/29/2010	6/29/2010	0.013	0.013	0.013	0.013	0.013	0.013	0	0%
	UV_152	221	10/1/2002	3/13/2007	0.048	0.001	0.019	0.030	0.048	0.439	4	2%
	UV_THO	89	11/12/2002	3/13/2007	0.046	0.003	0.016	0.029	0.043	0.448	2	2%
	UV_UCP	1	7/10/2006	7/10/2006	0.006	0.006	0.006	0.006	0.006	0.006	0	0%
	UV_URA	77	1/7/2003	3/13/2007	0.052	0.003	0.017	0.030	0.051	0.448	3	4%
	UV_URB	115	10/15/2002	3/13/2007	0.039	0.001	0.016	0.028	0.041	0.319	1	1%
Watsonville Slough	**All sites**	1,083	8/26/1998	12/17/2013	0.346	0.005	0.142	0.255	0.472	6.390	477	44%
	305WAT-AND	279	10/4/2000	12/17/2013	0.335	0.005	0.162	0.263	0.475	2.100	126	45%
	305WAT-HAR	3	5/17/2003	5/7/2005	0.219	0.018	0.159	0.300	0.320	0.340	2	67%
	305WAT-LEE	171	10/4/2000	3/20/2007	0.304	0.012	0.135	0.215	0.348	3.902	54	32%
	305WAT-SHE	255	10/25/2000	12/17/2013	0.261	0.005	0.104	0.199	0.409	1.028	89	35%
	305-WATSO-23	3	5/17/2003	5/7/2005	0.466	0.018	0.209	0.399	0.690	0.980	2	67%
	305WSA	106	8/26/1998	4/30/2013	0.508	0.033	0.280	0.449	0.629	2.400	76	72%
	WS_ERR	173	10/4/2000	3/20/2007	0.298	0.006	0.125	0.238	0.417	1.334	71	41%
	WS1	93	12/12/2002	12/17/2013	0.597	0.005	0.150	0.360	0.710	6.390	57	61%

A 0.3 mg/L is not a California regulatory Standard, it is a State of Nevada phosphate criteria for Class B and most Class A streams. It is used in this table as a numeric guideline indicating sites which may have elevated orthophosphate concentrations.

Table 5-13.Pajaro River basin summary statistics for orthophosphate as P (mg/L) as compared to 0.14 mg/L.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation	Geometric Mean	Exceeds 0.14 mg/L?[A]

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds 0.14 mg/L?[A]
Beach Road Ditch	**All sites**	1,117	10/4/2000	12/17/2013	0.11	No
	305-BEACH-21	169	10/4/2000	3/20/2007	0.11	No
	BR_DW2	49	2/13/2001	12/29/2002	0.06	No
	BR_FGB	165	10/4/2000	3/20/2007	0.19	**Yes**
	BR_PAN	56	1/30/2001	9/21/2004	0.17	**Yes**
	BR_THU	57	12/5/2000	9/21/2004	0.22	**Yes**
	BR_WMI	165	10/4/2000	3/20/2007	0.12	No
	BR_WS1	29	1/16/2001	12/12/2006	0.32	**Yes**
	BR_WS2	162	11/22/2000	3/20/2007	0.14	No
	BR_WS3	177	10/25/2000	3/20/2007	0.11	No
	BRD	88	12/10/2002	12/17/2013	0.01	No
Browns Creek	BC	85	12/10/2002	12/17/2013	0.01	No
Casserly Creek	**All sites**	143	12/10/2002	12/17/2013	0.02	No
	CA1	58	1/21/2003	4/1/2013	0.01	No
	CA2	83	12/10/2002	12/17/2013	0.02	No
	CC_CAS	1	3/11/2003	3/11/2003	0.15	**Yes**
	CS_MMR	1	8/17/2006	8/17/2006	0.13	No
Corralitos Creek	**All sites**	758	10/4/2000	12/17/2013	0.03	No
	305-CORRA-21	314	10/4/2000	5/21/2013	0.05	No
	305-CORRA-22	6	5/17/2003	5/1/2010	0.18	**Yes**
	305-CORRA-24	86	12/10/2002	12/17/2013	0.01	No
	305-SALSI-21	1	5/1/2004	5/1/2004	0.14	No
	CO_BVR	188	10/4/2000	12/17/2013	0.04	No
	CO_VAR	80	1/16/2001	4/1/2013	0.02	No
	CO3	83	12/12/2002	12/17/2013	0.01	No
Unnamed tributary to Corralitos Creek	UNT	78	12/12/2002	12/17/2013	0.03	No
Coward Creek	CW	9	4/3/2003	1/23/2012	0.34	**Yes**
Gallighan Slough	GS	67	12/12/2002	12/17/2013	0.01	No
Green Valley Creek	GV	84	12/10/2002	12/17/2013	0.02	No
Green Valley Creek Tributary	GVT	84	12/10/2002	12/17/2013	0.34	**Yes**
Harkins Slough	**All sites**	229	12/12/2002	12/17/2013	0.02	No
	305HAR	114	12/12/2002	12/17/2013	0.01	No
	305HAR-BUE	3	5/17/2003	5/7/2005	0.03	No

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds 0.14 mg/L?^{A}
	305-HARKI-22	3	5/17/2003	5/7/2005	0.35	**Yes**
	HS1	89	12/12/2002	12/17/2013	0.04	No
	HS3	20	1/16/2003	4/16/2012	0.06	No
Hughes Creek	HC	20	1/21/2003	1/31/2013	0.01	No
Mattos Gulch	MG	1	4/20/2006	4/20/2006	0.01	No
Pajaro River	**All sites**	1,691	1/19/1998	12/17/2013	0.06	No
	305CHI	559	1/19/1998	12/10/2013	0.11	No
	305MUR	291	2/10/1998	6/26/2013	0.05	No
	305PJP	360	10/4/2000	12/10/2013	0.10	No
	305PS0034	1	6/17/2008	6/17/2008	0.11	No
	305THU	271	1/19/1998	12/17/2013	0.03	No
	PA_30	1	7/13/2006	7/13/2006	0.12	No
	PA_31	1	7/13/2006	7/13/2006	0.13	No
	PA_FLR	17	12/23/2002	5/25/2004	0.08	No
	PA_H25	86	7/8/2003	3/13/2007	0.04	No
	PajPump	20	5/15/2009	12/7/2010	0.01	No
	PR1	84	12/12/2002	12/17/2013	0.11	No
Pescadero Creek	305PES	2	2/10/1998	2/19/1998	0.06	No
Pinto Lake Outflow Ditch	PLO	81	12/12/2002	8/15/2013	0.01	No
Salsipuedes Creek	305COR	326	12/18/1997	11/21/2013	0.13	No
Struve Slough	**All sites**	107	5/17/2003	12/12/2011	0.43	**Yes**
	305STL	104	5/17/2003	12/12/2011	0.45	**Yes**
	305STR-HAR	3	5/17/2003	5/7/2005	0.10	No
West Branch of Struve Slough	305-WSTRU-21	3	5/17/2003	5/7/2005	0.04	No
Watsonville Slough	**All sites**	1,083	8/26/1998	12/17/2013	0.20	**Yes**
	305WAT-AND	279	10/4/2000	12/17/2013	0.21	**Yes**
	305WAT-HAR	3	5/17/2003	5/7/2005	0.12	No
	305WAT-LEE	171	10/4/2000	3/20/2007	0.22	**Yes**
	305WAT-SHE	255	10/25/2000	12/17/2013	0.12	No
	305-WATSO-23	3	5/17/2003	5/7/2005	0.19	**Yes**
	305WSA	106	8/26/1998	4/30/2013	0.41	**Yes**
	WS_ERR	173	10/4/2000	3/20/2007	0.21	**Yes**
	WS1	93	12/12/2002	12/17/2013	0.21	**Yes**

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds 0.14 mg/L?[A]

A - Streams located in the Monterey Bay Plains & Terraces and Santa Cruz Mountains Level IV ecoregions were evaluated using the criteria of 0.14 mg/L. Orthophosphate as P exceeding 0.14 mg/L is evidence of phosphorus enrichment. This value is equal to the 75th percentile of orthophosphate results from sampled stream reference background sites in these two Level IV ecoregions. Please see Table 5-20 for more information.

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds 0.02 mg/L?[A]
Carnadero Creek	**All sites**	128	1/25/2005	12/10/2013	0.03	**Yes**
	305CAN	100	1/24/2006	12/10/2013	0.02	No
	305CAR	28	1/25/2005	12/13/2011	0.05	**Yes**
Clear Creek	305CLCSBR	1	6/11/2008	6/11/2008	0.00	No
Furlong Creek	**All sites**	132	3/11/2003	12/13/2011	0.16	**Yes**
	305FUF	27	1/25/2005	12/13/2011	0.15	**Yes**
	FC_FLR	105	3/11/2003	3/13/2007	0.16	**Yes**
Laguna Creek	305LGCACR	1	7/16/2008	7/16/2008	0.06	**Yes**
Llagas Creek	**All sites**	1,162	1/19/1998	12/10/2013	0.04	**Yes**
	305CHE	98	2/10/1998	3/13/2007	0.02	No
	305HOL	17	2/10/1998	1/25/2008	0.01	No
	305LEA	48	12/15/2002	5/25/2011	0.04	**Yes**
	305LGCBRC	2	7/11/2006	6/30/2010	0.01	No
	305LHB	41	6/9/2004	3/26/2008	0.03	**Yes**
	305LLA	275	1/19/1998	12/13/2011	0.06	**Yes**
	305LUC	240	2/10/1998	12/10/2013	0.05	**Yes**
	305MON	238	2/10/1998	3/13/2007	0.04	**Yes**
	305OAK	134	2/10/1998	3/13/2007	0.04	**Yes**
	305PS0061	1	6/17/2009	6/17/2009	0.03	**Yes**
	305VIS	17	2/10/1998	6/9/2004	0.02	No
	LL_CHU	51	10/1/2002	12/17/2004	0.04	**Yes**
West Branch Llagas Creek	**All sites**	12	12/15/2002	5/2/2003	0.62	**Yes**
	LL_WDA	5	12/15/2002	3/15/2003	0.68	**Yes**
	LL_WHI	7	12/15/2002	5/2/2003	0.59	**Yes**
Little Llagas	LL_LLC	4	12/23/2002	5/11/2004	0.08	**Yes**
Millers Canal	**All sites**	362	2/10/1998	5/30/2013	0.07	**Yes**
	305FRA	352	2/10/1998	5/30/2013	0.07	**Yes**
	MC_10	1	7/12/2006	7/12/2006	0.15	**Yes**
	MC_11	1	7/12/2006	7/12/2006	0.15	**Yes**
	MC_12	1	7/12/2006	7/12/2006	0.13	**Yes**
	MC_2	1	7/12/2006	7/12/2006	0.05	**Yes**
	MC_3	1	7/12/2006	7/12/2006	0.03	**Yes**

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds 0.02 mg/L?[A]
	MC_4	1	7/12/2006	7/12/2006	0.10	No
	MC_5	1	7/12/2006	7/12/2006	0.14	**Yes**
	MC_6	1	7/12/2006	7/12/2006	0.12	**Yes**
	MC_7	1	7/12/2006	7/12/2006	0.13	**Yes**
	MC_9	1	7/12/2006	7/12/2006	0.14	**Yes**
Pacheco Creek	**All sites**	467	1/19/1998	12/13/2011	0.03	**Yes**
	305PAC	214	1/19/1998	12/13/2011	0.04	**Yes**
	305PACLOV	86	11/11/2003	3/13/2007	0.03	**Yes**
	305PACWAL	41	9/2/2003	10/24/2006	0.02	No
	Pach_conf	19	5/31/2005	11/3/2006	0.08	**Yes**
	PC_CDF	1	9/2/2003	9/2/2003	0.01	No
	PC_NFK	1	7/17/2006	7/17/2006	0.10	**Yes**
	PC_SFR	105	10/1/2002	8/29/2006	0.03	**Yes**
Pajaro River	**All sites**	391	1/19/1998	12/17/2013	0.09	**Yes**
	305PAJ	273	1/19/1998	12/13/2011	0.09	**Yes**
	305PS0057	1	6/16/2009	6/16/2009	0.16	**Yes**
	PA_13	1	7/12/2006	7/12/2006	0.11	**Yes**
	PA_14	1	7/12/2006	7/12/2006	0.07	**Yes**
	PA_15	1	7/12/2006	7/12/2006	0.07	**Yes**
	PA_16	1	7/12/2006	7/12/2006	0.07	**Yes**
	PA_18	1	7/12/2006	7/12/2006	0.06	**Yes**
	PA_19	1	7/13/2006	7/13/2006	0.09	**Yes**
	PA_21	1	7/13/2006	7/13/2006	0.07	**Yes**
	PA_22	1	7/13/2006	7/13/2006	0.07	**Yes**
	PA_23	1	7/13/2006	7/13/2006	0.09	**Yes**
	PA_24	1	7/13/2006	7/13/2006	0.09	**Yes**
	PA_26	1	7/13/2006	7/13/2006	0.09	**Yes**
	PA_27	1	7/13/2006	7/13/2006	0.10	**Yes**
	PA_29	1	7/13/2006	7/13/2006	0.15	**Yes**
	PA_FLR	17	12/23/2002	5/25/2004	0.23	**Yes**
	PA_H25	86	7/8/2003	3/13/2007	0.08	**Yes**
	PA_UVAS	1	7/13/2006	7/13/2006	0.09	**Yes**
San Benito River	**All sites**	386	1/19/1998	12/12/2011	0.02	No
	305BRI	26	1/24/2005	12/12/2011	0.01	No
	305SAN	355	1/19/1998	12/12/2011	0.02	No
	305SBH	3	1/24/2008	2/22/2008	0.03	**Yes**
	SB_BWC	1	6/19/2006	6/19/2006	0.08	**Yes**
	SB_PA	1	7/13/2006	7/13/2006	0.02	No
San Juan Creek	**All sites**	392	11/6/2002	12/10/2013	0.27	**Yes**
	305MVR	9	1/24/2008	12/17/2008	0.07	**Yes**

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Geometric Mean	Exceeds 0.02 mg/L?[A]
	305PRR	9	1/24/2008	12/17/2008	0.05	**Yes**
	305SJN	318	1/29/2013	12/10/2013	0.29	**Yes**
	SJ_101	53	11/6/2002	9/29/2004	0.33	**Yes**
	SJ_156	2	8/4/2003	3/29/2005	0.15	**Yes**
	SJ_PA	1	7/13/2006	7/13/2006	0.39	**Yes**
West Branch of San Juan Creek	305ACR	9	1/24/2008	12/17/2008	0.86	**Yes**
San Martin Creek	SM_FOO	1	2/25/2004	2/25/2004	0.63	**Yes**
Swanson Creek	305SSCAUC	1	6/29/2010	6/29/2010	0.02	No
Tequisquita Slough	**All sites**	244	1/19/1998	12/10/2013	0.20	**Yes**
	305TES	223	1/19/1998	12/10/2013	0.19	**Yes**
	Teq_conf	19	6/17/2005	11/3/2006	0.38	**Yes**
	TS_SFL	2	6/23/2006	7/12/2006	0.61	**Yes**
Tres Pinos Creek	**All sites**	26	2/19/1998	10/19/2011	0.02	No
	305TRE	25	2/19/1998	10/19/2011	0.01	No
	TP_H25	1	6/22/2006	6/22/2006	0.11	**Yes**
Uvas Creek	**All sites**	673	1/19/1998	12/13/2011	0.03	**Yes**
	305UVA	169	1/19/1998	12/13/2011	0.04	**Yes**
	305UVCASC	1	6/29/2010	6/29/2010	0.01	No
	UV_152	221	10/1/2002	3/13/2007	0.03	**Yes**
	UV_THO	89	11/12/2002	3/13/2007	0.03	**Yes**
	UV_UCP	1	7/10/2006	7/10/2006	0.01	No
	UV_URA	77	1/7/2003	3/13/2007	0.03	**Yes**
	UV_URB	115	10/15/2002	3/13/2007	0.03	**Yes**

A - Streams located in all other Level IV ecoregions in the Pajaro River basin (excluding Monterey Bay Plains & Terraces and Santa Cruz Mountains) were evaluated using the criteria of 0.02 mg/L. Orthophosphate as P exceeding 0.02 mg/L is evidence of phosphorus enrichment. This value is equal to the 75th percentile of orthophosphate results from sampled stream reference background sites in the Leeward Hills (Upper Santa Clara Valley), East Bay Hills, and Western Diablo range Level IV ecoregions. Please see Table 5-20 for more information.

Table 5-14. Pajaro River basin summary statistics for dissolved oxygen (units = mg/L).

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. below 5.0 mg/L	% below 5.0 mg/L	No. below 7.0 mg/L[A]	% below 7.0 mg/L[A]
Beach Road Ditch	**All sites**	939	10/4/2000	2/6/2007	0.22	8.33	26.39	208	22%	n/a	n/a
	305-BEACH-21	153	10/4/2000	2/6/2007	0.22	8.53	26.39	37	24%	n/a	n/a
	BR_DW2	35	2/13/2001	12/29/2002	2.78	11.40	16.57	2	6%	n/a	n/a

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. below 5.0 mg/L	% below 5.0 mg/L	No. below 7.0 mg/L[A]	% below 7.0 mg/L[A]
	BR_FGB	152	10/4/2000	2/6/2007	0.4	7.93	19.24	26	17%	n/a	n/a
	BR_PAN	50	1/30/2001	9/21/2004	1.73	10.17	19.39	4	8%	n/a	n/a
	BR_THU	55	12/6/2000	9/21/2004	0.6	7.60	20.66	16	29%	n/a	n/a
	BR_WMI	157	10/4/2000	2/6/2007	0.31	7.54	17.49	37	24%	n/a	n/a
	BR_WS1	23	1/16/2001	5/18/2004	4.44	8.86	15.28	2	9%	n/a	n/a
	BR_WS2	155	11/22/2000	2/6/2007	0.32	7.59	22.5	46	30%	n/a	n/a
	BR_WS3	159	10/25/2000	2/6/2007	0.88	8.93	18.61	38	24%	n/a	n/a
Browns Creek	305-BROWN-21	38	9/7/2003	11/20/2004	7.6	8.90	10.4	0	0%	0	0%
Carnadero Creek	**All sites**	114	1/25/2005	12/10/2013	2.69	8.94	17.34	9	8%	29	25%
	305CAN	87	2/21/2006	12/10/2013	2.69	9.11	17.34	9	10%	19	22%
	305CAR	27	1/25/2005	12/13/2011	5.52	8.39	11.45	0	0%	10	37%
Casserly Creek	CS_MMR	1	8/17/2006	8/17/2006	10.3	10.30	10.3	0	0%	n/a	n/a
Clear Creek	305CLCSBR	51	1/2/1998	7/20/2011	7.2	9.69	12.9	0	0%	n/a	n/a
Corralitos Creek	**All sites**	472	7/13/2000	12/12/2011	2.40	9.43	18.47	31	7%	63	13%
	305COB_SCC	7	7/13/2000	5/8/2006	9.10	10.40	11.66	0	0%	0	0%
	305-CORRA-21	158	10/4/2000	2/6/2007	3.32	10.23	18.47	3	2%	14	9%
	305-CORRA-22	8	5/17/2003	5/2/2009	4.87	7.55	10.15	1	13%	3	38%
	305-CORRA-23	43	8/8/2003	11/20/2004	6.60	8.35	11.00	0	0%	2	5%
	305-CORRA-24	55	7/13/2000	5/8/2006	7.40	9.36	13.99	0	0%	0	0%
	305-SALSI-21	44	8/8/2003	11/20/2004	2.40	4.95	9.60	25	57%	37	84%
	CO_BVR	120	10/4/2000	12/12/2011	2.56	10.24	12.55	2	2%	6	5%
	CO_VAR	37	10/4/2000	4/20/2004	6.70	10.30	12.35	0	0%	1	3%
Furlong Creek	**All sites**	125	3/18/2003	12/13/2011	2.51	8.43	12.63	3	2%	n/a	n/a
	305FUF	27	1/25/2005	12/13/2011	6.47	9.32	11.74	0	0%	n/a	n/a
	FC_FLR	98	3/18/2003	1/17/2007	2.51	8.19	12.63	3	3%	n/a	n/a
Hanson Slough	305HAN-HAR	4	5/5/2007	5/2/2009	3.4	6.85	11	1	25%	n/a	n/a
Harkins Slough	**All sites**	61	5/1/2001	12/12/2011	0.08	6.33	14.54	23	38%	n/a	n/a
	305HAR	49	5/17/2003	12/12/2011	0.08	6.22	14.54	20	41%	n/a	n/a
	305HAR-BUE	4	5/17/2003	5/6/2006	6.00	7.92	9.80	0	0%	n/a	n/a
	305-HARKI-22	8	5/1/2001	5/2/2009	1.80	6.26	10.40	3	38%	n/a	n/a
Laguna Creek	305LGCACR	1	7/16/2008	7/16/2008	3.99	3.99	3.99	1	100%	n/a	n/a
Little Arthur Creek	305WE0883	1	6/28/2001	6/28/2001	9.5	9.50	9.5	0	0%	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. below 5.0 mg/L	% below 5.0 mg/L	No. below 7.0 mg/L[A]	% below 7.0 mg/L[A]
Llagas Creek	**All sites**	950	1/19/1998	12/10/2013	1.10	8.37	22.80	75	8%	255	27%
	305CHE	93	2/10/1998	1/17/2007	1.79	9.28	12.75	3	3%	8	9%
	305HOL	11	2/10/1998	1/25/2008	5.80	10.29	12.60	0	0%	2	18%
	305LEA	44	12/23/2002	5/25/2011	2.24	12.76	22.80	1	2%	2	5%
	305LGCBRC	2	7/11/2006	6/30/2010	9.55	10.00	10.45	0	0%	0	0%
	305LHB	42	6/9/2004	3/26/2008	1.91	7.95	15.67	8	19%	14	33%
	305LLA	193	1/19/1998	12/13/2011	3.98	7.69	14.92	2	1%	57	30%
	305LUC	227	2/10/1998	12/10/2013	1.10	6.48	15.67	58	26%	142	63%
	305MAS	1	7/15/1998	7/15/1998	2.60	2.60	2.60	1	100%	1	100%
	305MON	150	2/10/1998	2/9/2007	3.05	9.20	13.55	1	1%	18	12%
	305OAK	123	2/10/1998	1/17/2007	5.83	9.20	13.40	0	0%	7	6%
	305PS0061	1	6/17/2009	6/17/2009	7.40	7.40	7.40	0	0%	0	0%
	305VIS	16	2/10/1998	6/9/2004	2.60	9.91	14.30	1	6%	1	6%
	LL_CHU	47	10/15/2002	9/29/2004	5.55	9.03	12.86	0	0%	3	6%
Little Llagas	LL-LLC	3	12/23/2002	3/3/2004	8.51	9.69	11.05	0	0%	n/a	n/a
West Branch Llagas Creek	**All sites**	14	10/19/2004	7/18/2013	3.60	7.90	11.29	2	14%	n/a	n/a
	SW1	6	10/19/2004	4/25/2013	3.6	6.84	8.2	1	17%	n/a	n/a
	SW2	6	10/24/2004	7/18/2013	3.6	8.37	11.29	1	17%	n/a	n/a
	SW3	2	10/19/2004	4/20/2005	8.36	9.69	11.02	0	0%	n/a	n/a
West Branch LLagas Creek Tributary	SW4	2	10/19/2004	4/20/2005	6.49	7.27	8.05	0	0%	n/a	n/a
McGowan Ditch	**All sites**	17	11/14/2006	10/28/2009	0.01	8.75	14.60	2	12%	n/a	n/a
	305MDD	16	1/6/2008	10/28/2009	0.01	8.88	14.6	2	13%	n/a	n/a
	MC_TRA	1	11/14/2006	11/14/2006	6.7	6.70	6.7	0	0%	n/a	n/a
Millers Canal	**All sites**	279	2/10/1998	5/30/2013	1.45	8.26	17.56	16	6%	n/a	n/a
	305FRA	269	2/10/1998	5/30/2013	1.45	8.32	17.56	16	6%	n/a	n/a
	MC_10	1	7/12/2006	7/12/2006	7.27	7.27	7.27	0	0%	n/a	n/a
	MC_11	1	7/12/2006	7/12/2006	7.66	7.66	7.66	0	0%	n/a	n/a
	MC_12	1	7/12/2006	7/12/2006	5.83	5.83	5.83	0	0%	n/a	n/a
	MC_2	1	7/12/2006	7/12/2006	7.17	7.17	7.17	0	0%	n/a	n/a
	MC_3	1	7/12/2006	7/12/2006	6.96	6.96	6.96	0	0%	n/a	n/a
	MC_4	1	7/12/2006	7/12/2006	7.97	7.97	7.97	0	0%	n/a	n/a
	MC_5	1	7/12/2006	7/12/2006	5.7	5.70	5.7	0	0%	n/a	n/a
	MC_6	1	7/12/2006	7/12/2006	6.3	6.30	6.3	0	0%	n/a	n/a
	MC_7	1	7/12/2006	7/12/2006	5.18	5.18	5.18	0	0%	n/a	n/a
	MC_9	1	7/12/2006	7/12/2006	6.22	6.22	6.22	0	0%	n/a	n/a
Pacheco Creek	**All sites**	371	1/19/1998	12/13/2011	0.77	7.70	14.30	34	9%	137	37%
	305PAC	151	1/19/1998	12/13/2011	2.54	8.09	13.8	8	5%	44	29%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. below 5.0 mg/L	% below 5.0 mg/L	No. below 7.0 mg/L^{A}	% below 7.0 mg/L^{A}
	305PACLOV	81	11/11/2003	1/17/2007	3.58	7.41	9.68	7	9%	30	37%
	305PACWAL	41	11/11/2003	10/24/2006	5.41	9.66	14.3	0	0%	2	5%
	PC_NFK	1	7/17/2006	7/17/2006	6.74	6.74	6.74	0	0%	1	100%
	PC_SFR	97	10/1/2002	8/29/2006	0.77	6.50	10.7	19	20%	60	62%
Pajaro River	**All sites**	1,504	1/19/1998	12/10/2013	0.61	8.87	23.71	50	3%	273	18%
	305CHI	448	1/19/1998	12/10/2013	3.94	8.79	14.59	3	1%	41	9%
	305MUR	187	2/10/1998	12/12/2011	0.61	10.12	18.16	6	3%	15	8%
	305PAJ	250	1/19/1998	12/13/2011	1.54	7.69	11.23	10	4%	83	33%
	305PJE_L	13	1/6/2008	10/28/2009	5.41	9.15	14.78	0	0%	5	38%
	305PJE_U	14	1/6/2008	10/28/2009	2.00	8.94	14.73	1	7%	5	36%
	305PJP	297	10/4/2000	12/10/2013	0.80	9.04	16.56	18	6%	57	19%
	305PMO_SCC	17	12/11/2001	10/28/2009	5.40	9.20	14.80	0	0%	6	35%
	305PS0034	1	6/17/2008	6/17/2008	2.76	2.76	2.76	1	100%	1	100%
	305PS0057	1	6/16/2009	6/16/2009	3.28	3.28	3.28	1	100%	1	100%
	305THU	165	1/19/1998	8/15/2012	1.50	9.81	23.71	8	5%	29	18%
	PA_13	1	7/12/2006	7/12/2006	7.33	7.33	7.33	0	0%	0	0%
	PA_14	1	7/12/2006	7/12/2006	7.73	7.73	7.73	0	0%	0	0%
	PA_15	1	7/12/2006	7/12/2006	7.85	7.85	7.85	0	0%	0	0%
	PA_16	1	7/12/2006	7/12/2006	9.12	9.12	9.12	0	0%	0	0%
	PA_18	1	7/12/2006	7/12/2006	9.05	9.05	9.05	0	0%	0	0%
	PA_19	1	7/13/2006	7/13/2006	11.09	11.09	11.09	0	0%	0	0%
	PA_21	1	7/13/2006	7/13/2006	8.40	8.40	8.40	0	0%	0	0%
	PA_22	1	7/13/2006	7/13/2006	8.14	8.14	8.14	0	0%	0	0%
	PA_23	1	7/13/2006	7/13/2006	7.50	7.50	7.50	0	0%	0	0%
	PA_24	1	7/13/2006	7/13/2006	7.32	7.32	7.32	0	0%	0	0%
	PA_26	1	7/13/2006	7/13/2006	7.71	7.71	7.71	0	0%	0	0%
	PA_27	1	7/13/2006	7/13/2006	8.11	8.11	8.11	0	0%	0	0%
	PA_29	1	7/13/2006	7/13/2006	8.81	8.81	8.81	0	0%	0	0%
	PA_30	1	7/13/2006	7/13/2006	8.46	8.46	8.46	0	0%	0	0%
	PA_31	1	7/13/2006	7/13/2006	8.21	8.21	8.21	0	0%	0	0%
	PA_FLR	14	12/23/2002	5/25/2004	4.15	9.27	17.06	1	7%	3	21%
	PA_H25	81	7/8/2003	1/17/2007	4.68	7.59	12.45	1	1%	27	33%
	PA_UVAS	1	7/13/2006	7/13/2006	8.31	8.31	8.31	0	0%	0	0%
Salsipuedes Creek	305COR	299	1/19/1998	11/21/2013	0.41	8.92	16.93	37	12%	76	25%
San Benito River	**All sites**	285	1/19/1998	12/12/2011	2.17	8.93	16.90	16	6%	n/a	n/a
	305BRI	26	1/24/2005	12/12/2011	8.34	10.89	16.90	0	0%	n/a	n/a
	305SAN	255	1/19/1998	12/12/2011	2.17	8.71	14.66	16	6%	n/a	n/a
	305SBH	2	1/24/2008	2/22/2008	10.64	11.13	11.62	0	0%	n/a	n/a

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. below 5.0 mg/L	% below 5.0 mg/L	No. below 7.0 mg/L[A]	% below 7.0 mg/L[A]
	SB_BWC	1	6/19/2006	6/19/2006	9.67	9.67	9.67	0	0%	n/a	n/a
	SB_PA	1	7/13/2006	7/13/2006	8.57	8.57	8.57	0	0%	n/a	n/a
San Juan Creek	**All sites**	325	11/12/2002	12/10/2013	0.90	8.94	34.54	20	6%	n/a	n/a
	305MVR	10	1/24/2008	12/17/2008	7.40	9.24	13.97	0	0%	n/a	n/a
	305PRR	10	1/24/2008	12/17/2008	7.83	10.72	14.18	0	0%	n/a	n/a
	305SJN	255	8/4/2003	12/10/2013	0.90	9.21	34.54	11	4%	n/a	n/a
	SJ_101	48	11/12/2002	9/29/2004	2.33	7.07	10.58	9	19%	n/a	n/a
	SJ_156	1	3/29/2005	3/29/2005	10.17	10.17	10.17	0	0%	n/a	n/a
	SJ_PA	1	7/13/2006	7/13/2006	7.71	7.71	7.71	0	0%	n/a	n/a
West Branch of San Juan Creek	305ACR	10	1/24/2008	12/17/2008	4.95	8.40	10.43	1	10%	n/a	n/a
Struve Slough	**All sites**	133	5/17/2003	12/12/2011	0.10	4.47	15.04	81	66%	n/a	n/a
	305STL	111	5/17/2003	12/12/2011	0.43	4.82	15.04	69	62%	n/a	n/a
	305STR-HAR	12	5/17/2003	5/6/2006	0.10	1.25	4.50	12	100%	n/a	n/a
West Branch of Struve Slough	305-WSTRU-21	13	5/17/2003	5/6/2006	0.08	1.78	7.2	12	92%	n/a	n/a
Swanson Canyon Creek	305SSCAUC	1	6/29/2010	6/29/2010	9.22	9.22	9.22	0	0%	n/a	n/a
Tequisquita Slough	305TES	222	1/19/1998	12/10/2013	2.02	7.66	22.09	35	16%	n/a	n/a
Tres Pinos Creek	**All sites**	28	1/23/1998	10/19/2011	8.76	10.58	12.47	0	0%	n/a	n/a
	305TRE	27	1/23/1998	10/19/2011	8.76	10.59	12.47	0	0%	n/a	n/a
	TP_H25	1	6/22/2006	6/22/2006	10.3	10.30	10.3	0	0%	n/a	n/a
Uvas Creek	**All sites**	474	1/19/1998	12/13/2011	1.90	9.33	18.09	9	2%	52	11%
	305UVA	94	1/19/1998	12/13/2011	1.90	9.69	13.56	1	1%	9	10%
	305UVCASC	1	6/29/2010	6/29/2010	9.56	9.56	9.56	0	0%	0	0%
	UV_152	131	10/1/2002	2/9/2007	3.81	7.99	12.89	5	4%	31	24%
	UV_THO	73	11/12/2002	1/17/2007	4.32	11.56	18.09	1	1%	2	3%
	UV_UCP	1	7/10/2006	7/10/2006	9.81	9.81	9.81	0	0%	0	0%
	UV_URA	68	1/7/2003	1/17/2007	4.24	9.83	18.05	1	1%	3	4%
	UV_URB	106	10/15/2002	1/17/2007	4.38	8.79	13.65	1	1%	7	7%
Watsonville Slough	**All sites**	827	8/26/1998	4/30/2013	0.01	5.74	25.14	369	45%	n/a	n/a
	305WAT-AND	174	10/4/2000	2/6/2007	0.48	5.04	12.59	89	51%	n/a	n/a
	305WAT-HAR	23	5/17/2003	5/6/2006	0.02	2.10	7.20	21	91%	n/a	n/a
	305WAT-LEE	152	10/4/2000	2/6/2007	0.37	6.77	15.07	38	25%	n/a	n/a
	305WAT-SHE	160	10/25/2000	2/6/2007	0.28	5.24	11.03	78	49%	n/a	n/a
	305-WATSO-23	39	5/17/2003	10/28/2009	0.01	7.41	22.00	11	28%	n/a	n/a

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. below 5.0 mg/L	% below 5.0 mg/L	No. below 7.0 mg/L[A]	% below 7.0 mg/L[A]
	305WSA	122	8/26/1998	4/30/2013	0.51	5.06	12.64	63	52%	n/a	n/a
	WS_ERR	157	10/4/2000	2/6/2007	0.11	6.67	25.14	69	44%	n/a	n/a

A – If a waterbody is designated with a COLD beneficial use, dissolved oxygen measurements were analyzed to determine whether the concentration was reduced below 7 mg/L at any time (Basin Plan III-10). If the waterbody does not have a COLD beneficial use associated with it, staff did not perform this analysis.

Table 5-15. Pajaro River basin summary statistics for dissolved oxygen (units = mg/L).

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. above 13.0 mg/L	% above 13.0 mg/L
Beach Road Ditch	**All sites**	939	10/4/2000	2/6/2007	0.22	8.33	26.39	125	13%
	305-BEACH-21	153	10/4/2000	2/6/2007	0.22	8.53	26.39	25	16%
	BR_DW2	35	2/13/2001	12/29/2002	2.78	11.40	16.57	13	37%
	BR_FGB	152	10/4/2000	2/6/2007	0.4	7.93	19.24	17	11%
	BR_PAN	50	1/30/2001	9/21/2004	1.73	10.17	19.39	11	22%
	BR_THU	55	12/6/2000	9/21/2004	0.6	7.60	20.66	3	5%
	BR_WMI	157	10/4/2000	2/6/2007	0.31	7.54	17.49	14	9%
	BR_WS1	23	1/16/2001	5/18/2004	4.44	8.86	15.28	1	4%
	BR_WS2	155	11/22/2000	2/6/2007	0.32	7.59	22.5	11	7%
	BR_WS3	159	10/25/2000	2/6/2007	0.88	8.93	18.61	30	19%
Browns Creek	305-BROWN-21	38	9/7/2003	11/20/2004	7.6	8.90	10.4	0	0%
Carnadero Creek	**All sites**	114	1/25/2005	12/10/2013	2.69	8.94	17.34	6	5%
	305CAN	87	2/21/2006	12/10/2013	2.69	9.11	17.34	6	7%
	305CAR	27	1/25/2005	12/13/2011	5.52	8.39	11.45	0	0%
Casserly Creek	CS_MMR	1	8/17/2006	8/17/2006	10.3	10.30	10.3	0	0%
Clear Creek	305CLCSBR	51	1/2/1998	7/20/2011	7.2	9.69	12.9	0	0%
Corralitos Creek	**All sites**	472	7/13/2000	12/12/2011	2.40	9.43	18.47	11	2%
	305COB_SCC	7	7/13/2000	5/8/2006	9.10	10.40	11.66	0	0%
	305-CORRA-21	158	10/4/2000	2/6/2007	3.32	10.23	18.47	10	6%
	305-CORRA-22	8	5/17/2003	5/2/2009	4.87	7.55	10.15	0	0%
	305-CORRA-23	43	8/8/2003	11/20/2004	6.60	8.35	11.00	0	0%
	305-CORRA-24	55	7/13/2000	5/8/2006	7.40	9.36	13.99	1	2%
	305-SALSI-21	44	8/8/2003	11/20/2004	2.40	4.95	9.60	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. above 13.0 mg/L	% above 13.0 mg/L
	CO_BVR	120	10/4/2000	12/12/2011	2.56	10.24	12.55	0	0%
	CO_VAR	37	10/4/2000	4/20/2004	6.70	10.30	12.35	0	0%
Furlong Creek	**All sites**	125	3/18/2003	12/13/2011	2.51	8.43	12.63	0	0%
	305FUF	27	1/25/2005	12/13/2011	6.47	9.32	11.74	0	0%
	FC_FLR	98	3/18/2003	1/17/2007	2.51	8.19	12.63	0	0%
Hanson Slough	305HAN-HAR	4	5/5/2007	5/2/2009	3.4	6.85	11	0	0%
Harkins Slough	**All sites**	61	5/1/2001	12/12/2011	0.08	6.33	14.54	4	7%
	305HAR	49	5/17/2003	12/12/2011	0.08	6.22	14.54	4	8%
	305HAR-BUE	4	5/17/2003	5/6/2006	6.00	7.92	9.80	0	0%
	305-HARKI-22	8	5/1/2001	5/2/2009	1.80	6.26	10.40	0	0%
Laguna Creek	305LGCACR	1	7/16/2008	7/16/2008	3.99	3.99	3.99	0	0%
Little Arthur Creek	305WE0883	1	6/28/2001	6/28/2001	9.5	9.50	9.5	0	0%
Llagas Creek	**All sites**	950	1/19/1998	12/10/2013	1.10	8.37	22.80	24	3%
	305CHE	93	2/10/1998	1/17/2007	1.79	9.28	12.75	0	0%
	305HOL	11	2/10/1998	1/25/2008	5.80	10.29	12.60	0	0%
	305LEA	44	12/23/2002	5/25/2011	2.24	12.76	22.80	15	34%
	305LGCBRC	2	7/11/2006	6/30/2010	9.55	10.00	10.45	0	0%
	305LHB	42	6/9/2004	3/26/2008	1.91	7.95	15.67	1	2%
	305LLA	193	1/19/1998	12/13/2011	3.98	7.69	14.92	1	1%
	305LUC	227	2/10/1998	12/10/2013	1.10	6.48	15.67	1	0%
	305MAS	1	7/15/1998	7/15/1998	2.60	2.60	2.60	0	0%
	305MON	150	2/10/1998	2/9/2007	3.05	9.20	13.55	3	2%
	305OAK	123	2/10/1998	1/17/2007	5.83	9.20	13.40	1	1%
	305PS0061	1	6/17/2009	6/17/2009	7.40	7.40	7.40	0	0%
	305VIS	16	2/10/1998	6/9/2004	2.60	9.91	14.30	2	13%
	LL_CHU	47	10/15/2002	9/29/2004	5.55	9.03	12.86	0	0%
Little Llagas	LL-LLC	3	12/23/2002	3/3/2004	8.51	9.69	11.05	0	0%
West Branch Llagas Creek	**All sites**	14	10/19/2004	7/18/2013	3.60	7.90	11.29	0	0%
	SW1	6	10/19/2004	4/25/2013	3.6	6.84	8.2	0	0%
	SW2	6	10/24/2004	7/18/2013	3.6	8.37	11.29	0	0%
	SW3	2	10/19/2004	4/20/2005	8.36	9.69	11.02	0	0%
West Branch LLagas Creek Tributary	SW4	2	10/19/2004	4/20/2005	6.49	7.27	8.05	0	0%
McGowan Ditch	**All sites**	17	11/14/2006	10/28/2009	0.01	8.75	14.60	2	12%
	305MDD	16	1/6/2008	10/28/2009	0.01	8.88	14.6	2	13%
	MC_TRA	1	11/14/2006	11/14/2006	6.7	6.70	6.7	0	0%
Millers Canal	**All sites**	279	2/10/1998	5/30/2013	1.45	8.26	17.56	12	4%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. above 13.0 mg/L	% above 13.0 mg/L
	305FRA	269	2/10/1998	5/30/2013	1.45	8.32	17.56	12	4%
	MC_10	1	7/12/2006	7/12/2006	7.27	7.27	7.27	0	0%
	MC_11	1	7/12/2006	7/12/2006	7.66	7.66	7.66	0	0%
	MC_12	1	7/12/2006	7/12/2006	5.83	5.83	5.83	0	0%
	MC_2	1	7/12/2006	7/12/2006	7.17	7.17	7.17	0	0%
	MC_3	1	7/12/2006	7/12/2006	6.96	6.96	6.96	0	0%
	MC_4	1	7/12/2006	7/12/2006	7.97	7.97	7.97	0	0%
	MC_5	1	7/12/2006	7/12/2006	5.7	5.70	5.7	0	0%
	MC_6	1	7/12/2006	7/12/2006	6.3	6.30	6.3	0	0%
	MC_7	1	7/12/2006	7/12/2006	5.18	5.18	5.18	0	0%
	MC_9	1	7/12/2006	7/12/2006	6.22	6.22	6.22	0	0%
Pacheco Creek	**All sites**	371	1/19/1998	12/13/2011	0.77	7.70	14.30	4	1%
	305PAC	151	1/19/1998	12/13/2011	2.54	8.09	13.8	1	1%
	305PACLOV	81	11/11/2003	1/17/2007	3.58	7.41	9.68	0	0%
	305PACWAL	41	11/11/2003	10/24/2006	5.41	9.66	14.3	3	7%
	PC_NFK	1	7/17/2006	7/17/2006	6.74	6.74	6.74	0	0%
	PC_SFR	97	10/1/2002	8/29/2006	0.77	6.50	10.7	0	0%
Pajaro River	**All sites**	1,504	1/19/1998	12/10/2013	0.61	8.87	23.71	71	5%
	305CHI	448	1/19/1998	12/10/2013	3.94	8.79	14.59	4	1%
	305MUR	187	2/10/1998	12/12/2011	0.61	10.12	18.16	21	11%
	305PAJ	250	1/19/1998	12/13/2011	1.54	7.69	11.23	0	0%
	305PJE_L	13	1/6/2008	10/28/2009	5.41	9.15	14.78	1	8%
	305PJE_U	14	1/6/2008	10/28/2009	2.00	8.94	14.73	1	7%
	305PJP	297	10/4/2000	12/10/2013	0.80	9.04	16.56	20	7%
	305PMO_SCC	17	12/11/2001	10/28/2009	5.40	9.20	14.80	1	6%
	305PS0034	1	6/17/2008	6/17/2008	2.76	2.76	2.76	0	0%
	305PS0057	1	6/16/2009	6/16/2009	3.28	3.28	3.28	0	0%
	305THU	165	1/19/1998	8/15/2012	1.50	9.81	23.71	21	13%
	PA_13	1	7/12/2006	7/12/2006	7.33	7.33	7.33	0	0%
	PA_14	1	7/12/2006	7/12/2006	7.73	7.73	7.73	0	0%
	PA_15	1	7/12/2006	7/12/2006	7.85	7.85	7.85	0	0%
	PA_16	1	7/12/2006	7/12/2006	9.12	9.12	9.12	0	0%
	PA_18	1	7/12/2006	7/12/2006	9.05	9.05	9.05	0	0%
	PA_19	1	7/13/2006	7/13/2006	11.09	11.09	11.09	0	0%
	PA_21	1	7/13/2006	7/13/2006	8.40	8.40	8.40	0	0%
	PA_22	1	7/13/2006	7/13/2006	8.14	8.14	8.14	0	0%
	PA_23	1	7/13/2006	7/13/2006	7.50	7.50	7.50	0	0%
	PA_24	1	7/13/2006	7/13/2006	7.32	7.32	7.32	0	0%
	PA_26	1	7/13/2006	7/13/2006	7.71	7.71	7.71	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. above 13.0 mg/L	% above 13.0 mg/L
	PA_27	1	7/13/2006	7/13/2006	8.11	8.11	8.11	0	0%
	PA_29	1	7/13/2006	7/13/2006	8.81	8.81	8.81	0	0%
	PA_30	1	7/13/2006	7/13/2006	8.46	8.46	8.46	0	0%
	PA_31	1	7/13/2006	7/13/2006	8.21	8.21	8.21	0	0%
	PA_FLR	14	12/23/2002	5/25/2004	4.15	9.27	17.06	2	14%
	PA_H25	81	7/8/2003	1/17/2007	4.68	7.59	12.45	0	0%
	PA_UVAS	1	7/13/2006	7/13/2006	8.31	8.31	8.31	0	0%
Salsipuedes Creek	305COR	299	1/19/1998	11/21/2013	0.41	8.92	16.93	33	11%
San Benito River	**All sites**	285	1/19/1998	12/12/2011	2.17	8.93	16.90	9	3%
	305BRI	26	1/24/2005	12/12/2011	8.34	10.89	16.90	1	4%
	305SAN	255	1/19/1998	12/12/2011	2.17	8.71	14.66	8	3%
	305SBH	2	1/24/2008	2/22/2008	10.64	11.13	11.62	0	0%
	SB_BWC	1	6/19/2006	6/19/2006	9.67	9.67	9.67	0	0%
	SB_PA	1	7/13/2006	7/13/2006	8.57	8.57	8.57	0	0%
San Juan Creek	**All sites**	325	11/12/2002	12/10/2013	0.90	8.94	34.54	23	7%
	305MVR	10	1/24/2008	12/17/2008	7.40	9.24	13.97	1	10%
	305PRR	10	1/24/2008	12/17/2008	7.83	10.72	14.18	3	30%
	305SJN	255	8/4/2003	12/10/2013	0.90	9.21	34.54	19	7%
	SJ_101	48	11/12/2002	9/29/2004	2.33	7.07	10.58	0	0%
	SJ_156	1	3/29/2005	3/29/2005	10.17	10.17	10.17	0	0%
	SJ_PA	1	7/13/2006	7/13/2006	7.71	7.71	7.71	0	0%
West Branch of San Juan Creek	305ACR	10	1/24/2008	12/17/2008	4.95	8.40	10.43	0	0%
Struve Slough	**All sites**	133	5/17/2003	12/12/2011	0.10	4.47	15.04	2	2%
	305STL	111	5/17/2003	12/12/2011	0.43	4.82	15.04	2	2%
	305STR-HAR	12	5/17/2003	5/6/2006	0.10	1.25	4.50	0	0%
West Branch of Struve Slough	305-WSTRU-21	13	5/17/2003	5/6/2006	0.08	1.78	7.2	0	0%
Swanson Canyon Creek	305SSCAUC	1	6/29/2010	6/29/2010	9.22	9.22	9.22	0	0%
Tequisquita Slough	305TES	222	1/19/1998	12/10/2013	2.02	7.66	22.09	16	7%
Tres Pinos Creek	**All sites**	28	1/23/1998	10/19/2011	8.76	10.58	12.47	0	0%
	305TRE	27	1/23/1998	10/19/2011	8.76	10.59	12.47	0	0%
	TP_H25	1	6/22/2006	6/22/2006	10.3	10.30	10.3	0	0%
Uvas Creek	**All sites**	474	1/19/1998	12/13/2011	1.90	9.33	18.09	31	7%
	305UVA	94	1/19/1998	12/13/2011	1.90	9.69	13.56	2	2%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	No. above 13.0 mg/L	% above 13.0 mg/L
	305UVCASC	1	6/29/2010	6/29/2010	9.56	9.56	9.56	0	0%
	UV_152	131	10/1/2002	2/9/2007	3.81	7.99	12.89	0	0%
	UV_THO	73	11/12/2002	1/17/2007	4.32	11.56	18.09	25	34%
	UV_UCP	1	7/10/2006	7/10/2006	9.81	9.81	9.81	0	0%
	UV_URA	68	1/7/2003	1/17/2007	4.24	9.83	18.05	3	4%
	UV_URB	106	10/15/2002	1/17/2007	4.38	8.79	13.65	1	1%
Watsonville Slough	**All sites**	827	8/26/1998	4/30/2013	0.01	5.74	25.14	22	3%
	305WAT-AND	174	10/4/2000	2/6/2007	0.48	5.04	12.59	0	0%
	305WAT-HAR	23	5/17/2003	5/6/2006	0.02	2.10	7.20	0	0%
	305WAT-LEE	152	10/4/2000	2/6/2007	0.37	6.77	15.07	5	3%
	305WAT-SHE	160	10/25/2000	2/6/2007	0.28	5.24	11.03	0	0%
	305-WATSO-23	39	5/17/2003	10/28/2009	0.01	7.41	22.00	5	13%
	305WSA	122	8/26/1998	4/30/2013	0.51	5.06	12.64	0	0%
	WS_ERR	157	10/4/2000	2/6/2007	0.11	6.67	25.14	12	8%

Table 5-16. Pajaro River basin summary statistics for dissolved oxygen saturation (units = %).

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Median Saturation (%)	Max
Carnadero Creek	**All sites**	99	1/25/2005	12/10/2013	25.5	88.9	139.6
	305CAN	72	2/21/2006	12/10/2013	25.5	95.1	139.6
	305CAR	27	1/25/2005	12/13/2011	57.2	83.2	104.2
Clear Creek	305CLCSBR	50	1/2/1998	7/20/2011	95.0	103.0	112.0
Corralitos Creek	CO_BVR	22	1/24/2005	12/12/2011	90.9	105.8	113.6
Furlong Creek	305FUF	27	1/25/2005	12/13/2011	73.6	94.7	111.0
Harkins Slough	305HAR	26	1/24/2005	12/12/2011	33.3	91.9	148.6
Llagas Creek	**All sites**	236	1/19/1998	12/10/2013	17.2	83.1	191.3
	305CHE	13	2/10/1998	1/7/1999	69.8	98.7	181.5
	305HOL	10	2/10/1998	1/25/2008	56.5	114.1	136.8
	305LEA	10	2/23/2005	5/25/2011	90.8	113.0	191.3
	305LHB	3	1/25/2008	3/26/2008	87.0	87.5	98.0
	305LLA	62	1/19/1998	12/13/2011	66.7	85.1	170.4
	305LUC	108	2/10/1998	12/10/2013	17.2	66.4	121.1
	305MON	13	2/10/1998	1/7/1999	62.5	95.0	162.9
	305OAK	13	2/10/1998	1/7/1999	76.2	92.2	142.0
	305VIS	4	2/10/1998	6/12/1998	86.5	105.8	164.4
Millers Canal	305FRA	132	2/10/1998	5/30/2013	40.3	89.7	222.5

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Median Saturation (%)	Max
Pacheco Creek	305PAC	41	1/19/1998	12/13/2011	51.3	93.8	220.5
Pajaro River	**All sites**	521	1/19/1998	12/10/2013	19.6	91.0	279.3
	305CHI	152	1/19/1998	12/10/2013	47.3	90.2	163.2
	305MUR	41	2/10/1998	12/12/2011	71.9	100.8	142.1
	305PAJ	53	1/19/1998	12/13/2011	62.6	81.4	108.3
	305PJP	131	12/11/2002	12/10/2013	19.6	91.6	156.3
	305THU	144	1/19/1998	8/15/2012	41.1	94.3	279.3
Salsipuedes Creek	305COR	126	1/19/1998	11/21/2013	35.3	93.0	169.2
San Benito River	**All sites**	79	1/19/1998	12/12/2011	67.3	101.3	185.5
	305BRI	26	1/24/2005	12/12/2011	96.7	103.0	185.5
	305SAN	51	1/19/1998	12/12/2011	67.3	98.2	164.4
	305SBH	2	1/24/2008	2/22/2008	103.4	106.7	110.0
San Juan Creek	**All sites**	148	1/25/2005	12/10/2013	34.8	95.6	375.9
	305MVR	10	1/24/2008	12/17/2008	73.9	94.6	174.8
	305PRR	10	1/24/2008	12/17/2008	83.7	108.3	148.0
	305SJN	128	1/25/2005	12/10/2013	34.8	94.2	375.9
West Branch of San Juan Creek	305ACR	10	1/24/2008	12/17/2008	46.5	85.1	121.9
Struve Slough	305STL	102	1/24/2005	12/12/2011	4.7	42.3	167.1
Tequisquita Slough	305TES	114	1/19/1998	12/10/2013	26.4	80.3	272.4
Tres Pinos Creek	305TRE	26	1/23/1998	10/19/2011	96.6	108.4	185.6
Uvas Creek	305UVA	25	1/19/1998	12/13/2011	17.7	102.3	115.5
Watsonville Slough	**All sites**	10	10/5/2004	4/30/2013	46.5	85.1	121.9
	305WAT-LEE	1	2/21/2006	2/21/2006	59.2	59.2	59.2
	305WAT-SHE	1	10/5/2004	10/5/2004	48.5	48.5	48.5
	305WSA	113	1/24/2005	4/30/2013	5.0	45.1	121.1

Table 5-17. Pajaro River basin summary statistics for chlorophyll a (units = μg/L).

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceed 15 μg/L	% Exceed 15 μg/L	No. Exceed 40 μg/L	% Exceed 40 μg/L
Carnadero Creek	**All sites**	96	1/25/2005	12/10/2013	4.0	0.0	0.9	2.2	4.5	28.8	3	3%	0	0%
	305CAN	71	2/21/2006	12/10/2013	4.5	0.0	0.8	2.2	6.2	28.8	3	4%	0	0%
	305CAR	25	1/25/2005	12/13/2011	2.4	0.1	1.2	1.5	3.6	9.0	0	0%	0	0%
Corralitos Creek	**All sites**	39	1/13/2003	12/12/2011	5.5	0.1	1.0	2.0	3.5	56.1	4	10%	1	3%
	305-CORRA-21	20	1/13/2003	12/29/2003	9.0	0.6	1.9	3.0	10.9	56.1	4	20%	1	5%
	CO_BVR	19	1/24/2005	12/12/2011	1.8	0.1	0.6	1.3	1.8	12.1	0	0%	0	0%
Furlong Creek	305FUF	24	1/25/2005	12/13/2011	3.6	0.1	1.1	1.7	3.7	19.7	1	4%	0	0%
Harkins Slough	305HAR	25	1/24/2005	12/12/2011	83.4	4.1	23.8	74.8	123.5	270.0	19	76%	17	68%
Llagas Creek	**All sites**	302	2/10/1998	12/10/2013	6.2	0.0	1.1	2.6	5.7	118.3	24	8%	7	2%
	305CHE	11	2/10/1998	1/7/1999	0.7	0.0	0.2	0.8	1.0	1.9	0	0%	0	0%
	305HOL	11	2/10/1998	1/25/2008	9.3	0.6	2.2	3.1	16.0	31.0	3	27%	0	0%
	305LEA	8	2/23/2005	5/25/2011	18.0	0.4	1.7	3.3	6.5	118.3	1	13%	1	13%
	305LHB	3	1/25/2008	3/26/2008	1.5	0.9	1.0	1.0	1.8	2.6	0	0%	0	0%
	305LLA	83	2/10/1998	12/13/2011	3.5	0.1	1.8	2.7	4.3	20.6	1	1%	0	0%
	305LUC	129	2/10/1998	12/10/2013	4.8	0.0	0.9	2.1	4.0	75.0	5	4%	3	2%
	305MON	40	2/10/1998	12/29/2003	15.8	0.2	7.1	12.1	23.7	43.8	14	35%	3	8%
	305OAK	12	2/10/1998	1/7/1999	3.0	0.4	1.4	2.8	3.8	8.3	0	0%	0	0%
	305VIS	5	2/10/1998	6/12/1998	5.5	0.7	1.5	2.0	9.0	14.6	0	0%	0	0%
Miller's Canal	305FRA	162	2/10/1998	5/30/2013	64.9	0.0	12.6	44.3	90.3	575.0	114	70%	85	52%
Pacheco Creek	305PAC	61	2/19/1998	12/13/2011	2.5	0.1	0.8	1.4	2.8	27.8	1	2%	0	0%
Pajaro River	**All sites**	610	2/10/1998	12/10/2013	16.1	0.0	2.9	6.8	15.6	734.7		26%	45	7%
	305CHI	181	2/10/1998	12/10/2013	14.8	0.0	3.0	7.3	16.8	306.6	51	28%	14	5%
	305MUR	61	2/10/1998	12/12/2011	16.2	0.0	3.8	7.9	13.9	343.1	13	21%	3	20%
	305PAJ	75	2/10/1998	12/13/2011	26.4	0.2	8.5	21.9	35.5	126.2	46	61%	15	4%
	305PJP	158	12/11/2002	12/10/2013	17.3	0.1	2.4	4.8	9.4	734.7	20	13%	6	5%
	305THU	135	2/10/1998	8/15/2012	10.8	0.1	2.4	5.2	11.3	102.3	27	20%	7	5%
Salsipuedes Creek	305COR	122	2/19/1998	11/21/2013	9.5	0.0	2.1	4.5	9.4	231.9	18	15%	4	3%
San Benito River	**All sites**	99	2/19/1998	12/12/2011	4.6	0.1	1.1	2.2	4.8	31.5	8	8%	0	0%
	305BRI	25	1/24/2005	12/12/2011	3.6	0.1	0.8	1.2	1.9	27.4	2	8%	0	0%
	305SAN	72	2/19/1998	12/12/2011	5.0	0.1	1.5	3.2	5.3	31.5	6	8%	0	0%
	305SBH	2	1/24/2008	2/22/2008	2.1	1.8	2.0	2.1	2.2	2.4	0	0%	0	0%
San Juan Creek	**All sites**	171	1/25/2005	12/10/2013	7.3	0.0	2.5	4.4	7.5	59.0	20	12%	5	3%
	305MVR	11	1/24/2008	12/17/2008	11.9	0.5	1.2	5.3	16.9	45.2	3	27%	1	9%
	305PRR	11	1/24/2008	12/17/2008	6.6	0.5	2.8	4.1	9.6	20.3	1	9%	0	0%

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Arithmetic Mean	Min	25%	50% (median)	75%	Max	No. Exceed 15 µg/L	% Exceed 15 µg/L	No. Exceed 40 µg/L	% Exceed 40 µg/L
	305SJN	149	1/25/2005	12/10/2013	7.0	0.0	2.5	4.3	7.2	59.0	16	11%	4	3%
West Branch San Juan Creek	305ACR	11	1/24/2008	12/17/2008	15.4	2.7	3.3	6.7	11.5	70.2	2	18%	2	18%
Struve Slough	305STL	102	1/24/2005	12/12/2011	74.0	0.0	9.2	28.4	85.6	775.3	60	59%	42	41%
Tequisquita Slough	305TES	111	2/19/1998	12/10/2013	146.7	0.0	3.4	7.4	37.8	4344.9	37	33%	28	25%
Tres Pinos Creek	305TRE	24	2/19/1998	10/19/2011	2.6	0.1	1.0	1.7	4.2	7.2	0	0%	0	0%
Uvas Creek	**All sites**	60	2/19/1998	12/13/2011	2.3	0.1	0.9	1.5	2.3	22.2	1	2%	0	0%
	305UVA	34	2/19/1998	12/13/2011	2.6	0.1	0.8	1.4	2.2	22.2	1	3%	0	0%
	UV_152	26	1/13/2003	12/29/2003	2.0	0.5	1.1	1.5	2.7	7.0	0	0%	0	0%
Watsonville Slough	305WSA	111	1/24/2005	4/30/2013	27.4	0.3	3.4	7.5	23.8	240.0	42	38%	17	15%

Table 5-18. Pajaro River basin summary statistics for floating algal mats (% cover).

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	Number of times over 50% cover
Carnadero Creek	**All sites**	31	2/23/2005	12/13/2011	0	3	65	1
	305CAN	6	5/26/2010	6/24/2011	0	5	15	0
	305CAR	25	2/23/2005	12/13/2011	0	3	65	1
Corralitos Creek	CO_BVR	21	1/24/2005	12/12/2011	0	0	0	0
Furlong Creek	305FUF	25	2/23/2005	12/13/2011	0	0	0	0
Harkins Slough	305HAR	15	2/22/2005	4/20/2011	0	0	2	0
Llagas Creek	**All sites**	43	1/25/2005	12/13/2011	0	4	55	1
	305LEA	10	2/23/2005	5/25/2011	0	10	55	1
	305LUC	27	1/25/2005	12/13/2011	0	0	0	0
	305LLA	6	5/26/2010	6/27/2011	0	14	45	0
Miller’s Canal	305FRA	28	1/25/2005	12/13/2011	0	1	25	0
Pacheco Creek	305PAC	27	1/25/2005	12/13/2011	0	1	25	0
Pajaro River	**All sites**	213	5/31/2001	8/15/2012	0	6	90	9
	305CHI	29	1/24/2005	12/12/2011	0	1	20	0
	305MUR	27	1/24/2005	12/12/2011	0	0	10	0
	305PAJ	25	2/23/2005	12/13/2011	0	0	0	0
	305PJP	33	12/11/2002	12/12/2011	0	3	25	0
	305THU	99	5/31/2001	8/15/2012	0	11	90	9

Waterbody	Monitoring Site ID	No. of Samples	Temporal Representation		Min	Arithmetic Mean	Max	Number of times over 50% cover
Salsipuedes Creek	305COR	30	1/24/2005	12/12/2011	0	2	30	0
San Benito River	**All sites**	53	1/24/2005	12/12/2011	0	4	90	1
	305BRI	26	1/24/2005	12/12/2011	0	4	90	1
	305SAN	27	1/24/2005	12/12/2011	0	3	35	0
San Juan Creek	305SJN	34	1/25/2005	12/12/2011	0	10	85	2
Struve Slough	305STL	14	3/23/2005	6/24/2011	0	0	0	0
Tequisquita Slough	305TES	2	6/22/2011	6/24/2011	10	15	20	0
Tres Pinos Creek	305TRE	16	2/22/2005	10/19/2011	0	0	5	0
Uvas Creek	305UVA	16	2/23/2005	12/13/2011	0	0	0	0
Watsonville Slough	305WSA	23	4/21/2005	12/12/2011	0	7	70	2

Table 5-19. Pajaro River basin summary statistics for microcystins (units = µg/L).

No. of Samples	Sample Location	Sample Date	Concentration Reported	OEHAA[A] Recommended Public Health Threshold
1	Pajaro River @ Thurwatcher Rd.	November 15, 2011	0.24	0.8[B]

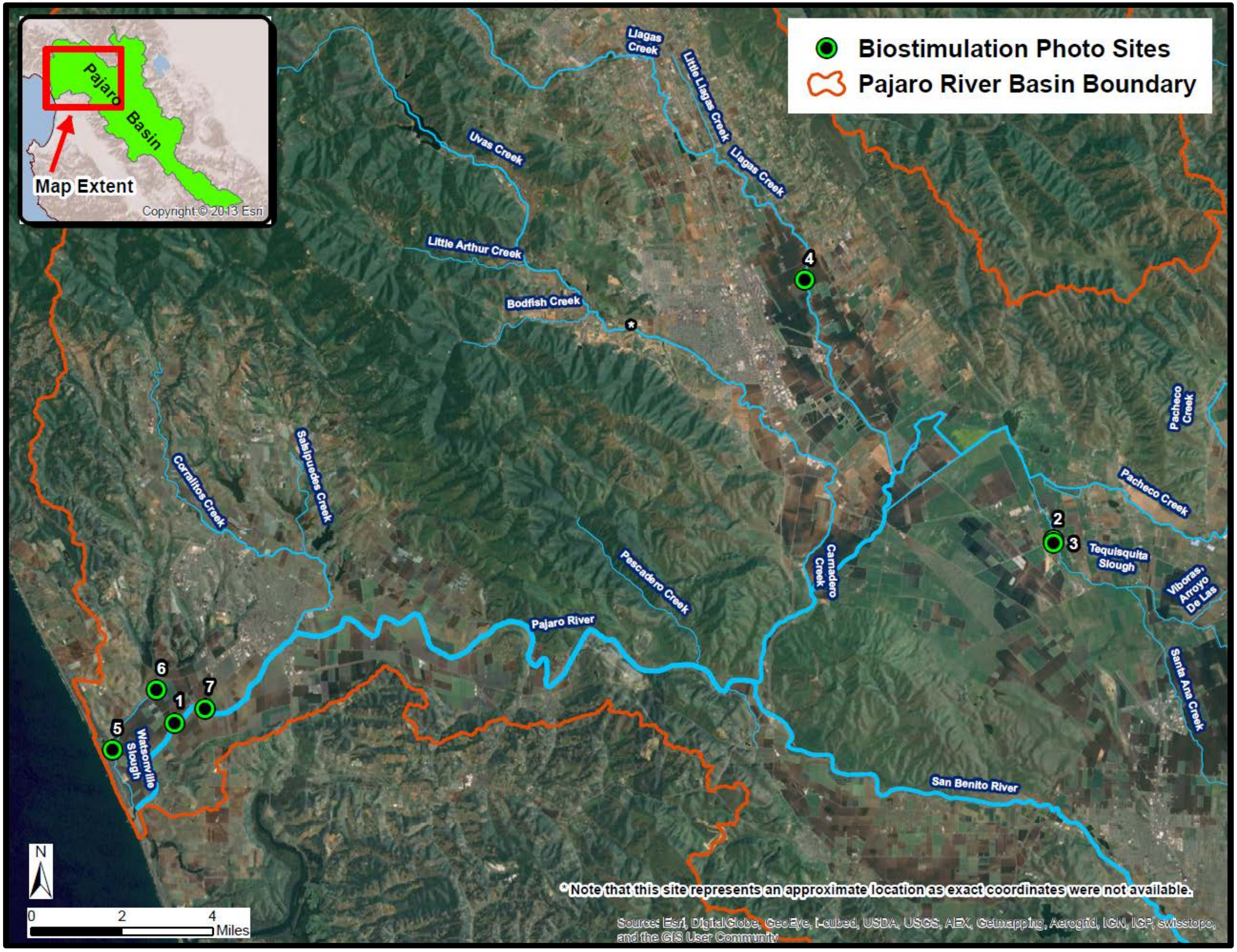
[A] OEHAA = California Office of Environmental Health Hazard Assessment

[B] 0.8 µg/L is a California Office of Environmental Health Hazard Assessment has public health action level for microcystins

5.12 Photo Documentation of Biostimulation

Water Board staff, researchers, and City of Watsonville staff have periodically photo-documented evidence of biostimulation and excessive algal growth at water quality monitoring sites in the Pajaro River basin. Photographic documentation of biostimulatory effects on surface waters of the Pajaro River basin is shown in Figure 5-71; it should be noted that these photos represent conditions that are episodic and not a constant baseline condition. It is also important to recognize that not all biomass, like macrophytes, can or should be expected to be removed from streams. Algae are natural components of freshwater systems and play roles essential to the health of the ecosystem. While an overall goal of nutrient TMDLs is to significantly reduce excessive and harmful amounts of biomass in freshwater systems, some level of biomass is necessary to provide habitat to fish and other aquatic organisms.

Figure 5-71. Location of stream biostimulation photos.

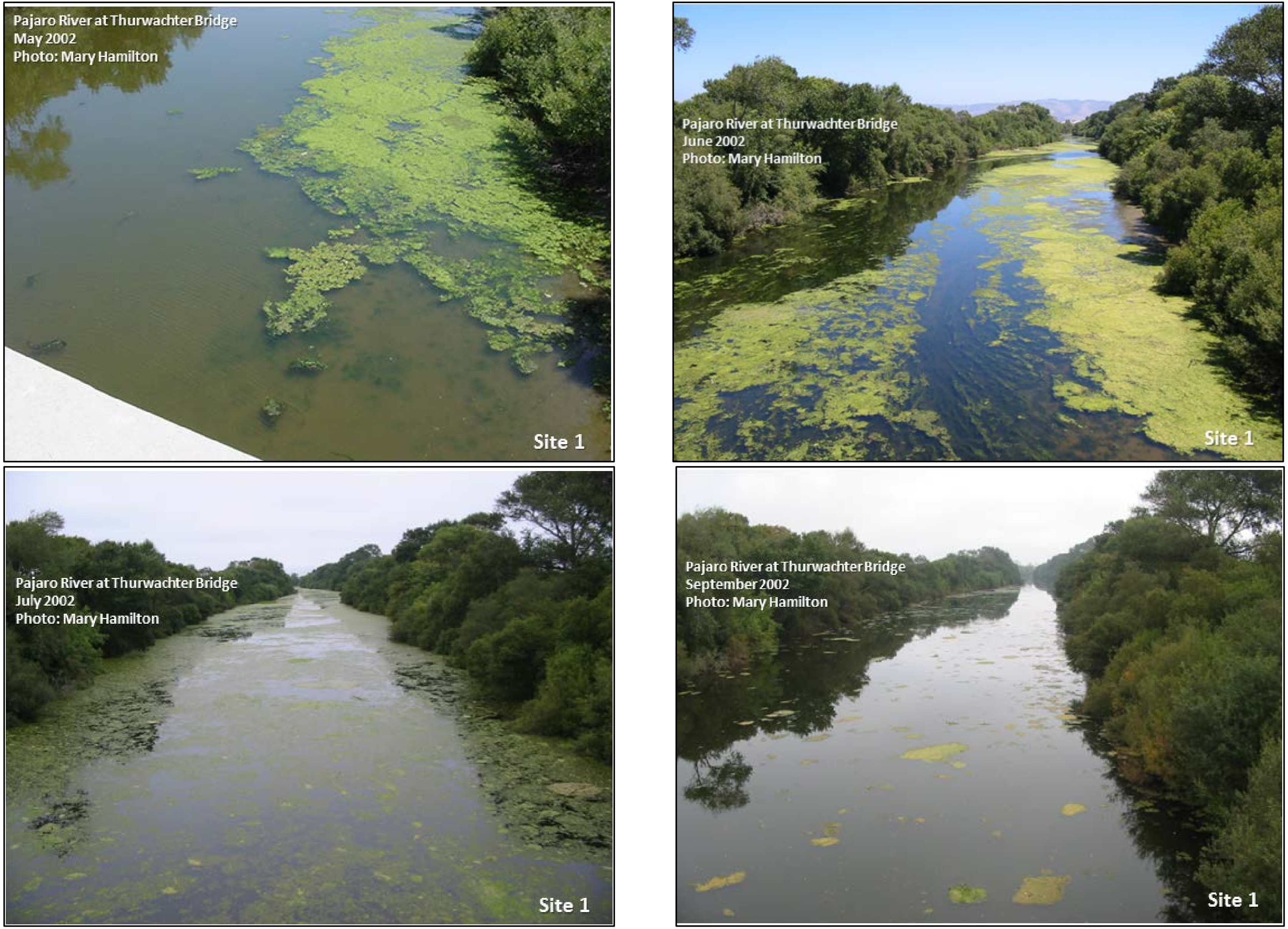


* Note that this site represents an approximate location as exact coordinates were not available.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 5-72. Photo documentation of biostimulation in the Pajaro River basin.

Photo documentation



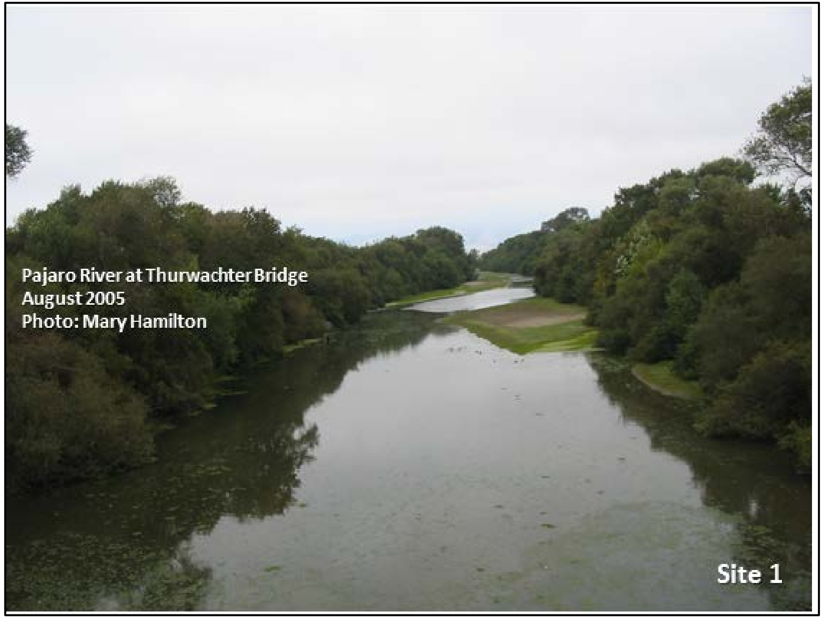
Pajaro River at Thurwachter Bridge
May 2002
Photo: Mary Hamilton

Pajaro River at Thurwachter Bridge
June 2002
Photo: Mary Hamilton

Pajaro River at Thurwachter Bridge
July 2002
Photo: Mary Hamilton

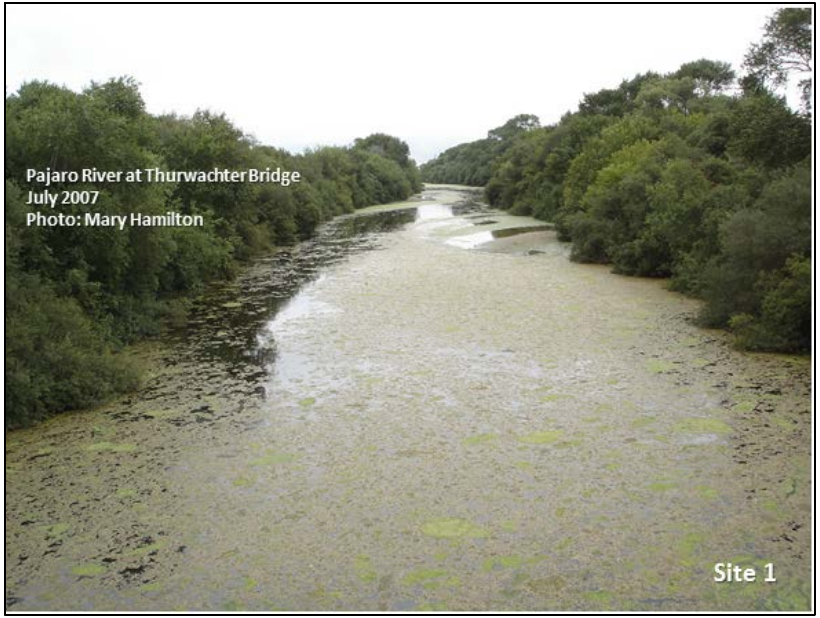
Pajaro River at Thurwachter Bridge
September 2002
Photo: Mary Hamilton

Photo documentation



Pajaro River at Thurwachter Bridge
August 2005
Photo: Mary Hamilton

Site 1

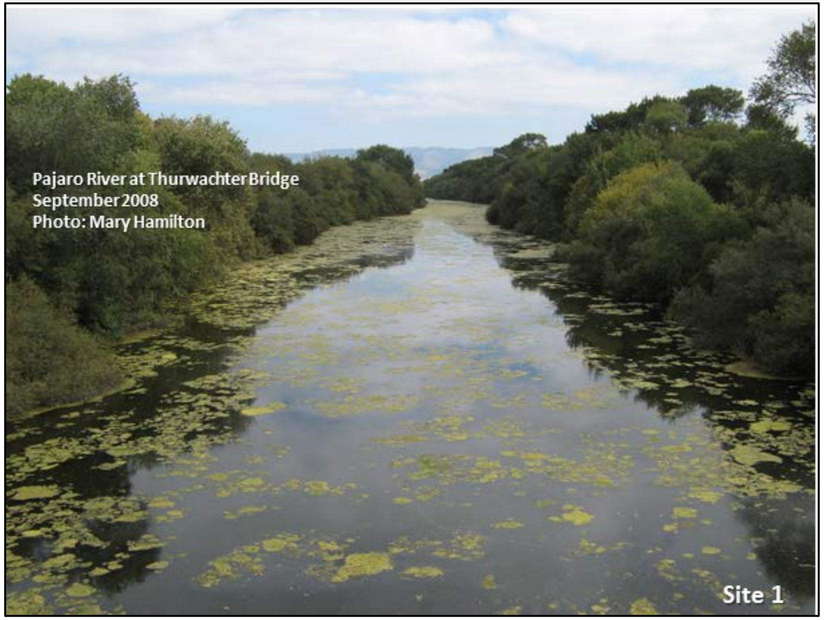


Pajaro River at Thurwachter Bridge
July 2007
Photo: Mary Hamilton

Site 1

Pajaro River at Thurwachter Bridge
May 2008
Photo: Mary Hamilton

Site 1

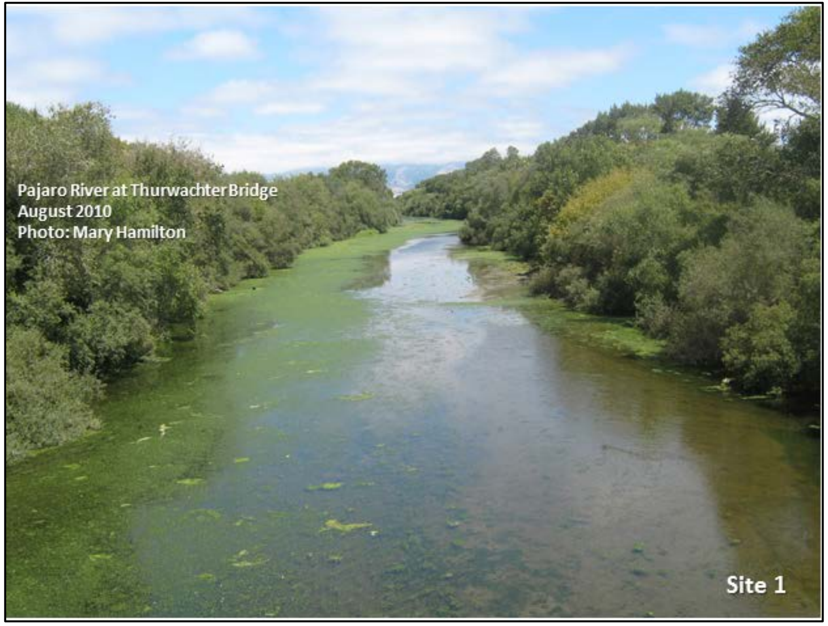


Pajaro River at Thurwachter Bridge
September 2008
Photo: Mary Hamilton

Site 1

Photo documentation


Pajaro River at Thurwachter Bridge
June 2009
Photo: Mary Hamilton


Pajaro River at Thurwachter Bridge
August 2010
Photo: Mary Hamilton


Pajaro River at Thurwachter Bridge
August 2011
Photo: Mary Hamilton

08/15/2011 14:33

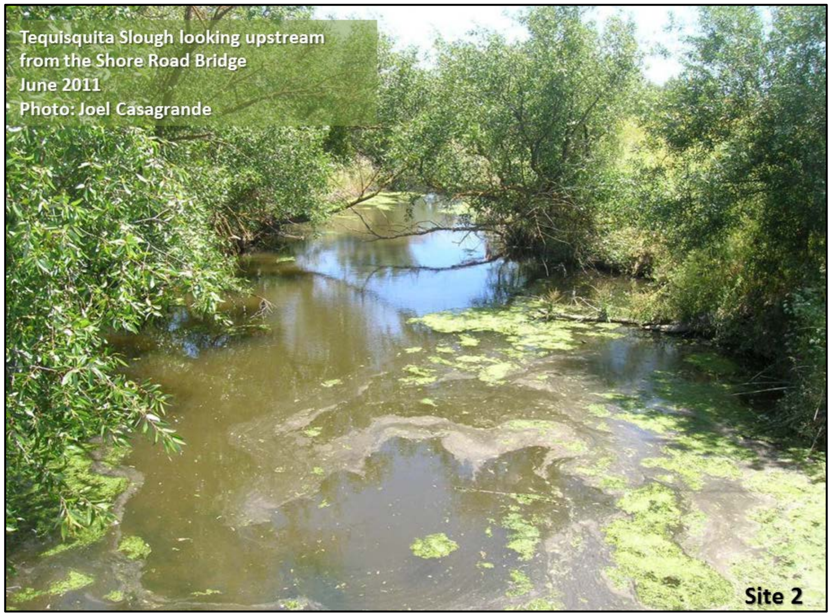
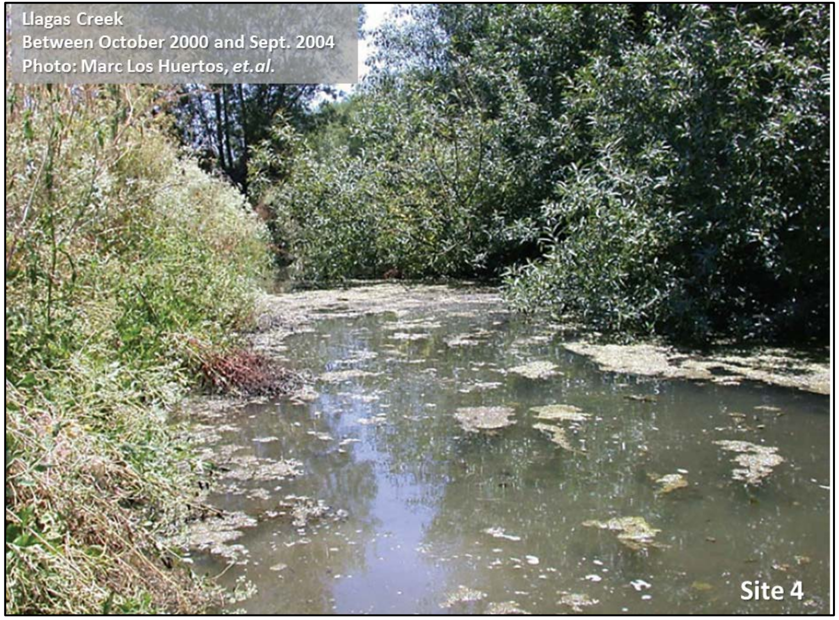

Tequisquita Slough looking upstream
from the Shore Road Bridge
June 2011
Photo: Joel Casagrande

Photo documentation

Tequisquita Slough upstream about 150 m
from the Shore Road (looking upstream)
June 2011
Photo: Joel Casagrande

Blue-green algal blooms (inset) were extensive throughout this reach



Llagas Creek
Between October 2000 and Sept. 2004
Photo: Marc Los Huertos, *et.al.*

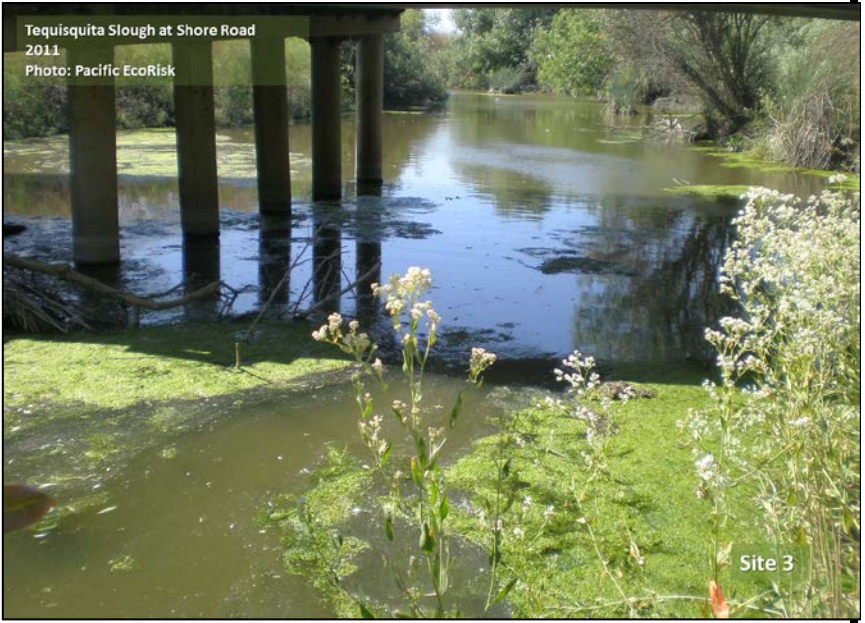
Watsonville Slough Near Shell Road
June 2012
Photo: B. Hecht

Pajaro River
Upstream of Watsonville Wastewater Treatment Facility
July 2015
Photo: Robert Ketley

Photo documentation

Watsonville Slough upstream of Harkins Slough
2011
Photo: Pacific EcoRisk

Site 6



Tequisquita Slough at Shore Road
2011
Photo: Pacific EcoRisk

Site 3

Pajaro River
upstream of Watsonville Wastewater Treatment Facility
April 2015
Photo: Robert Ketley

Site7

Pajaro River
Upstream of Watsonville Wastewater Treatment Facility
June 2015
Photo: Robert Ketley

Site 7

5.13 Factors Limiting the Risk of Biostimulation

5.13.1 Total Nitrogen / Total Phosphorus Ratios (Limiting Nutrient)

The term limiting nutrient refers to the nutrient that limits plant growth when it is not available in sufficient quantities. Algal cells require nitrogen and phosphorus in relatively fixed stoichiometric proportions; the limiting nutrient is the nutrient that will run out before other nutrients. Therefore, if there is potentially less available phosphorus relative to algal stoichiometric requirements, then phosphorus is the limiting nutrient. On balance, the published literature indicates that TN:TP ratios above about 20:1 typically imply that phosphorus is the limiting nutrient; TN:TP ratios below about 10:1 can indicate that nitrogen in the limiting nutrient; and TN:TP ranges between about 10:1 and 20:1 indicate a transitional range where N and P can be co-limiting. It should be recognized however, than in some agricultural drainages of the California central coast region, water column nutrient concentrations are so high it is likely nutrients themselves do not limit biological productivity.

Reporting by Tetra Tech, Inc. indicates that currently control of nitrogen in streams of the California central coast region may be considerably more important than control of phosphorus. Tetra Tech scientists found that streams in the Calfornia chaparral and oak nutrient subecoregion (subecoregion III-6) are more often limited by nitrogen than by phosphorus[139]. Accordingly, as a practical matter staff maintains that at this time the focus of resources and implementation should be directed with respect to nitrogen.

However, as reported by USEPA (2007b), while controlling one nutrient may potentially prevent productivity, control of both nutrients (nitrogen and phosphorus) in upstream waters can also provide additional assurance that excess productivity will remain in control. For example, under conditions of nitrogen limitation, even if local excess primary productivity is ultimately controlled to a large extent by nitrogen reduction alone, there will be consequent export of the excess nutrient, phosphorus, because the excess of that nutrient would not have the opportunity for uptake into biomass. The larger the excess of phosphorus in upstream systems is, the greater the contribution to potential phosphorus-sensitive downstream systems. Therefore, concurrent reduction of both nitrogen and phosphorus in a basin is often warranted in order to protect downstream use. More recently, USEPA provided further guidance on why the development of dual numeric criteria for both nitrogen and phosphorus can be an effective tool to protect beneficial uses of the nation's streams, lakes, estuaries, and coastal systems (USEPA, 2015).

5.13.2 Sunlight Availability (Turbidity & Canopy)

Because nutrients occur in such high water column concentrations in the TMDL project area, it is likely that nutrients do not limit biological productivity. Researchers who study Monterey Bay area watersheds have indicated that nutrients in streams and coastal waterbodies that receive agricultural drainage can saturate the productivity potential in downstream receiving waters, and thus is some cases sunlight availability is probably what actually limits productivity:

> *"...when nutrients are as high as they are in this system, talking about limiting nutrients probably isn't that relevant. In those cases,* ***light is probably what actually limits production*** *either* ***<u>because of turbidity</u>*** *which keeps overall biomass low or surface blooms which reduce light levels at depth."**
>
> **emphasis added*
> *— Dr. Jane Caffrey[140], estuarine researcher (University of West Florida), personal communication to Water Board staff, Sept. 12, 2011, regarding nutrient water quality in the streams and coastal waters of the lower Salinas Valley and Elkhorn Slough areas.*

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[139] See TetraTech (2004). *2004 Overview of Nutrient Criteria Development and Relationship to TMDLs*

[140] Dr. Caffrey has substantial research experience in Elkhorn Slough water quality issues and has published peer-reviewed literature on water quality issues pertaining to Elkhorn Slough and the lowermost Salinas Valley.

Further, during a presentation to Water Board staff in February 2012, scientists[141] who are currently researching algal response variables and biotic integrity in California central coast inland streams emphasized the “shading” effect water column turbidity has in relation to light availability and algal photosynthesis.

Accordingly, light availability is a response variable that should be considered in developing nutrient water column targets for biostimulatory impairments. Staff used the California Nutrient Numeric Endpoints Approach (Calif. NNE) in developing numeric targets for nutrients for this TMDL (see Section 6.3). It is important to recognize that the Calif. NNE spreadsheet tool is highly sensitive to user inputs for tree canopy shading and turbidity. Shading and turbidity have significant effects on light availability, and consequently photosynthesis and potential biostimulation. The light extinction coefficient is an important input parameter to the NNE spreadsheet tool. This coefficient is calculated in the spreadsheet as a function of turbidity. Higher levels of turbidity can preclude good sunlight penetration. Consequently, staff strongly took into account sunlight availability, and developed plausible approximations of spatial-variations in turbidity and canopy cover in the derivation of nutrient numeric targets (refer to Section 6.3).

5.13.3 Stream Flow & Aeration

Winter nutrient loads are often associated with higher velocity stream flows which are likely to scour filamentous algae and transport it out of the watershed. These higher flows also flush nutrient compounds through the watershed and ultimately into the ocean; in other words the residence time of nutrients in inland streams is typically shorter than in lakes, reservoirs, or other static waterbodies. Further, load duration analysis in this project report (refer back to Section 5.7) illustrates that water column nitrate and algal biomass (as represented by chlorophyll *a*) are typically more problematic during low-flow conditions in the Pajaro River basin, which is consistent with a flow-based and/or seasonal component to biostimulatory problems. In short, evidence of algal impairment is less conclusive for winter time and wet weather conditions, than for summer and dry season conditions.

However, there is some evidence of episodic excessive chlorophyll concentrations in the winter months. There is also substantial scientific uncertainty about the extent to which winter-time nitrogen phosphorus and nitrogen loads from valley floor and headwater reaches of the TMDL project area ultimately contribute to summer-time biostimulation problems in downstream receiving waterbodies. Loading during the winter months may have little effect on summer algal densities[142]. Alternatively, substantial internal loading of phosphorus and nitrogen in downstream and coastal confluence waterbodies may result over time from loads released from particulate matter, such as sediment or organic matter. The extent to which this sediment and organic matter-associated internal loading is consequential to summertime biostimulation problems in the TMDL project area or in downstream receiving waterbodies is currently uncertain. It is important to note that, in particular, phosphorus loads from headwater reaches which ultimately may be released from sediments when reduction-oxidation conditions changes may be a consequence of decades of natural loads that have nothing to do with current activities (personal communication, Dr. Marc Los Huertos, Oct. 17, 2011).

Therefore, to account for these uncertainties staff conclude that it is necessary to set numeric targets for winter months, but at this time these targets should be less stringent than dry-season nutrient targets in acknowledgement of these uncertainties. Previous California nutrient TMDLs[143] have similarly incorporated seasonal targets for nutrients for the same reasons. Seasonal biostimulatory nutrient targets are developed and presented in Section 6.3.

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[141] Dr. Scott Rollins (Spokane Falls Community College) and Dr. Marc Los Huertos (Calif. State University at Monterey Bay).

[142] State of Connecticut Dept. of Environmental Protection. 2005. A Total Maximum Daily Load Analysis for Linsley Pond in North Branford and Branford, Connecticut

5.14 Downstream Impacts

It is important to recognize that excess nutrients in inland streams which drain alluvial or headwater reaches will ultimately end up in a receiving body of water (lakes, estuaries, bays, etc.) where the nutrient concentrations and total load may degrade the water resource. The USEPA Scientific Advisory Board has stressed the importance of recognizing downstream impacts associated with excessive nutrients with respect to developing numeric nutrient concentration criteria for inland streams (USEPA, 2010, Worcester et al., 2010); further downstream impacts must be protected in accordance with federal water quality standards regulations[144]. Numeric targets developed for inland surface streams should generally be applied to also minimize downstream impacts of nutrients in receiving waterbodies, which are exhibiting signs of eutrophication. In other words, tributaries themselves may not exhibit routine or severe signs of biostimulation and eutrophication, but because they are feeding into a waterbody that is showing signs of eutrophication, the downstream effects of the tributaries should be considered.

The importance of considering downstream impacts was previously discussed in more detail in Section 3.13. Downstream impacts are considered in the context of assessing biostimulatory water quality problems in streams of the Pajaro River basin (see Section 5.15).

5.15 Assessment of Biostimulatory Impairments

Staff used a range of numeric water quality objectives and peer-reviewed biostimulatory numeric screening criteria specific to the Central Coast region (Worcester et al., 2010)[145] to assess Pajaro River basin waterbodies which may exhibit a range of indicators of biostimulation. These ranges of indicators collectively constitute a weight-of-evidence approach which demonstrates if and where biostimulatory conditions are impairing beneficial uses.

It is worth reiterating that elevated nutrients, in and of themselves, do not necessarily indicate biostimulation-eutrophication and impairment of beneficial uses (refer back to Section 3.1). A linkage between elevated nutrients and actual impairment of beneficial uses must be demonstrated; e.g. dissolved oxygen and/or pH imbalances and other water quality-aquatic habitat indicators. Note that the USEPA Science Advisory Board (2010) and Worcester et al. (2010) report that draft numeric targets for biostimulatory impairments may need to be supported with a weight of evidence approach, rather than stand-alone statistical methods. The weight of evidence approach could use other evidence of eutrophication; for example, presence and abundance of floating algal mats, water column chlorophyll a concentrations, evidence of oxygen depression and/or supersaturation, and pH over 9.5.

As such, staff used a wide range of Basin Plan numeric water quality objectives and peer-reviewed screening numeric criteria specific to the central coast region (Worcester et al., 2010) to assess the spatial distribution of biostimulatory effects and impairments in order to adequately determine where biostimulatory problems are being expressed in Pajaro River basin streams. Consistent with USEPA guidance, staff asserted biostimulatory impairment only where a waterbody exhibits a range of biostimulatory water quality indicators. Text Box 5-2 summarizes the range of biostimulatory indicators needed to assert biostimulatory impairment. The range of indicators in Text Box 5-2 thus constitute multiple lines of evidence, in a weight-of-evidence approach, to assess biostimulatory impairments.

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[144] 40 C.F.R. 131.10(b) states: *"In designating uses of a water body and the appropriate criteria for those uses, the state shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters."*

[145] Worcester, K., D. Paradies, and M. Adams. 2010. Interpreting Narrative Objectives for Biostimulatory Substances for California Central Coast Waters. California Surface Water Ambient Monitoring Technical Report, July 2010.

Text Box 5-2. Range of indicators needed to assert biostimulatory impairment problems.

Biostimulation Indicators
1) At least one line of evidence of dissolved oxygen problems – i.e., dissolved oxygen depletion and/or supersaturation (based on basin plan water quality objectives, and peer-reviewed numeric screening values) and/or wide diel swings in DO/pH;
2) At least one line of evidence indicating elevated algal biomass exceeding central coast reference conditions (peer-reviewed numeric screening criteria values for the central coast region, i.e., Worcester et al, 2010);
3) Evidence of elevated water column nutrients concentrations exceeding central coast reference conditions (e.g., Worcester et al., 2010); and
4) At least one additional line of evidence including photo documentation of excessive algal growth, or evidence of downstream nutrient impacts to a waterbody that does show multiple indicators of biostimulation problems (see Section 5.14– Downstream Impacts).
5) For stream reaches that do not exhibit the full range of biostimulatory indicators (bullets 1 through 4, above), but contain nutrient concentrations elevated above reference conditions and are discharging directly into a downstream waterbody that does show a full range of biostimulatory indicators, these stream reaches will be given a numeric target protective against the risk of potential biostimulation, and to protect against downstream impacts (as consistent with USEPA Scientific Advisory Board guidance).

On the basis of the information outlined above, Table 5-20 presents the numeric criteria and screening values used to assess the potential indicators of biostimulation.

In an effort to use a systematic and consistent approach in assessing potential for biostimulation impairments, staff organized bistimulatory criteria, approaches, and measures identified in Text Box 5-2 and in Table 5-20 into a tabular format, and accordingly Table 5-21 presents the biostimulatory assessment matrix for Pajaro River basin streams.

Table 5-20. Water quality objectives and screening criteria which can be used as indicators of biostimulation in a weight of evidence approach.

Water Quality Objectives (Regulatory Standards)		
Constituent Parameter	**Source of Water Quality Objective**	**Numeric Water Quality Objective**
Dissolved Oxygen	General Inland Surface Waters numeric objective	Dissolved Oxygen shall not be depressed below 5.0 mg/L Median values should not fall below 85% saturation.
	Basin Plan numeric objective WARM, COLD, SPWN	Dissolved Oxygen shall not be depressed below 5.0 mg/L (**WARM**) Dissolved Oxygen shall not be depressed below 7.0 mg/L (**COLD**, **SPWN**)
pH	General Inland Surface Waters numeric objective	pH value shall not be depressed below 7.0 or raised above 8.5.
	Basin Plan numeric objective MUN, AGR, REC1, REC-2	The pH value shall neither be depressed below 6.5 nor raised above 8.3.
	Basin Plan numeric objective WARM, COLD	pH value shall not be depressed below 7.0 or raised above 8.5
Biostimulatory Substances	Basin Plan General Objected for all Inland Surface Waters, Enclosed Bays, and Estuaries	Basin Plan narrative objective: *"Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses." (Basin Plan, Chapter 3)*
Additional Indicators Supporting Evidence for Biostimulation and Nutrient over-enrichment **(Many of these are NOT Regulatory Standards, and should not be used as stand-alone guidelines, but used collectively they can used in a weight of evidence approach for assessing the presence or absence of biostimulation problems)**		
Constituent – Parameter	**Source of Screening Criteria**	**Screening Criteria/Method**

Additional Indicators Supporting Evidence for Biostimulation and Nutrient over-enrichment

(Many of these are NOT Regulatory Standards, and should not be used as stand-alone guidelines, but used collectively they can used in a weight of evidence approach for assessing the presence or absence of biostimulation problems)

Constituent – Parameter	Source of Screening Criteria	Screening Criteria/Method
Wide diel swings in DO - pH	California 303(d) listing Policy [A]. Also, wide diel swings widely reported in scientific literature as indicating potential biostimulation and nutrient enrichment	Observational – compare diel swings to reference sites (reference sites show diel DO variation of less than 1 mg/L).
Low dissolved oxygen and/or oxygen super saturation	Basin Plan Objectives and California Surface Water Ambient Monitoring Program Technical Report [B]	1) Below Basin Plan Objectives: 7.0 mg/L (COLD, SPWN), or 5.0 mg/L (general objective); or below Basin Plan saturation objective of median 85% saturation; – and/or – 2) Exceeding 13 mg/L = evidence of supersaturated conditions and potential nutrient over-enrichment and biostimulation. Low DO or supersaturated DO conditions indicating potential biostimulatory impairments were asserted if exceedances of numeric screening values exceeding sample size and frequencies identified in Table 3.2 of the State Water Board Listing Policy (2004) [c]
Chlorophyll *a*	California Surface Water Ambient Monitoring Program Technical Report [B]	Exceeding 15 µg/L (central coast reference condition)= supporting evidence of potential nutrient over-enrichment and biostimulation.
Evidence of nitrogen enrichment relative to Central Coast reference conditions	California Surface Water Ambient Monitoring Program Technical Report [B]	NO3-N exceeding 1 mg/L (central coast reference condition) = evidence of nutrient enrichment. (Assessed using geomean of all samples at monitoring site. If site geomean > 1 mg/L, nitrogen enrichment is presumed).
Evidence of phosphorus enrichment relative to reference conditions	USEPA 75th percentile reference approach for streams (USEPA, 2000a)	1) Streams located in Monterey Bay Plains & Terraces and Santa Cruz Mountains Level IV ecoregions: Criteria = orthophosphate-P exceeding 0.14 mg/L is evidence of phosphorus enrichment. This value is equal to the 75th percentile of orthophosphate results from sampled stream reference background sites in these two Level IV ecoregions. (Assessed using geomean of all samples at monitoring site. If site geomean > 0.14 mg/L, phosphorus enrichment is presumed). – or – 2) Streams located in all other Level IV ecoregions in the Pajaro River basin: Criteria = orthophosphate-P exceeding 0.02 mg/L is evidence of phosphorus enrichment. This value is equal to the 75th percentile of orthophosphate results from sampled stream reference background sites in the Leeward Hills (Upper Santa Clara Valley), East Bay Hills, and Western Diablo range Level IV ecoregions. (Assessed using geomean of all samples at monitoring site. If site geomean > 0.02 mg/L, phosphorus enrichment is presumed). Notes: A separate orthophosphate numeric criteria was identified for the Monterey Bay Plains & Terraces and Santa Cruz Mountains area of the river basin because parts of this area are associated with a different Level III ecoregion than the rest of the river basin (refer back to Figure 3-19) and geologic conditions may be locally conducive to higher phosphorus inputs in this area (refer back to report Section 3.10). Refer back to Figure 3-17 for a map of Level IV ecoregions in the Pajaro River basin. Refer back to report Section 3.6 for information about stream reference background conditions in the Pajaro River basin.
Percent Floating Algal Cover	California Surface Water Ambient Monitoring Program Technical Report [B]	One or more observances of 50% cover or greater represents supporting evidence of potential nutrient over-enrichment and biostimulation.
Photo evidence of nuisance algae	—	Photo documentation of nuisance algae and aquatic plant growth, etc.
Fish Kills	—	Visual evidence or reporting of fish kills likely or possibly related to dissolved oxygen problems. *Note: based on a cursory review, staff wre unable to locate published reports of fish kills in the Pajaro River basin.*

Additional Indicators Supporting Evidence for Biostimulation and Nutrient over-enrichment

(Many of these are NOT Regulatory Standards, and should not be used as stand-alone guidelines, but used collectively they can used in a weight of evidence approach for assessing the presence or absence of biostimulation problems)

Constituent − Parameter	Source of Screening Criteria	Screening Criteria/Method
Downstream Impacts	USEPA Scientific Advisory Board (2010) This scientific advisory board stressed the importance of recognizing downstream impacts in the context of nutrient pollution[D]	Observational: assess whether a stream reach exhibiting elevated nutrient concentrations (> 1mg/L NO3-N; see nutrient enrichment screening criteria above) has downstream outlet discharging directly into waterbody which shows evidence of biostimulation problems (as indicated by screening values weight of evidence in this Table). Note: special consideration could be given to protecting designated California Critical Coastal Areas [E] (CCAs) from nutrient pollution in streams that flow into the CCAs. CCAs are an administrative, non-regulatory designation for coastal waterbodies that need protection from polluted runoff.

[A] State Water Resources Control Board. 2004. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List, sometimes refered to more concisely as as the "Calfiornia 303(d) Listing Policy. Section 3.2 of the California 303(d) Listing Policy states that wide diel fluctuations in dissolved oxygen shall be assumed to result from nutrient-enrichment if other pertinent factors can be ruled out as controlling dissolved oxygen fluctuations.

[B] Worcester, K., D. M. Paradies, and M. Adams. 2010. Interpreting Narrative Objectives for Biostimulatory Substances for California Central Coast Waters. Surface Water Ambient Monitoring Program (SWAMP) Technical Report, July 2010.

[C] State Water Resources Control Board. 2004. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List, Table 3.2.

[D] USEPA Science Advisory Board Review of "Empirical Approaches for Nutrient Criteria Derivation". U.S Environmental Protection Agency. April 27, 2010.

[E] See California Coastal Commission, Critical Coastal Areas Program.

Table 5-21. Biostimulation assessment matrix for streams of the Pajaro River basin.

Stream Reach	**DO Problems**		**Nutrient Enrichment**		**Elevated Algal Biomass**		**Other Indicators of Biostimulation Problems**		**Biostimulation Impairment in Stream Reach?**
	Diel DO Swings?	**Low DO?** **DO super-saturation?**	**Nitrate-N exceeding reference conditions?**	**Ortho-phosphate-P exceeding reference conditions?**	**Chlorophyll-*a* exceeding reference conditions?**	**Excess floating algal cover (≥50% cover)?**	**Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?**	**Photo documentation of excessive algal biomass/aquatic plant growth?**	
Pajaro River Estuary (Lower) @ 306PJE_L	**No data**	**Yes** **No**	**No**	**Yes** ***(note: orthophosphate was not reported but total phosphate as P was quite elevated – 0.58 mg/L)***	**No data**	**No data**	**No** **This estuary site is the farthest downstream coastal location for surface waters of the river basin** ***(note: nearshore marine waters of Monterey Bay may be episodically adversely impacted by nutrient discharges from Monterey Bay watersheds)***	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems** ***(note: observation of low dissolved oxygen problems, elevated nutrients, historical reporting of excess algae in the estuary, and the estuary's administrative status as a California Critical Coastal Area, does merit the consideration of protecting the estuary from upstream nutrient enrichment)***
Pajaro River Estuary (Upper) @ 306PJE_U	**No data**	**Yes** **No**	**Yes**	**Yes** ***(note: orthophosphate was not reported but total phosphate as P was quite elevated – 0.67 mg/L)***	**No data**	**No data**	**No** **This estuary site is the farthest downstream coastal location for surface waters of the river basin** ***(note: nearshore marine waters of Monterey Bay may be episodically adversely impacted by nutrient discharges from Monterey Bay watersheds)***	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems** ***(note: observation of low dissolved oxygen problems, elevated nutrients, historical reporting of excess algae in the estuary, and the estuary's administrative status as a California Critical Coastal Area, does merit the consideration of protecting the estuary from upstream nutrient enrichment)***

Stream Reach	DO Problems		Nutrient Enrichment		Elevated Algal Biomass		Other Indicators of Biostimulation Problems		Biostimulation Impairment in Stream Reach?
	Diel DO Swings?	Low DO? DO super-saturation?	Nitrate-N exceeding reference conditions?	Ortho-phosphate-P exceeding reference conditions?	Chlorophyll-*a* exceeding reference conditions?	Excess floating algal cover (≥50% cover)?	Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?	Photo documentation of excessive algal biomass/aquatic plant growth?	
Pajaro River @305THU (Thurwatcher Bridge)	Yes	Yes No	Yes	No	Yes	Yes	No *(note: while there is no direct evidence of a downstream biostimulation impairment, observation of low dissolved oxygen problems, elevated nutrients, and historical reporting of excess algae in the Pajaro River estuary does merit the consideration of protecting the estuary from upstream nutrient enrichment)*	Yes	Yes
Pajaro River @ 305PJP (Porter Road)	No data	Yes No	Yes	No	No	No	Yes biostimulation observed in lower reaches of Pajaro River downstream of Watsonville	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to lower reaches of the Pajaro River are present.
Pajaro River @ 305MUR (Murphy's Crossing)	Yes (however, the diel swing is fairly moderate)	No No	Yes	No	Yes	No	Yes biostimulation observed in lower reaches of Pajaro River downstream of Watsonville	No	No – based on dissolved oxygen problems not being expressed; however, downstream nutrient impacts to lower reaches of the Pajaro River are present.
Pajaro River @ 305CHI (Chittenden Gap)	No	No No	Yes	No	Yes	No	Yes biostimulation observed in lower reaches of Pajaro River downstream of Watsonville	No	No – based on dissolved oxygen problems not being expressed; however, downstream nutrient impacts to lower reaches of the Pajaro River are present.
Pajaro River @ 305 PAJ (Betabel Road)	No data	Yes No	Yes	Yes	Yes	No	Yes biostimulation observed in lower reaches of Pajaro River downstream of Watsonville	No	Yes

Stream Reach	DO Problems		Nutrient Enrichment		Elevated Algal Biomass		Other Indicators of Biostimulation Problems		Biostimulation Impairment in Stream Reach?
	Diel DO Swings?	Low DO? DO super-saturation?	Nitrate-N exceeding reference conditions?	Ortho-phosphate-P exceeding reference conditions?	Chlorophyll-*a* exceeding reference conditions?	Excess floating algal cover (≥50% cover)?	Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?	Photo documentation of excessive algal biomass/aquatic plant growth?	
Watsonville Slough @305-WATSO-23 (at Beach Road)	**No data**	**Yes** **No**	**Yes**	**Yes**	**No data**	**No data**	**No** ***(note: while there is no direct evidence of a downstream biostimulation impairment, observation of low dissolved oxygen problems, elevated nutrients, and historical reporting of excess algae in the Pajaro River estuary does merit the consideration of protecting the estuary from upstream nutrient enrichment from Watsonville Slough)***	**Yes**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems** ***(note: observation of low dissolved oxygen problems, elevated nutrients, and the administrative status of Watsonville Slough and the downstream receiving waters of the Pajaro River Estuary as a California Critical Coastal Area, does merit the consideration of protecting the estuary from upstream nutrient enrichment)***
Watsonville Slough @ 305WSA (upstream of Harkins Slough)	**No data**	**Yes** **No**	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**Yes**
Harkins Slough	**No data**	**Yes** **No**	**Yes** ***(nitrate is relatively low, but totally nitrogen is elevated with a geometric mean of 2.94 mg/L; therefore nitrogen is presumed to exceed reference conditions)***	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**

Stream Reach	DO Problems		Nutrient Enrichment		Elevated Algal Biomass		Other Indicators of Biostimulation Problems		Biostimulation Impairment in Stream Reach?
	Diel DO Swings?	Low DO? DO super-saturation?	Nitrate-N exceeding reference conditions?	Ortho-phosphate-P exceeding reference conditions?	Chlorophyll-*a* exceeding reference conditions?	Excess floating algal cover (≥50% cover)?	Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?	Photo documentation of excessive algal biomass/aquatic plant growth?	
Gallighan Slough	**No data**	**No data** **No data**	**Yes**	**No**	**No data**	**No data**	**Yes** **biostimulation observed in Harkins Slough and Watsonville Slough**	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems and based on lack of data to confirm whether or not dissolved oxygen problems are being expressed; however, downstream nutrient impacts to Harkins Slough and Watsonville Slough can be present.**
Hanson Slough	**No data**	**Insufficient data *(only four samples)***	**No data**	**No data**	**No data**	**No data**	**Insufficient data to assess**	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems and based on lack of data to confirm whether or not dissolved oxygen problems are being expressed**
Struve Slough	**No data**	**Yes** **No**	**Yes** ***(nitrate is relatively low, but totally nitrogen is elevated with a geometric mean of 1.92 mg/L; therefore nitrogen is presumed to exceed reference conditions)***	**Yes**	**Yes**	**No**	**Yes** **biostimulation observed in Watsonville Slough**	**No**	**Yes**
West Branch of Struve Slough	**No data**	**Yes** **No**	**No**	**Insufficient data (only three samples)**	**No data**	**No data**	**Insufficient data to assess**	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems and based on lack of data to confirm whether or not dissolved oxygen problems are being expressed**

Stream Reach	**DO Problems**		**Nutrient Enrichment**		**Elevated Algal Biomass**		**Other Indicators of Biostimulation Problems**		**Biostimulation Impairment in Stream Reach?**
	Diel DO Swings?	**Low DO?** **DO super-saturation?**	**Nitrate-N exceeding reference conditions?**	**Ortho-phosphate-P exceeding reference conditions?**	**Chlorophyll-*a* exceeding reference conditions?**	**Excess floating algal cover (≥50% cover)?**	**Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?**	**Photo documentation of excessive algal biomass/aquatic plant growth?**	
Beach Road Ditch @ 305-BEACH-21 (Beach Road)	**No data**	**Yes** **Yes**	**Yes**	**No**	**No data**	**No data**	**No** ***(note: while there is no direct evidence of a downstream biostimulation impairment, observation of low dissolved oxygen problems, elevated nutrients, and historical reporting of excess algae in the Pajaro River estuary does merit the consideration of protecting the estuary from upstream nutrient enrichment)***	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problem however, downstream nutrient impacts to lower reaches of the Pajaro River can be present.** ***(note: observation of low dissolved oxygen problems, elevated nutrients, and the administrative status of the Pajaro River Estuary and the Watsonville Slough as California Critical Coastal Areas, does merit the consideration of protecting the estuary from upstream nutrient enrichment)***
Beach Road Dtich @BR_THU (Thuwatcher Bridge)	**No data**	**Yes** **No**	**Yes**	**Yes**	**No data**	**No data**	**No** ***(note: while there is no direct evidence of a downstream biostimulation impairment, observation of low dissolved oxygen problems, elevated nutrients, and historical reporting of excess algae in the Pajaro River estuary does merit the consideration of protecting the estuary from upstream nutrient enrichment)***	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problem however, downstream nutrient impacts to lower reaches of the Pajaro River can be present.** ***(note: observation of low dissolved oxygen problems, elevated nutrients, and the administrative status of the Pajaro River Estuary and the Watsonville Slough as California Critical Coastal Areas, does merit the consideration of protecting the estuary from upstream nutrient enrichment)***

Stream Reach	DO Problems		Nutrient Enrichment		Elevated Algal Biomass		Other Indicators of Biostimulation Problems		Biostimulation Impairment in Stream Reach?
	Diel DO Swings?	Low DO? DO super-saturation?	Nitrate-N exceeding reference conditions?	Ortho-phosphate-P exceeding reference conditions?	Chlorophyll-*a* exceeding reference conditions?	Excess floating algal cover (≥50% cover)?	Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?	Photo documentation of excessive algal biomass/aquatic plant growth?	
McGowan Ditch @305MDD (confluence w/ lower Pajaro River)	No data	No No data	Yes	Insufficient data (only one sample)	No data	No data	Yes biostimulation observed in lower reaches of Pajaro River downstream of Watsonville	No	No – based on dissolved oxygen problems not being expressed, and based on lack of data to confirm the presence or absence of excess algal biomass problems; however, downstream nutrient impacts to lower reaches of the Pajaro River are present.
Salsipuedes Creek @305COR (Hwy 129)	No data	Yes No	Yes	No	No	No	Yes biostimulation observed in lower reaches of Pajaro River downstream of Watsonville	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to lower reaches of the Pajaro River can be present.
Corralitos Creek @305-SALSI-21 (East Lake Ave. Bridge)	No data	Yes No	Yes	No	No data	No data	Yes biostimulation observed in lower reaches of Pajaro River downstream of Watsonville	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to lower reaches of the Pajaro River can be present.
Corralitos Creek @CO_BVR (Brown Valley Road)	No	No No	No	No	No	No	No	No	No
Carnadero Creek @ 305CAR	No data	Yes No	Yes	Yes	No	Yes	No *(note: while there is no evidence of a biostimulation impairment directly downstream in the receiving waters of the upper Pajaro River, biostimulation is observed farther downstream in lower reaches of Pajaro River downstream of Watsonville)*	No	Yes

Stream Reach	DO Problems		Nutrient Enrichment		Elevated Algal Biomass		Other Indicators of Biostimulation Problems		Biostimulation Impairment in Stream Reach?
	Diel DO Swings?	Low DO? DO super-saturation?	Nitrate-N exceeding reference conditions?	Ortho-phosphate-P exceeding reference conditions?	Chlorophyll-*a* exceeding reference conditions?	Excess floating algal cover (≥50% cover)?	Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?	Photo documentation of excessive algal biomass/aquatic plant growth?	
Carnadero Creek @ 305CAN (Hwy 25)	No data	Yes No	Yes	No	No	No	No	No	No - - based on algal biomass problems not being expressed; however, downstream nutrient impacts to lower Carnedero Creek is present.
Uvas Creek @ 305UVA (Bloomfield Ave.)	No data	No No	No	Yes	No	No	No	No	No
Llagas Creek @ 305LLA (Bloomfield Ave.)	No	Yes Yes	Yes	Yes	No	No	Yes biostimulation observed in reaches of the upper Pajaro River (see site 305PAJ)	Yes	Yes
Llagas Creek @ 305LUC (Southside)	No data	Yes Yes	Yes	Yes	No	No	Yes biostimulation observed in lower reaches of Llagas Creek and in reaches of the upper Pajaro River	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to lower reaches of Llagas Creek and to reaches of the upper Pajaro River is present.
Llagas Creek @305LHB (Hwy 125)	No data	Yes Yes	Yes	Yes	No	No data	Yes biostimulation observed in lower reaches of Llagas Creek and in reaches of the upper Pajaro River	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to lower reaches of Llagas Creek and to reaches of the upper Pajaro River is present.
Llagas Creek @305HOL (Holsclaw Rd.)	No data	Yes Yes	Yes	No	Yes	No data	Yes biostimulation observed in lower reaches of Llagas Creek and in reaches of the upper Pajaro River	No	Yes
Llagas Creek at 305LEA (Leavesley Rd.)	No data	No No	No	Yes	No	Yes	Yes biostimulation observed in lower reaches of Llagas Creek and in reaches of the upper Pajaro River	No	No – based on dissolved oxygen problems not being expressed; however, downstream nutrient impacts to lower reaches of Llagas Creek and to reaches of the upper Pajaro River is present.

Stream Reach	DO Problems		Nutrient Enrichment		Elevated Algal Biomass		Other Indicators of Biostimulation Problems		Biostimulation Impairment in Stream Reach?
	Diel DO Swings?	Low DO? DO super-saturation?	Nitrate-N exceeding reference conditions?	Ortho-phosphate-P exceeding reference conditions?	Chlorophyll-*a* exceeding reference conditions?	Excess floating algal cover (≥50% cover)?	Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?	Photo documentation of excessive algal biomass/aquatic plant growth?	
Furlong Creek @305FUF (Frazier Lake Rd.)	**No**	**No** **No**	**Yes**	**Yes**	**No**	**No**	**Yes** **biostimulation observed in lower reaches of Llagas Creek and in reaches of the upper Pajaro River**	**No**	**No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to lower reaches of Llagas Creek and to reaches of the upper Pajaro River is present.**
Miller's Canal @ 305FRA (Frazier Lake Rd.)	**No**	**No** **No**	**No**	**Yes**	**Yes**	**No**	**Yes** **biostimulation observed in reaches of the upper Pajaro River (see site 305PAJ)**	**No**	**No – based on dissolved oxygen problems not being expressed; however, downstream nutrient impacts to the upper Pajaro River is present.**
San Juan Creek @SJ_101 (Hwy 101)	**No data**	**Yes** **No**	**Yes**	**Yes**	**No data**	**No data**	**Yes** **biostimulation observed downstream in lower reaches of Pajaro River downstream of Watsonville**	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems; however, downstream nutrient impacts to the lower Pajaro River is present.**
San Juan Creek @ 305SJN (Anzar Rd.)	**Yes**	**No** **No**	**Yes**	**Yes**	**No**	**Yes**	**Yes** **biostimulation observed downstream in lower reaches of Pajaro River downstream of Watsonville**	**No**	**Yes**
San Juan Creek @ 305PRR (Prescott Rd.)	**No data**	**No** **Yes**	**Yes**	**Yes**	**No**	**No data**	**Yes**	**No**	**No – based on lack of data to confirm the presence or absence of excess algal biomass problems; however, downstream nutrient impacts to the lower Pajaro River is present.**
San Juan Creek @ 305MVR (Mission Vineyard Rd.)	**No data**	**No** **No**	**Yes**	**Yes**	**Yes**	**No data**	**Yes**	**No**	**No – based on dissolved oxygen problems not being expressed; however, downstream nutrient impacts to the upper Pajaro River is present.**

Stream Reach	DO Problems		Nutrient Enrichment		Elevated Algal Biomass		Other Indicators of Biostimulation Problems		Biostimulation Impairment in Stream Reach?
	Diel DO Swings?	Low DO? DO super-saturation?	Nitrate-N exceeding reference conditions?	Ortho-phosphate-P exceeding reference conditions?	Chlorophyll-*a* exceeding reference conditions?	Excess floating algal cover (≥50% cover)?	Downstream nutrient impacts to a surface waterbody exhibiting biostimulation?	Photo documentation of excessive algal biomass/aquatic plant growth?	
San Benito River @ 305SAN (Y Rd.)	No	No No	No	No	No	No	No	No	No
Tequisquita Slough @305TES (Shore Rd.)	No data	Yes No	No	Yes	Yes	No	No we do not currently have data to indicate whether or not biostimulation is a problem in the downstream receiving waters of San Felipe Lake	Yes	Yes
Pacheco Creek @305PACLOV (Lover's Lane)	No data	Yes No	No	Yes	No data	No data	No we do not currently have data to indicate whether or not biostimulation is a problem in the downstream receiving waters of San Felipe Lake	No	No – based on lack of data to confirm the presence or absence of excess algal biomass problems
Pachecho Creek @ 305PAC (HWY 156)	No data	Yes No	Yes	Yes	No	No	No	No	No – based on excess algal biomass problems problems not being expressed

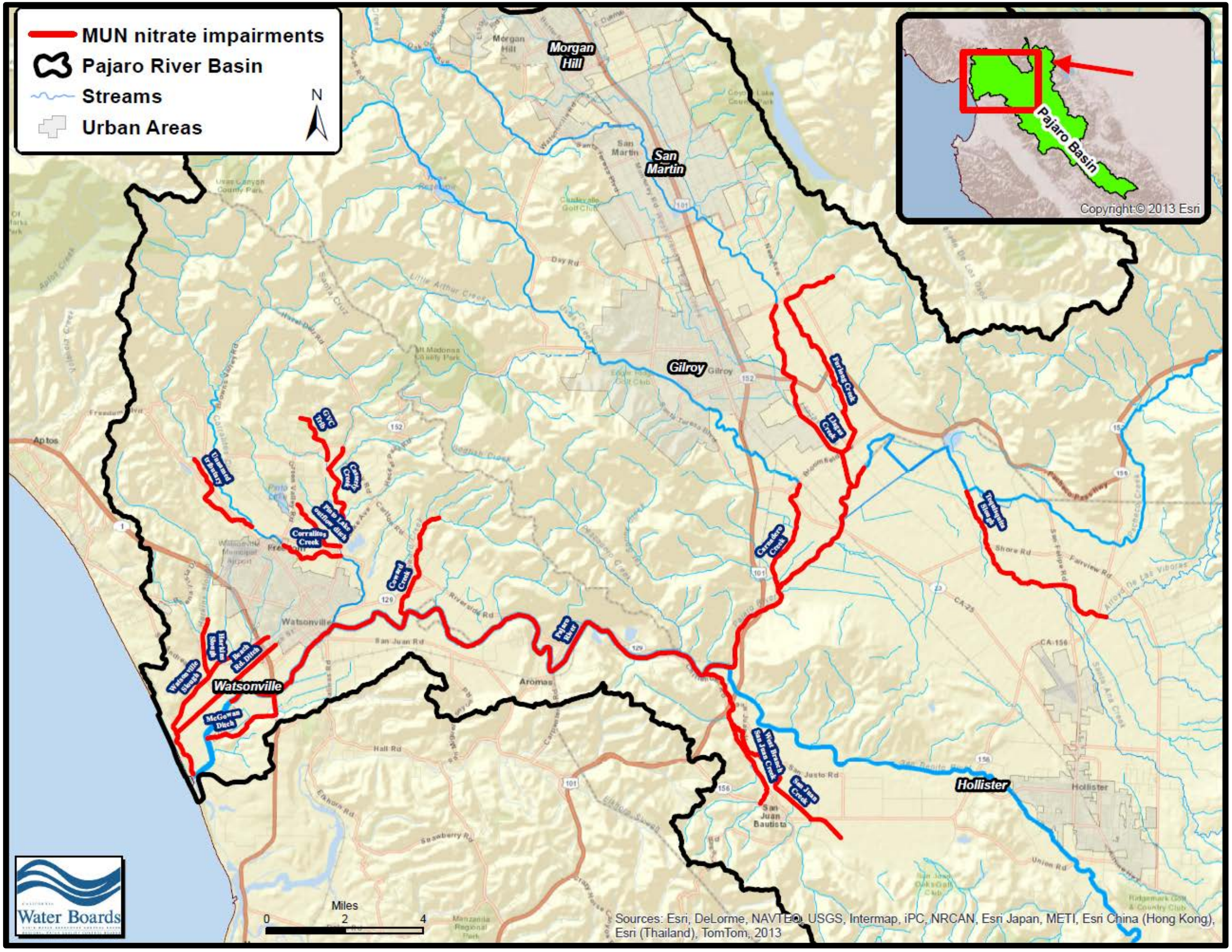
5.16 Maps & Summaries of Nutrient-Related Stream Impairments

The standards and water quality objectives being used to assess water quality conditions were previously presented in Table 4-2. Summary statistics of water quality parameters and exceedance frequencies as compared to numeric water quality objectives were previously presented in Section 5.11. Then these exceedance frequencies are compared to the guidelines in the California Listing Policy (refer back to Section 4.4) to determine impairment status. In addition, the numeric criteria and indicators used to assess the Basin Plan's narrative water quality objective for biostimulatory substances were previously presented in Section 5.15. On the basis of these data and assessment methodologies, the identified surface water quality impairments are summarized in Sections 5.16.7 through 5.16.7 below.

5.16.1 Map of Nitrate Impairments of Human Health Standard

Figure 5-73 illustrates the spatial distribution of MUN-designated stream reaches impaired for the nitrate as N drinking water standard (MUN).

Figure 5-73. Nitrate impairments of designated drinking water supply (MUN) uses.

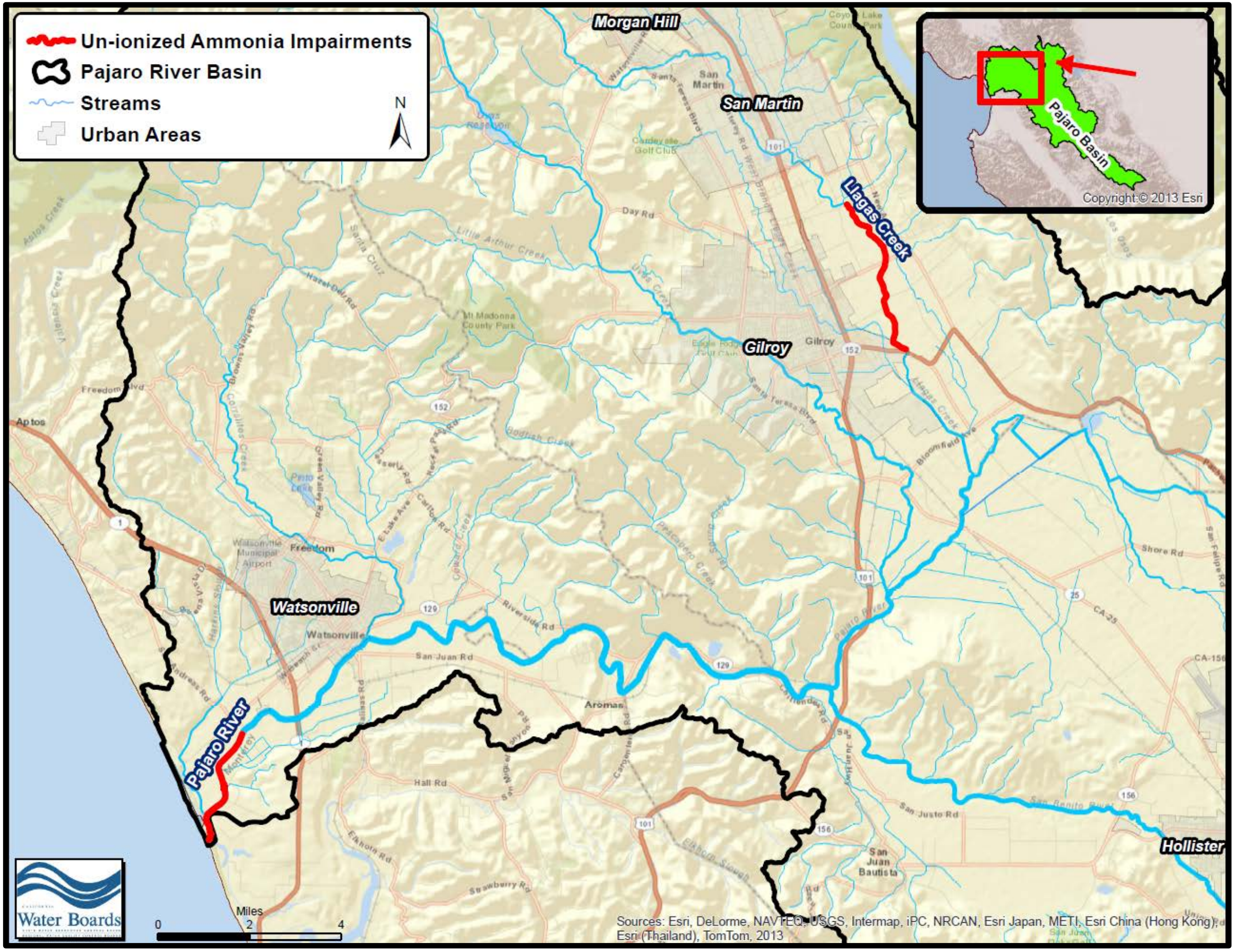


Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

5.16.2 Map of Un-ionized Ammonia Impairments

Figure 5-74 illustrates the spatial distribution of stream reaches impaired by toxicity associated with elevated levels of un-ionized ammonia.

Figure 5-74. Stream reaches impaired by toxicity due to un-ionized ammonia.

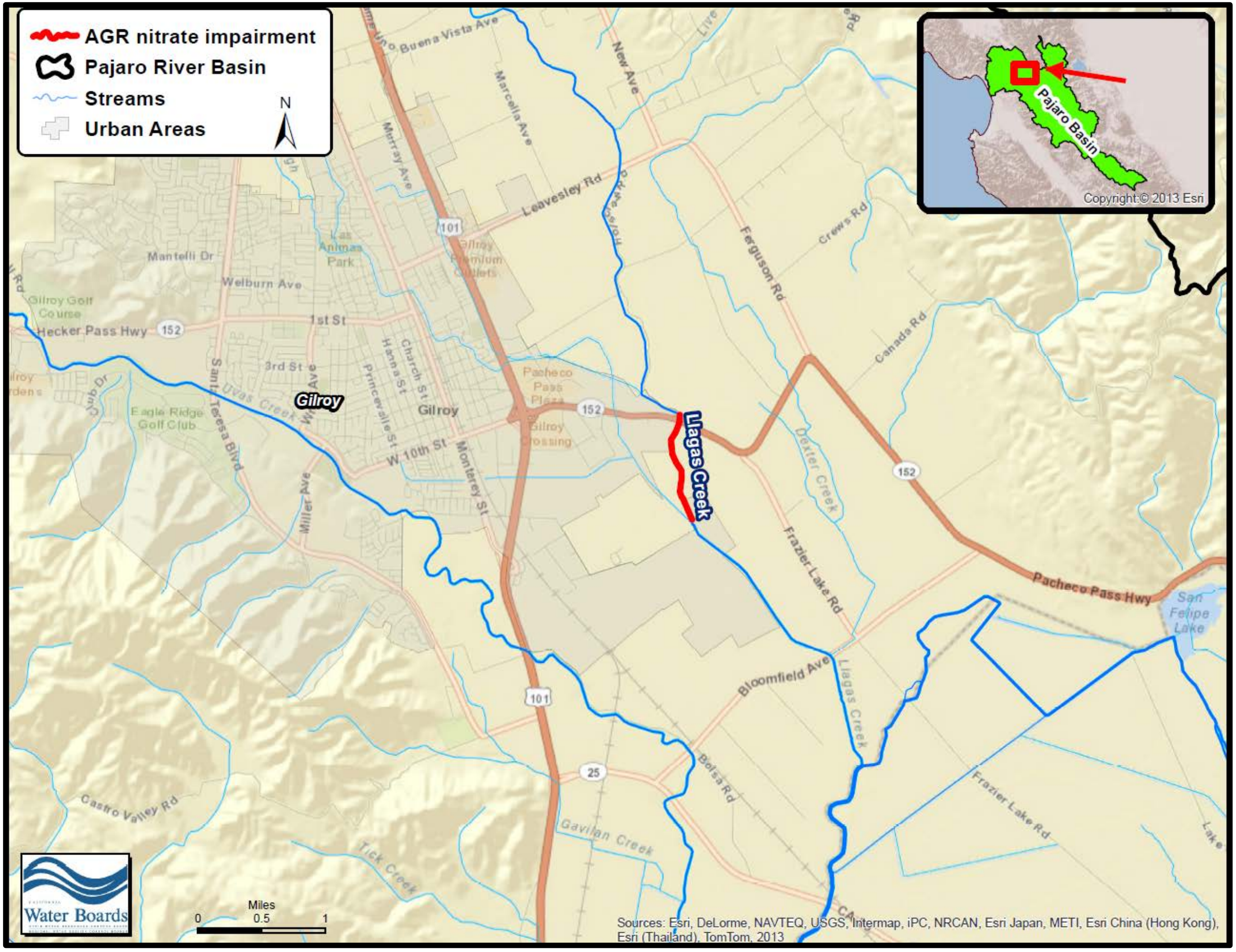


Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

5.16.3 Map of Nitrate Impairments of Agricultural Supply Guideline

Figure 5-75 illustrates the spatial distribution of AGR-designated stream reaches impaired for the nitrate as N agricultural supply (irrigation water watering) criterion (AGR).

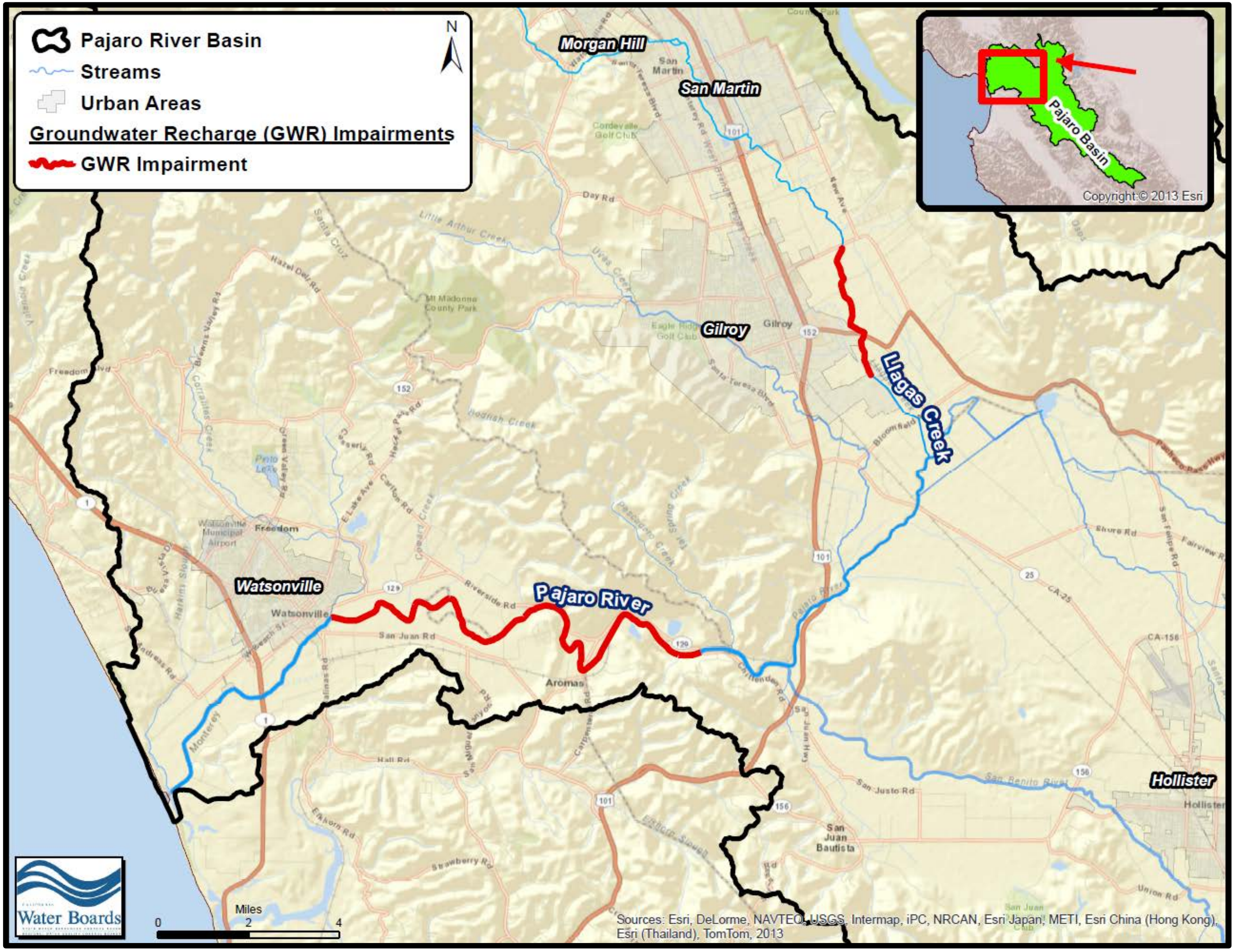
Figure 5-75. Nitrate impairment of designated agricultural supply (AGR) uses.



5.16.4 Map of Nitrate Impairments of Designated Groundwater Recharge Use

Figure 5-76 illustrates the spatial distribution of nitrate impairments of stream reaches designated for groundwater recharge (GWR) beneficial uses.

Figure 5-76. Nitrate impairments of stream reaches designated for groundwater recharge (GWR) uses.

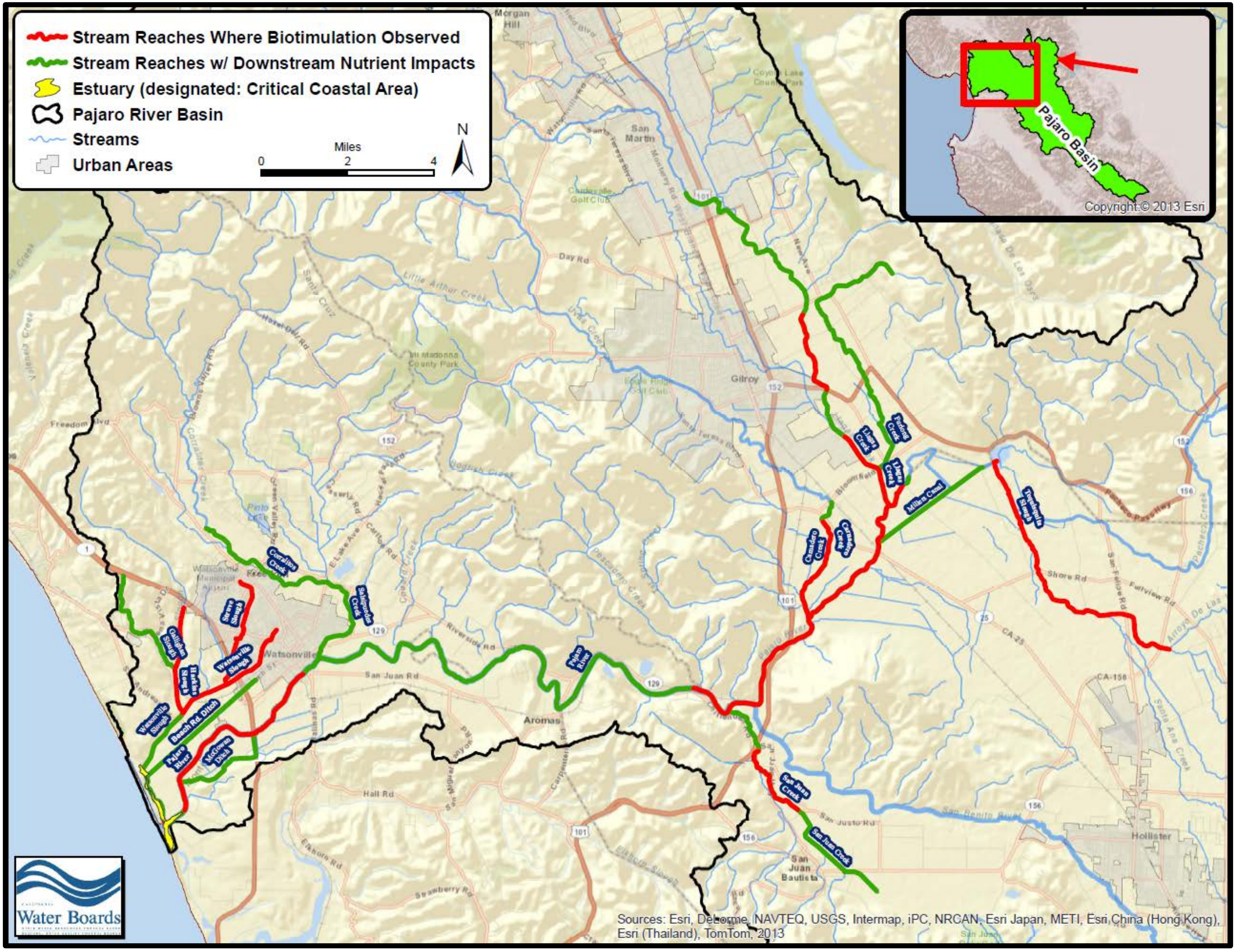


Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

5.16.5 Map of Biostimulatory Impairments (nutrients, chlorophyll-a, microcystins & low DO)

Figure 5-77 illustrates the spatial distribution of biostimulatory impairments in the Pajaro River basin on the basis of the biostimulation indicators previously presented in Section 5.15 and the biostimulation assessment matrix (refer back to Table 5-21). The extent of impairment shown on this map includes downstream impacts; i.e., stream reaches that are nutrient-enriched and yet do not show signs of biostimulation, but they flow downstream and discharge their nutrient loads into receiving waters where biostimulation problems are observed (refer to "downstream impacts" articulated previously in report Section 3.13).

Figure 5-77. Stream reaches exhibiting biostimulatory impairments (elevated nutrients + dissolved oxygen problems + elevated algal biomass, and including downstream nutrient impacts).



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

5.16.6 Map of Assessed High Quality Waters (anti-degradation issues)

While improvements to impaired waters is a goal of TMDLs, protection of existing high quality waters and prevention of any further degradation is also high priority for the Central Coast Water Board, and can be identified as a consideration in TMDLs (refer back to report Section 4.3). As articulated in the Central Coastal Basin Plan, anti-degradation is a stand-alone water quality objective in its own right (see Chapter 3 Section II.A. of the Central Coastal Basin Plan). For purposes of anti-degradation policy, "high quality waters" are defined on a constituent-by-constituent basis[146,147]. Therefore, in the context of the anti-degradation policy, a waterbody can be a high quality water for one constituent, but not for another.

From the water quality management perspective, it is simply not enough to improve impaired waters – protection of existing high quality waters and prevention of any further water quality degradation should be identified as a high priority goal[148]. Simply put, TMDL implementation efforts are justified in considering improved protection of high quality waters and addressing anti-degradation concerns, as well as focusing on improving impaired stream reaches.

> *"States can prepare TMDLs geared towards maintaining a "better than water quality standard" condition for a given waterbody-pollutant combination, and they can be a useful tool for high quality waters."*
>
> From: USEPA, 2014a. Opportunities to Protect Drinking Water Sources and Advance Watershed Goals Through the Clean Water Act: A Toolkit for State, Interstate, Tribal and Federal Water Program Managers. A State-USEPA collaboration initiative, November 2014.

Figure 5-78 illustrates assessed high quality waters in the Pajaro River basin on the basis of nutrient pollution on the basis of available water quality data. Undoubtedly, there are additional high quality water stream reaches that do not currently have water quality data.

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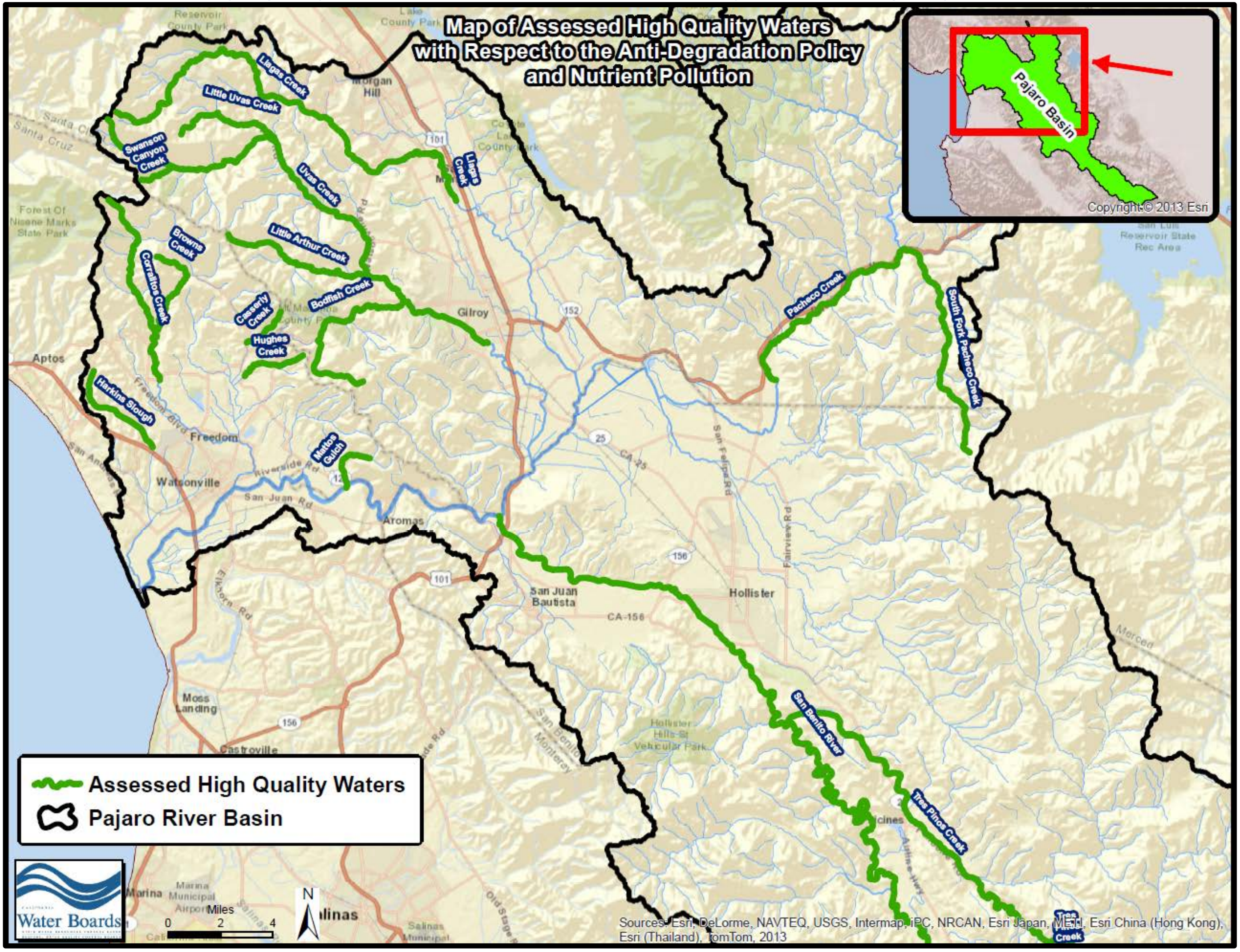
[146] See: State Water Resources Control Board (2008), *Water Quality Standards Academy, Basic Course, Module 14*. Presented by U.S. Environmental Protection Agency, Region 9 – Office of Science and Technology (May 12, 2008).

[147] Court of Appeal of the State of California Third Appellate District, Asocacion De Gente Unida Por El Agua et al. v. Central Valley Regional Water Quality Control Board (Super. Ct. No. 34-2008-00003604CU-WM-GDS).

[148] The Central Coast Water Board considers *preventing* impairment of waterbodies to be as important a priority as *correcting* impairments of waterbodies (see staff report for agenda item 3, July 11, 2012 Water Board meeting).

Figure 5-78. Map of assessed high quality waters, on the basis of nutrient pollution, in the Pajaro River basin. For purposes of anti-degradation policy, “high quality waters” are defined on a constiuent-by-constituent basis. This map illustates high quality waters on the basis of available data. It does not imply these are the only high quality waters in the river basin, with respect to nutrient pollution. Undoubtedly, there are other high quality stream reaches that do not currently have water quality data.



5.16.7 Tabular Summaries of All Identified Impairments

Table 5-22 presents a status summary of potential impairments of designated beneficial uses of surface waters in the Pajaro River basin. Table 5-23 presents all waterbody/pollutant combinations addressed in this TMDL report. It is important to note that there remains uncertainty about the spatial extent of impairments, or how far upstream the impairments extend for some individual stream reaches. However, the Central Coast Water Board protocol is to conservatively and presumptively presume that an identified impairment could reach all upstream reaches and tributaries, pending acquisition of further information or data to rule out upstream impairments. The pollutants addressed in this TMDL are nitrate, un-ionized ammonia, and orthophosphate – orthophosphate is included as a pollutant due to biostimulatory impairments of surface waters. Reducing these pollutants is also anticipated to address several 303(d)-listed dissolved oxygen and chlorophyll *a* impairments in the Pajaro River basin, as shown in Table 5-23.

Table 5-22. Status summary of Pajaro River basin designated beneficial uses of streams that could potentially be impacted by nutrient pollution.

Designated Beneficial Use	**Water Quality Objective, or recommended level [A]**	**Beneficial Use Impaired?[B]**	**Stream Reaches Impacted**
MUN (drinking water supply)	10 mg/L (nitrate as N)	Yes	Beach Road Ditch, Carnadero Creek, Casserly Creek, Corralitos Creek, Unnamed tributary to Corralitos Creek, Coward Creek, Furlong Creek, Tributary to Green Valley Creek, Harkins Slough, Llagas Creek, McGowan Ditch, Pajaro River, Pinto Lake outflow Ditch, San Juan Creek, West Branch San Juan Creek, Watsonville Slough (See Table 5-23 for more information)
AGR (irrigation water supply)	30 mg/L (nitrate as N) *(for sensitive crops)*	Yes[C]	Llagas Creek, *from upstream of Luchessa Ave at Southside Dr. to Llagas Creek at Highway 152.*
AGR (livestock watering)	100 mg/L (nitrate as N)	No	All assessed stream reaches in the Pajaro River basin are supporting the nitrate as N livestock water quality objective on the basis of available data.
GWR (groundwater recharge)	10 mg/L (nitrate as N) in conjunction with situation specific lines of evidence [D]	Yes	Pajaro River *from upstream of City of Watsonville to downstream of Chittenden Gap at Chittenden Road.* Lower Llagas Creek *from upstream of Southside Drive to downstream of Leavesley Road.*
Aquatic Habitat beneficial uses (WARM, COLD, SPWN)	Basin Plan's biostimulatory substances objective expressed as: nitrate as N and total nitrogen as N: 1.1 mg/L to 8.0 mg/L orthophosphate as P: 0.04 mg/L to 0.3 mg/L	Yes[E]	Beach Road Ditch, Carnadero Creek, Corralitos Creek, Furlong Creek, Llagas Creek, Pajaro River, San Juan Creek, Tequisquita Slough, Watsonville Slough (See Table 5-21 for more information)
Aquatic Habitat beneficial uses (WARM, COLD, SPWN)	Un-ionized ammonia Basin Plan objective 0.025 mg/L	Yes	Pajaro River estuary and the lower Pajaro River *from the estuary to downstream of Thurwatcher Rd.* Lower Llagas Creek *from upstream of Holsclaw Rd. to downstream of Buena Vista Rd.*
REC-1 (water contact recreation)	0.8 μg/L microcystins [F]	No[G]	Insufficient microcystin data currently available to assess streams of the Pajaro River basin, and therefore no impairments are identified at this time.

[A] Refer to Table 4-2 and Table 5-20

[B] Based on exceedance frequencies published in the California 303(d) Listing Policy - see Table 4-3

[C] The University of California Agricultural Extension Service guideline values are flexible, and may not necessarily be appropriate due to local or special conditions of crop, soil, and method of irrigation. Staff conservatively selected the uppermost threshold value (30 mg/L) which therefore conservatively identifies stream reaches where the designated AGR use may be detrimentally impacted.

[D] Refer to Section 5.10 and the California Listing Policy Section 3.11 (State Water Board, 2004)

[E] Biostimulatory impairments include both stream reaches that are expressing a range of biostimulation-eutrophication indicators, and stream reaches that are contributing to downstream biostimulation impairment. Note that States must address downstream pollution impacts to receiving waters in accordance with federal regulations – 40 C.F.R. 131.10(b)

[F] OEHHA public health action level for algal toxins – May 2012. Includes microcystins LA, LR, RR, and YR.

[G] Limited amounts of microcystin data in streams are currently available for streams of the Pajaro River basin

Table 5-23. Tabular summary of waterbody impairments addressed in this TMDL report.

		Unionized Ammonia		**Nitrate (Impairment of MUN Standard)**		**Impairment by Biostimulatory Substances**[A, B]		**303(d) List Information**	
Water Body Name	Waterbody Identification (WBID) or NHDplus reach code[E]	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Listed on the 2010-303(d) List for nutrient-related impairments?	Impairments and 303(d) Listing(s) **Addressed in this TMDL? (no. of impairments addressed)**[F]
Beach Road Ditch	CAR30510030200806031 23839	No data	-	Yes	All reaches	Yes [B]	-	Yes, dissolved oxygen Yes, nitrate (MUN)	Yes, dissolved oxygen, nitrate, biostimulatory[D] substances (2)
Carnadero Creek	CAR30530020199902231 55037	No	-	Yes	From confluence with Pajaro River to downstream of Bloomfield Rd.	Yes [B]	From confluence with Pajaro River to downstream of Bloomfield Rd.	Yes, dissolved oxygen Yes, nitrate (MUN)	Yes, dissolved oxygen, nitrate, biostimulatory[D] substances (2)
Casserly Creek	NHDplus reach code 18060002001643	No data	-	Yes	All reaches downstream of Casserly Road (site CA1)	No[C]	-	No	Yes, nitrate (1)
Corralitos Creek	CAR30510010199902251 02704	No	-	Yes	From Lake Ave.bridge to downstream of Green Valley Rd.	Yes [B]	All reaches downstream of Browns Valley Rd. to the confluence with Salsipuedes Creek at Lake Ave.	No	Yes, nitrate, biostimulatory[D] substances (1)
Unnamed tributary to Corralitos Creek	NHDplus reach code 18060002001662	No data	-	Yes	From the confluence with Corralitos Creek to upstream of Corralitos Rd east of Corralitos Lagoon (also known as Freedom Lake)[G]	No[C]	-	No	Yes, nitrate (1)
Coward Creek	NHD reach code 18060002000394	No data	-	Yes	Presumed impaired from the confluence with the Pajaro River upstream to Cummings Canyon on the basis of impairment observed at the existing monitoring location at Carlton Rd.[G]	No[C]	-	No	Yes, nitrate (1)

		Unionized Ammonia		**Nitrate (Impairment of MUN Standard)**		**Impairment by Biostimulatory Substances[A, B]**		**303(d) List Information**	
Water Body Name	Waterbody Identification (WBID) or NHDplus reach code[E]	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Listed on the 2010-303(d) List for nutrient-related impairments?	Impairments and 303(d) Listing(s) **Addressed in this TMDL? (no. of impairments addressed)[F]**
Furlong Creek	CAR3053002019990222111932	No	-	Yes	Presumed impaired from the confluence with Llagas Creek upstream to the Leavesley Rd. crossing[G].	Yes [B]	All reaches	Yes, nitrate (MUN)	Yes, nitrate, biostimulatory[D] substances (1)
Tributary to Green Valley Creek	NHD reach code 18060002001638	No data	-	Yes	All reaches presumed impaired from the confluence with Green Valley Creek upstream to the uppermost reach of the tributary on the basis of impairment observed at the existing monitoring location at Casserly Rd.	No[C]	-	No	Yes, nitrate (1)
Harkins Slough	CAR3051001320080603122917	No	-	Yes	Downstream of Harkins Slough Road to the confluence with Watsonville Slough	Yes	All reaches presumed impaired downstream of State Highway 1	Yes, chlorophyll-a Yes, dissolved oxygen	Yes, chlorophyll-a, dissolved oxygen, nitrate. (3)
Llagas Creek	CAR3053002020020319075726	Yes	From monitoring site 305HOL to site 305VIS.	Yes	Downstream of site 305LEA (at Leavesley Road) to the confluence with the Pajaro River	Yes	All reaches downstream of monitoring site LL_CHU	Yes, dissolved oxygen Yes, nutrients (MUN)	Yes, dissolved oxygen, nitrate, ammonia, biostimulatory[D] substances (3)
McGowan Ditch	CAR3051003020100620223644	No	-	Yes	All reaches currently presumed impaired on the basis of two monitoring sites.	No[C]	-	Yes, nitrate (MUN)	Yes, nitrate (1)
Millers Canal	CAR3053002020080603171000	No	-	No	All reaches	Yes [B]	All reaches	Yes, chlorophyll-a Yes, dissolved oxygen	Yes, chlorophyll-a, dissolved oxygen (2)

		Unionized Ammonia		**Nitrate (Impairment of MUN Standard)**		**Impairment by Biostimulatory Substances**[A, B]		**303(d) List Information**	
Water Body Name	Waterbody Identification (WBID) or NHDplus reach code[E]	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Listed on the 2010-303(d) List for nutrient-related impairments?	Impairments and 303(d) Listing(s) **Addressed in this TMDL? (no. of impairments addressed)**[F]
Pajaro River	CAR3051003019980826115152	No	-	Yes	All reaches downstream of Frazier Lake Rd. to upstream of Thurwatcher Bridge.	Yes	All reaches upstream of Thurwatcher Bridge to downstream of Frazier Lake Rd.	Yes, dissolved oxygen Yes, nitrate (MUN) Yes, nutrients (MUN)	Yes, dissolved oxygen, nitrate, biostimulatory[D] substances (2)
Pajaro River Estuary	NHD reach code 18060002001843	Yes	Downstream Thurwatcher Bridge (site 305THU)	No	-	No	-	No	Yes, ammonia (1)
Pinto Lake outflow ditch	NHD reach code 18060002001656	No data	-	Yes	All reaches	No[C]	-	No	Yes, nitrate (1)
Salsipuedes Creek	CAR3051003020080603123522	No	-	No	-	Yes [B]	From the confluence with the Pajaro River upstream to East Lake Ave.	The creek is listed for a low dissolved oxygen (DO) impairment, but this low DO cannot be linked to evidence of excess algal biomass in the creek at this time, therefore the low DO conditions in the creek are presumed to result from other factors.	Yes, nitrate, biostimulatory[D] substances (1)
San Juan Creek	CAR3052005020090204001958	No	-	Yes	All reaches	Yes	All reaches	Yes, dissolved oxygen Yes, nitrate (MUN)	Yes, dissolved oxygen, nitrate, biostimulatory[D] substances (2)
Struve Slough	CAR3051003020080603125227	No	-	No	-	Yes	All reaches	Yes, dissolved oxygen	Yes, dissolved oxygen, biostimulatory[D] substances (1)
West Branch San Juan Creek	NHD reach code 18060002000611	No data	-	Yes	All reaches	No[C]	-	No	Yes, nitrate (1)
Tequisquita Slough	CAR3053002020011121091332	No	-	Yes	From upstream of an unnamed road crossing located 0.7 miles south of San Felipe Lake to the Arroyo Dos Picachos confluence at Churchill Rd.	Yes	All reaches	Yes, dissolved oxygen	Yes, dissolved oxygen, nitrate biostimulatory[D] substances (1)

		Unionized Ammonia		Nitrate (Impairment of MUN Standard)		Impairment by Biostimulatory Substances[A, B]		303(d) List Information	
Water Body Name	Waterbody Identification (WBID) or NHDplus reach code[E]	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Listed on the 2010-303(d) List for nutrient-related impairments?	Impairments and 303(d) Listing(s) **Addressed in this TMDL? (no. of impairments addressed)**[F]
Watsonville Slough	CAR3051003019981209150043	No	-	Yes	All reaches downstream of Ohlone Rd. to the confluence with the Pajaro River estuary.	Yes		Yes, dissolved oxygen	Yes, dissolved oxygen, nitrate, biostimulatory[D] substances (2)
Total Water Body/Pollutant Combinations addressed in this TMDL								**30**	

[A] includes 303(d)-listed dissolved oxygen impairments and 303(d)-Listed chlorophyll-a impairments credibly linked to the biostimulatory conditions identified in this project report.

[B] includes **downstream biostimulatory impacts**, as described and assessed in this TMDL report

[C] There were not enough data to determine whether there were biostimulatory impacts to this waterbody, so in the absence of data, we could not state there was an impairment.

[D] "Biostimulatory substances" describes the expression of biostimulation in the form of excess algal cover as brought about by excess nutrients (nitrogen + phosphorus), dissolved oxygen problems, and chlorophyll-a. Since the 303(d) list addresses specific pollutants (e.g. nitrate, dissolved oxygen), biostimulatory substances does not constitute a specific pollutant impairment, rather, it is more analogous to an pollutant category covering the pollutants nutrients and response indicators such as dissolved oxygen, and chorophyll-a.

[E] NHDPlus is the National Hydrography Dataset Plus, Edition1.0, published in 2005 by the USEPA and the US Geological Survey.

[F] If both nutrients and nitrate were listed on the 2010 303(d) list, only nitrate is repeated in this column as the two listings are addressing the same impairment.

[G] This stream impairment is identified on the basis of one monitoring site. Currently, there is no upstream monitoring site on this stream reach to geographically constrain the upstream extent of the impairment. Staff presumptively extended the nitrate MUN impairment upstream to the interface between the agricultural valley floor and the upland reaches of the stream catchment on the basis of a break in land slope (uplands were defined here as having land slopes of greater than three degrees); this break in slope also tends to represent noticeable changes in land use/land cover patterns in the Pajaro River basin. Note that on the basis of large amounts of regional, statewide, and national stream water quality data, streams in sparsely populated upland areas dominated by woodland, chaparral, and grasslands virtually never exceed 10 mg/L nitrate as N, and thus these sparsely populated upland areas would not reasonably be expected to have stream waters exceeding 10 mg/L nitrate as N.

5.17 Problem Statement

A number of streams in the Pajaro River basin are impaired due to exceedances of water quality criteria for nitrate, unionized ammonia, and associated nutrient-related problems such as excessive orthophosphate, dissolved oxygen imbalances, toxicity, and excess algal biomass. As a result, a wide range of legally designated beneficial uses – including aquatic habitat, drinking water supply, groundwater recharge, and agricultural supply - are not being supported in these waterbodies, and therefore these impairments constitute serious water quality problems.

6 WATER QUALITY NUMERIC TARGETS

6.1 Target for Nitrate (Human Health Standard)

The purpose of this target is to meet the water quality objective for nitrates in municipal and domestic drinking water sources (MUN: Municipal/Domestic Supply; GWR: Groundwater Recharge). The Basin Plan numeric water quality objective for nitrate (as nitrogen) is 10 mg/L NO3 as N, therefore the nitrate target is set at the Basin Plan water quality objective as follows:

- *10 mg/L nitrate as nitrogen to ensure that these surface waters are protected as drinking water sources and to assure compliance with the numeric water quality objective at all times.*

6.2 Target for Un-ionized Ammonia

The Basin Plan contains numeric water quality objectives for un-ionized ammonia which is protective of the general toxicity water quality objective, and is as follows:

- *The discharge of wastes shall not cause concentrations of unionized ammonia (NH3) to exceed 0.025 mg/l (as N) in receiving waters.*

6.3 Targets for Biostimulatory Substances (Nitrate and Orthophosphate)

The Basin Plan contains the following narrative water quality objectives for biostimulatory substances:

- *Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.*

Under most circumstances, compliance with all applicable water quality objectives, including narrative objectives is required (State Water Board, 2011a). Further, according to USEPA guidance, a TMDL and associated waste load allocations and load allocations must be set at levels necessary to result in attainment of all applicable water quality standards, including narrative water quality objectives (USEPA, 2000b). A narrative objective may be interpreted with respect to a specific pollutant or parameter by selecting an appropriate numeric threshold that meets the conditions of the narrative objective (State Water Board, 2011a). Therefore, in order to implement the Basin Plan's narrative objective for biostimulatory substances the Central Coast Water Board needs to develop technically defensible numeric water quality criteria to assess attainment or non-attainment of the narrative water quality objective:

> *"For waterbodies listed because of failure to meet a narrative water quality objective, **the numeric target will be a quantitative interpretation of the narrative objective***. For example, if a waterbody fails to achieve a narrative objective for settleable solids, the TMDL could include targets for annual mass sediment loading." (State Water Board, 1999a)*
>
> *-State Water Resources Control Board, Office of Chief Counsel (1999)*

> *"In situations where applicable water quality standards are expressed in narrative terms or where 303(d) listings were prompted primarily by beneficial use or antidegradation concerns**, it is necessary to develop a quantitative interpretation of narrative standards***. "*
>
> *-U.S. Environmental Protection Agency (2000b)*
>
> ***** emphasis added

To implement the Basin Plan's biostimulatory substances narrative objective, staff evaluated available data, studies, established methodologies, technical guidance, peer-reviewed numeric criterion, and other information to estimate the levels of nitrogen and phosphorus that can be present without causing violations of this objective. It is important to recognize that definitive and unequivocal scientific certainty is not necessary in a TMDL process with regard to development of nutrient water quality targets protective against biostimulation. Numeric targets should be scientifically defensible, but are not required to be definitive. USEPA guidance (USEPA, 2000a) provides for methodologies which USEPA explicitly states will result in nutrient numeric targets of "greater scientific validity"; therefore it is clearly recognized that scientific certainty is not a requirement for nutrient targets. Biostimulation is an ongoing and active area of research. If the water quality objectives and numeric targets for biostimulatory substances are changed in the future, then any TMDLs and allocations that are potentially adopted for biostimulatory substances pursuant to this project may sunset and be superseded by revised water quality objectives.

Recent research on biostimulation on inland surface waters from agricultural watersheds in the California central coast region indicates that the existing nutrient numeric water quality objectives to protect drinking water standards found in the Basin Plan (i.e., the 10 mg/L nitrate-nitrogen MUN objective) is unlikely to reduce benthic algal growth below even the highest water quality benchmarks. This is because aquatic organisms respond to nutrients at lower concentrations[149,150]. Therefore, the 10 mg/L nitrate-nitrogen objective is insufficiently protective against biostimulatory impairments. Consequently, it is typically necessary to set biostimulatory numeric water quality targets at more stringent levels than the existing numeric objectives found for nitrate in the Basin Plan (i.e., the 10 mg/L MUN objective).

USEPA recently stated that total nitrogen concentrations in streams which are protective against biostimulatory effects should generally be expected to be in an acceptable range of 2 mg/L to 6 mg/L, see the text box below and see Figure 6-1. Noteworthy is that the aforementioned concentrations ranges are substantially lower than the 10 mg/L drinking water quality standard for nitrate as nitrogen.

> *"(A)n excess amount of nitrogen in a waterway may lead to low levels of oxygen and negatively affect various plant life and organisms…An acceptable range of total nitrogen is **2 mg/L to 6 mg/L***, though it is recommended to check tribal, state, or federal standards…"*
>
> *From USEPA, 2013a, "Total Nitrogen" fact sheet, revised June 4, 2013*
>
> *******emphasis added by Central Coast Water Board staff*

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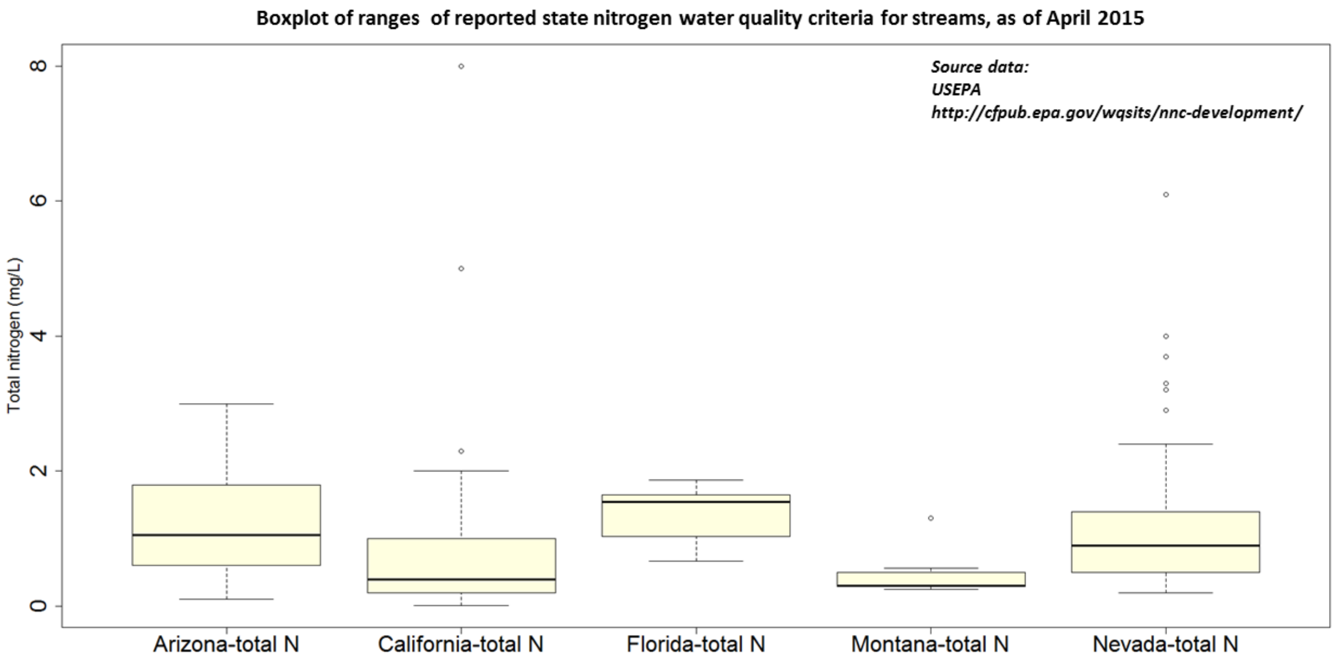
[149] University of California, Santa Cruz. 2010. Final Report: Long-term, high resolution nutrient and sediment monitoring and characterizing in-stream primary production. Proposition 40 Agricultural Water Quality Grant Program. Dr. Marc Los Huuertos, Ph.D., project director.

[150] Rollins, S., M. Los Huertos, P. Krone-Davis, and C. Ritz. 2012. Algae Biomonitoring and Assessment for Streams and Rivers of California's Central Coast. Final Report for Proposition 50 Grant Agreement No. 06-349-553-2

Figure 6-1. Boxpolt and numerical summary of ranges of state nitrogen water quality criteria for streams (as of April, 2015).



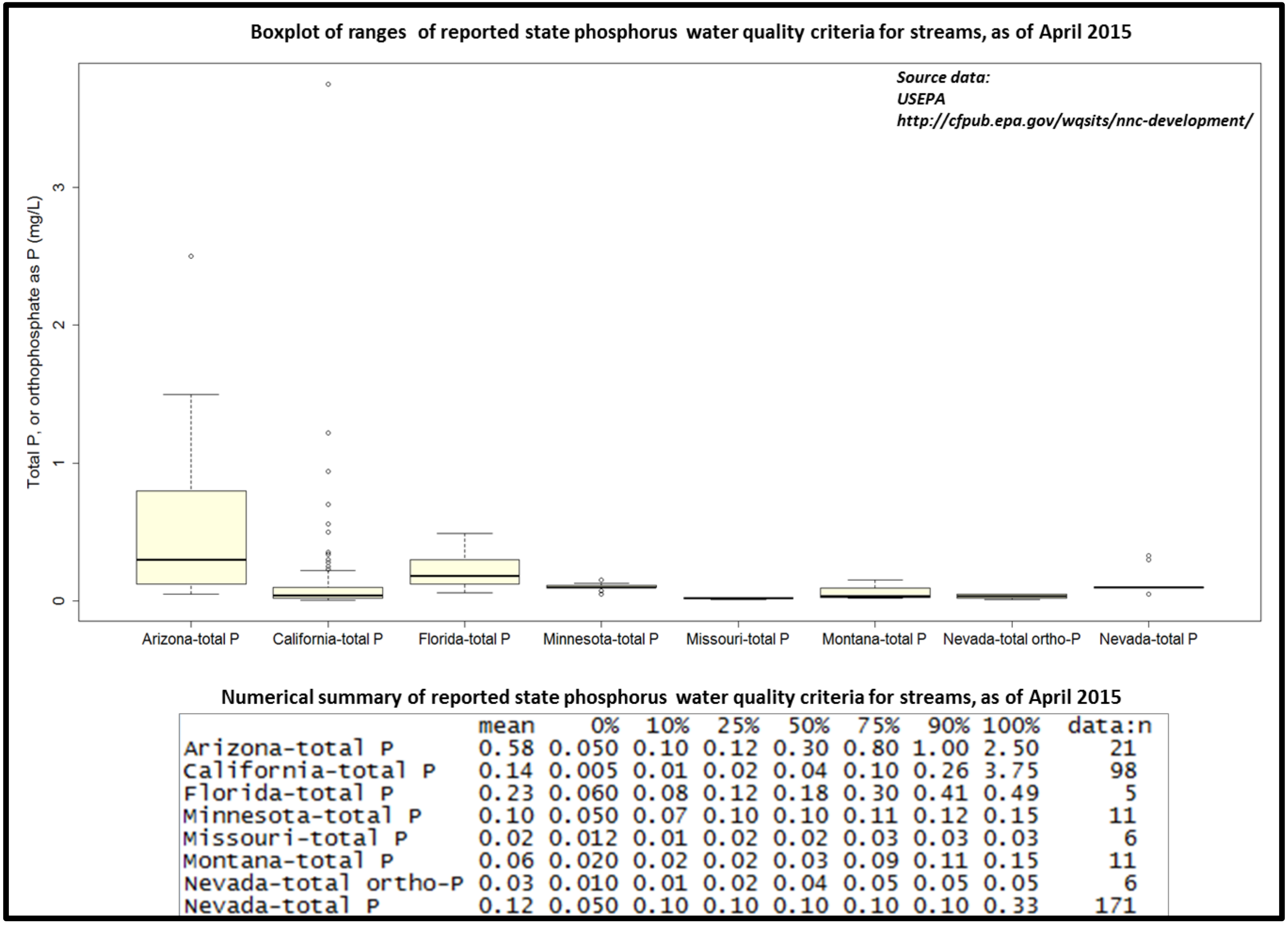
Numerical summary of reported state nitrogen water quality criteria for streams, as of April 2015

```
                     mean   0%   10%   25%  50%  75%  90%   100% data:n
Arizona-total N      1.24  0.10  0.32  0.60  1.0  1.7  2.5   3.0     22
California-total N   1.25  0.01  0.15  0.20  0.4  1.0  5.0   8.0    115
Florida-total N      1.35  0.67  0.81  1.03  1.5  1.6  1.8   1.9      5
Montana-total N      0.51  0.25  0.28  0.29  0.3  0.5  1.3   1.3     11
Nevada-total N       1.17  0.20  0.30  0.50  0.9  1.4  2.4   6.1    111
```

At this time, USEPA generally expects nutrient TMDLs to have dual nutrient criteria, for both nitrogen and for phosphorus. As reported by USEPA (2007b), while controlling one nutrient may potentially prevent productivity, control of both nutrients (nitrogen and phosphorus) in upstream waters can also provide additional assurance that excess productivity will remain in control. For example, under conditions of nitrogen limitation, even if local excess primary productivity is ultimately controlled to a large extent by nitrogen reduction alone, there will be consequent export of the excess nutrient, phosphorus, because the excess of that nutrient would not have the opportunity for uptake into biomass. The larger the excess of phosphorus in upstream systems is, the greater the contribution to potential phosphorus-sensitive downstream systems. Therefore, concurrent reduction of both nitrogen and phosphorus in a basin is often warranted in order to protect downstream use. More recently, USEPA provided further guidance and scientific support on why the development of dual numeric criteria for both nitrogen and phosphorus can be an effective tool to protect beneficial uses of the nation’s streams, lakes, estuaries, and coastal systems (USEPA, 2015).

Since dual nutrient criteria are being developed for this TMDL project, it is worth reviewing phosphorus and orthophosphate as P water quality criteria for streams developed previously in California and in other states (see Figure 6-2). In general, phosphorus and orthophosphate as P stream water quality criteria developed by the states are generally less than 0.3 mg/L, and often around 0.1 mg/L or less.

Figure 6-2. Boxpolt and numerical summary of ranges of state phosphorus water quality criteria for streams (as of April, 2015).



Boxplot of ranges of reported state phosphorus water quality criteria for streams, as of April 2015

Source data:
USEPA
http://cfpub.epa.gov/wqsits/nnc-development/

Numerical summary of reported state phosphorus water quality criteria for streams, as of April 2015

```
                     mean    0%  10%  25%  50%  75%  90% 100%  data:n
Arizona-total P      0.58 0.050 0.10 0.12 0.30 0.80 1.00 2.50     21
California-total P   0.14 0.005 0.01 0.02 0.04 0.10 0.26 3.75     98
Florida-total P      0.23 0.060 0.08 0.12 0.18 0.30 0.41 0.49      5
Minnesota-total P    0.10 0.050 0.07 0.10 0.10 0.11 0.12 0.15     11
Missouri-total P     0.02 0.012 0.01 0.02 0.02 0.03 0.03 0.03      6
Montana-total P      0.06 0.020 0.02 0.02 0.03 0.09 0.11 0.15     11
Nevada-total ortho-P 0.03 0.010 0.01 0.02 0.04 0.05 0.05 0.05      6
Nevada-total P       0.12 0.050 0.10 0.10 0.10 0.10 0.10 0.33    171
```

The proposed numeric targets for biostimulatory substances for streams of the Pajaro River basin are presented in Table 6-1. Appendix B contains all the data, assessments, and information used to derive numeric targets for biostimulatory substances. Note that the proposed numeric targets comport reasonable well, and within similar ranges, of nutrient stream water quality criteria developed previously throughout the nation (refer back to Figure 6-1 and Figure 6-2). Central Coast Water Board staff used USEPA guidance in developing draft target with the goal being to account for physical and hydrologic variation within the TMDL project area (see *Nutrient Criteria Technical Guidance Manual, River and Streams* - USEPA July 2000). The USEPA nutrient criteria guidance manual recommends that nutrient criteria need to be developed to account for natural variation existing at the regional and basin level-scale.

Additionally, different waterbody processes and responses dictate that nutrient criteria be specific to waterbody type. No single criterion will be sufficient for each waterbody type. USEPA recommends classifying and group streams by type or comparable characteristics (e.g., fluvial morphology, hydraulics, physical, biological or water quality attributes). Classification will allow criteria to be identified on a broader scale rather than a site-specific scale. The aforementioned stream classification recommendation by USEPA is supported by recent research published for California's central coast region, as illustrated below:

> "*Sections of the Pajaro River watershed have been listed by the State of California as impaired for nutrient and sediment violations under the Clean Water Act ……****The best evidence linking elevated nutrient concentrations to algae growth was shown*** ***when the stream physiography, geomorphology, and water chemistry were incorporated into the survey and analysis."****
>
> ***emphasis added***
>
> *From: University of California, Santa Cruz (2009). Final Report: Long-Term, High Resolution Nutrient and Sediment Monitoring and Characterizing In-stream Primary Production. Proposition 40 Agricultural Water Quality Grant Program (Project Lead: Dr. Marc Los Huertos).*

Further, numeric target development in this TMDL is consistent with policy recommendations outlined in the draft State Water Resources Control Board's Statewide Nutrient Policy (State Water Board, 2011b). The draft Statewide Nutrient Policy recognizes both the California Nutrient Numeric Endpoints (CA NNE) approach and the USEPA percentile-approach as the two valid alternatives under consideration for a statewide policy for nutrient policy. Indeed, central coast water board staff evaluated and utilized both the CA NNE and the USEPA percentile approach in development of numeric targets. Further background on development of numeric targets are presented in Section 6.3.1 and Section 6.3.2. As noted previously, Appendix B presents detailed information and the full scope of data and methods used for the evaluation and development of nutrient numeric targets. A brief summary of technical guidance used by staff in nutrient target development is presented below:

> ***Summary of published technical guidance used by staff in nutrient target development:***
>
> ✓ Using a combination of recognized approaches (i.e., literature values, statistical approaches, predictive modeling approaches) result in criteria of greater scientific validity *(guidance source: USEPA, 2000a. Nutrient Criteria Guidance Manual*);
>
> ✓ Classify and group streams needing nutrient targets, based on similar characteristics *(guidance source: USEPA, 2000a. Nutrient Criteria Guidance Manual);*
>
> ✓ Targets should not be lower than expected concentrations found in background/natural conditions *(guidance source: California NNE Approach guidance – Tetra Tech, 2006).*

Also worth noting, nutrient targets here are developed consistent with methodologies that previously underwent independent scientific peer review in the TMDLs for nitrogen compounds and orthophosphate in the Salinas River and Reclamation Canal Basin and the Moro Cojo Slough Subwatershed (Resolution No. R3-2013-0008).

Table 6-1. Numeric targets for biostimulatory substances

Stream Reaches Assigned Nitrate (as N) and Orthophosphate Water Quality Targets						
Waterbody Type	**Geomorphology & Stream Characteristics**	**Stream Reaches**	**Allowable Nitrate as N (mg/L)**	**Allowable Orthophosphate as P (mg/L)**	**Methodology for Developing Numeric Target**	**Notes Pertaining to Development of Targets**
Alluvial Floodplain River – Pajaro River	Generally low gradient alluvial basin floor and floodplains. Moderate ambient turbidity (9–21 NTU). Generally moderate canopy cover (20-25%). Substrates variable, but generally characterized by finer-grained material such as loams, clay loams, and fine- sandy loams.	Pajaro River, all reaches including the Pajaro River estuary.	**3.9** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Relatively finer-grained substrates and local soil conditions, such as loams, and clay loams likely result in relatively higher ambient turbidity (9–21 NTU) which limits good sunlight penetration of water column; risk of biostimulation thus occurs at relatively higher nutrient concentrations. Orthophosphate water quality targets in the dry season are based on background, reference conditions (USEPA 75th percentile reference approach) for the Santa Cruz Mountains and Watsonville Plains level IV ecoregions.
Pajaro Valley –Alluvial Fan & Plains Tributary Creeks	Alluvial fans and alluvial plain tributary reaches. Generally low ambient turbidity (0.1–2 NTU). Generally moderate to higher canopy cover (40-50%). Substrates variable, with finer grained material such as clay loams and sandy loams in lower reaches of these tributaries, and coarser grained material such as gravelly loams and sand in middle reaches of these tributaries.	Corralitos Creek, all reaches	**1.8** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Orthophosphate water quality targets in the dry season are based on background, reference conditions (USEPA 75th percentile reference approach) for the Santa Cruz Mountains and Watsonville Plains level IV ecoregions.
		Salsipuedes Creek, all reaches				
Pajaro Valley – Agricultural Ditches	Agricultural ditches located on the basin floor and coastal flood plain of the Pajaro Valley. Low canopy cover (0% to 15%). Substrates expected to be fine-grained mud and clay.	Beach Road Ditch, all reaches	**3.3** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Substrates expected to be muddy and fine-grained substrates based on local soil conditions which contribute to relatively higher ambient turbidity (up to 19 NTU) which could preclude good sunlight penetration of water column; risk of biostimulation occurs at relatively higher nutrient concentrations.
		McGowan Ditch, all reaches				

Stream Reaches Assigned Nitrate (as N) and Orthophosphate Water Quality Targets

Waterbody Type	Geomorphology & Stream Characteristics	Stream Reaches	Allowable Nitrate as N (mg/L)	Allowable Orthophosphate as P (mg/L)	Methodology for Developing Numeric Target	Notes Pertaining to Development of Targets
South Santa Clara Valley – Basin Floor & Floodplain Tributary Creeks	Alluvial fan and alluvial plain tributary creek reaches of the south Santa Clara Valley. Generally moderate canopy cover (35% to 50%). Substrates expected to be variable, fine-grained silts and clays close to the Soap Lake Basin area, and courser grained sands and gravels in upstream reaches.	Llagas Creek, all reaches downstream of Chesbro Reservoir	**1.8** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.04** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supported by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Relatively low ambient turbidity (around 5 NTU) can promote good sunlight penetration resulting in somewhat lower predicted nutrient targets protective against biostimulation.
		Carnedaro and Uvas Creeks, all reaches				
		Furlong Creek, all reaches				
San Juan Valley – Basin Floor & Floodplain Tributary Creeks	Flood plain and basin floor tributary creek reaches of the San Juan Valley. Relatively lower canopy cover (10% to 40%). Substrates expected to be generally silts and clays, with some gravel in the lowermost reaches.	San Juan Creek, all reaches	**3.3** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.12** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	San Juan Creek is specifically designated in the Central Coast Basin Plan (Table II-1) for warm freshwater aquatic habitat (WARM), and the assigned nutrient targets are protective of WARM habitat.
		West Branch San Juan Creek, all reaches				
Lower Pacheco Creek Subbasin – Basin Floor & Floodplain Streams	Flood plain and basin floor tributary streams. Relatively low canopy cover (10% to 20%). Substrates expected to be generally silts and clays	Tequisquita Slough, all reaches	**2.2** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.12** **Dry Season Samples (May 1-Oct31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Tequisquita Slough is specifically designated in the Central Coast Basin Plan (Table II-1) for warm freshwater aquatic habitat (WARM), and the assigned nutrient targets are protective of WARM habitat.

Stream Reaches Assigned Total Nitrogen (as N) and Orthophosphate Water Quality Targets

Waterbody Type	Geomorphology & Stream Characteristics	Stream Reaches	Allowable Total Nitrogen as N (mg/L)	Allowable Orthophosphate as P (mg/L)	Methodology for Developing Numeric Target	Notes Pertaining to Development of Targets
Watsonville Slough System – Coastal Sloughs	Coastal sloughs located in low gradient basin floor and marine terrace areas. Generally moderate levels of ambient turbidity.(7–21 NTU) Generally lower riparian canopy cover; Generally clayey substrates; some sandy loams in upper slough reaches.	Watsonville Slough, all reaches	**2.1** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.14** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Generally moderate ambient turbidity, clayey substrate, moderate sunlight penetration, low canopy cover indicates moderate risk of biostimulation at relatively low concentrations of nutrients. Downstream nutrient-related impacts to the Critical Coastal Area (CCA) of the Pajaro River-Watsonville Slough Estuary are possible. Total nitrogen water quality targets are assigned because nitrate generally only measures a small fraction of the total nitrogen in this system, presumably because these sloughs and wetlands are areas of high primary productivity and thus much nitrogen is bound up in organic phases and biomass.
		Harkins Slough, all reaches				
		Gallighan Slough, all reaches				
		Struve Slough, all reaches				
Soap Lake Basin – Floodplain & Basin Floor Canal	Valley basin floor canal located in the inland Santa Clara Valley Estimated relatively higher levels of ambient, background turbidity.(12–21 NTU), on the basis of turbidity data from 26 agricultural drains in the Central Valley and in the Pajaro Valley. Low riparian canopy cover; Clayey substrates.	Millers Canal	**1.1** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.04** **Dry Season Samples (May 1-Oct. 31)** **0.3** **Wet Season Samples (Nov. 1-Apr. 30)**	Statistical Analysis (USEPA percentile-based approaches) Supplemented by Calif. NNE approach (NNE benthic biomass model tool) Wet-season targets based on Central Coastal Basin Plan nitrate objective and State of Nevada phosphate criteria for streams	Downstream nutrient-related impacts to the Pajaro River are possible. Total nitrogen water quality targets are assigned because nitrate because nitrate generally only measures a small fraction of the total nitrogen in this system, possible because much of the available nitrogen may be bound up in organic phases and biomass – field observation and water quality data indicate high levels of chlorophyll *a* in Millers Canal.

6.3.1 Background Information

Water Board staff are required to develop scientifically-valid numeric nutrient water quality targets that are protective of the Basin Plan's narrative biostimulatory water quality objective. Table 6-2 summarizes the USEPA-recommended approaches for assessing and developing numeric nutrient criteria that will be protective of the Basin Plan's narrative biostimulatory water quality standard. USEPA (2000) reports that a weight of evidence approach to developing nutrient criteria that ***"combines any or all three of the recommended of the approaches will produce criteria of greater scientific validity."*** Consistent with this USEPA guidance, staff evaluated and utilized multiple USEPA-recognized methodologies in the evaluation and development of nutrient numeric targets (see Appendix B)

Table 6-2. USEPA-recommended approaches for developing nutrient criteria.

USEPA-Recommended Approaches	Approach Assessed in this TMDL project?	Methodology	Staff Notes
Use of **Predictive Relationships** (modeling; biocriteria)	☑	California NNE Approach	Staff used NNE benthic biomass model tool to supplement and validate USEPA-25th percentile draft targets for reasonableness.
Statistical Analysis of Data	☑	USEPA-recommended statistical analysis: 25th percentile of nutrient data for stream population	Staff used USEPA 25th percentile approach to develop numeric targets in this TMDL project. – targets were supplemented and refined using the NNE biomass model tool.
Use of established concentration **thresholds from published literature**	☑	USEPA published nutrient criteria for Ecoregion III, Subecoregion 6	Staff evaluated USEPA ecoregional criteria. Staff finds ecoregion 6 criteria are inappropriate for the Pajaro River basin – ecoregional approach lumps together streams of with significantly different characteristics: headwater streams, alluvial valley streams, coastal confluence streams, etc. USEPA itself recognizes ecoregional criteria may not sufficiently address local variation.

California Central Coast researchers studying nutrient pollution in the Pajaro River basin have likewise recognized and concurred with the USEPA's guidance that using a combination of these recognized methods will help in establishing the scientific validity of numeric criteria for nutrients, for example:

> *"This work was conducted within the nutrient criteria framework developed by the U.S. Environmental Protection Agency (USEPA 2000). The USEPA guidance document for streams and rivers prescribes a combination of several approaches when developing water quality criteria for nutrients, including the application of reference conditions, stressor-response relationships, mathematical/statistical models, and existing literature.* ***Combining these approaches will help in the development of biologically relevant and scientifically valid numeric objectives for nutrients in the Pajaro River watershed."****
>
> From: University of California, Santa Cruz (2009). Final Report: Long-Term, High Resolution Nutrient and Sediment Monitoring and Characterizing In-stream Primary Production. Proposition 40 Agricultural Water Quality Grant Program (Project Lead: Dr. Marc Los Huertos).
>
> ******emphasis added by Water Board staff*

Further, biostimulatory numeric target development in this TMDL is consistent with policy recommendations outlined in the draft State Water Resources Control Board's Statewide Nutrient Policy (State Water Board, 2011b). The draft Statewide Nutrient Policy recognizes both the California Nutrient Numeric Endpoints (CA NNE) approach and the USEPA percentile-approach as the two valid alternatives under consideration for a statewide policy for nutrient policy. Consistent with this draft policy Staff indeed evaluated and utilized both the CA NNE and the USEPA percentile approach in development and refinement of numeric targets.

While USEPA generally recommends total nitrogen and total phosphorus as targets protective against biostimulation, USEPA also states that ***other factors should be considered in selecting targets***; for example consistency with already available data. In many cases, many existing Pajaro River basin monitoring programs do not collect or report total kjeldahl nitrogen (TKN) or total phosphorus (TP), and only report nitrate and nitrite, and orthophosphate. The limited relatively limited amounts of total phosphorus data that has been collected (Central Coast Ambient Monitoring Program - CCAMP) is episodic and does not have adequate temporal and spatial representation for purposes of TMDL development. As such total nitrogen and total phosphorus data are generally not widely or consistently available for the Pajaro River basin.

Accordingly, USEPA guidance on selecting numeric targets is reproduced below:

> *Various factors will affect the selection of an appropriate TMDL indicator. These factors include issues associated with the indicator's scientific and technical validity, as well as practical management considerations. The importance of these factors will vary for each waterbody, depending, for instance, on the time and resources available to develop the TMDL, the availability of already existing data, and the water's designated uses. Final selection of the indicator should depend on site-specific requirements. The following sections identify some factors to keep in mind during indicator selection.*
>
> *Practical considerations:*
> *Measurement of the indicator should cost as little as possible, while still meeting other requirements. Indicators that can be suitably monitored through volunteer monitoring programs or other cost-effective means should be evaluated for adequate quality control and assurance of sample collection, preservation, laboratory analysis, data entry, and final reporting. Monitoring should introduce as little stress as possible on the designated uses of concern.*
>
> *It is advantageous to select an indicator* ***consistent with already available data****. Choice of an indicator also should take into account how "obvious" it is to the public that the target value must be met to ensure the desired level of water quality. (For example, the public understands Secchi depth and chlorophyll indicators fairly well.)*
>
> ***Recommendation: Scientific and technical issues should be balanced against practical considerations when deciding upon a water quality indicator****.*
>
> *From: USEPA Protocol for Developing Nutrient TMDLs, 1999 (emphasis added)*

It should be noted that in inland rivers and streams, nitrate and orthophosphate are generally the bioavailable forms of nutrients. In static or stagnant receiving waterbodies, such as lakes and reservoirs, other forms of nitrogen and phosphorus tend to accumulate and ultimately contribute to internal loading due to the nitrogen and phosphorus cycle. However, in rivers and streams, this internal loading and cycling affect typically is less pronounced.

Based on the above information and consistent with USEPA guidance for practical monitoring considerations, staff proposes that nutrient targets for this TMDL project shall be based on nitrate and orthophosphate because:

(1) nitrate is overwhelmingly the dominant fraction of total water column nitrogen in agricultural valley areas of Pajaro River basin inland streams;

(2) because the limited amounts of available total nitrogen data are inadequate to represent spatial and temporal variation

(3) because the limited amounts of available total phosphorus data are completely inadequate to represent spatial and temporal variation; and

(4) because nitrate and orthophosphate are the generally bioavailable forms of nitrogen and phosphorus in inland surface streams.

With regard to statistical approaches to developing nutrient targets, USEPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams (2000) describes two ways of establishing a reference condition. One method is to choose the upper 75th percentile of a reference population of streams. The 75th percentile was chosen by EPA since it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility. With regard to identifying reference streams USEPA defines a reference stream "as a least impacted waterbody within an ecoregion that can be monitored to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans."

USEPA proposed that the 75th percentiles of all nutrient data of these reference stream(s) could be assumed to represent unimpacted reference conditions for each aggregate ecoregion, and also provided a comparison of reference condition for the aggregate ecoregion versus the subecoregions.

Alternatively, when reference streams are not identified, the second method USEPA recommends is to determine the lower 25th percentile of the population of all streams within a region. The 25th percentile of the entire population was chosen by EPA to represent a surrogate for an actual reference population. To further clarify this point, USEPA (2000) reports that "(d)ata analyses to date indicate that the lower 25th percentile from an entire population roughly approximates the 75th percentile for a reference population (see case studies for Minnesota lakes in the Lakes and Reservoirs Nutrient Criteria Technical Guidance Document [U.S. EPA, 2000a], the case study for Tennessee streams in the Rivers and Streams Nutrient Criteria Technical Guidance Document [U.S. EPA, 2000b], and the letter from Tennessee Department of Environment and Conservation to Geoffrey Grubbs [TNDEC, 2000]). New York State has also presented evidence that the 25th percentile and the 75th percentile compare well based on user perceptions of water resources (NYSDEC, 2000)."

These 25th percentile values are thus characterized as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000a). This is because the 25th percentile of the entire population was chosen by EPA to represent a surrogate for an actual reference population.

It is important to note that the USEPA Science Advisory Board (2010) and Worcester et al. (2010) and report that draft numeric targets for nutrients may need to be supported with a weight of evidence approach, rather than stand-alone statistical methods. The weight of evidence approach could use other evidence of eutrophication; for example, presence and abundance of floating algal mats, water column chlorophyll a concentrations, evidence of oxygen depression and/or supersaturation, and pH over 9.5.

Accordingly, Staff finds that it is not warranted to apply the USEPA 25th percentile approach to all Pajaro River basin streams with elevated nutrients absent a demonstrable beneficial use impairment that can be linked to nutrients. It is worth reiterating that elevated nutrients, in and of themselves, do not necessarily indicate biostimulation-eutrophication and impairment of beneficial uses (refer back to Section 5.15). A linkage between elevated nutrients, and actual impairment of beneficial uses must be demonstrated; e.g. dissolved oxygen and/or pH imbalances and other water quality-aquatic habitat indicators. As such, staff used a range of Basin Plan numeric water quality objectives and peer-reviewed screening criteria to assess the spatial distribution of biostimulatory effects and impairments in order to adequately determine where a nutrient numeric target based on USEPA-recommended statistical criteria is warranted (for example, refer back to Table 5-21).

Also, because nutrient loads, and nutrient effects can vary substantially in different seasons, refinements may include developing a temporal, seasonal (e.g., summer versus winter targets), or statistical component (e.g., annual or seasonal mean value of a suite of water quality samples) that may be embedded in the final numeric targets.

6.3.2 Nutrient Numeric Endpoint Analysis

An additional line of evidence for establishing nutrient water quality targets in the TMDL project area was provided by an application of the California Nutrient Numeric Endpoint (California NNE) approach (Tetra Tech 2006) (see Appendix B of this report). The California nutrient numeric endpoints (NNE) approach was developed as a methodology for the development of nutrient (nitrogen and phosphorus) numeric endpoints for use in the water quality programs of the California's State Water Resources Control Board (State Water Board) and Regional Water Quality Control Boards (Regional Water Boards).

The California NNE approach is a risk-based approach in which algae and nutrient targets can be evaluated based on multiple lines of evidence; the intention of the NNE approach is to use nutrient response indicators to develop potential nutrient water quality criteria. The California NNE approach also includes a spreadsheet scoping tool for application in river systems to assist in evaluating the translation between response indicators (e.g. algal biomass) and nutrient concentrations. It is noteworthy that another important tenet of the CA NNE approach (Tetra Tech 2006) is that targets should not be set lower than the value expected under natural conditions. The models used in the spreadsheet tool and their application are described extensively in Appendix 3 of the California NNE Approach (Creager, 2006). They include empirical models (Dodds, 1997 and 2002) and the QUAL2K simulation models (Chapra and Pelletier, 2003), including the standard model, a revised model that provides a better fit to Dodd's empirical data, and a revised model that adjusts for algae accrual time between scour events. The revised QUAL2K simulation model also predicts the anticipated maximum algal contribution to oxygen deficit. This is the maximum amount of dissolved oxygen expected to be removed from the water as a result of predicted benthic algal growth. The outputs can then be evaluated using the numeric targets for secondary indicators, established by the California NNE Approach to determine the risk of impairment at a given site from nutrient over-enrichment.

As part of the development of biostimulatory nutrient targets for this TMDL project, multiple lines of evidence including the use of the California NNE scoping tools were used. Consequently, the California NNE approach scoping spreadsheet tool is used in this TMDL project to evaluate and support the appropriateness of targets staff developed based on the USEPA 25th percentile statistical approach. Reasonably close agreement between California NNE spreadsheet tool nutrient targets with USEPA 25th percentile approach nutrient targets is taken to indicate a higher level of scientific validity and confidence in the proposed targets, consistent with nutrient criteria guidance provided by USEPA (refer back to Section 6.3.1 and Table 6-2).

It is noteworthy that the draft State Water Board Statewide Nutrient Policy (State Water Board, 2011b) recognizes both the CA NNE approach and the USEPA percentile-approach as the two alternatives under consideration for a statewide policy for development numeric targets. As such, the methodologies used to develop nutrient numeric targets in this project report, as outlined above are consistent with the recognized methodologies currently under consideration by State Water Board for statewide application.

6.4 Targets for Nutrient-Response Indicators

Low dissolved oxygen, chlorophyll *a.* and algal toxins (microcystins) are nutrient-response indicators and represent both a primary biological response to excessive nutrient loading in waterbodies which exhibit biostimulatory conditions, and a direct linkage to the support or impairment of designated beneficial uses. The justification for their inclusion as numeric targets in this TMDL can conceptually be emphasized with the following technical guidance published as part of California's nutrient numeric criteria approach:

> *"As a first and critical step, it is proposed in this study that **nutrient criteria not be defined solely in terms of the concentrations of various nitrogen and phosphorus species**, **<u>but also include consideration of primary biological responses to nutrients</u>***. It is these biological responses that correlate to support or impairment of uses. It is proposed that the consideration of biological responses be **in addition to*** chemical concentrations in the final form of the nutrient criteria. Further, the development of chemical concentration criteria should be closely linked to the evaluation of biological responses."*
>
> *Progress Report - Development of Nutrient Criteria in California: 2003-2004 (Tetra Tech, Inc., October 2004, prepared for U.S. EPA Region IX)*
>
> *(***** emphasis added by Central Coast Water Board staff)*

Further, the U.S. Environmental Protection Agency likewise recognizes biological response indicators are a necessary component of measuring and tracking nutrient pollution:

> *The purpose of these guiding principles is to offer clarity to states about an optional approach for developing a numeric nutrient criterion that integrates causal (nitrogen and phosphorus) **and response parameters*** into one water quality standard…These guiding principles apply when states wish to rely on **response parameters to indicate that a designated use is protected***, even though a nitrogen and/or phosphorus level is/are above an adopted threshold.*
>
> *U.S. Environmental Protection Agency (USEPA, 2013b). Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters. EPA-820-F-13-039.*
>
> *(***** emphasis added by Central Coast Water Board staff)*

Current 303(d)-listed dissolved oxygen (DO) and chlorophyll *a* impairments in the TMDL project area are not directly addressed in the TMDL implementation plan in terms of calculating loads (TMDLs) or setting waste load or load allocations for these constituents. However reductions in nutrient loading are anticipated to be beneficial in attainment of water quality standards for DO and chlorophyll *a* and restoring the waterbodies to a desired condition. Note that this approach regarding nutrient pollution and dissolved oxygen has similarly been used in previous USEPA-approved TMDLs[151]. Therefore, the current 303(d) listings for dissolved oxygen and chlorophyll that are associated with identified biostimulatory problems (refer to Section 5.16.7) are addressed by the TMDLs established herein. It is important to reiterate that nutrient concentrations by themselves constitute indirect indicators of biostimulatory conditions (refer back to Section 3.1), and there is an interrelationship between high nutrient loads, excessive algal growth, and the subsequent impacts of excessive algae on dissolved oxygen and aquatic habitat. Accordingly staff is also proposing dissolved oxygen and chlorophyll a numeric targets to ensure that streams do not show evidence of biostimulatory conditions; additionally numeric targets identified for DO and chlorophyll *a* in this TMDL will be used as indicator metrics to assess primary biological response to future nutrient water column concentration reductions, and compliance with the Basin Plan's biostimulatory substances objective.

6.4.1 Dissolved Oxygen

The Basin Plan contains the following water quality objectives for dissolved oxygen (DO):

- ➢ *For warm beneficial uses and for waters not mentioned by a specific beneficial use, dissolved oxygen concentrations shall not be reduced below 5.0 mg/L at any time.*
- ➢ *For cold and spawning beneficial uses, dissolved oxygen concentrations shall not be reduced below 7.0 mg/L at any time.*

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[151] For example: Wabash River Nutrient and Pathogen TMDL, Final Report. Indiana Dept. of Environmental Management, 2006. Approved by USEPA under Section 303(d) of the Clean Water Act on Sept. 22, 2006.

- *Median values for dissolved oxygen should not fall below 85% saturation as a result of controllable conditions.*

In addition, due to the nature of algal respiration and photosynthesis (refer back to Section 5.8) and since daytime monitoring programs are unlikely to capture most low DO crashes, it is prudent to identify a numeric guideline that can measure daytime biostimulatory problems on the basis of DO supersaturation. Peer-reviewed research in California's central coast region (Worcester et al., 2010) has established an upper limit of 13 mg/L for DO to screen for excessive DO saturation, and addresses the USEPA "Gold Book" water quality standard for excessive gas saturation. Of monitoring sites evaluated in the central coast region that are supporting designated aquatic habitat beneficial uses and do not show signs of biostimulation, DO virtually never exceeded 13 mg/L at any time[152]. Note that the 13 mg/L DO saturation target is not a regulatory standard, but can be used as a TMDL nutrient-response indicator target to assess primary biological response to nutrient pollution reduction. Accordingly, staff proposes the numeric target for DO supersaturation indicative of biostimulatory conditions as follows:

- *Dissolved oxygen concentrations not to exceed 13 mg/L.*

Note that this TMDL is addressing biostimulatory impairments; as such only dissolved oxygen impairments that are credibly linked to biostimulation problems (i.e., elevated algal biomass, wide diel swings in DO/pH, and elevated nutrients) will be addressed in this TMDL. It is important to recognize that there are other factors that affect the concentration of dissolved oxygen in a waterbody. Oxygen can be introduced by additions of higher DO water (e.g., from tributaries); additions of lower DO water (groundwater baseflow), temperature (warm water holds less oxygen than cold water), and reductions in oxygen due to organic decomposition. Dissolved oxygen impairments that are not credibly linked to biostimulation impairments will potentially be addressed in another TMDL process, or in a future water quality standards action.

6.4.2 Chlorophyll *a*

Chlorophyll *a* is an algal biomass indicator. The Basin Plan does not include numeric water quality objectives or criteria for chlorophyll *a*. Staff considered a range of published numeric criteria. The State of Oregon uses an average chlorophyll a concentration of > 15 μg/L as a criterion for nuisance phytoplankton growth in lakes and rivers[153]. The state of North Carolina has set a maximum acceptable chlorophyll *a* standard of 15 μg/L for cold water (lakes, reservoir, and other waters subject to growths of macroscopic or microscopic vegetation designated as trout waters), and 40 μg/L for warm water (lakes, reservoir, and other waters subject to growths of macroscopic or microscopic vegetation not designated as trout waters)[154]. A chlorophyll a concentration of 8 μg/L is recommended as a threshold of eutrophy for plankton in EPA's Nutrient Criteria Technical Guidance Manual for Rivers and Streams (USEPA, 2000a). The Central Coast Region has used 40 μg/L as stand-alone evidence to support chlorophyll *a* listing recommendations for the 303(d) Impaired Water Bodies list.

A recent peer-reviewed study conducted by CCAMP reports that in the California central coast region inland streams that do not show evidence of eutrophication all remained below the chlorophyll *a* threshold of 15 μg/L (Worcester et al., 2010). As this value is consistent with several values reported in published literature and regulations shown above, and as the CCAMP study by Worcester et al. is central coast-specific, staff proposes the numeric target for chlorophyll *a* indicating biostimulatory conditions as follows:

- *Water column chlorophyll a concentrations not to exceed 15 μg/L.*

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[152] Of 2,399 samples at these reference sites, only about 1% of the samples ever exceeded 13 mg/L DO.

[153] Oregon Adminstrative Rules (OAR). 2000. Nuisance Phytoplankton Growth. Water Quality Program Rules, 340-041-0150.

[154] North Carolina Administrative Code 15A NCAC 02B .0211(3)(a).

6.4.3 Microcystins

Microcystins are toxins produced by cyanobacteria (blue-green algae) and are associated with algal blooms and biostimulation in surface waterbodies[155]. The Basin Plan does not contain numeric water quality objectives for microcystins. However, the California Office of Environmental Health Hazard Assessment has published final microcystin public health action levels[156] for human recreational uses of surface waters. These are not regulatory standards, but are suggested public health action levels. This public health action level is 0.8 μg/L for human recreational uses of water. Therefore, staff proposes the numeric water quality target for microcystins[157] as follows:

- *Microcystins concentrations not to exceed 0.8 μg/L.*

These targets are therefore protective of the REC-1 designated beneficial uses of surface waters. Currently, there are no identified impairments in the Pajaro River basin on the basis of algal toxins. However, numeric targets identified for microcystins in the TMDL will be used as an indicator metric to assess primary biological response to future nutrient water column concentration reductions and to ensure compliance with the Basin Plan's biostimulatory substances objective and designated REC-1 beneficial uses.

It should be noted that implementing parties are not required to collect microcystin data, unless they choose to do so voluntarily. At this time, the Water Board is currently funding microcystin data collection which may be used for future assessments of biostimulatory problems in waterbodies of the Pajaro River basin.

7 SOURCE ANALYSIS

7.1 Introduction: Source Assessment Using STEPL Model

Both nitrogen and phosphorus reach surface waters at an elevated rate as a result of human activities (USEPA, 1999). In this TMDL Report nutrient source loading estimates were accomplished using the US Environmental Protection Agency's Spreadsheet Tool for Estimating Pollutant Loads, version 4.0 (STEPL). STEPL is a watershed-scale water quality spreadsheet model developed by Tetra Tech, Inc. for the USEPA. This spreadsheet tool can be used for estimating watershed pollutant loads for nutrients (Nandi et al., 2002). STEPL can also be used to evaluate load reductions that could result from the implementation of various management practices. STEPL was selected for its relative ease in application, the minimal amount of required input data, and because of its endorsement by the USEPA. STEPL employs simple algorithms to calculate long-term average annual watershed nutrient loads from different land uses and source categories. STEPL provides a Visual Basic (VB) interface to create a customized, spreadsheet-based model in Microsoft (MS) Excel. STEPL calculates watershed surface runoff, nutrient loads, including nitrogen and phosphorus based on various land uses and watershed characteristics. STEPL has been used previously in USEPA-approved TMDLs to estimate source loading[158]. It should be recognized that, as with any relatively simple watershed model, STEPL outputs are subject to significant uncertainties and the model pollutant load estimates should not be considered definitive or conclusive. However, STEPL is useful tool in estimating the long-term average relative proportions of various source categories (Nejadhashemi et al., 2011).

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[155] See: U.S. Environmental Protection Agency. Drinking Water Treatability Database.

[156] California Office of Environmental Health Hazard Assessment. 2012. *Toxicological Summary and Suggested Action Levels to Reduce Potential Adverse Health Effects of Six Cyanotoxins* (Final, May 2012).

[157] Includes microcystins LA, LR, RR, and YR

[158] For example, see USEPA, 2010: Decision Document for Approval of White Oak Creek Watershed (Ohio) TMDL Report. February 25, 2010; and Indiana Dept. of Environmental Management, 2008. South Fork Wildcat Creek Watershed Pathogen, Sediment, and Nutrient TMDL.

The annual nutrient loading estimate in STEPL is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution, precipitation data, soil characteristics, groundwater inputs, and management practices. Additional documentation and information on the model can be found at: http://it.tetratech-ffx.com/steplweb/models$docs.htm.

STEPL input parameters used in this TMDL project are outlined in Table 7-1. STEPL spreadsheet results are presented in Appendix C. It should be emphasized that average annual nutrient load estimates calculated by STEPL are indeed estimates and subject to uncertainties; actual loading at the stream-reach scale can vary substantially due to numerous factors over various temporal and spatial scales.

Table 7-1. Spreadsheet Tool for Estimating Pollutant Loads version 4.0 (STEPL) input data.

Input Category	STEPL Input Data	Sources of STEPL Input Data
Mean Annual Rainfall	Range = 14.8 to 32.7 inches/year depending on location of individual subwatersheds	PRISM precipitation dataset, accounting for orographic effects Refer back to report Section 3.7 and refer back to Table 3-22.
Mean Rain Days/Year *(where daily precipitation event >0.01 inches)*	Range = 46 to 58 days per year depending on location of individual subwatersheds	Western Regional Climate Data Center, http://www.wrcc.dri.edu/coopmap/ Weather stations used for STEPL inputs: Weather station: (044025) Hollister 2 Weather station: (047721) San Benito Willow Creek Weather station: (043417) Gilroy Weather station: (045853) Morgan Hill Weather station: (049473) Watsonville Waterworks
Weather Station *(for rain correction factors)*	San Francisco WSO Airport Provided as a default in STEPL	San Francisco WSO Airport as provided in STEPL version 4.0 *(this is the closest weather station to the Pajaro River basin available in STEPL version 4.0 for rain correction factors)*
Land Cover	See STEPL spreadsheets See Appendix C	Farmland Mapping and Monitoring Program (2010) data. Refer back to Table 3-6 in report Section 3.3.
Urban Land Use Distributions (%) *(impervious surfaces categories)*	STEPL default values See Appendix C	STEPL, version 4,0 default values for urban land use category distributions.
Agricultural Animals	See STEPL spreadsheets Appendix C	Estimates of quantities of agricultural animals by individual subwatersheds from information developed and reported by Tetra Tech, Inc. for use in STEPL version 4.0 See: http://mingle.tetratech-ffx.com/steplweb2/steplweb.html
Septic system discharge and failure rate data	See STEPL spreadsheets Appendix C	Input data derived from sewage disposal and onsite wastewater treatment systems (septics) data reported by U.S. Census Bureau and by State Water Resources Control Board – refer to report Section 7.9 and Table 7-25 . Default values given in STEPL version 4.0 were used for septic failure rates (%).
Hydrologic Soil Group (HSG)	B, C, or D (by subwatershed) The predominant HSG present is identified for each individual subwatershed	U.S. Department of Agriculture National Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) Database – refer back to Table 3-34 in report Section 3.11
Soil N and P concentrations (%)	N = 0.068% P = 0.038%	Data available from the International Geosphere–Biosphere Programme Data Information System; Post and Mann (1990); and the Kearney Foundation of Soil Science–University of California, Davis. Refer back to report Section 3.11. and to Text Box 3-6 on page 102.
NRCS reference runoff curve numbers	STEPL default values	NRCS default curve numbers provided in STEPL version 4.0
Universal Soil Loss Equation (USLE) Parameters	See STEPL spreadsheets Appendix C USLE inputs for each individual subwatershed, based on county-level USLE data	County-level USLE data as developed and reported by Tetra Tech, Inc. for use in STEPL version 4.0. See: http://mingle.tetratech-ffx.com/steplweb2/steplweb.html

Input Category	STEPL Input Data	Sources of STEPL Input Data
Nutrient (total N and total P) concentrations in runoff (mg/L)	Agricultural Lands mean N = 11.4 mg/L mean P = 0.64 mg/L Urban Lands N = 1.9 to 3.62 mg/L (range) P = 0.15 to 0.5 mg/L (range) Grazing Lands (aka, rangeland) mean N = 0.25 mg/L mean P = 0.21 mg/L Woodlands mean N = 0.2 mg/L mean P = 0.1 mg/L	• Agricultural lands mean N runoff concentration data from Southern California Coastal Water Research Project, Technical Report 335 (Nov. 2000), Appendix C; and the U.S. Dept. of Agriculture's MANAGE database – refer to Figure 7-19 in report Section 7.6. • Agricultural lands mean P runoff concentration data from Southern California Coastal Water Research Project, Technical Report 335 (Nov. 2000), Appendix C • Urban lands N runoff concentrations from commercial, industrial, residential, transportation, and open space land categories were derived from the arithmetic means of N concentrations reported in the National Stormwater Quality Database (version 3, Feb. 2, 2008) – see Table 7-3 in report Section 7.2. Urban N runoff concentrations for institutional, urban-cultivated, and vacant land categories are the default valued provided in STEPL version 4.0. • Urban lands P runoff concentrations from commercial, industrial, residential, transportation, and open space land categories were derived from the arithmetic means of P concentrations reported in the National Stormwater Quality Database (version 3, Feb. 2, 2008) – see Table 7-4 in report Section 7.2. Urban P runoff concentrations for institutional, urban-cultivated, and vacant land categories are the default valued provided in STEPL version 4.0. • Grazing lands mean N runoff concentration. from California Rangeland Watershed Laboratory rangeland presentation for stream water quality (average of the concentrations given for moderate grazing intensity and no grazing land use categories) http://rangelandwatersheds.ucdavis.edu/Recent%20Outreach/tate%20oakdale%20mar%202012.pdf • Grazing lands (aka, rangeland) mean P runoff concentration is derived from the arithmetic mean of dissolved P concentrations in runoff from all land use categories defined as native grasses, native grasslands, and native prairie reported in the U.S. Dept. of Agriculture MANAGE database (version year 2013). • Woodlands mean N runoff concentration: staff used STEPL version 4.0 default values for "forest" land use category • Woodlands mean P runoff concentration: staff used STEPL version 4.0 default values for "forest" land use category
Nutrient (nitrate and phosphorus) concentrations in shallow groundwater (mg/L)	Valley floor (agricultural lands) NO_3-N = 5.93 P = 0.04 Valley floor (urban lands) NO_3-N = 1.8 P = 0.04 Uplands (woodlands & rangeland) NO_3-N = 0.14 P = 0.04	• Mean groundwater nitrate (NO_3-N) and phosphorus concentrations values are derived on the basis of data available from the U.S. Geological Survey Groundwater Vulnerability Assessment (GWAVA) model; the U.S. Geological Survey National Water Quality Assessment Program (NAWQA); and the U.S. Geological Survey National Geochemical Database. Refer back to the discussion in report Section 3.9, and refer back to Text Box 3-3 on page 71

Assumptions: composted manure was assumed to not be applied to cultivated cropland in the Pajaro River basin, and it is presumed that chemical fertilizers are almost universally used for fertilization in the river basin. This assumption is supported by reporting from local resource professionals and local stakeholders.

7.2 Urban Runoff (Municipal Stormwater)

Urban runoff, in the form of municipal separate storm sewer system (MS4) discharges, can be a contributor of nutrients to waterbodies. USEPA policy explicitly specifies that National Pollutant Discharge Elimination System (NPDES)-regulated urban stormwater discharges are point source discharges and, therefore, must be addressed by the waste load allocation component of a TMDL.[159] The Central Coast Water Board is the permitting authority for NPDES urban stormwater permits in the Central Coast region. According to the U.S. Environmental Protection Agency and the State Water Resources Control Board, all NPDES-permitted point sources identified in a TMDL must be given a waste load allocation, even if their current load to receiving waters is zero[160, 161] (refer to report Section 9.2.4 for further clarification).

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[159] See 40CFR 130.2(g) & (h) and USEPA Office of Water Memorandum (Nov. 2002) *"Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs"*

[160] Personal communication, February 18, 2015, Janet Parrish, Central Coast Regional Liason, U.S. Environmental Protection Agency, Region 9.

Figure 7-1 illustrates the locations and extent of currently enrolled MS4 permit entities in the Pajaro River basin. Within residential areas, potential controllable nutrient sources can include lawn care fertilizers, grass clippings, organic debris from gardens and other green waste, trash, and pet waste (Tetra Tech, 2004). Many of these pollutants enter surface waters via runoff without undergoing treatment. Impervious cover characterizes urban areas and refers to roads, parking lots, driveways, asphalt, and any surface cover that precludes the infiltration of water into the soil. Pollutants deposited on impervious surface have the potential of being entrained by discharges of water from storm flows, wash water, or excess lawn irrigation, etc. and routed to storm sewers, and potentially being discharged to surface water bodies.

Figure 7-1. Generalized and approximate boundaries of permitted MS4 entities in the Pajaro River basin, on the basis of shapefiles for 2010 census-designated urbanized areas and urban clusters.

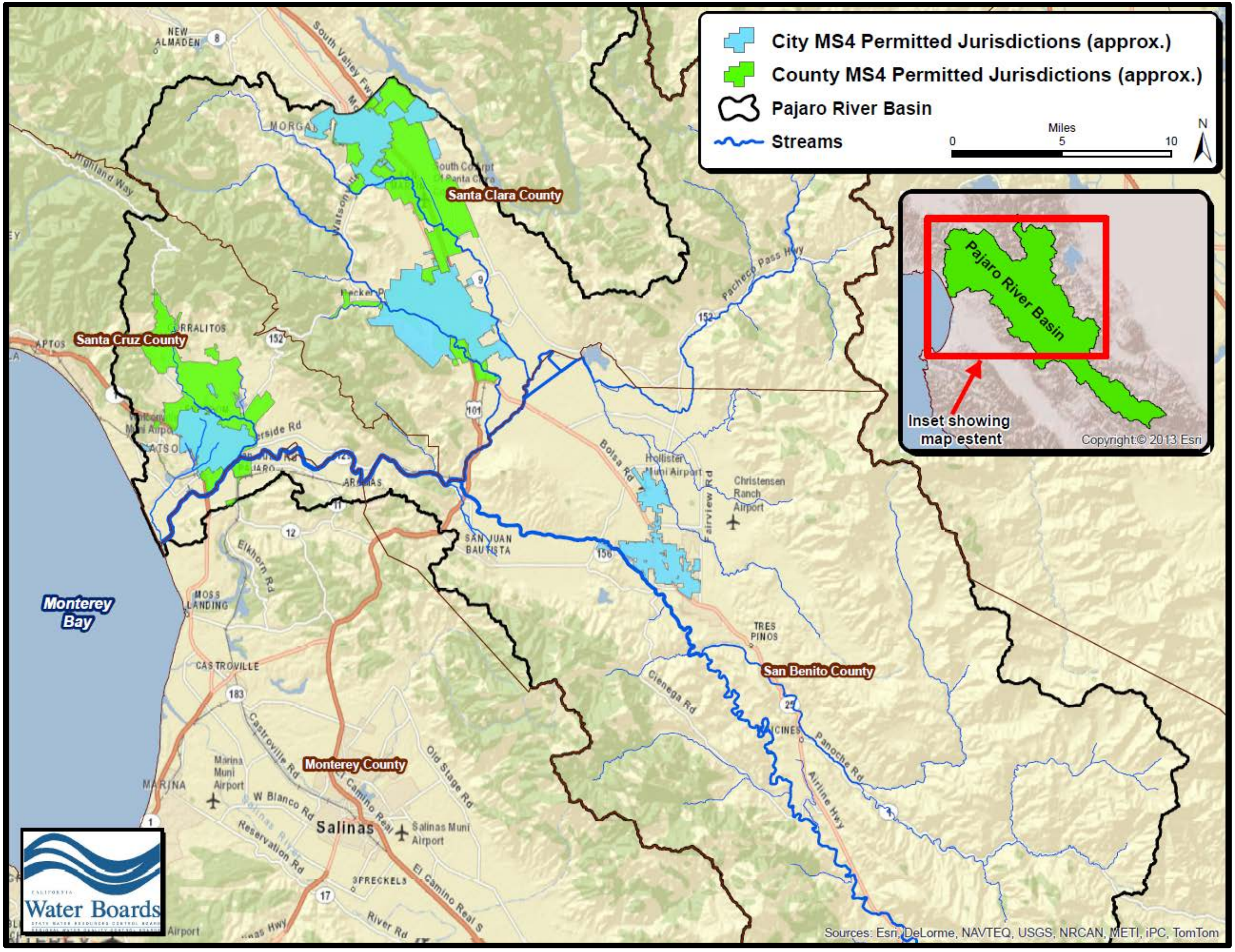

Table 7-2 presents a tabulation of currently enrolled municipal stormwater permit entities having NPDES-permitted jurisdictions within the Pajaro River basin.

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[161] Communication, August 2014, Phil Wyels, Assistant Chief Counsel, State Water Resources Control Board.

Table 7-2. Tabulation of enrolled municipal stormwater permit entities with NPDES-permitted jurisdictions in the Pajaro River basin[A].

Type	Status	Responsible Entity
Phase II Small MS4	Active	City of Watsonville
Phase II Small MS4	Active	City of Gilroy
Phase II Small MS4	Active	City of Morgan Hill
Phase II Small MS4	Active	City of Hollister
Phase II Small MS4	Active	County of Monterey
Phase II Small MS4	Active	County of Santa Clara
Phase II Small MS4	Active	County of Santa Cruz

[A] On the basis of reporting from the: State Water Resources Control Board, Storm Water Multiple Application and Report Tracking System (SMARTS)

Site-specific urban stormwater runoff and storm drain outfall nutrient concentration data for the Pajaro River basin are not available, so estimates of nutrient loading to streams from these sources must be based on plausible approximations and indirect evidence. It should be noted that there is a large quantity of nationwide and California-specific data characterizing nutrient concentrations in urban runoff (see Figure 7-2). Staff filtered the available data to include only data regionally from California and other arid western states. These data (> 1,000 total samples) illustrate that total nitrogen concentrations in urban runoff virtually never exceed the 10 mg/L drinking water regulatory standard for nitrate as N[162] (see Table 7-3). However, the available data suggest that urban runoff nutrient concentrations can episodically be elevated high enough above natural background to potentially contribute to a risk of biostimulation in surface waters (e.g., the data show urban runoff total nitrogen concentrations is episodically > 4 mg/L, and total phosphorus concentrations > 0.5 mg/L) – see Table 7-3, Figure 7-2, Table 7-4, and Figure 7-3.

Table 7-3. Total nitrogen concentrations in urban runoff (units = mg/L) from National Stormwater Quality Database (NSQD version 3) for sites in NSQD rain zones 5, 6, and 9 (arid west and southwest [A]). Temporal range of data is December 1978 to July 2002. Note that the nitrate as N drinking water quality standard is not necessarily directly comparable to total nitrogen aqueous concentrations shown here[B], but the nitrate as N water quality standard is shown in the table for informational purposes.

Stormwater Runoff Category	Predominant land use at monitoring site location	No. of Samples	Arithmetic Mean	Min	25%	50% (median)	75%	90%	Max	No. Exceeding Drinking Water Standard (>10 mg/L)	% Samples Exceeding 10 mg/L
Urban runoff	**All Sites**	1,085	3.08	0.03	1.30	2.03	3.62	6.50	68.03	35 of 1,085	**3.2%**
	commercial	162	2.71	0.50	1.18	1.80	3.28	5.53	15.90	–	Not calculated for individual land use types
	freeways	322	2.51	0.03	1.10	1.71	2.80	5.25	36.15	–	
	industrial	198	3.53	0.26	1.34	2.15	4.65	7.86	17.90	–	
	open space	68	2.75	0.73	1.45	1.98	3.34	5.30	9.14	–	
	residential	335	3.62	0.20	1.51	2.64	4.39	7.10	68.03	–	

[A] Includes central and southern California, Arizona, Colorado, central and west Texas, and western South Dakota and includes monitoring locations from cities of Arlington (TX), Aurora (CO), Austin (TX), Castro Valley (CA), Colorado Springs (CA), Dallas (TX), Denver (CO), Fort Worth (TX), Fresno (CA), Garland (TX), Irving (TX), Los Angeles (CA), Maricopa City (AZ), Mesquite (TX), Orange County (CA), Plano (TX), Sacramento (CA), Rapid City (SD), Riverside (CA), San Bernardino (CA), San Diego (CA), Tucson (AZ).

[B] Total nitrogen measured in aqueous systems includes nitrate as well as other compounds and phases of nitrogen, such as ammonia and organic nitrogen. Often, but not always, nitrate makes up the largest fraction of the nitrogen compounds found in total nitrogen measurements from stream waters.

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[162] Elevated nitrogen levels in urban runoff can, however, locally contribute to biostimulatory impairments of receiving waters where eutrophication has been identified as a water quality problem regardless of whether or not the nitrogen levels exceed the drinking water quality standard.

Figure 7-2. Box plot of total nitrogen concentrations in urban runoff from National Stormwater Quality Database (NSQD) monitoring locations in NSQD rain zones 5,6, and 9 (arid west and southest). Raw statistics for this dataset were previously shown in Table 7-3. Note that the nitrate as N water quality standard is not necessarily directly comparable to total nitrogen aqueous concentrations shown here, but the water quality standard is shown on the graph for informational purposes. Temporal range of data is Dec. 1978 to July 2002.

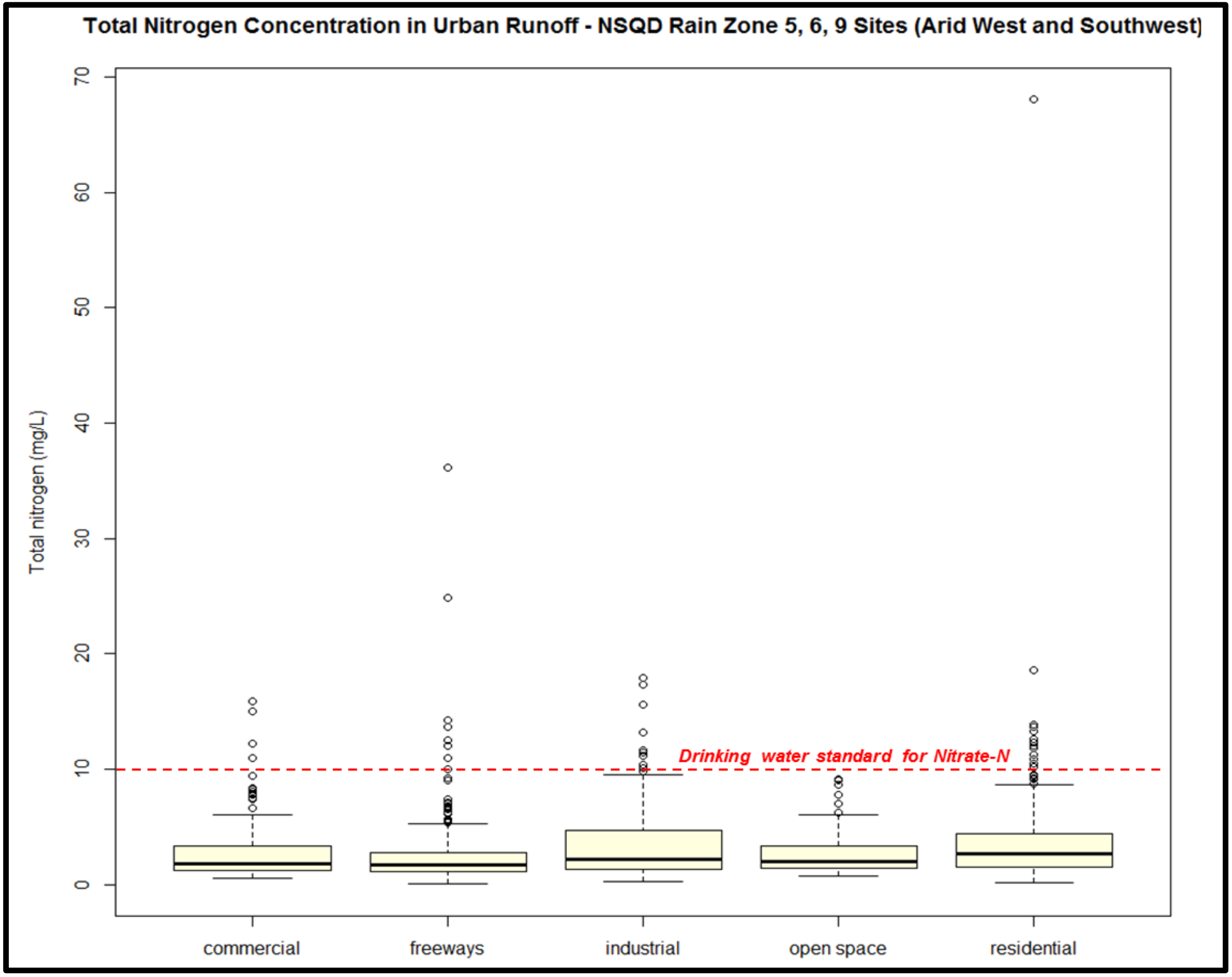


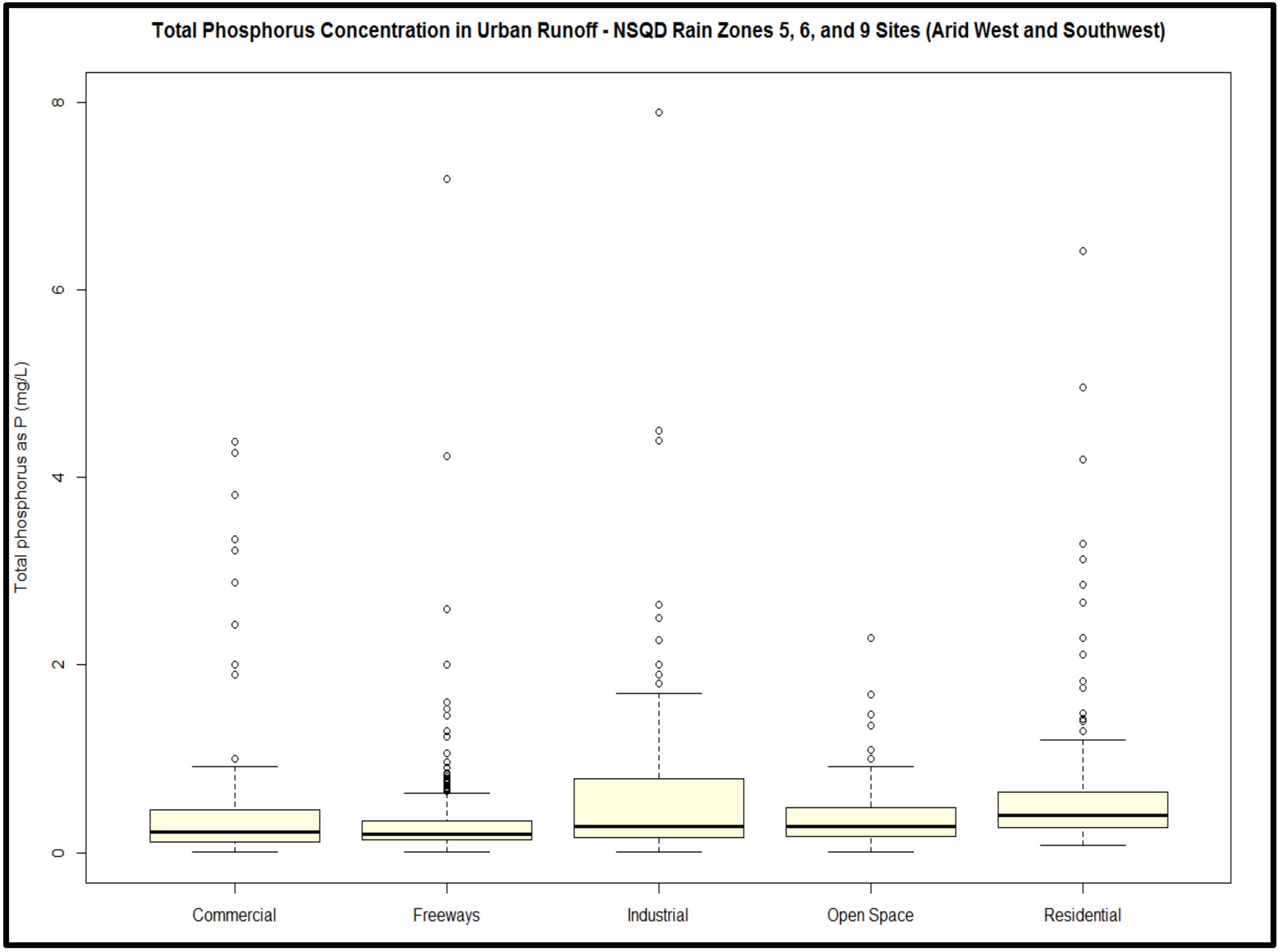
Table 7-4. Total phosphorus as P concentrations in urban runoff (units = mg/L) from National Stormwater Quality Database (NSQD version 3) for sites in NSQD rain zones 5, 6, and 9[A] (arid west and southwest). Temporal range of data is December 1978 to July 2002.

Stormwater Runoff Category	Predominant land use at monitoring site location	No. of Samples	Arithmetic Mean	Geometric Mean	Min	25%	50% (median)	75%	90%	Max
Urban runoff	**All Sites**	1,160	0.550	0.287	0.01	0.16	0.29	0.49	0.92	80.2
	commercial	381	0.590	0.24	0.01	0.11	0.22	0.46	0.80	15.60
	freeways	192	0.525	0.21	0.01	0.14	0.20	0.34	0.54	80.20
	industrial	76	0.614	0.34	0.01	0.16	0.28	0.78	1.46	7.90
	open space	348	0.401	0.24	0.01	0.17	0.28	0.48	0.96	2.29
	residential	381	0.555	0.42	0.08	0.27	0.40	0.64	1.00	6.42

[A] Includes central and southern California, Arizona, Colorado, central and west Texas, and western South Dakota and includes monitoring locations from cities of Aurora (CO), Austin (TX), Carlsbad (CA), Castro Valley (CA), Colorado Springs (CA), Dallas (TX), Denver (CO), Encinitas (CA), Fort Worth (TX), Garland (TX), Fresno (CA), Garland (TX), Irving (TX), Maricopa City (AZ), Mesquite (TX), Plano (TX), Rapid City (SD), San Diego (CA), Tucson (AZ).

Stormwater Runoff Category	Predominant land use at monitoring site location	No. of Samples	Arithmetic Mean	Geometric Mean	Min	25%	50% (median)	75%	90%	Max

Figure 7-3. Box plot of total phosphorus as P concentrations in urban runoff from National Stormwater Quality Database (NSQD) monitoring locations in NSQD rain zones 5,6, and 9 (arid west and southeast). Raw statistics for this dataset were previously shown in Table 7-4. Temporal range of data is December 1978 to July 2002.



Average annual nutrient loads delivered to surface waterbodies in the Pajaro River basin from urban runoff were estimated on the basis of the STEPL input parameters previously identified in Section 7.1 – these estimated loads are tabulated in Table 7-5.

Table 7-5. Estimated average annual nutrient loads (lbs./year) delievered to surface waterbodies from urban runoff (i.e., municipal stormwater) in the Pajaro River basin.

Source	N Load (lbs/yr)	P Load (lbs/yr)
Urban Runoff (i.e., municipal stormwater system discharges)	182,542	21,565

Based on the aforementioned information, stormwater from MS4s are estimated to be a relatively minor source of nutrient loading to streams of the Pajaro River basin. This assessment comports well with an independent line of scientific reporting provided by Williamson et al. (1994). These researchers concluded that at the basin-scale, nutrient loads from municipal stormwater runoff was relatively insignificant. However, because MS4 stormwater sources can potentially have significant localized effect on water quality, waste load allocations will be assigned to Pajaro River basin NPDES MS4 stormwater permits.

7.3 Industrial & Construction Stormwater

According to guidance from the State Water Resources Control Board, all NPDES point sources should receive a waste load allocation (communication from Jonathan Bishop, Chief Deputy Director and Phil Wyels, Assistant Chief Counsel, State Water Resources Control Board, August 2014), and thus NPDES–permitted industrial stormwater and construction stormwater entities should be considered during TMDL development (refer to report Section 0 for further clarification).. Similarly, USEPA guidance recommends disaggregating stormwater sources in the waste load allocation of TMDL where feasible, including disaggregating industrial stormwater discharges (USEPA, 2014b).

As of December, 2014 there are 72 active NPDES stormwater-permitted industrial facilities in the Pajaro River basin, and 87 active NPDES stormwater-permitted construction sites in the Pajaro River basin[163]. Table 7-6 and Table 7-7 present a tabulation of stormwater-permitted industrial facilities and construction sites, respectively.

Table 7-6. List of active NPDES stormwater-permitted industrial facilities located in the Pajaro River basin as of December 5, 2014.

Site/Facility Name	Facility City
Sandman Inc DBA Star Concrete	Gilroy
Metech Recycling Inc	Gilroy
Pacific Coast Recycling Inc	Gilroy
Cardlock Fuels System Inc	Gilroy
Gilroy Bin	Gilroy
A and S Metals	Gilroy
Olam West Coast Inc	Gilroy
Christopher Ranch LLC	Gilroy
Gilroy Unified Sch Dis	Gilroy
Pacific Coast Recycling Inc	Gilroy
Recology South Valley	Gilroy
Freeman Quarry	Gilroy
International Paper	Gilroy
Gilroy Energy Ctr LLC KC	Gilroy
Gilroy Maintenance Facility	Gilroy
Architectural Facades Unlimit	Gilroy
Z Best Products	Gilroy
South Cnty Reg Ww Auth Gilroy	Gilroy
TIN Inc dba Temple Inland	Gilroy
Boral Roofing	Gilroy
Pacheco Pass Recology	Gilroy
San Benito Recycling	Hollister
RJR Environmental Prof Svs Inc DBA RJR Recycling	Hollister
Peninsula Packaging Company	Hollister
Kents Oil Service Inc	Morgan Hill
Morgan Hill Unified School District Transportation Facility	Morgan Hill
Andpak Inc	Morgan Hill
Greif Packaging LLC	Morgan Hill
Moreno Petroleum Co	Pajaro
Willis Const Co	San Juan Bautista
Calstone Company	San Martin
South County Airport	San Martin
Alf Auto Wreckers	San Martin
San Martin Transfer Station	San Martin
Paicines Quarry	Tres Pinos
A & S Metals	Watsonville
North Star Biofuels LLC	Watsonville
Watsonville Bin	Watsonville
Greenwaste Recovery Inc	Watsonville
Cascade Properties	Watsonville
Sunland Garden Prod Inc	Watsonville
Gerry S Foreign Auto Wreckers	Watsonville
Smith & Vandiver Corp	Watsonville
River Run Vintners	Watsonville
Westlake Transport Inc	Watsonville
S Martinelli & Co	Watsonville
Salsipuedes Auto Wreckers	Watsonville
Granite Rock Co Watsonville Co	Watsonville

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[163] On the basis of information publically available in the State Water Resource Control Board's Storm Water Multiple Applications & Report Tracking System (SMARTS). https://smarts.waterboards.ca.gov/smarts/faces/SwSmartsLogin.jsp

Site/Facility Name	Facility City		Site/Facility Name	Facility City
KMG Electronic Chemicals Inc	Hollister		Coast Auto Supplies & Dism Inc	Watsonville
Herbert Family Organic Farm Inc	Hollister		Del Mar Food Prod Corp	Watsonville
BAE Systems Land & Armaments LP	Hollister		Watsonville Municipal Ser Cen	Watsonville
San Benito Auto Wreckers	Hollister		Watsonville City Airport	Watsonville
Spring Grove Sch	Hollister		Watsonville Landfill	Watsonville
Pacific Scientific Energetic Materials Company California	Hollister		Roy Wilson Yard	Watsonville
Brent Redmond Trans	Hollister		Mizkan Americas Inc	Watsonville
Hollister City Airport	Hollister		Santa Cruz Cnty Buena Vista La	Watsonville
San Benito Cnty John Smith Rd landfill	Hollister		S Martinelli & Co	Watsonville
Trical Soil Fumigation	Hollister		Lewis Rd Sanitary Landfill	Watsonville
TenCate Advanced Composites USA Inc	Morgan Hill		Hildebrand & Sons Trucking	Watsonville

Table 7-7. List of active NPDES stormwater-permitted construction site facilities located in the Pajaro River basin as of December 5, 2014.

Site/Facility Name	Facility City		Site/Facility Name	Facility City
Twin Creeks Residential Development	Gilroy		Diamond Creek	Morgan Hill
GCF Frozen Inc	Hollister		Madrone Plaza Arbors and Villas	Morgan Hill
Hollister Municipal Airport Runway Rehabilitation	Hollister		Lands of McBain	Gilroy
Joint Trunk Sewer Replacement	Gilroy		Walnut Grove	Morgan Hill
Lessalt Water Treatment Plant	Hollister		Highlands at Eagle Ridge	Gilroy
South County Recycled Water Pipeline Short Term Phase 1B Project Camino Arroyo Service Line	Gilroy		Walnut Park 13 Phase 2	Hollister
Shadow Pines	Morgan Hill		Oak Place	Gilroy
Pajaro River	Watsonville		Mission Ranch Phase 12A	Morgan Hill
Rajkovich Property	Hollister		Edmunson Piazza	Morgan Hill
Morgan Hill 3	Morgan Hill		Gilroy Sobrato Apartments	Gilroy
New Distribution Facility For UNFI	Gilroy		Rucker Elementary School	Gilroy
Glen Loma Ranch Phase 1A	Gilroy		Rataul Residence	Morgan Hill
Parking Lot C Expansion	Gilroy		Kim Son Meditation Center	Watsonville
Hollister Solar	Hollister		MH CLayton Phase I	Morgan Hill
Rocha property	Watsonville		Morgan Hill Residences	Morgan Hill
East Dunne Park	Morgan Hill		Medina Residence	Watsonville
Dara Farms	Hollister		PAN PACIFIC RV CENTERS	Morgan Hill
Ladd Lane Hillock Extension	Hollister		Ironhorse North	Morgan Hill
Creekside 6	Hollister		Villas of San Marco Phase 2 and 3	Morgan Hill
Loden Place	Morgan Hill		Walnut Park 13 Phase 1	Hollister
Mission Ranch Phase 13	Morgan Hill		Hollister Courthouse	Hollister
Stonebridge 2	Hollister		Foster Farms Hollister Ranch Complex	Hollister
Masoni III	Gilroy		Storemore Westage America	Watsonville
Santana Ranch Grading Phase 1 & 2	Hollister		Schafer Ave	Morgan Hill
Hecker Pass	Gilroy		Jasper Park	Morgan Hill
Silver Oaks	Hollister		Hollister Hills SVRA	Hollister
Morgan Hill 3	Morgan Hill		Carriage Hills III 8 Lots	Gilroy
Christopher High School Track & Field	Gilroy		Butterfield South	Morgan Hill
Kamboj School Road	San Juan Bautista		Womens Center and Parking Lots	Hollister
Primary Influent Forcemain Construction	Gilroy		ARCO AMPM Watsonville	Watsonville
Rancho Hills	Gilroy		New CA5 Building Storage	Gilroy

Site/Facility Name	Facility City		Site/Facility Name	Facility City
Mission Ranch Phase 12B	Morgan Hill		Anderson Visitor Center	Morgan Hill
Evans circle phase 1	Watsonville		Lone Hill Drive	Morgan Hill
Z BEST Composting Facility	Gilroy		Oliveri	Gilroy
Blanca Terrace	Watsonville		Lions Creek Trail Projects	Gilroy
Connemara Phase 1	Morgan Hill		Lands of Leavesley Road	Gilroy
Gilroy Self Storage	Gilroy		Mission Ranch Phase 10 and 11	Morgan Hill
Eden West	Hollister		Perham Residence	Gilroy
Vintage Estates	Morgan Hill		Mast Condo Dev	Morgan Hill
Harvest Park	Gilroy		George Chiala Farms	Morgan Hill
Gilroy Monterey Manor	Gilroy		Gilroy Cannery Proj	Gilroy
Pajaro Neighborhood Park	Pajaro		Creek Side At Eagle Ridge	Gilroy
Creekside 5	Hollister			

Site specific industrial and construction stormwater runoff nutrient data for the Pajaro River basin are not available, so direct inferences about nutrient loading to surface waters from these facilities in the river basin are not possible. However, there is a large amount of statewide stormwater runoff nitrate water quality from a wide range of industrial facilities, and also from some construction sites providing a plausibly good spatial representation of a variety of these types of sites within California (see Figure 7-4). These data can give some insight into expected nitrate and nitrogen concentrations typically found in stormwater runoff from industrial and construction sites throughout California (see Table 7-8, Table 7-9, Table 7-10, and Figure 7-5). Based on the available data, stormwater runoff from industrial and construction facilities throughout California typically have relatively low nitrogen concentrations averaging less than 2 mg/L for nitrate as N and for total nitrogen. Further, as the large number of samples collected statewide indicate, the nitrate concentrations in stormwater runoff from these facilities almost never exceed or even approach the numeric threshold for the drinking water standard = 10 mg/L nitrate as N.

Therefore, indirect and anecdotal evidence suggests that NPDES stormwater-permitted industrial facilities and construction sites in the Pajaro River basin would not be expected to be a significant risk or cause of the observed nutrient water quality impairments, and these types of facilities are generally expected to be currently meeting waste load allocations identified in this report. To maintain existing water quality and prevent any further water quality degradation, these permitted industrial facilities and construction operators shall continue to implement and comply with the requirements of the statewide Industrial General Permit or the Construction General Permit, respectively.

The information outlined above does not conclusively demonstrate that stormwater from all industrial facilities and construction sites are meeting proposed waste load allocations. More information will be obtained during the implementation phase of these TMDLs to further assess the level of nutrient contributions to surface waters from these source categories, and to identify any actions needed to reduce nutrient loading.

Figure 7-4. California industrial and contruction stormwater permitted sites with reported nitrate water quality results. Site specific industiral and construction stormwater runoff nutrient data for the Pajaro River basin are not available, so statewide data are presented in this section for informational purposes and as supporting lines of indirect evidence.

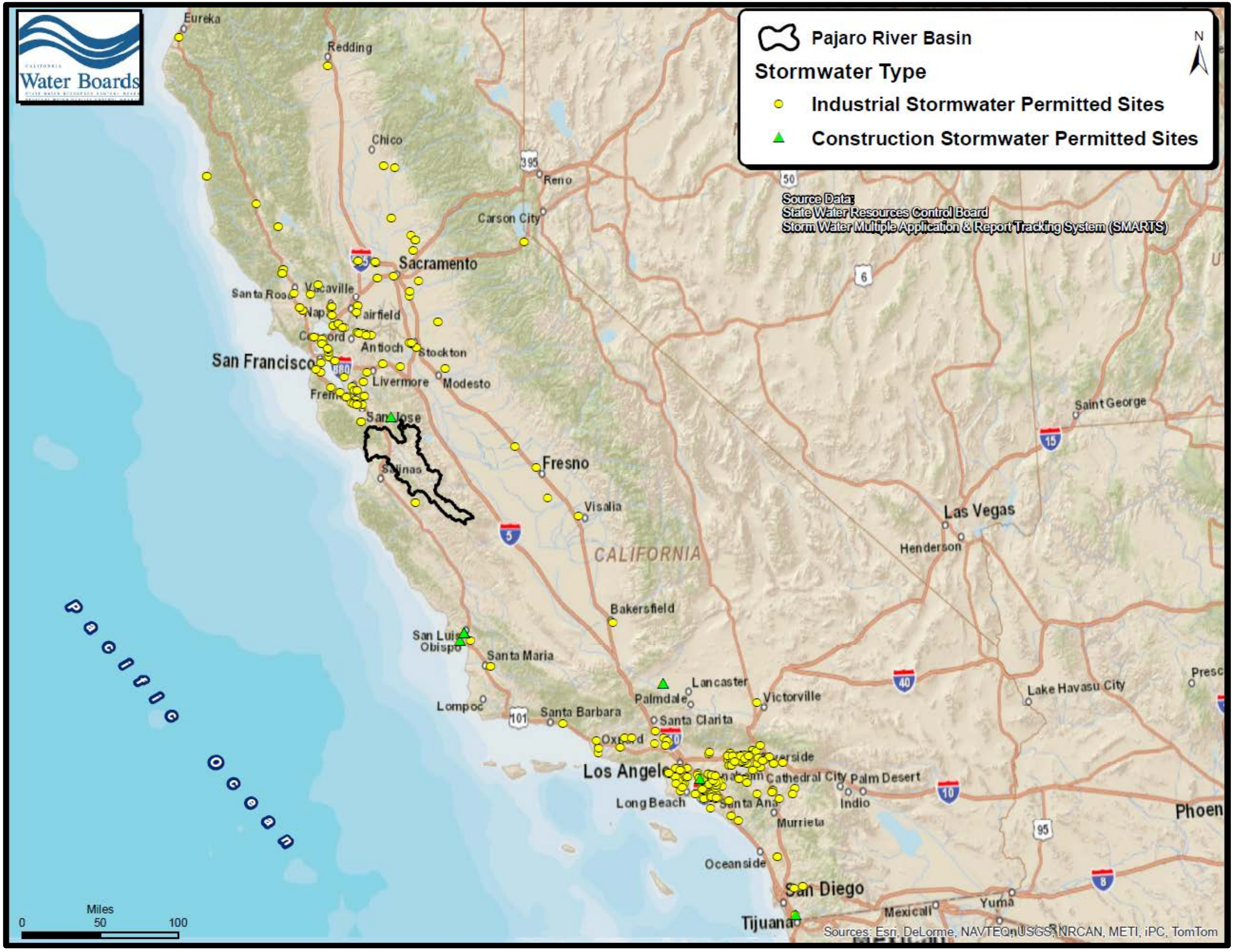


Table 7-8. Nitrate as N concentrations in industrial stormwater runoff (units = mg/L) from permitted California facility sites shown previously in Figure 7-4 and as reported in the State Water Resources Control Board's Stormwater Multiple Application & Report Tracking System. Site specific data for the Pajaro River basin are not available, so statewide data are presented for informational purposes. Temporal range of data is Oct. 2005 to Nov. 2014.

Stormwater Runoff Category	No. of Samples	Geometric Mean	Min	10%	25%	50% (median)	75%	90%	Max	No. Exceeding Drinking Water Standard (>10 mg/L)	% Samples Exceeding 10 mg/L
Industrial stormwater runoff	1,906	0.78	0	0.1	0.25	0.72	2.1	6	13,100	119 of 1,906	**3.2%**

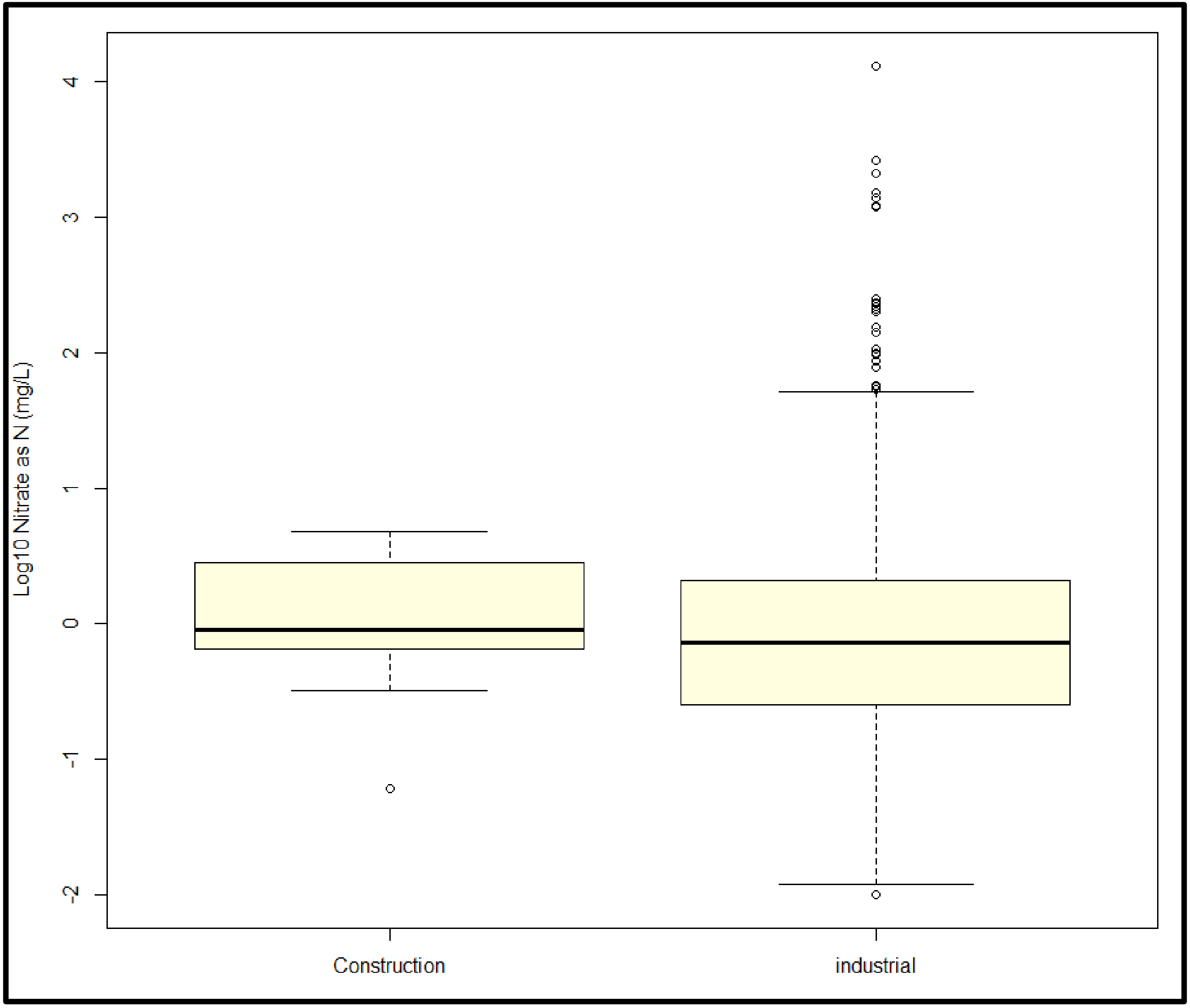
Table 7-9. Total nitrogen as N concentrations in industrial stormwater runoff (units = mg/L) from permitted California facility sites shown previously in Figure 7-4 and as reported in the State Water Resources Control Board's Stormwater Multiple Application & Report and Tracking System. Site specific data for the Pajaro River basin are not available, so statewide data are presented for informational purposes. Temporal range of data is from October 2005 to November 2014.

Industrial Stormwater: Type of Facility	**No. of Samples**	**Arithmetic Mean**	**Min**	**10%**	**25%**	**50%**	**75%**	**90%**	**Max**	**No. of samples.**
All industrial stormwater facilities	76	1.53	0.01	0.02	0.08	0.32	1.30	3.85	22.00	76
Aircraft Parts and Auxiliary Equipment	8	0.48	0.21	0.28	0.33	0.37	0.60	0.79	0.97	8.00
Aluminum Die-Castings	12	0.13	0.02	0.06	0.08	0.12	0.17	0.21	0.24	12.00
Chemicals and Allied Products	2	0.43	0.40	0.41	0.42	0.43	0.45	0.45	0.46	2.00
Coating Engraving and Allied Services	7	2.67	0.01	0.01	0.01	0.01	4.33	8.92	10.00	7.00
Electroplating Plating Polishing Anodizing and Coloring	5	0.05	0.02	0.02	0.03	0.04	0.05	0.08	0.10	5.00
Fabricated Plate Work (Boiler Shops)	3	0.15	0.07	0.08	0.08	0.09	0.19	0.24	0.28	3.00
Fertilizers Mixing Only	4	1.58	0.10	0.13	0.18	0.31	1.72	4.05	5.60	4.00
General Warehousing and Storage	1	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.50	1.00
Industrial Valves	1	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	1.00
Pesticides and Agricultural Chemicals	6	2.48	0.72	0.79	0.91	1.70	2.45	4.95	7.40	6.00
Plastics Material and Synthetic Resins and Nonvulcanizable Elastomers	2	0.06	0.02	0.03	0.04	0.06	0.08	0.09	0.10	2.00
Poultry Slaughtering and Processing	1	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.00
Prepared Feed and Feed Ingredients for Animals and Fowls	2	13.00	4.00	5.80	8.50	13.00	17.50	20.20	22.00	2.00
Printed Circuit Boards	2	0.02	0.01	0.01	0.02	0.02	0.03	0.03	0.03	2.00
Refuse Systems	4	0.47	0.05	0.16	0.34	0.46	0.59	0.79	0.92	4.00
Sheet Metal Work	2	0.10	0.07	0.07	0.08	0.10	0.11	0.12	0.13	2.00
Soaps and Other Detergents Except Specialty Cleaners	10	2.66	0.51	1.13	1.73	3.20	3.47	3.75	4.20	10.00
Trucking Except Local	2	1.43	0.16	0.41	0.80	1.43	2.07	2.45	2.70	2.00
Wood Office Furniture	2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	2.00

Table 7-10. Nitrate as N concentrations in construction stormwater runoff (units = mg/L) from permitted California construction sites as shown previously previously in Figure 7-4 and as reported in the State Water Resources Control Board's Stormwater Multiple Application & Report Tracking System. Site specific data for the Pajaro River basin are not available, so statewide data are presented for informational purposes. Temporal range of data is from July 2010 to February 2014.

Stormwater Runoff Category	**No. of Samples**	**Arithmetic Mean**	**Min**	**10%**	**25%**	**50% (median)**	**75%**	**90%**	**Max**	**No. Exceeding Drinking Water Standard (>10 mg/L)**	**% Samples Exceeding 10 mg/L**
Construction stormwater runoff	21	1.64	0.06	0.32	0.65	0.9	2.8	4.5	4.8	0 of 21	**0%**

Figure 7-5. Boxplot of reported nitrate as N concentrations observed in California industrial and construction stormwater sites. Site specific data for the Pajaro River basin are not available, so statewide data are presented for informational purposes. Note the vertical axis is log concentrations, thus log10 value of one represents a concentration of 10 mg/L nitrate at N; a log10 value of 0 represents a concentration of 1 mg/L nitrate as N; a log10 value of (negative)one represents a nitrate as N concentration of 0.1 mg/L, as so on.



7.4 Wastewater Treatment Facilities

Treated municipal wastewater can potentially be a source of nutrient loads to streams in any given watershed. According to Williamson et al. (1994), at the river basin-scale, nutrient loads to surface waters of the Pajaro River basin was relatively insignificant. It should be noted that this assessment is two decades old. However, even if point sources of pollution are relatively small at the scale of a river basin in any given river basin, they could potentially have adverse localized effects on stream water quality.

Figure 7-6 illustrates the location of municipal wastewater treatment plants within the Pajaro River basin. Table 7-11 presents a tabulation of municipal wastewater treatment facilities and their operating agencies within the river basin. Only three of these facilities are authorized to discharge to surface waters under NPDES-permitted conditions. Table 7-11 presents summary information about these three

NPDES-permitted wastewater treatment facilities. According to the U.S. Environmental Protection Agency and the State Water Resources Control Board, all NPDES-permitted point sources identified in a TMDL must be given a waste load allocation, even if their current load to receiving waters is zero[164, 165] (refer to report Section 9.2.4 for further clarification)..

Figure 7-6. Location of muncipal wastewater treatment facilities in the Pajaro River basin.

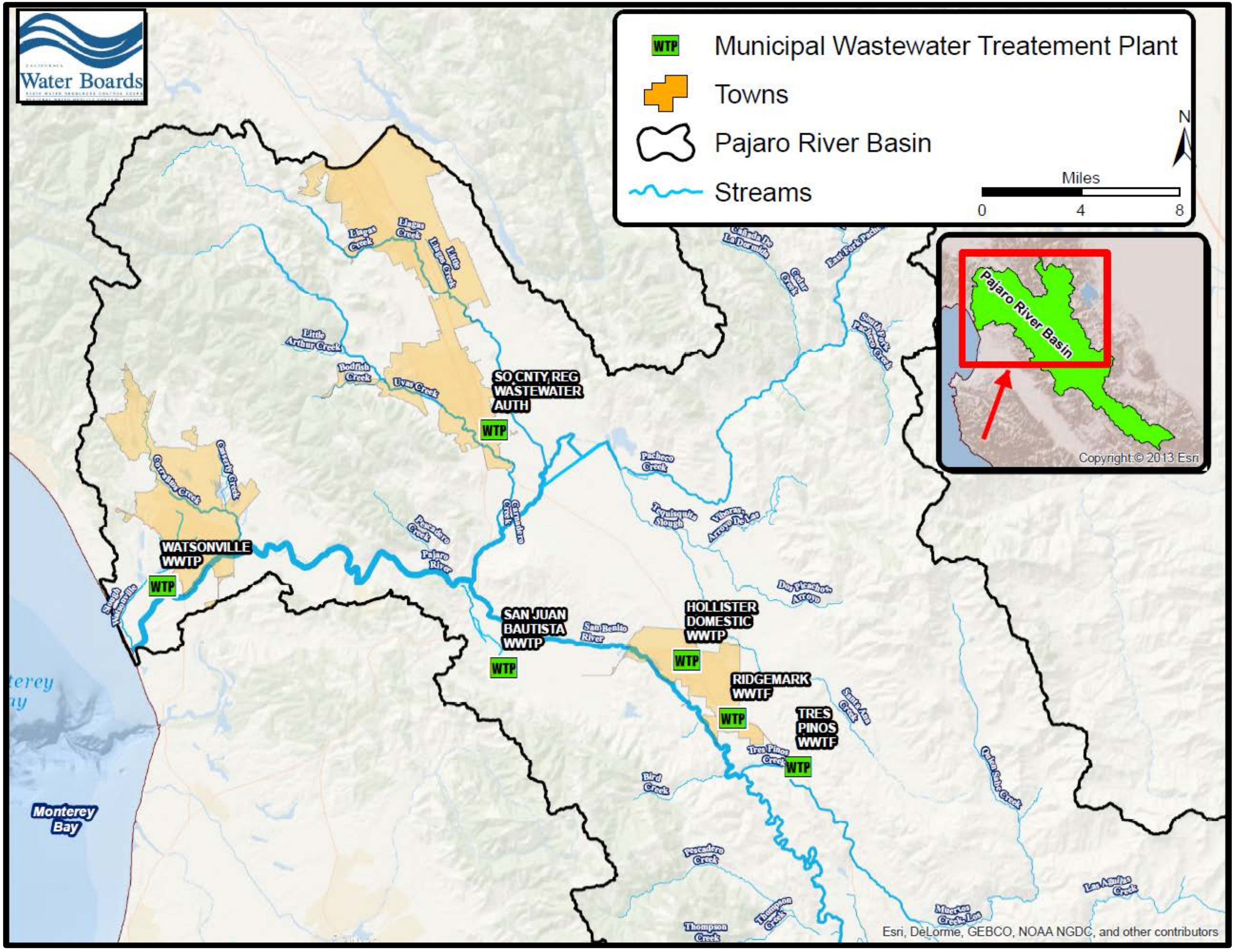


Table 7-11. Tabulation of all municipal wastewater treatement facilities in the Pajaro River basin as reported in the California Integrated Water Quality System (CIWQS). NPDES facilities are those that are authorized to discharge treated wastewater to surface waters.

Facility Name	Agency	Project Type	Regulatory Measure Status	Regulatory Measure Type[A]	Order No.	NPDES No.
Hollister Domestic WWTP	Hollister City	Wastewater Treatment Facility	Active	WDR (land discharge)	R3-2008-0069	N.A.
San Juan Bautista WWTP	San Juan Bautista City	Wastewater Treatment Facility	Active	NPDES Permit	R3-2009-0019	CA0047902

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[164] Personal communication, February 18, 2015, Janet Parrish, Central Coast Regional Liason, U.S. Environmental Protection Agency, Region 9.

[165] Communication, August 2014, Phil Wyels, Assistant Chief Counsel, State Water Resources Control Board.

Facility Name	Agency	Project Type	Regulatory Measure Status	Regulatory Measure Type[A]	Order No.	NPDES No.
Tres Pinos WWTP	Tres Pinos WD	Wastewater Treatment Facility	Active	WDR (land discharge)	R3-2012-0015	N.A.
South County Regional Wastewater Authority Reclaiming WW Facility	South County Regional WW Authority	Wastewater Treatment Facility	Active	WDR (land discharge)	98-052	N.A.
South County Regional Wastewater Authority WWTP	South County Regional WW Authority	Wastewater Treatment Facility	Active	NPDES Permit	R3-2010-0009	CA0049964
Pajaro Valley WMA & City of Watsonville Water Reclamation	Pajaro Valley Water Management Agency	Wastewater Treatment Facility	Active	WDR (land discharge)	R3-2008-0039	N.A.
City of Watsonville Wastewater Treatment Facility	Watsonville City	Wastewater Treatment Facility	Active	NPDES Permit	R3-2014-0006	CA0048216
Ridgemark Estates WWTP	Sunnyslope CWD	Wastewater Treatment Facility	Active	WDR (land discharge)	R3-2004-0065	N.A.

N.A. = not applicable

[A] WDR = waste discharge requirements (discharges of waste to land); NPDES = national pollutant discharge elimination system permit, referring here to discharges that do or may potentially discharge to surface receiving waters.

Table 7-12. NPDES-permitted wastewater treatment facilities in the Pajaro River basin.

Facility	Effluent Description	Discharge Point Latitude	Discharge Point Longitude	Receiving Water
City of Watsonville Wastewater Treatment Facility[A]	Secondary Treated Wastewater and Brine Wastes	35 º 50 ' 44 " N	121 º 49 ' 59 " W	Pacific Ocean (Monterey Bay)
South County Wastewater Treatment and Reclamation Facility[B]	Tertiary Treated Municipal Wastewater	36º 56' 52" N	121º 30' 43" W	Pajaro River
City of San Juan Bautista Wastewater Treatment Plant[C]	Treated Domestic Wastewater	36 º 50' 58.11" N	121 º 32' 41.90" W	Unnamed drainage channel tributary to San Juan Creek

[A] According to Order No. R3-2014-0006 (NPDES No. CA0048216), the U.S. Environmental Protection Agency and the Regional Water Quality Control Board have classified this as a major discharge.

[B] According to Order No. R3-2010-0009 (NPDES No. CA0049964), the U.S. Environmental Protection Agency and the Regional Water Quality Control Board have classified this as a major discharge.

[C] According to Order No. R3-2009-0019 (NPDES No. CA0047902), the U.S. Environmental Protection Agency and the Regional Water Quality Control Board have classified this as a minor discharge.

These TMDLs address nutrient discharges to streams of the Pajaro River basin, and thus the Watsonville Wastewater Treatment Facility's (Order No. R3-2014-0006 NPDES No. CA0048216) ocean discharge point (see Figure 7-7) is outside the scope of these TMDLs and therefore further regulatory measures in the context of these TMDLs for this facility is not warranted. This facility will be given a generic waste load allocation, to reserve discharge capacity if there is a need for future discharge points for this facility in surface waters of the Pajaro Valley. As noted above, all NPDES-permitted point sources identified in a TMDL must be given a waste load allocation, even if their current load to receiving waters is zero[166], otherwise their allocation is assumed to be zero and no discharges of the identified pollutant(s) are allowed now or in the future (refer to report Section 0 for further clarification).

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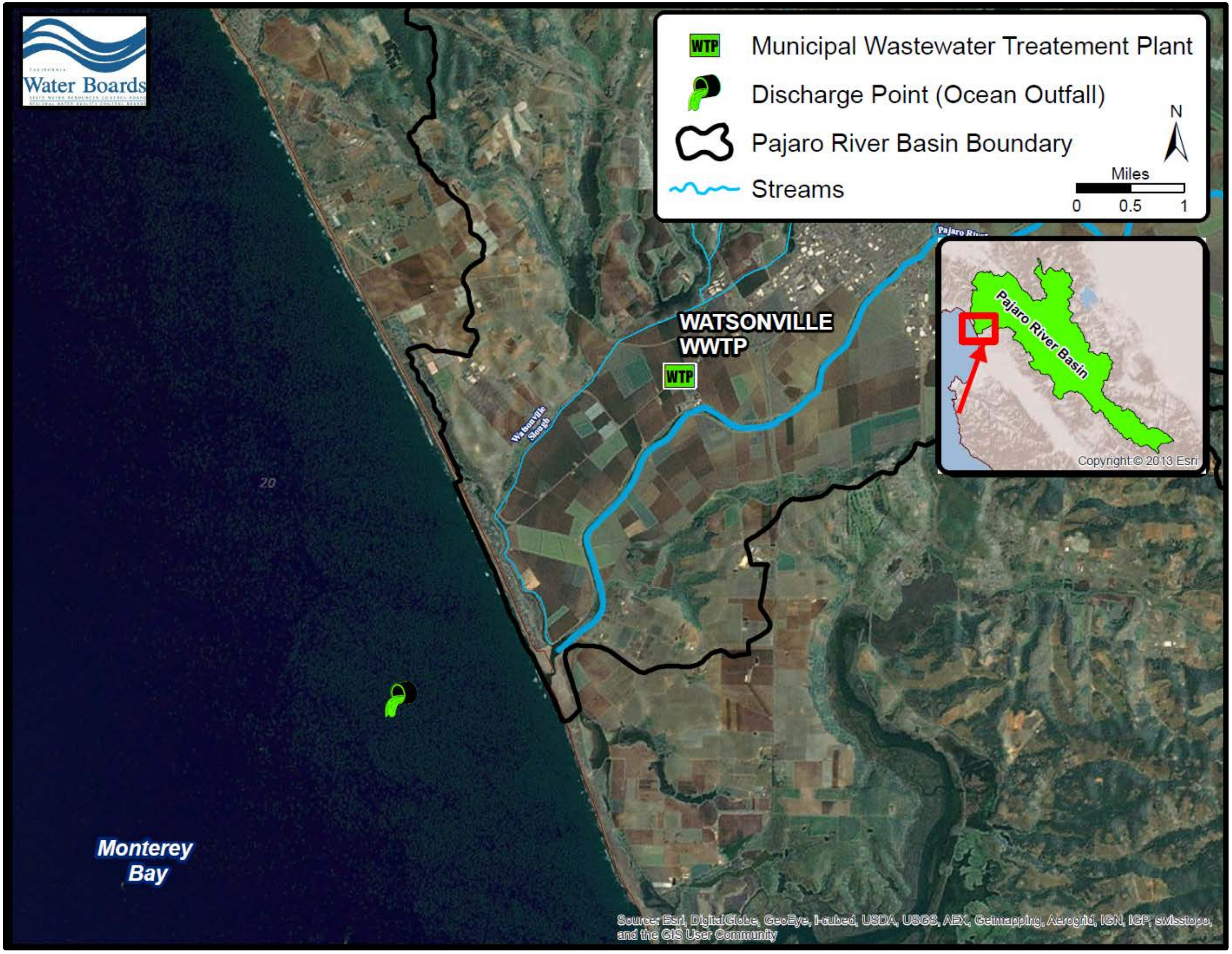
[166] *Ibid*

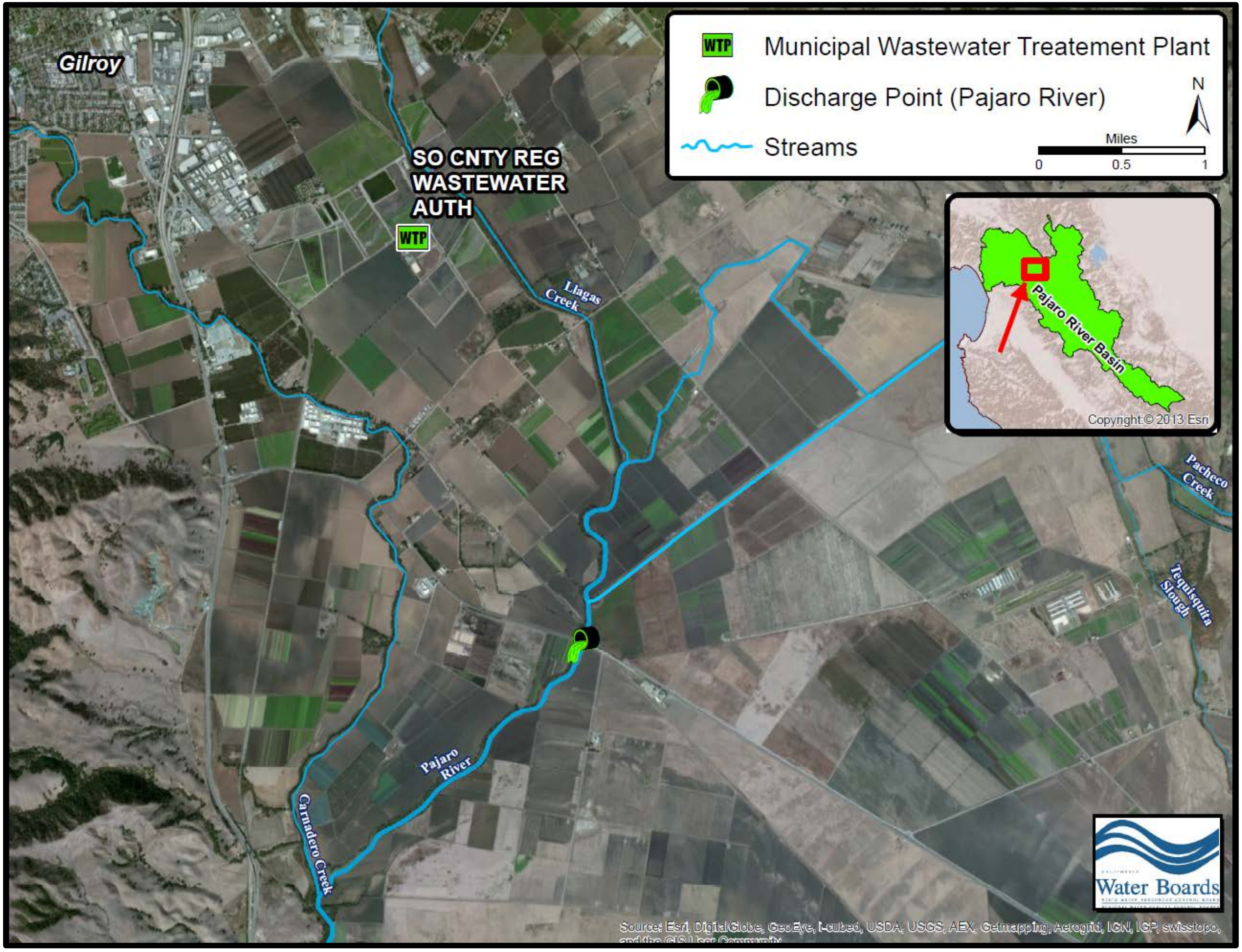
Figure 7-7. Location of City of Watsonville wastewater treatment facility and it’s ocean discharge point.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

The South County Wastewater Treatment Facility (Order No. R3-2010-0009, NPDES No. CA0049964), is permitted to discharge treated wastewater to the Pajaro River (see Figure 7-8), but only under certain flow conditions. The facility also has waste discharge requirements for land discharges of treated wastewater to percolation ponds, and for water reclamation activities.

Figure 7-8. Location of South County Regional Wastewater Authority wastewater treatment facility and it's permitted Pajaro River discharge point.



According to Order No. R3-2010-0009, this facility is only allowed to discharge to the Pajaro River when flow in the river is greater than 180 million gallons per day (i.e., 278 cubic feet/second), and only during the months of November through April when the risk of nutrient-driven biostimulation is minimal. For example, Figure 7-9 illustrates the Pajaro River flow conditions during which this wastewater treatment facility is permitted to discharge treated wastewater to the river. These flow conditions are only achieved rarely and episodically in the Pajaro River, and at these flows the river would be expected to be well aerated, resulting in good dissolved oxygen levels in the water. The flows would also be expected to scour and flush any excess algae.

Figure 7-9. Pajaro River flow conditions during which South County Regional Wastewater Authority is permitted to discharged treated wastewater to the river.

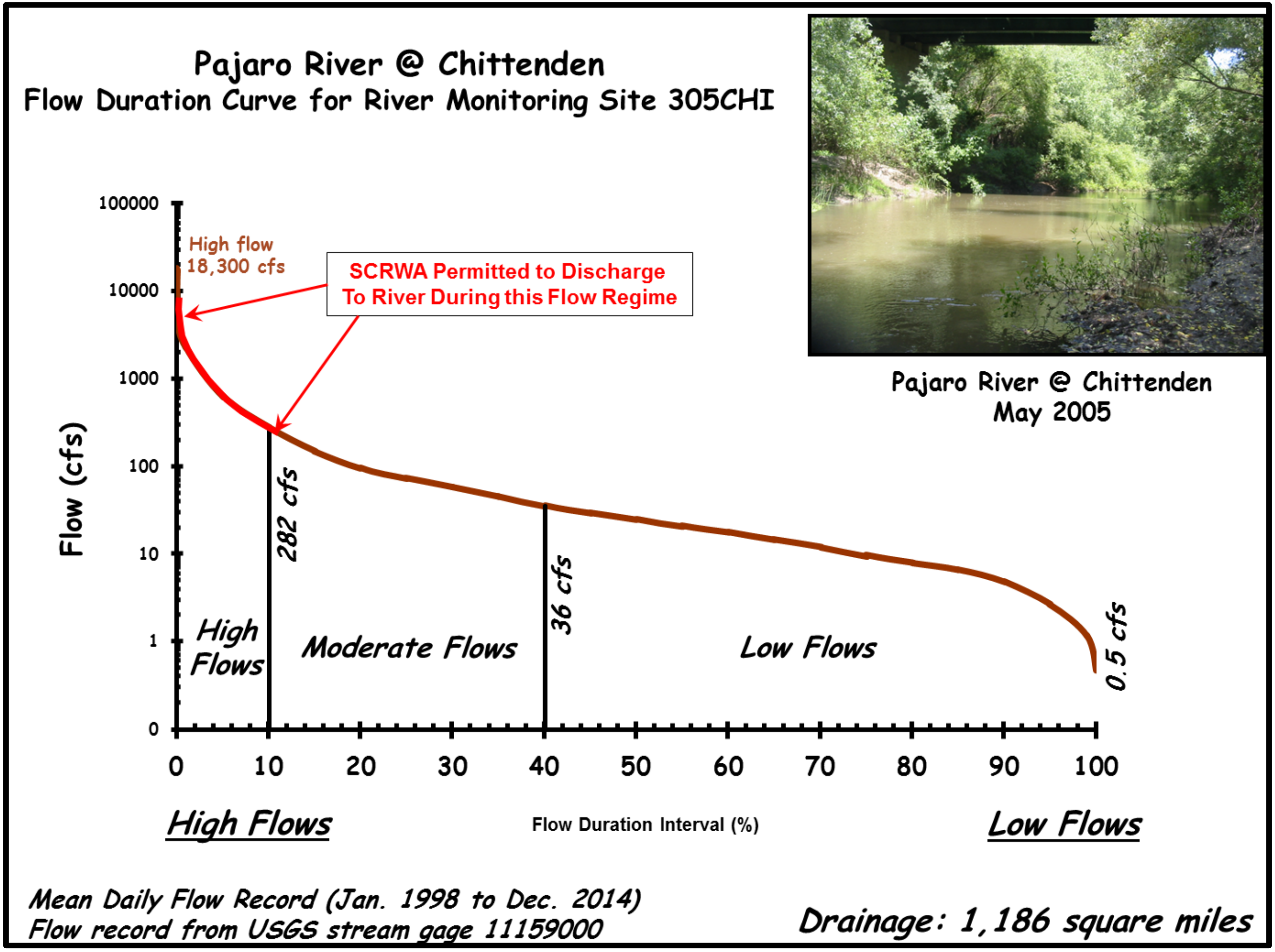


Table 7-13 presents nitrate concentration data in Pajaro River waters at Chittenden during high flow conditions (years 1998 through 2012). Based on the existing effluent limitations in the permit[167], and based on the limitation to discharge treated wastewater only during high flow conditions in the river[168], the existing effluent limitations and conditions in Order No. R3-2010-0009 would be expected to be capable of implementing and attaining the proposed waste load allocations identified in these TMDLs. Since the permitted discharge is only allowed at high flow conditions between November through April, only the human health, and the wet-season biostimulatory nutrient water quality targets are applicable to this discharge; the more stringent dry-season nutrient water quality targets would not be applicable. Finally, worth noting is that according to information available to Central Coast Water Board staff, there have been no discharges to the Pajaro River from the South County Wastewater Treatment Facility

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[167] The nitrogen-related effluent limitations are 5 mg/L for nitrate as N as a 30-day mean, and 0.025 mg/L for un-ionized ammonia as N as a 30 day mean. The South County Wastewater Treatment Facility is reportedly highly efficient at nitrogen removal from wastewater, and nitrate as N concentrations in effluent are frequently less than 5 mg/L, and sometimes as low as 2 mg/L (personal communication, Matt Keeling, water resources control engineer Central Coast Water Board, February 25, 2015).

[168] Previously, Section 0 and Figure 5-49 presented information illustrating that high flow conditions in the Pajaro River represent a flow regime during which nitrate concentrations are typically quite diluted and the increased assimilative capacity of the river is generally able to provide for attainment of nutrient-related water quality standards.

between 2004 to 2014[169]. Additionally, the South County Wastewater Treatment Facility reportedly has a goal to move to 100% recycled water[170], which would render potential river discharges moot.

Table 7-13. Nitrate as N concentrations in Pajaro River water at Chittenden during high flow conditions (> 287 cubic ft. per sec.), years 1998-2012. This location is downstream of the South County Wastewater Treatment Faility's permitted discharge point on the Pajaro River. During these high flow conditions, nitrate concentrations are low due to dilution and increased assimilative capcity in the river. Based on available data, 99% of river samples met all human health and wet-season aquatic habitat water quality targets for nitrate as N identified in this TMDL report during these flow conditions.

Parameter	Temporal Representation	Flow Conditions[A] (cubic ft./sec)	mean	0%	10%	25%	50%	75%	90%	95%	99%	100%	no. of samples
nitrate as N	Jan. 1998-Dec. 2012	288 to 7,510	3.05	0.83	1.3	2.01	2.74	3.99	5.06	5.32	6.71	11.6	87

[A] Daily flow data source: U.S. Geological Survey, gage 11159000

The City of San Juan Bautista Wastewater Treatment Facility (Order No. R3-2009-0019 NPDES No. CA0047902), is permitted to discharge up to treated wastewater to an unnamed drainage ditch that is tributary to the San Juan Creek (see Figure 7-10). The current permit has nitrate effluent limitations intended to be protective of the drinking water beneficial uses of groundwater.

The City of San Juan Bautista Wastewater Treatment Facility (Order No. R3-2009-0019 NPDES No. CA0047902), is permitted to discharge up to treated wastewater to an unnamed drainage ditch that is tributary to the San Juan Creek. The maximum permitted design flow capacity is 0.27 million gallons per day, or a maximum discharge rate equivalent to 0.4 cubic feet per second at the point of discharge. At this time, the hydraulic connectivity of this ditch with other creeks and drainages of the San Juan Valley is uncertain; however, elevated nutrient concentrations in the treated wastewater discharged to the ditch appear to be generally exceeding water quality numeric targets identified in these TMDLs.

Table 7-14 presents estimates of daily nitrate a N loads at the San Juan Bautista Wastewater Treatment Facility discharge point and at two downstream locations in the San Juan Creek System. Average daily nitrate as nitrogen load in the effluent at the discharge point is approximately 14 pounds. 2.1 miles downstream in the San Juan Creek system at San Juan Creek near Anzar Road, the average daily nitrate as nitrogen load in the creek is 448 pounds. Thus the load from the effluent would be equal to about three percent of the total creek load at this location. It should be noted that these are rough approximations, and there are uncertainties due to different temporal representation and sample sizes at each monitoring location.

Central Coast Water Board may use its Water Code §13267 authorities to have the City of San Juan Bautista estimate their nutrient loading contribution, and nutrient-related water quality impacts to downstream receiving waters. On the basis of this, and other information collected during TMDL implementation, the Central Coast Water Board will incorporate effluent and receiving water limitations for the surface water discharge at the San Juan Bautista Wastewater Treatment Facility. Effluent limitations need to be consistent with the assumptions of the TMDLs (refer to report Section 0).

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[169] Personal communication, Sheila Soderberg, NPDES program manager, Central Coast Water Board, February 21, 2015.

[170] Communication to Central Coast Water Board staff, March 2, 2015 from Jamie Marincola, Water Division, U.S. Environmental Protection Agency, Region IX.

Figure 7-10. Location of City of San Juan Bautista wastewater treatment facility and it's permitted discharge point to an unnamed drainage ditch..

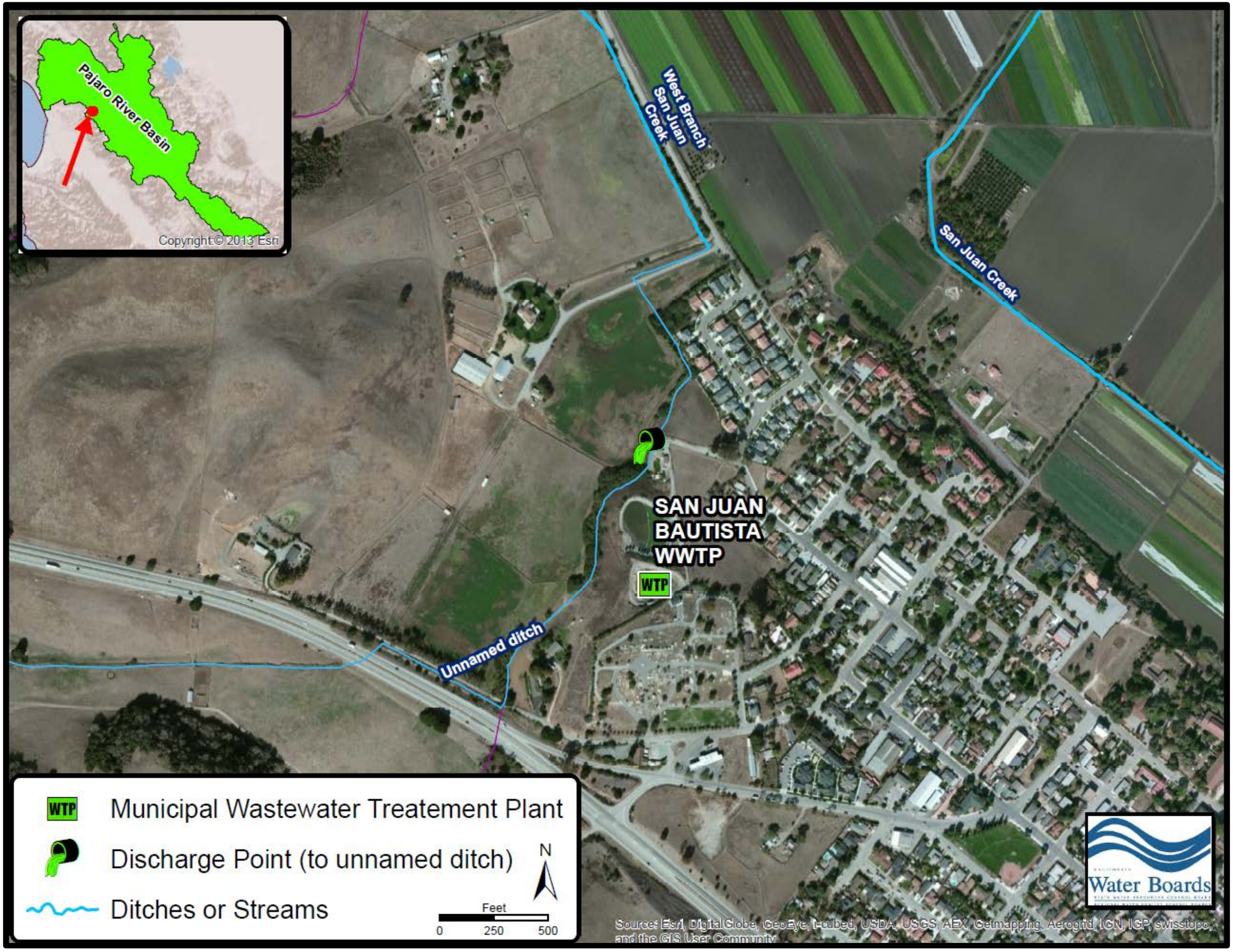


Table 7-14. Estimates of nitrate as N daily loads at the San Juan Bautista wastewater treatment facility discharge point, and at two downstream locations in the San Juan Creek system (units: nitrate as N = mg/L, flow = cfs, daily load = pounds per day nitrate as N). Average daily loads are calculated on the basis of mean flow and mean nitrate as N concentration.

Location	Parameter	Temporal Representation	mean	0%	10%	25%	50%	75%	90%	100%	data:n	Ave. Daily Load (pounds)
Effluent Discharge Point (Unnamed Ditch)	nitrate as N[A]	June 2009-Sept 2013	12.1	2.04	3	5.4	9.2	20	25	27	17	13.7
	flow[A]	June 2009-Sept 2013	0.21	0.08	0.17	0.18	0.19	0.24	0.29	0.32	17	
W. Branch San Juan Creek 1,200 ft dwnstrm. of discharge point	nitrate as N	Jan 2008-Dec 2008	6.7	0.51	1.7	2.4	4.5	11	14	16	8	27.5
	flow	Jan 2008-Dec 2008	0.76	0	0.16	0.24	0.55	0.91	1.85	2.11	8	
San Juan Creek @ Anzar Rd. 2.1 miles dwnstrm of discharge point	nitrate as N	Mar 2005-Dec 2011	30.4	5.06	13	21.1	30.9	40	47	54	82	448
	flow	Mar 2005-Dec 2011	2.73	0.001	0.7	1.07	1.8	2.94	3.9	35.44	82	

[A] Data from the California Integrated Water Quality Management System

7.5 Golf Courses

Some concerns have been raised about the surface water quality impact of chemicals, including fertilizers, applied on golf courses (Hindahl et al, 2009; Minnesota Dept. of Agriculture website accessed June 27, 2013). The regular use of fertilizers on golf course turf grass can result in concerns that these chemicals may be transported into surface waterbodies following application.

Figure 7-11 presents a map showing locations of golf courses within the Pajaro River basin. Worth noting is that, in general, these golf courses are not spatially associated or closely linked with streams that have been impaired by nutrient pollution. Specifically, these golf courses are located in the Uvas Creek watershed, the San Benito River subbasin, the Tres Pinos Creek Watershed, the Salsipuedes Creek subwatershed, and upper reaches of the Llagas Creek Watershed.

Some golf course water quality data is available for the Pajaro River basin. Table 7-15 and Table 7-16 present data from the West Branch Llagas Creek as it flows through, and exits, the Cordevalle golf course located near San Martin. In general, nitrate and phosphorus concentrations remain relatively low as the creek flows through the golf course. Limited amounts of golf course creek data are also available from several nearby bay area golf courses in Santa Clara County – these data indicate that nitrate concentrations in these Santa Clara County golf course creeks are typically relatively low (see Figure 7-12 and Table 7-17).

An additional line of indirect evidence is available from published studies which researched golf course creek and runoff water quality. On balance, national and regional studies conducted over many years report no significant or widespread impacts on surface water quality in golf courses following application of fertilizers (Hindahl et al, 2009, Miltner and Hindahle, 2009, Baris, et al., 2010). While golf course runoff does not generally appear to cause violations of water quality standards in creeks, a couple of studies from Texas and North Carolina have reported increases in nutrient concentrations as runoff and creeks flow through and exit some golf courses (Mallin and Wheeler, 2000, King et al, 2001) – landscape management practices appeared to play a critical role in whether or not nutrient water quality problems were observed in golf course creeks and downstream receiving waters (Mallin and Wheeler, 2000).

Figure 7-11. Golf courses in the Pajaro River basin on the basis of data available from the Geographic Names Information System (GNIS).

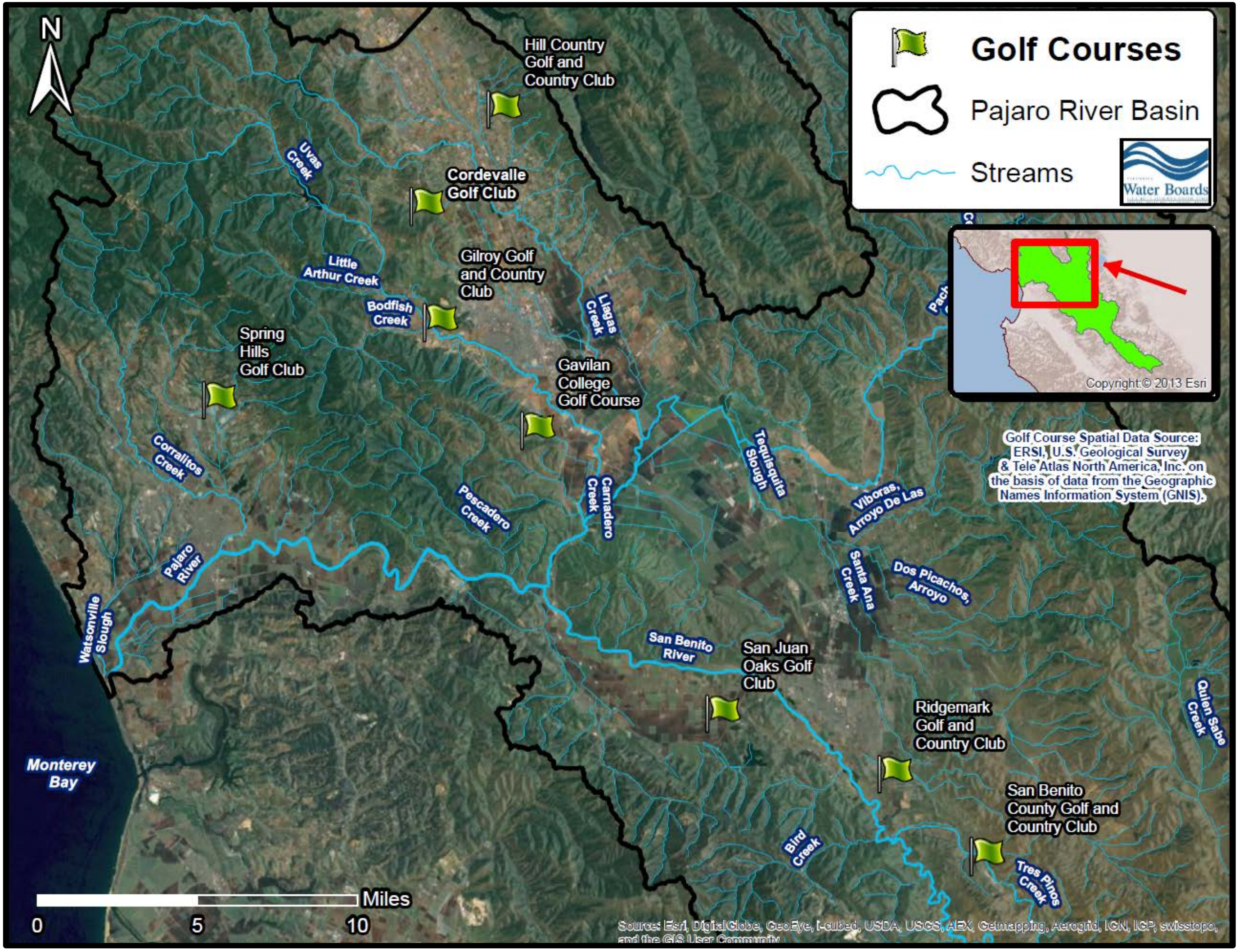


Table 7-15. Nitrate as N water quality data from the West Branch Llagas Creek where if flows through the Coredevalle golf course, southern Santa Clara County (units = mg/L).

Stream	Monitoring Site	No. of Samples	Arithmetic Mean	Min	25%	50% (median)	75%	Max
West Branch Llagas Creek @ Cordevalle Golf Course	**All Sites**	42	1.28	0.018	0.537	1	2	4
	SW1	18	0.96	0.018	0.452	0.929	1	3
	SW2	18	1.27	0.1	0.757	1	1.92	3
	SW3	6	2.32	1.198	1.805	2	2.75	4

Source data: monitoring data submitted to the Central Coast Regional Water Quality Control Board.

Table 7-16. Phosphorus as P water quality data from the West Branch Llagas Creek where if flows through the Coredevalle golf course, southern Santa Clara County (units = mg/L).

Stream	Monitoring Site	No. of Samples	Arithmetic Mean	Min	25%	50% (median)	75%	Max
West Branch Llagas Creek @ Cordevalle Golf Course	**All Sites**	46	0.21	0.01	0.01	0.09	0.2	1.2
	SW1	20	0.21	0.01	0.01	0.11	0.23	1.2
	SW2	20	0.14	0.01	0.01	0.01	0.16	0.9
	SW3	6	0.42	0.01	0.03	0.35	0.75	1

Source data: monitoring data submitted to the Central Coast Regional Water Quality Control Board.

Figure 7-12. Nitrate as N water quality data from creeks in three golf courses in the California central coast and bay area regions – Cordevalle golf course (near San Martin/Gilroy), Riverside golf course (at Coyote Creek), and Saratoga golf course (at Prospect Creek). Sample size = 76.

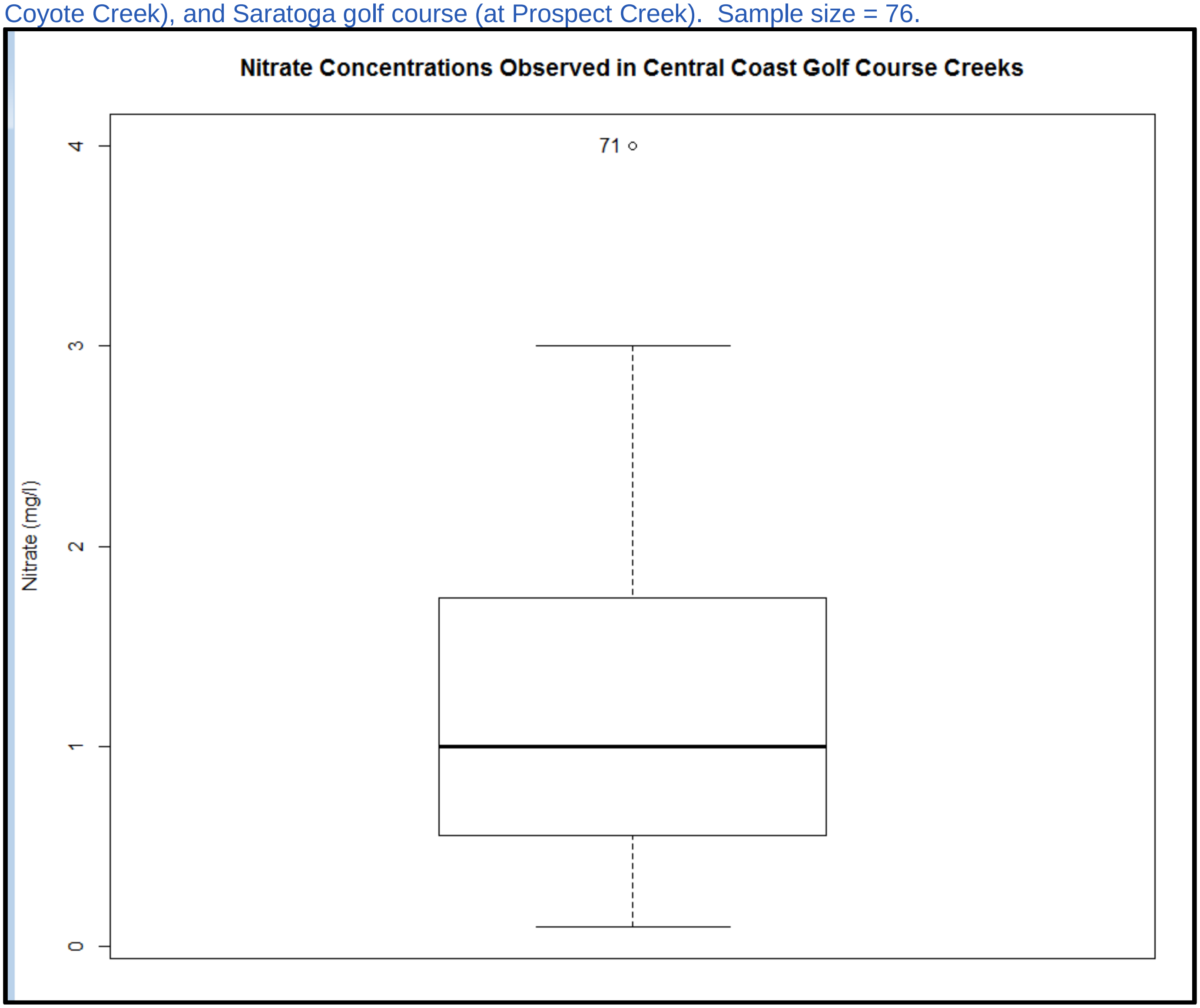
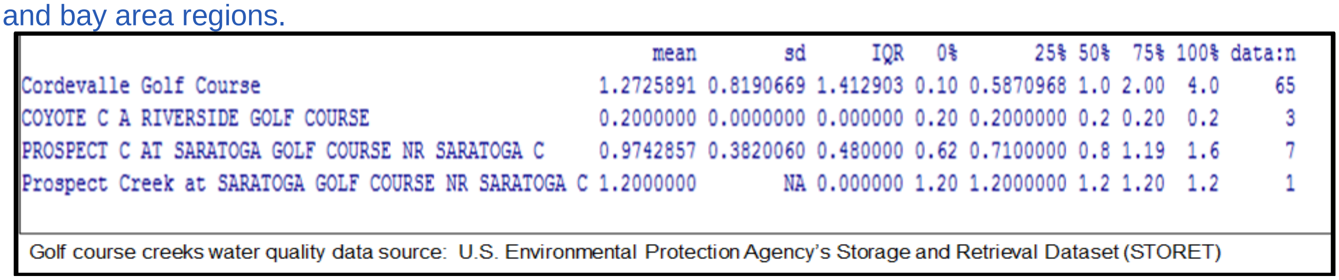


Table 7-17. Numerical summary of golf courses creeks water quality data from California central coast and bay area regions.



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                                                mean        sd      IQR   0%       25% 50%  75% 100% data:n
Cordevalle Golf Course                     1.2725891 0.8190669 1.412903 0.10 0.5870968 1.0 2.00  4.0     65
COYOTE C A RIVERSIDE GOLF COURSE           0.2000000 0.0000000 0.000000 0.20 0.2000000 0.2 0.20  0.2      3
PROSPECT C AT SARATOGA GOLF COURSE NR SARATOGA C     0.9742857 0.3820060 0.480000 0.62 0.7100000 0.8 1.19  1.6      7
Prospect Creek at SARATOGA GOLF COURSE NR SARATOGA C 1.2000000        NA 0.000000 1.20 1.2000000 1.2 1.20  1.2      1
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Golf course creeks water quality data source: U.S. Environmental Protection Agency's Storage and Retrieval Dataset (STORET)

Based on available data, formal regulatory actions or regulatory oversight of golf courses to implement these TMDLs is unwarranted. Available data from golf course creeks in the Pajaro River basin, regionally, and nationally, suggest that golf courses would be expected to be meeting anticipated load allocations protective of designated beneficial uses in streams of the river basin. Because anti-degradation is an element of all water quality standards, golf courses should continue to implement turf management practices which help to protect and maintain existing water quality in surface waters and to prevent any further quality degradation.

Information developed in this report does not conclusively demonstrate that all golf courses in the Pajaro River basin are currently meeting proposed nutrient load allocations for discharges to surface waters. Central Coast Water Board staff will obtain more information, if merited, during the implementation phase of the TMDL to further assess the levels of nutrient contribution from these source categories, and to identify any actions if necessary to reduce nutrient loading to surface waters.

7.6 Cropland

Fertilizers or compost applied to cropland can constitute a significant source of nutrient loads to waterbodies. The primary concern with the application of fertilizers on crops or forage areas is that the application can exceed the uptake capability of the crop. If this occurs, the excess nutrients become mobile and can be transported to either nearby surface waters, to groundwaters, or the atmosphere (Tetra Tech, April 29, 2004).

As of summer 2014, there were 1,152 farming operations, entities, or operators in the Pajaro River basin enrolled in the Central Coast Water Board's, irrigated lands regulatory program[171]. The overwhelming majority of these farming operations are found in the Pajaro River Valley, the Santa Clara Valley, and the San Juan Valley (a valley near the confluence of San Juan Creek and the San Benito River, with the Pajaro River).

Farming operations in the river basin are quite diversified, with row crops, orchards, vineyards, nurseries, and greenhouses represented. Row crops are the most commonly reported farming operation in the river basin. Berry crops (e.g., blackberry, raspberry, and strawberry) are generally grown in the lowermost reaches of the river basin in the lower Pajaro River, Corrilitos Creek, Salsipuedes Creek, and Watsonville Slough subwatersheds, while prominent row crops, such as lettuce and broccoli are grown throughout the Pajaro River Valley, the southern Santa Clara Valley, and the San Juan Valley[172]. A large proportion of the river basin's greenhouses are located in the Llagas Creek watershed (Santa Clara valley), while nurseries appear to be mostly located in the lower reaches of the river basin (Salsipuedes Creek, Corrilitos Creek, and Watsonville Slough subwatersheds). Vineyards tend to be located in upland reaches of the river basin (e.g., upland/foothill reaches of the Corrilitos Creek, Uvas Creek and Llagas Creek watersheds, as well as the lower San Benito River and Tres Pinos Creek watersheds)[173].

Figure 7-13 illustrates the frequency generalized crop type–categories in the Pajaro River basin, on the basis of reporting from growers to the Central Coast Water Board. This reporting does not include acreage, so this reporting should not be conflated with the geographic size, distribution, and importance of a particular crop type–category. However, this type of information does provide insight into which crop types are most frequently reported by growers in the river basin. Row crops are the most commonly reported crop type–category within the Pajaro River basin. The most frequently reported crops, as of summer 2014, in the Pajaro River basin are berries (e.g., strawberries, blackberries), head lettuce, and leaf lettuce, with other row crops, vineyards, orchards, and nurseries having noteworthy roles in the river basin's cultivated agricultural production (see Figure 7-14).

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[171] Information available for State Water Resources Control Board's Geotracker information management system.
[172] *Ibid*
[173] *Ibid*

Figure 7-13. Grower-reported frequencies of crop type–categories in the Pajaro River basin, as reported to the Central Coast Water Board, summer 2014.

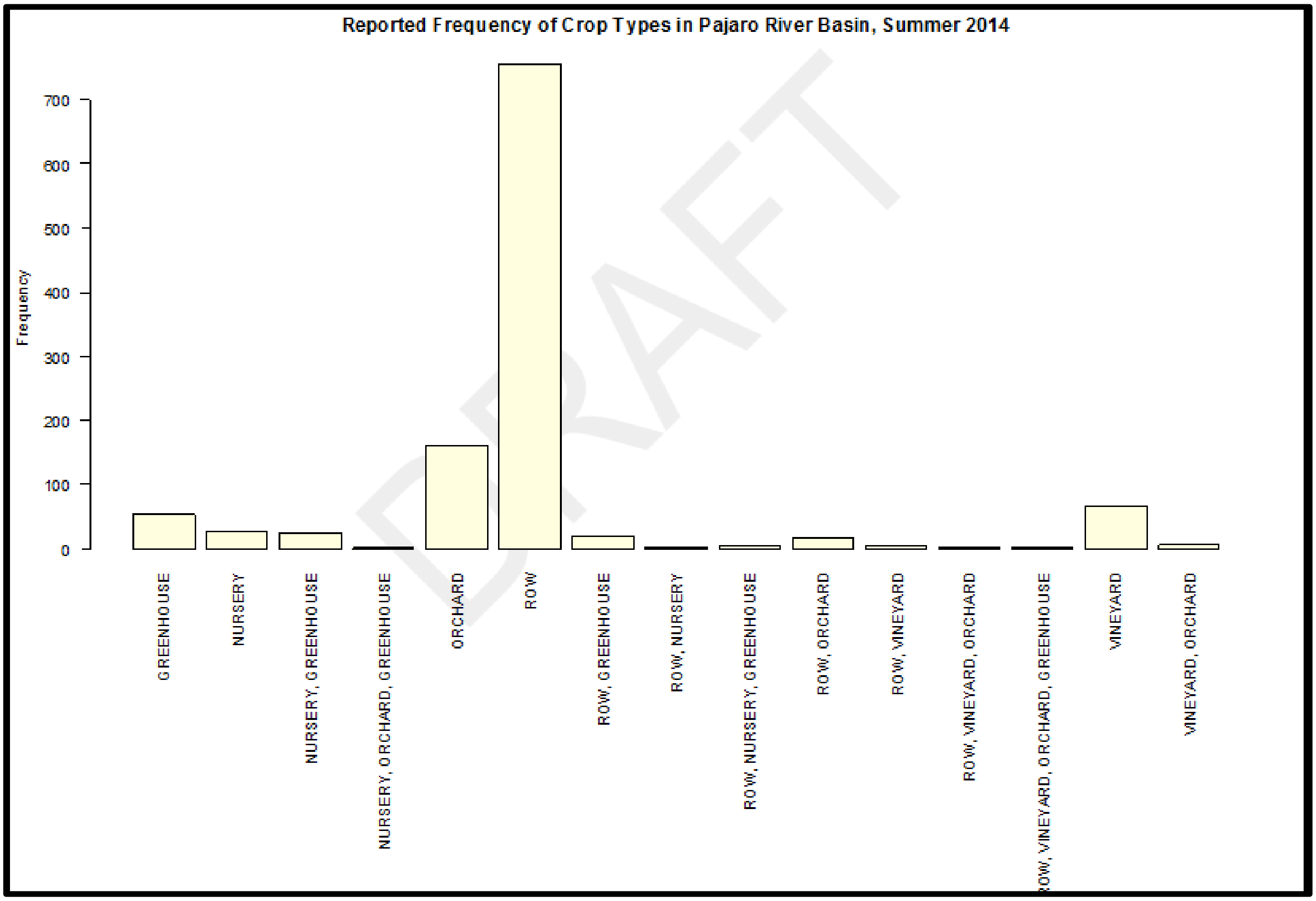

Figure 7-14. Grower–reported frequencies of specific cultivated crops in the Pajaro River basin, as reported to the Central Coast Water Board, summer 2014.

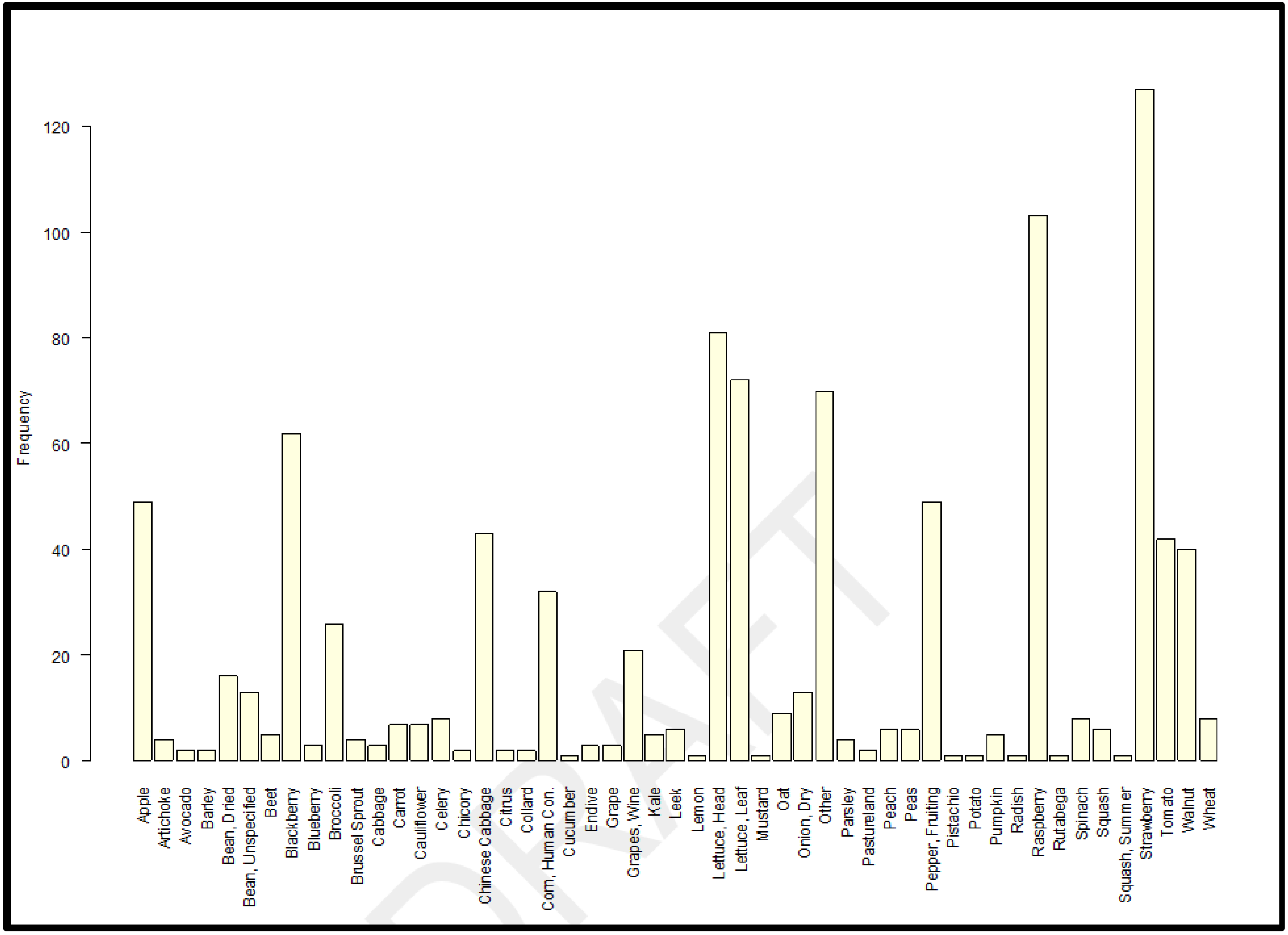

Figure 7-15 and Figure 7-16 illustrate estimated temporal trends of the amounts of nitrogen and phosphorus from fertilizers applied within the Pajaro River basin, on the basis of data of data published by the U.S. Geological Survey[174]. These data indicate that commercially-sold fertilizers are overwhelming used on farmlands. Based on the available data, Central Coast Water Staff estimates that around 97 to 98 percent of the nitrogen and phosphorus from fertilizers is applied to farmland in the Pajaro River basin, and around two to three percent are applied in urbanized areas. These estimates comport well with California Department of Food and Agriculture reporting indicating that for the annual period July 2007 to July 2008, non-farm entities purchased about 3% of fertilizing materials sold in

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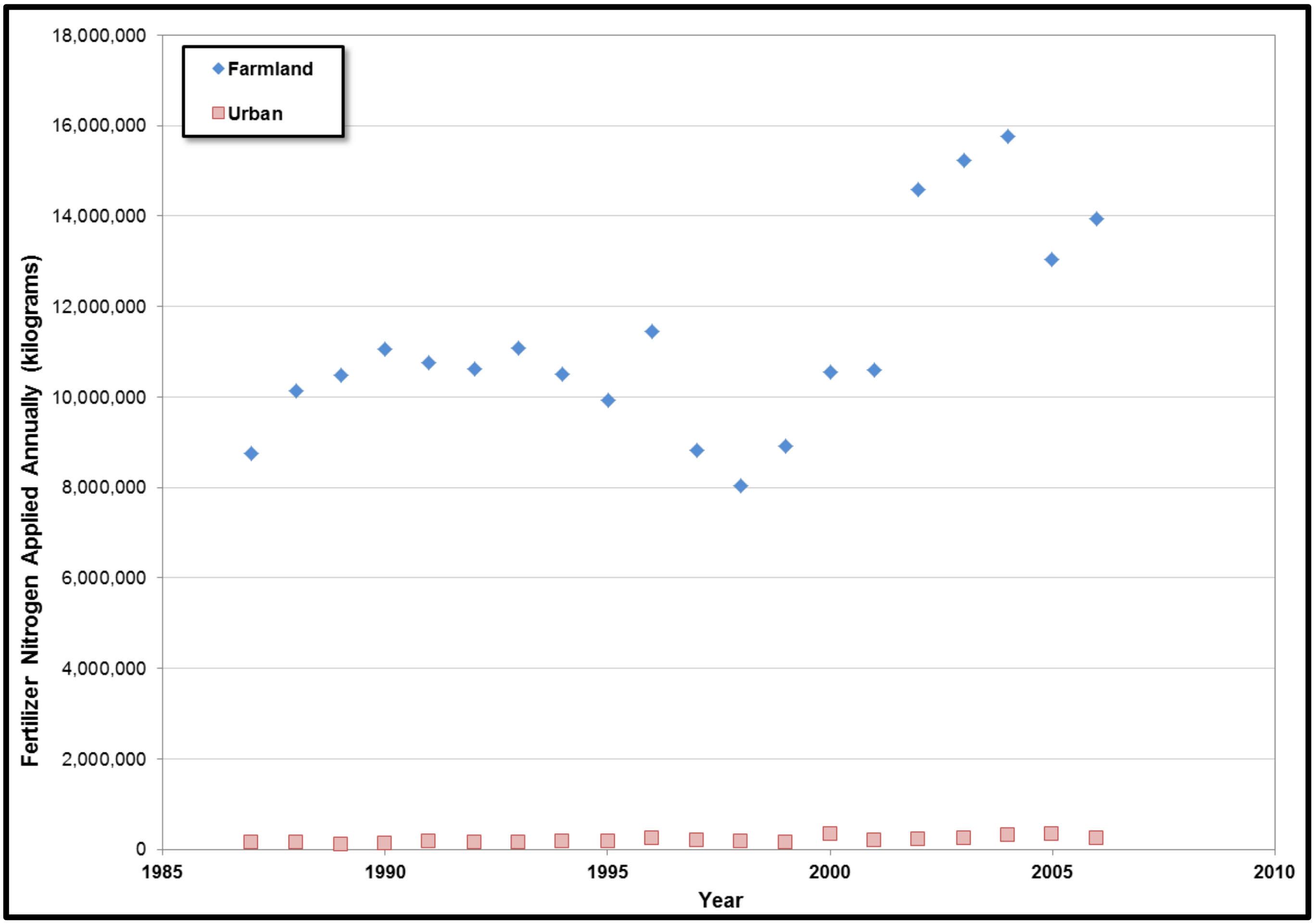
[174] U.S. Geological Survey, 2012 – *County-Level Estimates of Nitrogen and Phosphorus from Commercial Fertilizer for the Conterminous United States, 1987-2006.* Scientific Investigations Report 2012-5207. This dataset contains county-level estimates of nitrogen and phosphorus from fertilizer, for both farm and non-farm uses, for the conterminous United States, for 1987 through 2006. Since these data are reported at the county-level, Central Coast Water Board staff converted these estimates spatially to the scale of the Pajaro River Basin, by assuming that farm fertilizer is applied uniformly throughout a given county on farmland, and non-farm fertilizer is likewise applied uniformly on urbanized areas of a given county. Then we adjusted the U.S. Geological Survey estimates by multiplying by a ratio. The ratio was calculated by dividing the amount of urban or farmland within the portions of the four counties (Santa Cruz, Santa Clara, San Benito, and Monterey) which geographically intersect the river basin, by the total amount of urban or farmland found in each of the four counties. The 2010 Farmland Mapping and Monitoring Program Land Cover dataset was used in the land use ratio calculations.

Monterey County[175], thus providing an indirect, anecdotal line of supporting evidence to Central Coast Water Board staff's estimates. It should be noted that the aforementioned U.S. Geological Survey commercial fertilizer estimates may not include fertilizing materials such as peat, potting soils, compost, and soil additives[176]; these materials can often be used in some residential landscaping.

Figure 7-15. Estimates of fertilizer nitrogen applied annually (kilogram, 1987-2006) in the Pajaro River basin in urbanized areas and in farmland



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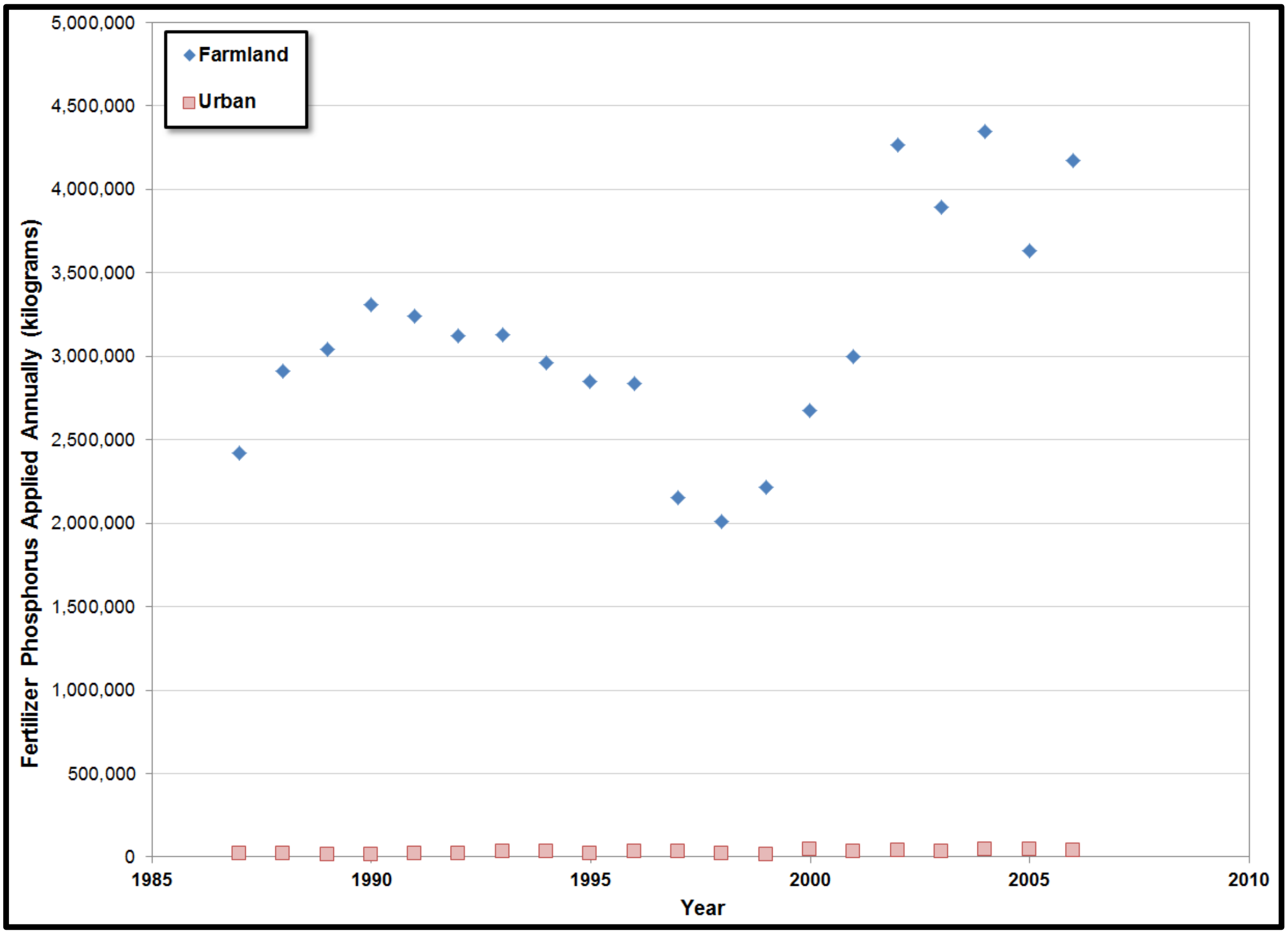
[175] California Department of Food and Agriculture Tonnage Report of Commercial Fertilizers and Agricultural Minerals, July 2007-July 2008.

[176] See U.S. Environmental Protection Agency "Commercial Fertilizer Purchased" webpage @ http://www2.epa.gov/nutrient-policy-data/commercial-fertilizer-purchased#table1

Figure 7-16. Estimates of fertilizer phosphorus applied annually (kilogram, 1987-2006) in the Pajaro River basin in urbanized areas and in farmland



California fertilizer application rates on specific crop types are available from the U.S. Department of Agriculture, National Agricultural Statistics Service, as shown in Table 7-18 and Figure 7-17. Estimates of nitrogen application rates on California crops, as reported by California resource professionals and agencies, are presented in Table 7-19. Where the reporting from these different federal and state sources overlap (aka, strawberries, lettuce, broccoli), the nitrogen application estimates comport reasonably well with each other.

Table 7-18. California reported fertilizer application rates (National Agricultural Statistics Service).

Crop	**Application Rate per Crop Year (pounds per acre) in California**			**Source**
	Nitrogen	**Phosphate**	**Potash**	
Tomatoes	243	133	174	2007 National Agricultural Statistics (NASS) report
Sweet Corn	226	127	77	2007 NASS report
Rice	124	46	34	2007 NASS report
Cotton	123	74	48	2008 NASS report
Barley	73	19	7	2004 NASS report
Oats[1]	64	35	50	2006 NASS report
Head Lettuce	200	118	47	2007 NASS report
Cauliflower	232	100	43	2007 NASS report
Broccoli	216	82	49	2007 NASS report
Celery	344	114	151	2007 NASS report
Asparagus	72	20	46	2007 NASS report
Spinach	150	60	49	2007 NASS report

Strawberries[2]	155	88	88	University of Delaware Ag, Nutrient Recommendations on Crops webpage

[1] insufficient reports to publish fertilizer data for P and potash; used national average from 2006 NASS report for P and K

[2] median of ranges, calculated from table 1, table 4, and table 5 @ http://ag.udel.edu/other_websites/DSTP/Orchard.htm

Figure 7-17. California fertilizer application rates on crops (source: USDA-NASS, 2004-2008).

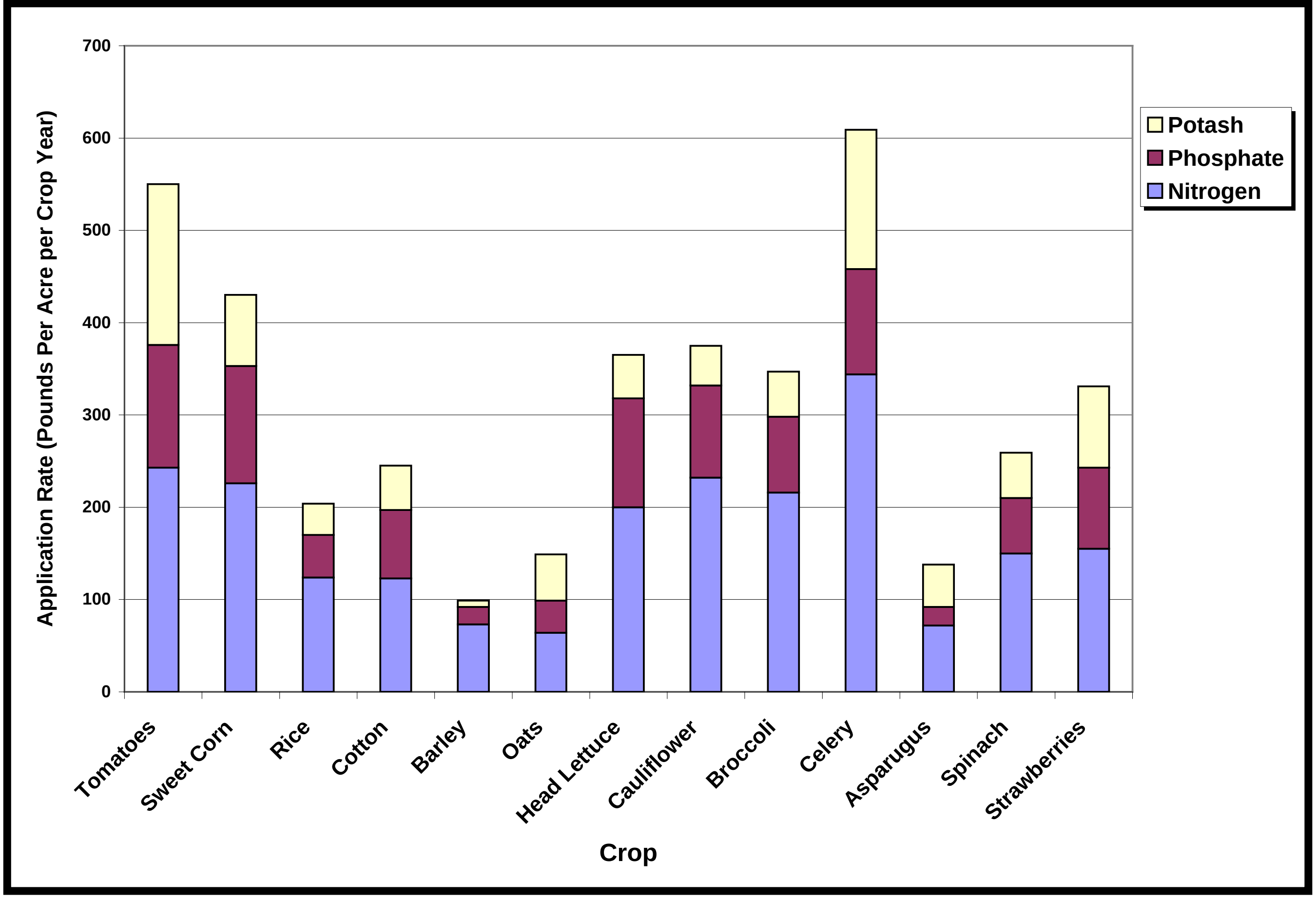


Table 7-19. Nitrogen application rates on California crops, reported by California resource professionals and agencies.

Crop Type	Estimated Crop Application Rates (lbs N/acre)	Source of Application Estimate (see notes below)
Lettuce	150	4, 6
Broccoli	200	5
Celery	275	1
Misc. Vegetables	150	2
Strawberries	180	8
Raspberries	60	3
Grapes	19.76	9
Citrus	170	7
Avocados	50	2
Nuts	200	10
Misc. Fruit	151	11
Seed	150	2

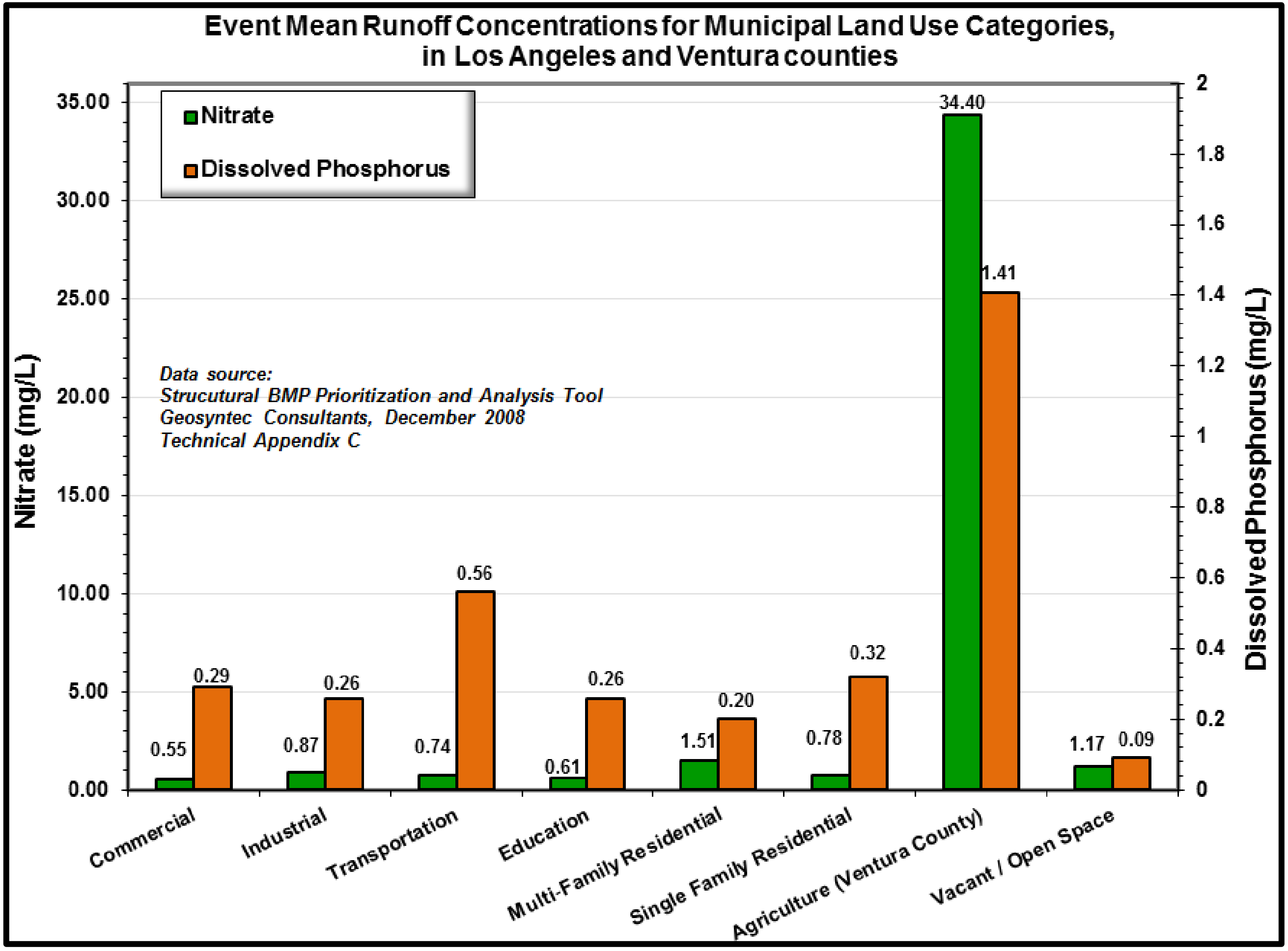
Crop Type	Estimated Crop Application Rates (lbs N/acre)	Source of Application Estimate (see notes below)
Flowers	300	2
Nurseries	300	2
Field Crops	50	2

Notes:
1. Tim Hartz, Fertilizer Symposium presentation, Santa Maria, November 2008
2. Peter Meertens, Central Coast Water Board staff, based on similar crop type.
3. Univ. of Calif. Cooperative Extension (UCCE), 2005 Sample Cost to Produce Fresh Market Raspberries, Santa Cruz & Monterey Counties
4. UCCE, 2009 Sample Costs to Produce Romaine Hearts, Central Coast Region - Monterey County
5. UCCE, 2004 Sample Costs to Produce Fresh Market Broccoli, Central Coast Region - Monterey County
6. UCCE, 2009 Sample Costs to Produce Iceberg Lettuce, Central Coast Region - Monterey County
7. UCCE, 2005 Sample Cost to Produce Mandarins, Ventura County (170 trees/ acre 1lbs N/ tree)
8. UCCE, 2005 Sample Costs to Produce Strawberries, Santa Barbara County
9. UCCE, 2004 Sample Cost to Establish and Produce Wine Grapes, Chardonnay, North Coast Region - Sonoma County
10. UCCE, 2007 Sample Cost to Establish a Walnut Orchard and Produce Walnuts, Sacramento County (N rate for established orchard)
11. UCCE, 2004 Sample Cost to Establish and Produce Fresh Market Nectarines, San Joaquin Valley

Because of variability in nitrogen and phosphorus application rates noted above, undoubtedly the estimated magnitude of nutrient loads to land and to streams from agricultural lands can vary substantially based on crop type (Harmel et al., 2006). Nutrient loads refer to the amount of nitrogen or phosphorus exported from an area or specific land use over a specific time period (e.g., typically, kilograms per hectare per year). Harmel et al. (2006) report nutrient loading values that range from a national median of 21.9 kg/ha nitrogen for soybean crop, to a national median of 3.02 kg/ha nitrogen for sorghum. Therefore, it is important to be cognizant of local agricultural conditions and crop types in order to gage a plausible level of risk of nutrient loading to surface water from these sources.

Because of the relative intensity of fertilizer applications on many types of cultivated crops as outlined previously, nutrient concentrations in agricultural surface runoff are often expected to be higher than in nutrient concentrations in municipal and residential runoff, as illustrated in Figure 7-18 (data is from Geosyntec Consultants, 2008). Nutrient concentrations in runoff and drainage are important to consider as discussed below.

Figure 7-18. Runoff event mean nutrient concentration data for municipal land use categories, Los Angeles and Ventura counties.



To develop nutrient loading estimates for agricultural lands in the Pajaro River basin, it is necessary to have plausible estimates of nutrient concentrations in agricultural runoff. Estimates for the average concentration of nitrogen in agricultural runoff used in this project report was derived using two data sources: Southern California Coastal Water Research Project (SCCWRP, 2000) and the U.S. Department of Agricultural-Agricultural Research Service's MANAGE database[177]. Because of the nature of crop types grown in the Pajaro River basin, as outlined previously, agricultural runoff concentrations were weighted towards vegetable crops, which are highlighted for visual reference in Figure 7-19. An average of the SCCWRP nitrogen runoff concentration estimate (13.8 mg/L) and the MANAGE database runoff mean (9.0 mg/L) for vegetable crops[178] is equivalent to 11.4 mg/L nitrogen-N, as illustrated in Figure 7-19. Average concentration of phosphorus-P in agricultural runoff used in this TMDL report is taken from the aforementioned SCCWRP (2000) report = 0.64 mg/L phosphate-P.

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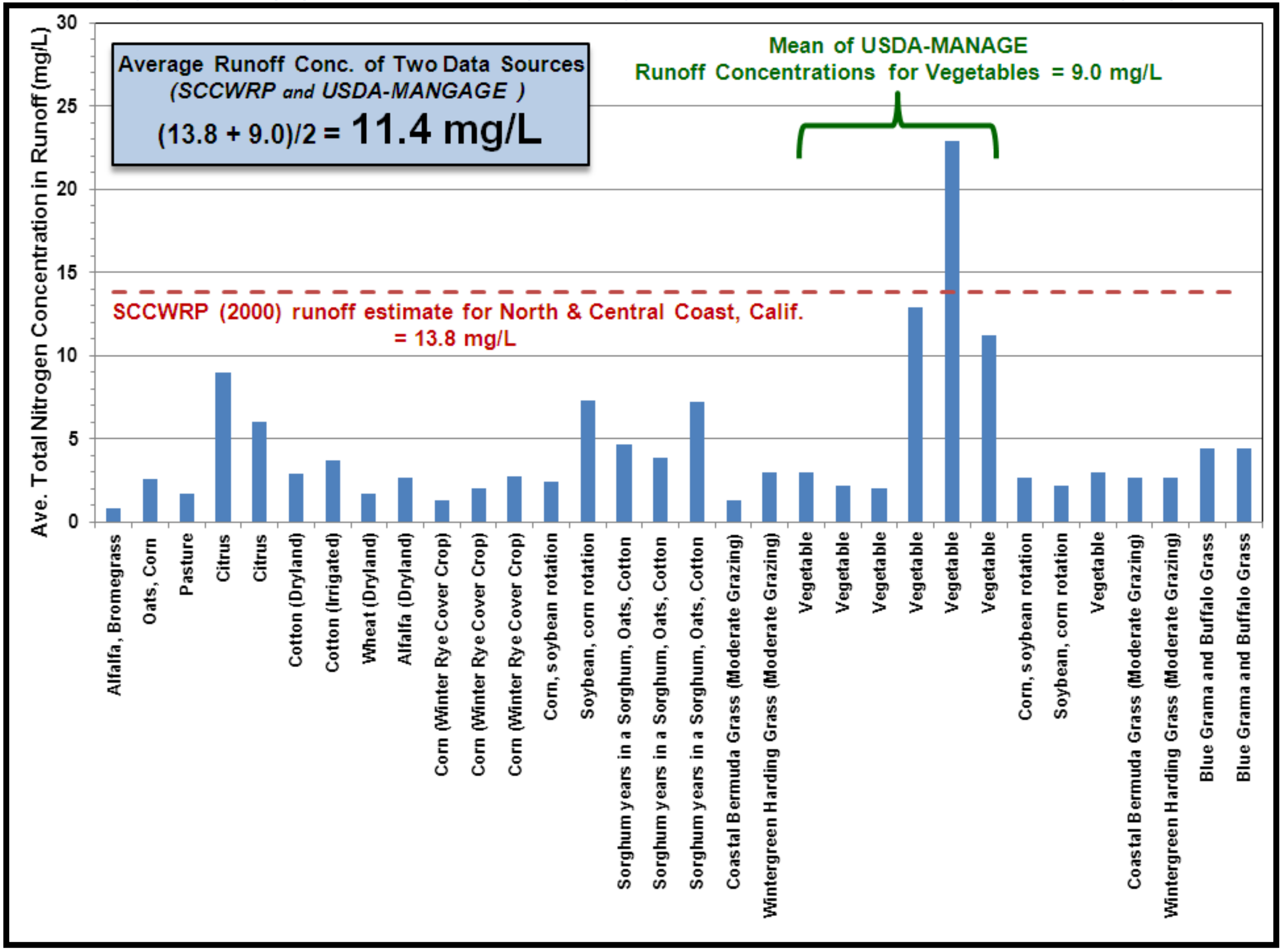
[177] Manage Nutrient Database - Nutrient Loss Database for Agricultural Fields in the US. The primary objective of this effort was to compile measured annual nitrogen (N) and phosphorus (P) load and concentration data representing field-scale transport from agricultural land uses. http://www.ars.usda.gov/Research/docs.htm?docid=11079

[178] Vegetable crops are the dominant type of crop cover in the TMDL project area.

Figure 7-19. Estimated nitrogen as N concentrations in agricultural lands runoff on the basis of taking an average of the mean runoff concentrations from two different datasets: USDA Manage dataset (9.0 mg/L mean for vegatable crops), and SCCWRP (13.8 mg/L mean for north and central coast region).



Finally, average annual nutrient loads delivered to surface waterbodies in the Pajaro River basin from cropland discharges were estimated on the basis of the STEPL input parameters previously identified in Section 7.1 – these estimated loads are tabulated in Table 7-20.

Table 7-20. Estimated average annual nutrient loads (lbs./year) delievered to surface waterbodies from cropland in the Pajaro River basin.

Source	N Load (lbs/yr)	P Load (lbs/yr)
Cropland	1,869,231	204,350

7.7 Grazing Lands & Livestock Waste

Grazing lands, as defined by the Farmland Mapping and Monitoring Program (FMMP) land cover dataset used in this report refers to lands where the vegetation is *suitable* for cattle foraging; it does not imply those lands are necessarily actively being grazed by livestock. Therefore, the FMMP "grazing lands" land cover category could also be considered equivalent to rangeland – whether grazed or ungrazed – and therefore Central Coast Water staff interchangeably use "rangeland" with "grazing lands" in this report to refer to grasslands of the Pajaro River basin, which may or may not be used locally for forage by livestock.

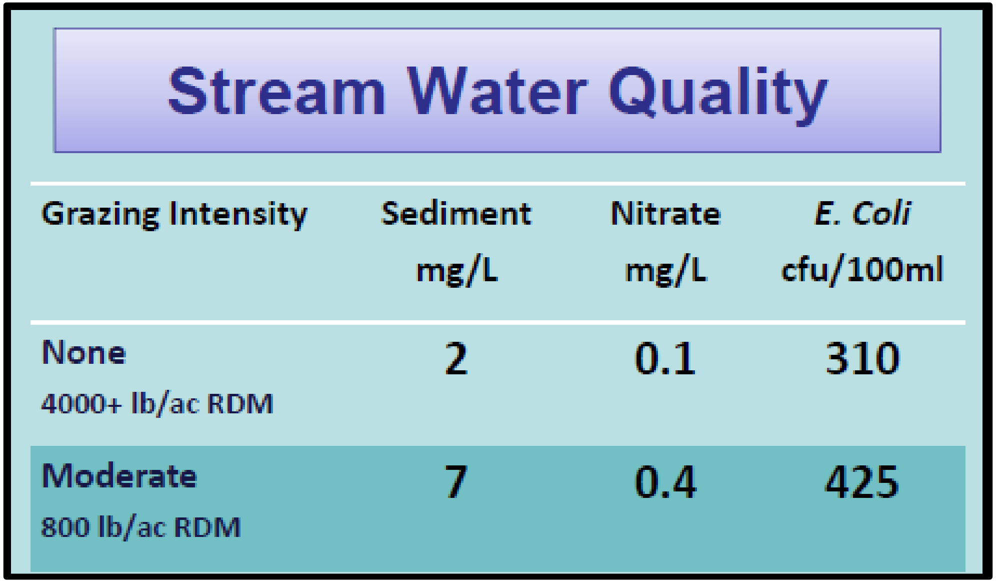
The only human activity associated with grazing lands that could conceivably contribute to nutrient loading to surface waterbodies is livestock grazing. Livestock and other domestic animals that spend significant periods of time in or near surface waters can contribute significant loads of nitrogen and phosphorus through their manure because they use only a portion of the nutrients fed to them and the remaining nutrients are excreted (Tetra Tech, 2004). The remainder of nutrients loads to streams from grazing lands is associated with natural background.

Expected nutrient concentrations in rangeland runoff can be estimated from data reported by the University of California, Davis Rangeland Watershed Laboratory, and from the U.S. Department of Agriculture – see Figure 7-20 and Table 7-21. On the basis of these data, nutrient concentrations in from ungrazed grasslands or from moderately grazed lands are expected to typically be relatively low.

Staff's observations above are supported by an independent line of research available from scientists at the University of Santa Cruz, California. These researchers concluded that data from Pajaro River basin indicates nitrate concentrations in drainage from grazed lands are generally quite low, thus suggesting that the risk of nitrate pollution from gazing lands is relatively minimal.

> *"Nitrate as N concentrations were typically <1 mg N/L in grazing lands, oak woodlands, and forests, but increased to a range of 1 to 20 mg N/L as surface waters passed through agricultural lands. Very high concentrations of nitrate (in excess of 80 mg N/L) were found in selected agricultural ditches that received drainage from tiles (buried perforated pipes)."*
>
> from: Los Huertos, M., L. Gentry, and C. Shennan. 2001. Land Use and Stream Nitrogen Concentrations in Agricultural Watersheds Along the Central Coast of California. Research Article. Proceedings of the 2nd International Nitrogen Conference on Science and Policy. The Scientific World (2001), 1(S2), pp. 615-622.

Figure 7-20. Average nutrient creek water quality in California rangelands based on ten years of data as reported by the Rangeland Watershed Laboratory at University of California, Davis. Based on this reporting, the average nitrate as N creek water quality from moderatly grazed rangelands and ungrazed rangelands is 0.25 mg/L (figure credit: Rangeland Watershed Laboratory: rangelandwatersheds.ucdavis.edu).



Stream Water Quality

Grazing Intensity	Sediment mg/L	Nitrate mg/L	*E. Coli* cfu/100ml
None 4000+ lb/ac RDM	2	0.1	310
Moderate 800 lb/ac RDM	7	0.4	425

Table 7-21. Total dissolved phosphorus as P concentrations in native grasslands runoff (units = mg/L) from the U.S. Department of Agriculture's MANAGE database [A].

Runoff Category	Types of Land Cover at Monitoring Sites	No. of Samples	Arithmetic Mean	Min	10%	25%	50% (median)	75%	90%	Max
Runoff from Grazing Lands (aka, rangeland)	Native grassland Native grass (no grazing) Native grass (light grazing) Native grass (moderate grazing) Native grass (heavy grazing) Native prairie	19	0.21	0.01	0.028	0.09	0.17	0.24	0.526	0.67

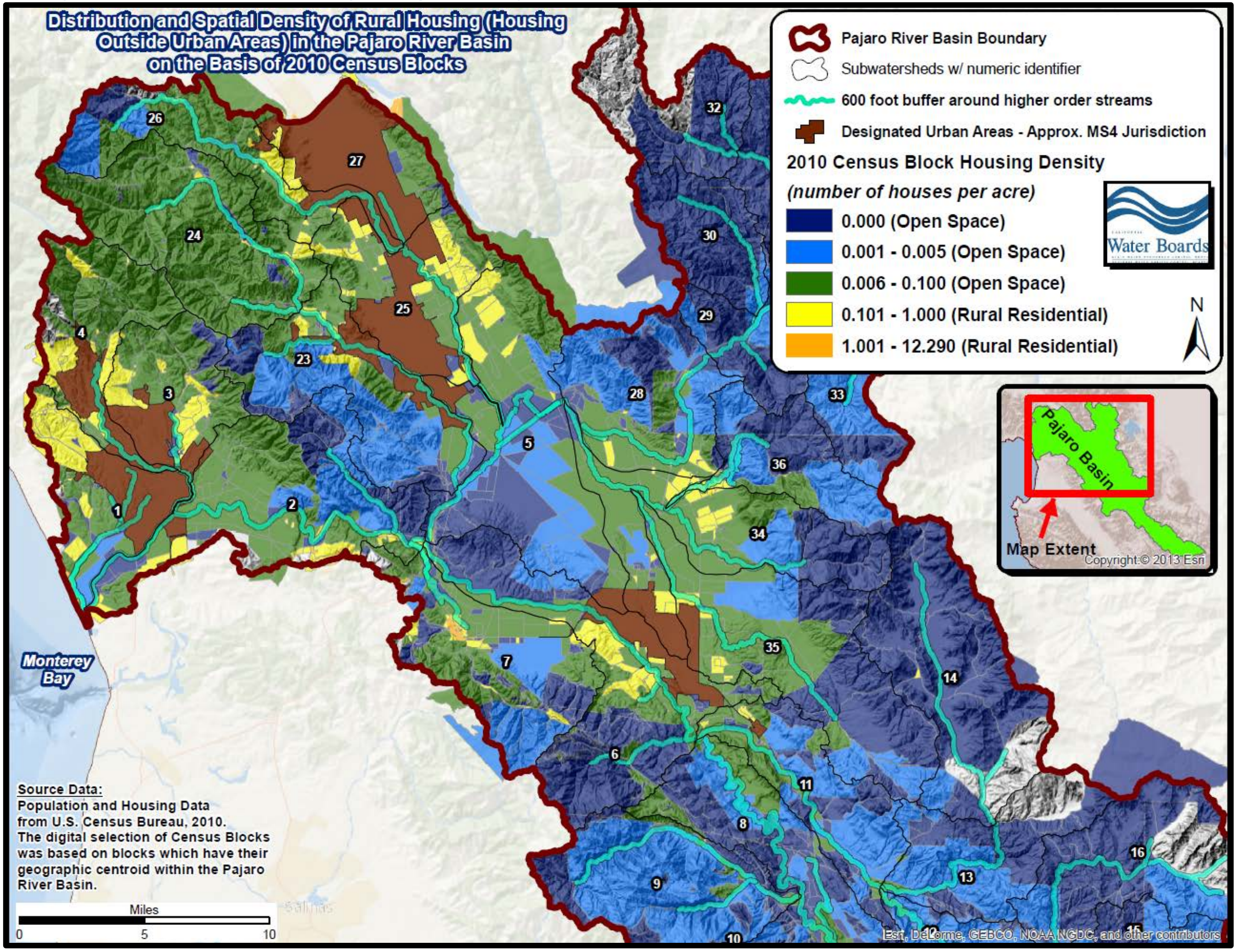
[A] California or Pajaro River basin specific data for grasslands runoff are not available. Data available for phosphorus concentrations in grasslands runoff in the MANAGE database come from northern, south-central, and west Texas and from central Oklahoma.

Another potential source category could be considered for manure from livestock. Livestock and domestic animals, such as horses, which occur in rural residential areas and are housed within corralled or confined animal areas, can also be considered a potential source of nutrients to surface waters. The management of these animals is notably different from range livestock on lightly-grazed rangelands. Figure 7-21 presents spatial estimates of rural residential areas within the northern Pajaro River basin. On balance, these rural residential areas occur in areas where streams are not impaired by nutrients on the basis of available data. Thus, in general it is expected that owners and operators of livestock and domestic animals on rural residential lands would currently achieving any load allocations or nutrient water quality targets identified for this TMDL report. The current nutrient load from this source category – while not expected to result in water quality standards violations – is unknown because STEPL does not provide an option to calculate loads from this land use category.

This assessment does not imply there is no risk at all from confined animals or corralled animals in rural residential areas. To maintain existing water quality and prevent any further water quality degradation, owners and operators of confined livestock and domestic animals in rural residential areas which do not drain to a municipal separate stormwater sewer system, as well as livestock owners/operators of unconfined livestock on rangelands, should begin or continue to self-assess, self-monitor and make animal management and manure management decisions which comport with accepted manure management practices or rangeland management practices recommended or published by reputable resource professionals or local agencies.

The information outlined above does not conclusively demonstrate that discharges from all confined animal facilities and properties are meeting proposed load allocations. More information will be obtained during the implementation phase of these TMDLs to further assess the level of nutrient contributions to surface waters from these source categories, and to identify any actions needed to reduce nutrient loading.

Figure 7-21. Distribution and spatial density of rural housing (housing outside census-designated urban areas) in the Pajaro River basin on the basis of 2010 Census block data. Blue and green shades are characaterized as "open space" (areas with zero housing units to less than one housing unit per every ten acres); yellow and orange shades are characterized as "rural residential" areas (areas with housing density more than one housing unit per every ten acres).



Distribution and Spatial Density of Rural Housing (Housing Outside Urban Areas) in the Pajaro River Basin on the Basis of 2010 Census Blocks

Source Data:
Population and Housing Data from U.S. Census Bureau, 2010. The digital selection of Census Blocks was based on blocks which have their geographic centroid within the Pajaro River Basin.

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

It is important to note that the Pajaro River basin is currently subject to a Domestic Animal Waste Discharge Prohibition and livestock owners are subject to compliance with an approved indicator bacteria TMDL load allocation[179]. As a practical matter, implementation efforts owners and operators of livestock and domestic animals implement to comply with this prohibition and with the indicator bacteria load allocations will also reduce the risk of nitrogen and phosphorus loading to surface waters from domestic animal waste.

Summing up, average annual nutrient loads delivered to surface waterbodies in the Pajaro River basin from grazing lands (i.e., rangeland) were estimated on the basis of the STEPL input parameters previously identified in Section 7.1 – these estimated loads are tabulated in Table 7-22.

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[179] Central Coast Water Board Resolution No. R3-2009-0008 (March 2009).

Table 7-22. Estimated average annual nutrient loads (lbs./year) delievered to surface waterbodies from grazing lands (i.e., rangeland) in the Pajaro River basin.

Source	N Load (lbs/yr)	P Load (lbs/yr)
Grazing Lands	377,410	249,930

7.8 Woodlands & Undeveloped Areas

Streams in lightly disturbed or undeveloped woodlands and open space are generally characterized by low concentrations of nutrients in surface waters on the basis of regional data previously presented in Section 3.6, and on the basis of water quality data collected from undeveloped stream basins across the conterminous United States – see Table 7-23. Thus, surface waters and surface runoff from woodland and undeveloped upland areas of the Pajaro River basin would be expected to have quite low nutrient concentrations relative to other types of land use categories which are more influenced by human activities.

Table 7-23. Mean annual flow-weighted nutrient concentrations observed in streams in undeveloped basins of the conterminous United States.

Water Quality Parameter	No. of sampled streams	Arithmetic Mean	Min	25%	50% (median)	75%	90%	Max	No. Exceeding Drinking Water Standard (>10 mg/L)	% Samples Exceeding 10 mg/L
Nitrate as N	82	0.15	0.00	0.03	0.09	0.20	0.44	0.77	0 of 82	0%
Total nitrogen	63	0.39	0.10	0.17	0.25	0.50	0.72	2.57	N.A.	N.A.
Total phosphorus	63	0.04	0.02	0.02	0.02	0.04	0.08	0.20	N.A.	N.A.

Source data: Clark et al. (2000). Nutrient Concentrations and Yields in Undeveloped Basins of the United States.

Average annual nutrient loads delivered to surface waterbodies in the Pajaro River basin from woodlands were estimated on the basis of the STEPL input parameters previously identified in Section 7.1 – these estimated loads are tabulated in Table 7-24.

Table 7-24. Estimated average annual nutrient loads (lbs./year) delievered to surface waterbodies from woodlands in the Pajaro River basin.

Source	N Load (lbs/yr)	P Load (lbs/yr)
Woodlands & undeveloped areas	44,199	22,434

7.9 Onsite Wastewater Treatment Systems

In any given watershed, onsite wastewater treatment systems (OWTS), also known as septic systems, are sometimes assessed as a possible source of nutrient or fecal bacteria surface water pollution. According to USEPA, the distribution and density of OWTS vary widely by region and by state[180]. Statewide, California has a fairly low distribution of its population served by OWTS – around 10 percent. In contrast, in the New England states, about half the population is served by OWTS[181]. An estimated distribution of OWTS density in the Pajaro River basin, based on 1990 vintage data, is presented in Figure 7-22. Based on the 1990 vintage Census Bureau data, about 30 percent of the population of the Pajaro River basin is served by OWTS. 1990 was the last decennial national census that collected household sewage disposal data.

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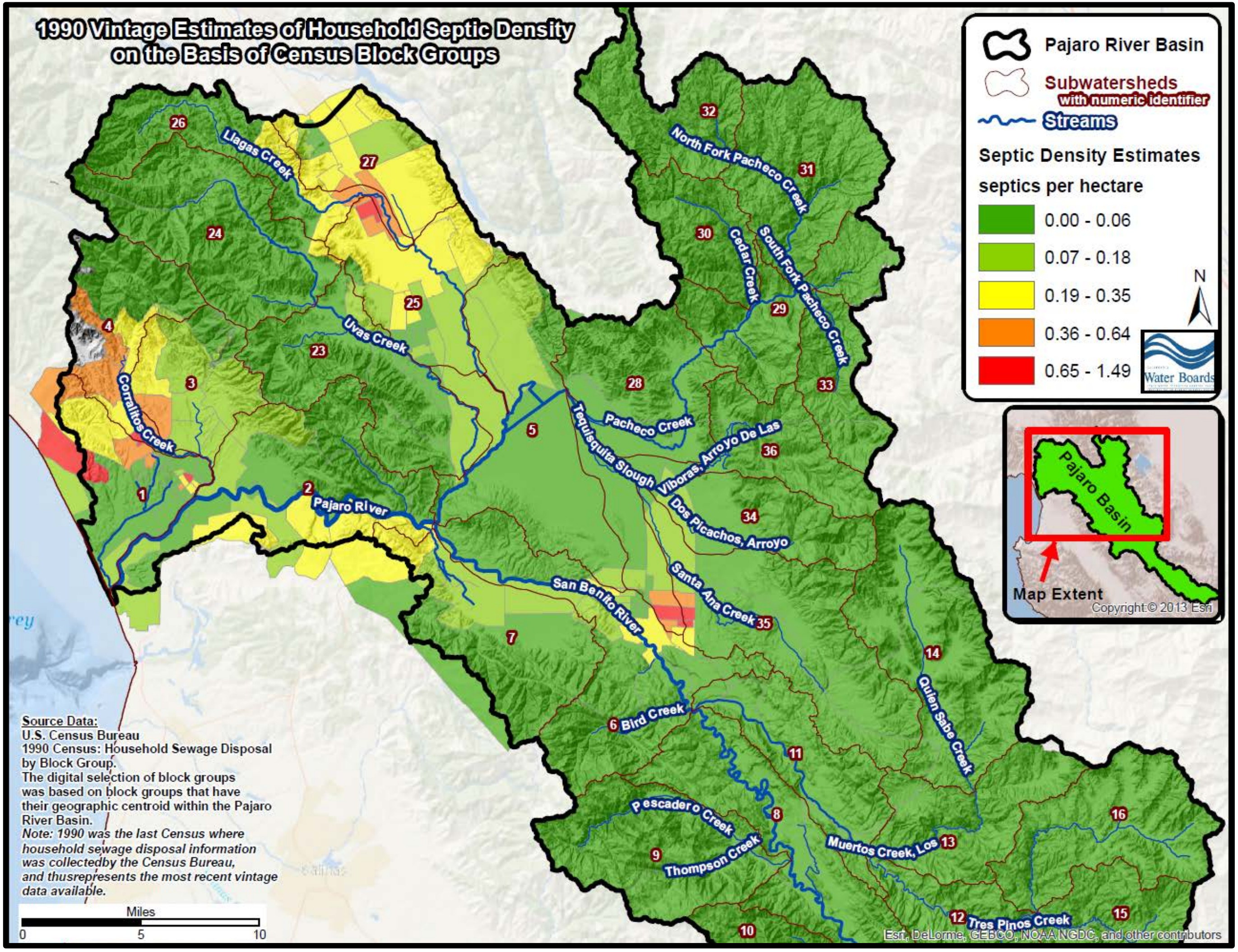
[180] USEPA septic systems webpage, http://water.epa.gov/infrastructure/septic/FAQs.cfm#faq2

[181] *Ibid*

Figure 7-22. 1990 vintage estimates of household septic density on the basis of census block groups in the northern Pajaro River basin (units = number of septic systems per hectare).

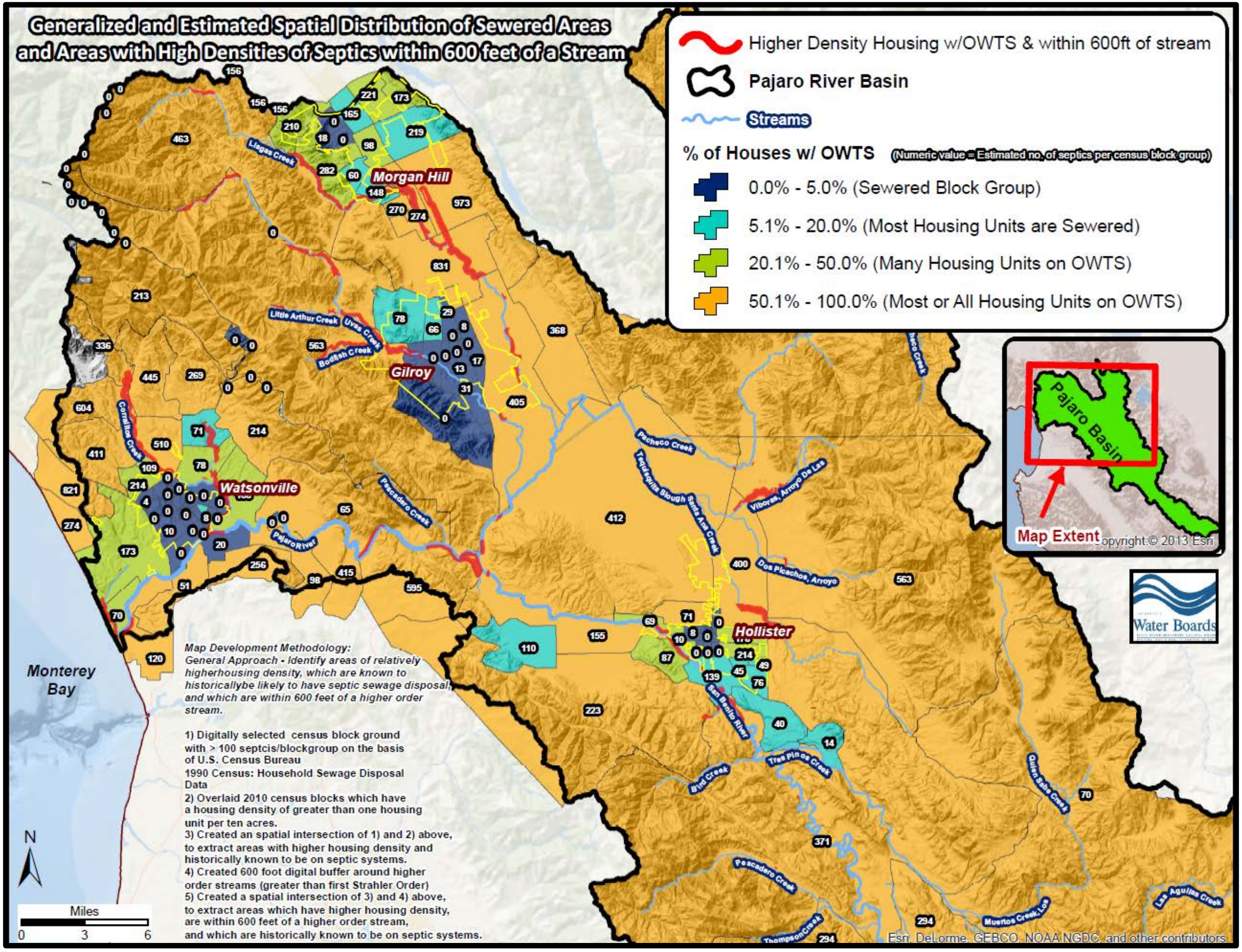


Source Data:
U.S. Census Bureau
1990 Census: Household Sewage Disposal by Block Group.
The digital selection of block groups was based on block groups that have their geographic centroid within the Pajaro River Basin.
Note: 1990 was the last Census where household sewage disposal information was collectedby the Census Bureau, and thusrepresents the most recent vintage data available.

The State Water Resources Control Board recently estimated the number of existing onsite wastewater treatment systems found within 600 feet of 303(d)-listed California waterbodies, including streams within the Pajaro River basin (State Water Board, 2008). These estimates were based on the assumption that only homes and businesses within 600 feet of the impaired water bodies would have the potential to have an impact on surface waters. The OWTS counts were based on an investigation using multiple sources: The main sources for the investigation are TOPO! (a U.S. Geological Survey [U.S. Geological Survey] map based program), Zillow.com, Realtor.com, and Google Maps. TOPO! were used to track water bodies through forest canopy, urban settings, and in some areas where the water body had few distinguishing features from the surrounding landforms.

In addition, Central Coast Water Board staff estimated approximately 70 OWTS within a 600 foot buffer of Watsonville Slough based on the presence of housing units in the Rio Boca road and Pajaro Dunes area (see Figure 7-23). Pajaro River basin 303(d)-listed streams with estimates of the number OWTS located within a 600 buffer of the stream, are tabulated in Table 7-25.

Figure 7-23. Generalized and estimated spatial distribution of sewered areas, and areas with relatively high densities of housing units served by septic systems within 600 feet of a stream.



Map Development Methodology:
General Approach - Identify areas of relatively higherhousing density, which are known to historicallybe likely to have septic sewage disposal, and which are within 600 feet of a higher order stream.

1) Digitally selected census block ground with > 100 septcis/blockgroup on the basis of U.S. Census Bureau 1990 Census: Household Sewage Disposal Data
2) Overlaid 2010 census blocks which have a housing density of greater than one housing unit per ten acres.
3) Created an spatial intersection of 1) and 2) above, to extract areas with higher housing density and historically known to be on septic systems.
4) Created 600 foot digital buffer around higher order streams (greater than first Strahler Order)
5) Created a spatial intersection of 3) and 4) above, to extract areas which have higher housing density, are within 600 feet of a higher order stream, and which are historically known to be on septic systems.

Table 7-25. Estimated locations and number of onsite wastewater treatment systems (OWTS) proximal to streams of the Pajaro River basin.

Stream	Estimated OWTS within 600 Feet of Stream	Subwatershed
Corrilitos Creek	200[A]	Corrilitos Creek Subwatershed
Llagas Creek (at San Martin)	150 [A, B]	Upper Llagas Creek Subwatershed
Llagas Creek (downstream of San Martin)	150 [A, B]	Lower Llagas Creek Subwatershed
Pajaro River (downstream of San Benito River confluence)	125[A]	Lower Pajaro River Watershed
San Benito River	100[A]	Bird Creek–San Benito River Subwatershed
Tequisquita Slough	31[A]	Tequisquita Slough Subwatershed
Watsonville Slough	70[C]	Watsonville Slough Subwatershed
	Total = 826	

[A] Data source: State Water Board, 2008. AB 885 On-site Wastewater Treatment Systems Program DEIR.

[B] State Water Control, 2008 DEIR literature source indicates there are an estimated 300 OWTS within 600 feet of Llagas Creek. Central Coast Water Board staff divided the 300 OWTS evenly between the upper Llagas Creek Subwatershed and the Lower Llagas Creek Subwatershed.

[C] Data source: Estimated on the basis of information developed in Figure 7-23.

Finally, the average annual nutrient loads delivered to streams in the Pajaro River basin from OWTS were estimated on the basis of the STEPL input parameters previously identified in Section 7.1 – these estimated loads are tabulated in Table 7-26. Because of the small and negligible magnitude of these loads, nutrient loading to streams from this source category is considered to be insignificant and negligible in the Pajaro River basin. This assessment comports well with an independent line of scientific reporting from Williamson et al. (1994). These researchers concluded that at the basin-scale, nutrient loads to streams from OWTS is negligible, although some localized effects may occur. It should be noted that OWTS impacts to underlying groundwater can locally be significant, but these potential OWTS groundwater impacts are outside the scope of this TMDL. Although not directly related to the Pajaro River basin, it is worth noting that researchers have concluded that at the basin-scale and regional-scale of the nearby Salinas Valley, OWTS impacts to groundwater are relatively insignificant compared to agricultural fertilizer impacts (University of California-Davis, 2012).

Table 7-26. Estimated average annual nutrient loads (lbs./year) delievered to surface waterbodies from onsite wastewater treatment systems (e.g, septic systems) in the Pajaro River basin.

Source	N Load (lbs/yr)	P Load (lbs/yr)
Onsite Wastewater Treatment Systems	566	222

7.10 Shallow Groundwater

Shallow groundwater provides the base flows to streams and can locally be an substantial source of surface water flows especially during low flow conditions or during the dry season (refer back to Section 3.9). Nitrate in groundwater can occur from both leaching of anthropogenic sources at the land surface, and from natural sources. Note that controllable phosphorus leaching to groundwater is presumed to be negligible in this TMDL report; phosphorus readily binds to sediment, is relatively insoluble, and is generally not expected to be leached to groundwater from surface sources in significant amounts. Phosphorus in groundwater is generally expected to result from leaching of geologic materials in the subsurface.

Average annual nutrient loads delivered to surface waterbodies in the Pajaro River basin from shallow groundwater were estimated on the basis of the STEPL input parameters previously identified in Section 7.1 – these estimated loads are tabulated in Table 7-27. In valley floor reaches of the Pajaro River basin, concentrations of nitrate in groundwater elevated above natural background are expected to largely be a result of human land use activities.

Table 7-27. Estimated average annual nutrient loads (lbs./year) delievered to surface waterbodies from shallow groundwater in the Pajaro River basin.

Source	N Load (lbs/yr)	P Load (lbs/yr)
Shallow groundwater inputs to streams	384,812	19,074

7.11 Direct Atmospheric Deposition

Atmospheric inputs of nutrients in rainfall are a source of loading in any watershed. Because nitrogen can exist as a gaseous phase (while phosphorus cannot), nitrogen is more prone to atmospheric transport and deposition. Phosphorus associated with fine-grained airborne particulate matter can also exist in the atmosphere (USEPA, 1999). It is important to recognize however that atmospheric deposition of nutrients is typically more significant in lakes and reservoirs, than in creeks or streams (USEPA, 1999). This is because the surface area of a stream is typically small compared to the area of a watershed. Atmospheric deposition also occurs on the land surfaces throughout any given watershed and these loads could ultimately be transported to a waterbody if entrained in runoff, These loads would be considered part of the ambient background load, in contrast to the direct atmospheric deposition onto the surfaces of streams and lakes being addressed here.

The STEPL spreadsheet model staff used in source analysis does not estimate atmospheric inputs of nutrients to surface waterbodies. Consequently, staff used available information of atmospheric nutrient loading, and river basin parameters, to develop estimates independent of the STEPL spreadsheet (see Table 7-28). The total summed length of all NHDplus digitized surface water flowlines in the Pajaro River basin, is approximately 10.7 E+06 feet, and the average width streams in the Pajaro River basin is assumed to be approximately 10 feet. Accordingly, the total surface area of Pajaro River basin streams is approximately 997 hectares as calculated in ESRI™ ArcMap® 10.1 using a digital NHD flowline buffer equal to ten feet in width. With an estimated average annual total nitrogen atmospheric deposition rate of 5.42 kg of nitrogen/ha/year (data source: refer back to Figure 3-24 and to Text Box 3-2 on page 49), the typical annual load from atmospheric deposition in the river basin would therefore be 5,404 kg of nitrogen/year, or equivalent to 11,914 pounds of nitrogen/year.

Atmospheric phosphorus can be found in organic and inorganic dust particles. The general atmospheric deposition rate for total phosphorus can be estimated as 0.6 kg of phosphorus/ha/year (USEPA 1994, as reported in San Diego Regional Water Quality Control Board, 2006). Accordingly, using the summed total stream surface area presented above, the typical annual load of phosphorus would therefore be 598 kg of total phosphorus/year, or equivalent to 1,319 pounds/year (see Table 7-29).

A tabular summary of the aforementioned estimates for nutrient atmospheric deposition in the Pajaro River basin is presented in Table 7-29.

Table 7-28. Nutrient atmospheric deposition in the Pajaro River basin: parameters considered and used.

Parameters Considered	Estimates
Total summed length of all streams in the Pajaro River basin	10,734,285 ft.
Total summed surface area of all streams in the Pajaro River basin	997 hectares[A]
Estimated average annual atmospheric deposition rate of total nitrogen to streams in the Pajaro River basin	5.42 kg/hectare per year
Estimated average annual atmospheric deposition rate of total phosphorus to streams in the Pajaro River basin	0.6 kg/hectare per year

[A] Calculated from the total summed length of NHD stream flowlines and a digitized 10 foot-wide polygon centered on the NHD flowlines .

Table 7-29. Estimated average annual atmospheric deposition of total nitrogen and total phosphorus to streams of the Pajaro River basin (lbs./year).

Source	N Load (lbs/yr)	P Load (lbs/yr)
Atmospheric deposition	11,914	1,319

7.12 Summary of Sources

Table 7-30 presents a summary of nutrient source categories and estimated annual nutrient loads to streams of the Pajaro River basin. The estimated relative source contributions (%) of source categories are also shown graphically in Figure 7-24. Further, Figure 7-25 presents estimates of the average annual nutrient yield (aka, the "intensity" of loading to streams) from various land use/land cover categories. These estimates indicate that nutrient yields from cropland are expected to be much higher than other land use/land cover categories, while urban land uses can also be expected to deliver nutrient yields well in excess of natural background conditions. Nutrient yields from grazing lands (aka, rangeland) and from woodlands and undeveloped areas are expected to be relatively low. Table 7-31 presents estimates of the average annual nutrient load and yield to streams for subwatersheds in the Pajaro River basin. The highest nutrient yields are expected to be from valley floor subwatersheds with substantial areas of agriculture, urban, and developed lands. Lastly, it is worth noting that shallow groundwater is expected, locally, to be a significant source of nutrients to streams on the basis of information presented in this section of the report.

Table 7-31 presents a summary of average annual nutrient loads and nutrient yields by individual subwatersheds. This information suggests that the major sources of nutrients in streams of the Pajaro River basin originate from valley floor areas the southern Santa Clara Valley, and substantial amounts of nutrient loading also occurs as stream waters pass through agricultural areas in the Pajaro Valley. San Juan Creek, located in the San Juan Canyon subwatershed, was also noted by Los Huertos et al. (2004) as likely contributing significant nutrient loads to the Pajaro River, particularly during the summer months.

On balance, at the basin, watershed and subwatershed scales Central Coast Water Board staff's assessment of the spatial distribution and magnitude of nutrient loads and nutrient yields comports well with previous independent assessments by central coast researchers (Williamson et al. 1994, Los Huertos et al. 2001, Los Huertos et al. 2004).

Table 7-30. Estimated average annual nutrient source loads to streams of the Pajaro River basin on the basis of recent vintage land use and water quality data compiled in this report.

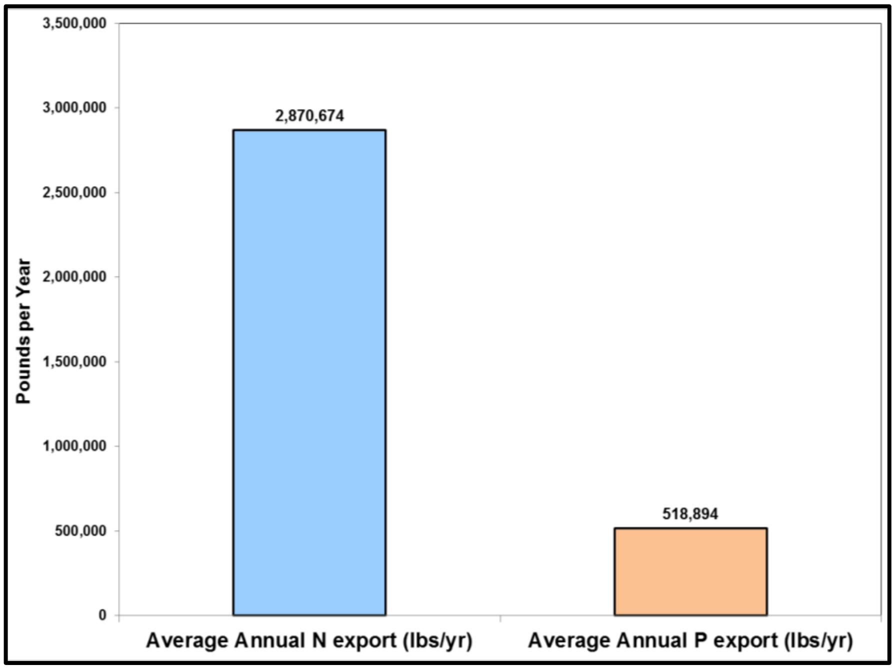
<table>
<tr><th>Sources</th><th>N Load (lbs/yr)</th><th>P Load (lbs/yr)</th><th>Bar Chart – Total Nitrogen and Phosphorus Annual Load</th></tr>
<tr><td>Urban</td><td>182,542</td><td>21,565</td><td rowspan="10"> </td></tr>
<tr><td>Cropland</td><td>1,869,231</td><td>204,350</td></tr>
<tr><td>Grazing Lands</td><td>377,410</td><td>249,930</td></tr>
<tr><td>Woodlands, Undeveloped, Restricted</td><td>44,199</td><td>22,434</td></tr>
<tr><td>Onsite Wastewater Treatment Systems (septics)</td><td>Negligible (<600 lbs.)</td><td>Negligible (<300 lbs.)</td></tr>
<tr><td>Municipal Wastewater Treatment Facility discharges</td><td>Negligible See report Section 7.4</td><td>Unknown</td></tr>
<tr><td>Shallow Groundwater</td><td>384,812</td><td>19,074</td></tr>
<tr><td>Golf Courses</td><td>Unknown presumed negligible</td><td>Unknown presumed negligible</td></tr>
<tr><td>Atmospheric Deposition</td><td>11,914</td><td>1,319</td></tr>
<tr><td>**Average Annual Total**</td><td>2,870,674</td><td>518,894</td></tr>
</table>

Figure 7-24. Estimated average annual nitrogen and phosphorus source contributions (%) to streams of the Pajaro River basin

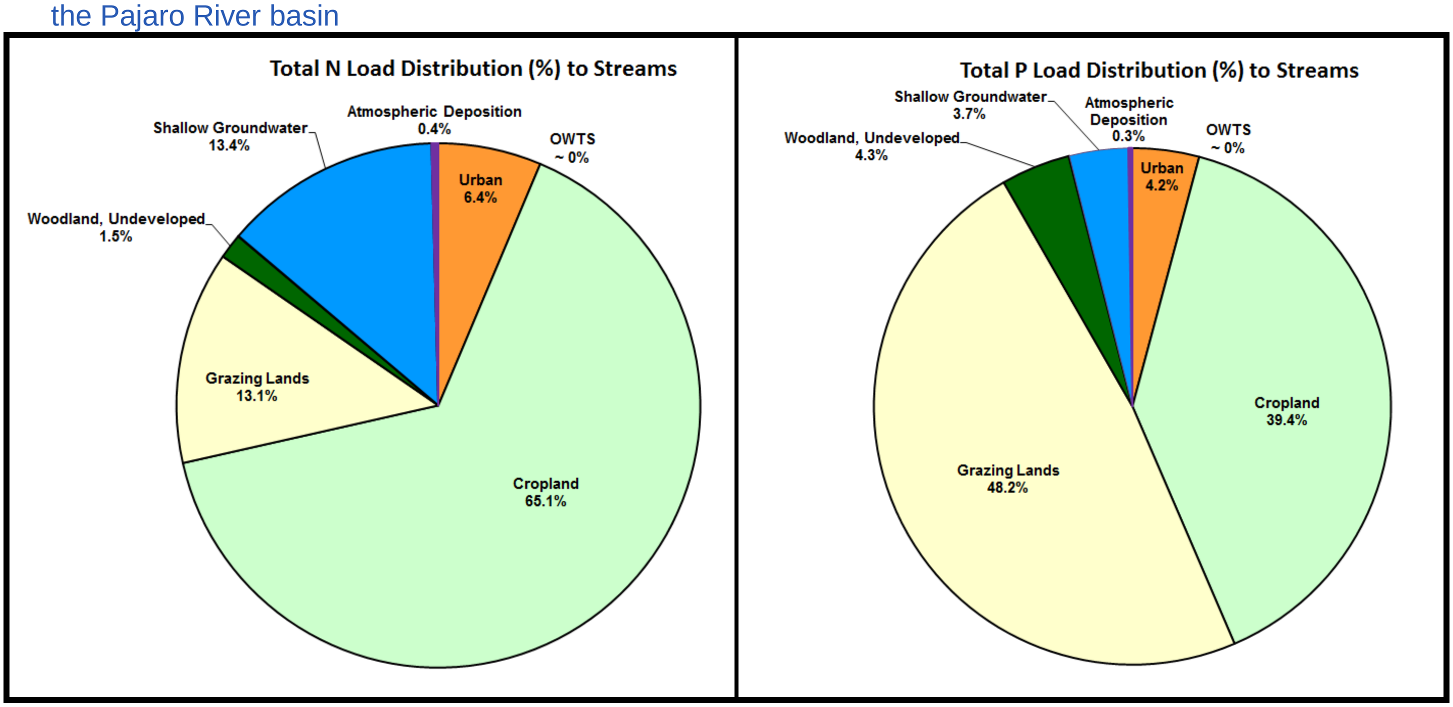


Figure 7-25. Estimated average annual nitrogen and phosphorus source yields (pounds per acre per year) to streams of the Pajaro River basin from various land use/land cover categories.

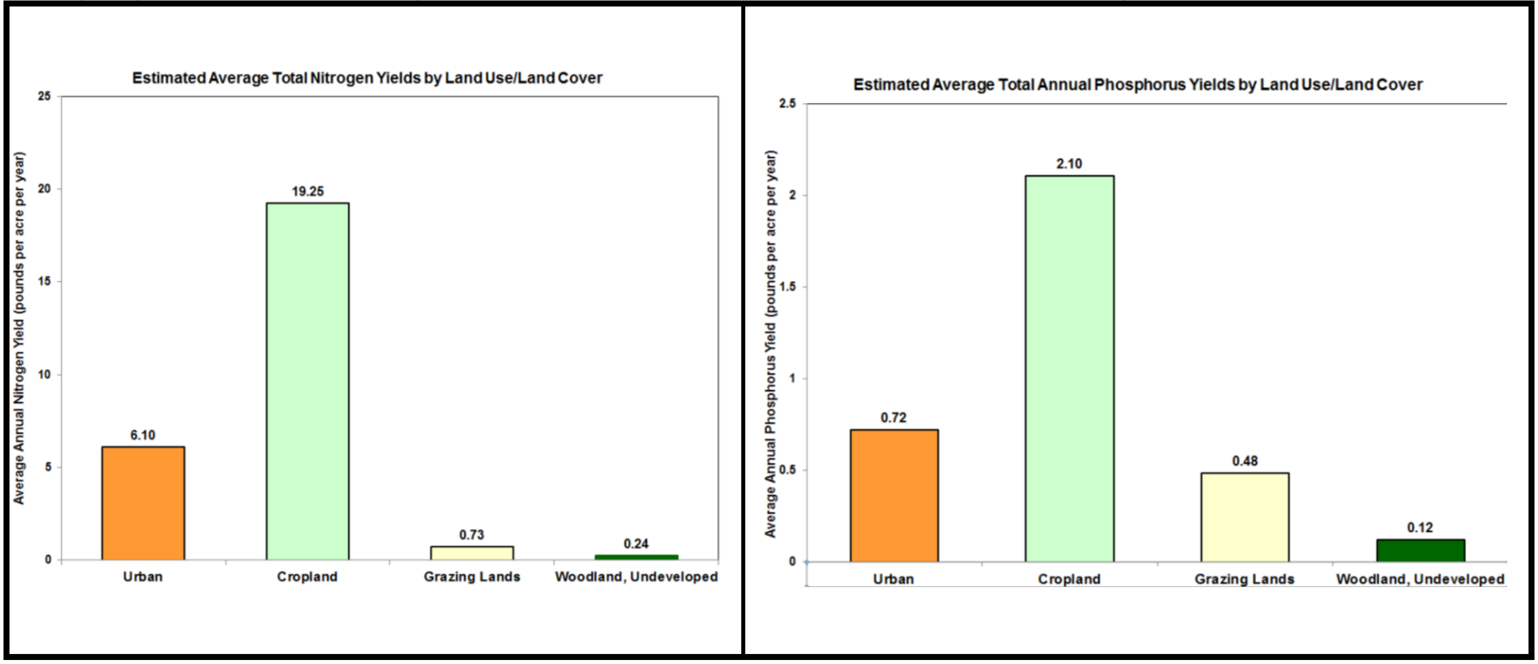


Table 7-31. Estimated average annual nutrient loads and nutrient yields by subwatershed (units: land cover = acres, load = pounds, yield = pounds per acre per year).

Subwatershed	**Urban and Built up Land**	**Cropland**	**Grazing Lands**	**Woodlands, Undeveloped, Restricted**	**Land Cover Total**	**Predicted Average Annual N Load *(pounds)***	**Predicted Average Annual P Load *(pounds)***	**Predicted Average Annual N Yield *(pounds per acre per year)***	**Predicted Average Annual P Yield *(pounds per acre per year)***
Arroyo De Las Viboras	0	327	14,229	184	14,740	18,289	7,606	1.2	0.52
Bird Creek-San Benito River	3,034	3,779	17,505	8,424	32,742	90,814	15,156	2.8	0.46
Cedar Creek	0	0	7890	4,876	12,766	9,755	6,002	0.8	0.47
Clear Creek-San Benito River	0	0	13,205	21,625	34,843	19,314	11,605	0.6	0.33
Corralitos Creek	1,108	2,594	178	13,909	17,789	114,848	9,558	6.5	0.54
Hernandez Reservoir-San Benito River	0	178	8,821	9,888	19,512	15,690	7,109	0.8	0.36
James Creek-San Benito River	0	10	16,330	12,401	28,740	16,615	9,736	0.6	0.34
Las Aguilas Creek	0	0	24,509	220	24,730	17,753	11,096	0.7	0.45
Little Llagas Creek	5,257	2,216	5,284	2,636	15,392	98,191	14,550	6.4	0.95
Los Muertos Creek	0	42	18176	710	18,928	13,075	7,661	0.7	0.40
Lower Llagas Creek	5,442	5,378	4,721	4,467	20,007	177,780	23,851	8.9	1.19
Lower North Fork Pacheco Creek	0	0	24,891	688	25,746	25,322	16,046	1.0	0.62
Lower Pacheco Creek	192	4,172	15,796	1,717	21,986	117,935	21,973	5.4	1.00
Lower Pajaro River	963	11,321	11,680	9,321	33,285	293,027	26,565	8.8	0.80
Lower Tres Pinos Creek	231	2,179	13,973	1,468	17,850	43,292	9,457	2.4	0.53
Lower Uvas Creek	1,602	4,142	13,677	6,269	25,690	146,597	24,277	5.7	0.95
Middle Tres Pinos Creek	0	19	22,470	508	22,997	16,222	10,343	0.7	0.45
Paicines Reservoir-San Benito River	16	4,354	26,909	2,610	33,976	86,775	18,611	2.6	0.55
Pescadero Creek	87	672	13,486	11,420	25,665	25,600	7,831	1.0	0.31

Subwatershed	Urban and Built up Land	Cropland	Grazing Lands	Woodlands, Undeveloped, Restricted	Land Cover Total	Predicted Average Annual N Load *(pounds)*	Predicted Average Annual P Load *(pounds)*	Predicted Average Annual N Yield *(pounds per acre per year)*	Predicted Average Annual P Yield *(pounds per acre per year)*
Quien Sabe Creek	0	3,172	29268	116	32,662	83,090	20,011	2.5	0.61
Rock Springs Creek-San Benito River	0	303	23,080	6,397	29,781	24,813	11,979	0.8	0.40
Salsipuedes Creek	1,342	4,019	2,344	7,993	15,881	124,894	9,864	7.9	0.62
San Juan Canyon	927	6,136	11,360	5,774	24,415	146,067	19,161	6.0	0.78
Santa Ana Creek	853	7,084	24,603	1,177	33,717	131,947	22,765	3.9	0.68
South Fork Pacheco Creek	0	0	11,497	10	11,507	11,801	7,226	1.0	0.63
Stone Creek	0	5	8,133	1,922	10,060	6,410	3,490	0.6	0.35
Sulphur Creek-San Benito River	0	461	20911	2,802	24,174	22,397	9,719	0.9	0.40
Tequisquita Slough	1,966	8,966	12,638	2,393	25,964	205,065	26,291	7.9	1.01
Upper Llagas Creek	1,232	505	14,056	2,713	18,737	48,257	14,729	2.6	0.79
Upper North Fork Pacheco Creek	0	0	1,372	15,667	17,040	5,707	2,916	0.3	0.17
Upper Pacheco Creek	0	0	18,094	222	18,316	18,012	10,932	1.0	0.60
Upper Pajaro River	1,313	19,596	13,487	1,070	35,466	441,210	49,577	12.4	1.40
Upper Tres Pinos Creek	0	81	20,916	2,243	23,240	17,435	9,956	0.8	0.43
Upper Uvas Creek	201	316	15,576	13,491	29,823	44,352	18,633	1.5	0.62
Watsonville Slough	4,178	5,049	292	5,952	15,472	167,708	14,595	10.8	0.94
Willow Creek	0	41	15,962	2,583	18,585	12,699	6,696	0.7	0.36

7.12.1 Comparison of Source Analysis with Previous Studies

Staff compared the source analysis conclusions presented herein with conclusions reached by other scientists in previous Pajaro River basin nutrient pollution studies. Summary conclusions from these previous studies are highlighted below:

> *"The dominance of agriculture and the locations of our sampling sites leave little doubt that agricultural practices are a major source of the elevated nutrients recorded at each [Pajaro River basin] stream sampled. The nutrient concentrations justify actions that farmers have already taken to improve water quality. Nutrient concentrations at the levels we found may lead to possible health hazards for humans and damage aquatic ecosystems."*
>
> from: Los Huertos, M., L. Gentry, and C. Shennan. 2003. Land Use and Water Quality on California's Central Coast: Nutrient Levels in Coastal Waterways. University of California, Santa Cruz Center for Agroecology & Sustainable Food Systems, Research Brief #2.
>
> *Parenthetical clarification, in brackets, added by Central Coast Water Board staff*

> *"Cropland runoff is the nutrient source with the greatest potential impact on nutrient water quality [in the Pajaro River and Llagas Creek watersheds]."*
>
> from: Williamson et al. San Jose State University Department of Civil Engineering and Applied Mechanics and Merritt Smith Consulting. 1994. The Establishment of Nutrient Objectives, Sources, Impacts, and Best Management Practices for the Pajaro River and Llagas Creek. Final Report. Prepared for California State Water Resources Control Board and the Regional Water Quality Control Board, Central Coast Region. Contract Number 0-212-253-0.
>
> *Parenthetical note for geographic context added by Central Coast Water Board staff*

Additionally, while grazing lands constitute a large and substantial proportion of land use in Pajaro River basin, staff's analysis in this report indicates that the river basin's grazing lands are a relatively low risk of nutrient pollution and that this source category is currently meeting its load allocations (refer to section 9.5). Staff's conclusions are supported by an independent line of research available from scientists at the University of Santa Cruz, California. These researchers concluded that data from Pajaro River basin indicates nitrate concentrations in drainage from grazed lands are generally quite low, thus suggesting that the risk of nitrate pollution from gazing lands is relatively minimal.

> *"Nitrate as N concentrations were typically <1 mg N/L in grazing lands, oak woodlands, and forests, but increased to a range of 1 to 20 mg N/L as surface waters passed through agricultural lands. Very high concentrations of nitrate (in excess of 80 mg N/L) were found in selected agricultural ditches that received drainage from tiles (buried perforated pipes). Nitrate concentrations in these ditches remained high throughout the winter and spring, indicating nitrate was not being flushed out of the soil profile. We believe unused N fertilizer has accumulated in the shallow groundwater through many cropping cycles."*
>
> from: Los Huertos, M., L. Gentry, and C. Shennan. 2001. Land Use and Stream Nitrogen Concentrations in Agricultural Watersheds Along the Central Coast of California. Research Article. Proceedings of the 2nd International Nitrogen Conference on Science and Policy. The Scientific World (2001), 1(S2), pp. 615-622.

Summing up, Central Coast Water Board staff concludes that the Pajaro River basin nutrient source analysis conclusions developed in this TMDL report generally comports with previous independent findings published by university and consulting scientific researchers, thus adding some measure of confidence to our source analysis.

7.12.2 Supporting Lines of Evidence from Geochemical Research

Overall, staff's source analysis indicates that cropland is the overwhelming source of controllable nutrient loading to surface waters of the Pajaro River basin. These conclusions generally are consistent with findings from the Pajaro River basin published by researchers from Lawrence Livermore National Laboratory (2005). Lawrence Livermore National Laboratory reported that geochemical and isotopic data indicates that inorganic fertilizers are the largest source of nitrate to shallow groundwater in sampled areas of the Llagas Creek watershed.

> *"Inorganic fertilizer is almost certainly the main source of nitrate to shallow groundwater in the Llagas subbasin, so continued efforts to minimize application of fertilizer that is not taken up by plants but rather leached to groundwater is critical."*
>
> *from: Lawrence Livermore National Laboratory. 2005. California GAMA Program: Sources and transport of nitrate in shallow groundwater in the Llagas Basin of Santa Clara County, California.*

While isotopic data for creek waters were not within the scope of the Lawrence Livermore National Laboratory study, it should be recalled that shallow groundwater is locally expected to be a significant source of nutrients to streams in the Pajaro River basin (refer back to report sections 3.9 and 7.10), and that groundwaters can locally be in hydraulic communication with stream waters (refer back to Section 3.9). It is important to note that the Lawrence Livermore National Laboratory study was limited in geographic scope, and should not be extrapolated to represent site specific conditions for all catchments, subwatersheds, and groundwater subbasins of the Pajaro River basin. However, this geochemical evidence provides an indirect additional line of evidence supporting the mass balance-based source analysis developed in this TMDL Report.

7.12.3 Comparison of Source Analysis to Export Coefficient Model Results

It can be useful to compare source load estimations derived from using different assessment methodologies. Close agreement of estimates using different assessment methodologies gives some added measure of confidence in the precision of the results.

Previously, in the 2005 Pajaro River Nitrate TMDL, Central Coast Water Board staff estimated nitrate as N loads, using the Export Coefficient Model. The Export Coefficient Model (Reckhow et al., 1980) is a scoping model regularly used to compute lumped annual basin nitrogen or phosphorous loads based on summing nonpoint and point source estimated loads. The Export Coefficient Method uses a pollutant loading equation that is accepted by the U.S. Environmental Protection Agency, as contained in PLOAD Version 3.0, An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watersheds and Stormwater Projects, User Manual (U.S. EPA, 2001b).

The source assessment methodology (STEPL) used in this TMDL report provides results that comport quite well with the Export Coefficient Model results from the 2005 Pajaro River Nitrate TMDL. In this TMDL report, annual estimated average nitrogen load for the Pajaro River basin is 2.870.674 pounds per year (refer back to Table 7-30). The Pajaro River basin estimated nitrate load in the 2005 Pajaro River nitrate TMDL was 2,943,460 pounds per year (see Table 7-32). These two estimates are in close agreement. Similarly, in this TMDL report, annual estimated average nitrogen load for cultivated croplands the Pajaro River basin is 1,869,231 pounds per year, while the Pajaro River basin estimated nitrate load for cultivated croplands in the 2005 Pajaro River nitrate TMDL was 1,880,542 pounds per year. These two estimates are in close agreement.

Table 7-32. Nitrate source load assessment from the 2005 Pajaro River nitrate TMDL (Resolution R3-2005-0131) which used the export coefficient model method of source assessment. These export coefficient model estimates comport reasonably well with the estimates developed in this report using the STEPL spreadsheet source analysis tool. .

Land Use	Pajaro River basin (lbs./year)
Agriculture	1,880,527
Open Space	962,163
Urban	100,770
Total Load	2,943,460

7.12.4 Comparison of Predicted Loads to Observed Loads

Table 7-33 illustrates observed nitrate and phosphate loads observed in the lower Pajaro River at Chittenden on the basis of observed mean stream flow and observed mean concentrations. The Pajaro River at Chittenden drains 1,186 square miles[182] of the Pajaro River basin, and thus represents about 91% of the total drainage area of the river basin. Combined with the fact that this is a perennial reach of river with a long record of daily flow measurements, makes this location a reasonably good approximation of pollutant loads being exported from the watershed to downstream coastal confluence surface waters, and to receiving groundwaters of the Pajaro Valley.

Table 7-33. Estimated mean annual flows, mean nutrient concentrations, and estimated mean annual nutrient stream loads in the Pajaro River at Chittenden.

Waterbody	**Parameter**	**Mean Annual Flow (cfs)[A]**	**Mean Concentration [B] (mg/L)**	**Number of Samples**	**Mean Annual Observed Load (pounds/year)**
Pajaro River @ Chittenden	nitrate as N	173.1	8.3	164	2,828,911
Pajaro River @ Chittenden	phosphate, total as P	173.1	0.7	48	238,583

[A] source:: U.S. Geological Survey gage 1159000

[B] Water quality data compiled for this report.

Figure 7-26 illustrates a comparison of the observed mean annual nitrate as nitrogen load[183] in the Pajaro River at Chittenden compared to predicted mean annual nitrogen loads based on the STEPL spreadsheet assessment method used in this report, and the 2005 export coefficient model assessment method used by the Central Coast Water Board in the 2005 Pajaro Nitrate TMDL (Resolution No. R3-2005-0131). The mean annual observed load and the mean annual predicted loads are in reasonably good agreement with each other, thus providing a measure of confidence in the predicted mean annual nitrogen loads derived using the STEPL spreadsheet tool in this report.

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[182] Source: U.S. Geological Survey stream gage 11159000, Pajaro River at Chittenden.

[183] Stream load is calculated by multiplying stream flow, concentration, and appropriate unit conversion factors.

Figure 7-26. Comparison of observed mean annual nitrate as nitrogen loads in the Pajaro River at Chittenden, to predicted mean annual nitrogen loads from two different assessment methodologies – Central Coast Water Board 2014 STEPL assessment, and Central Coast Water Board 2005 export coeffiient model (ECM) assessment method.

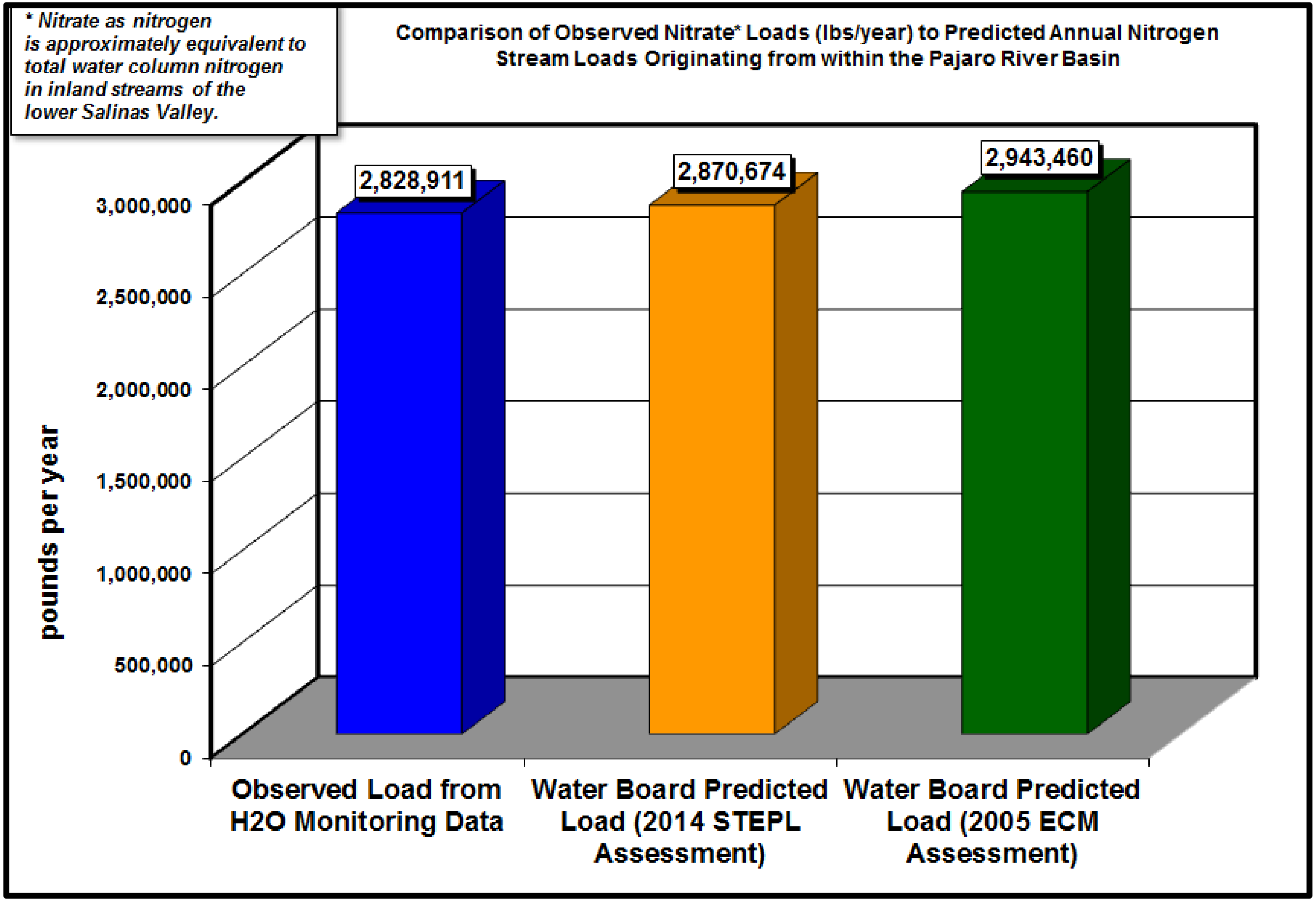
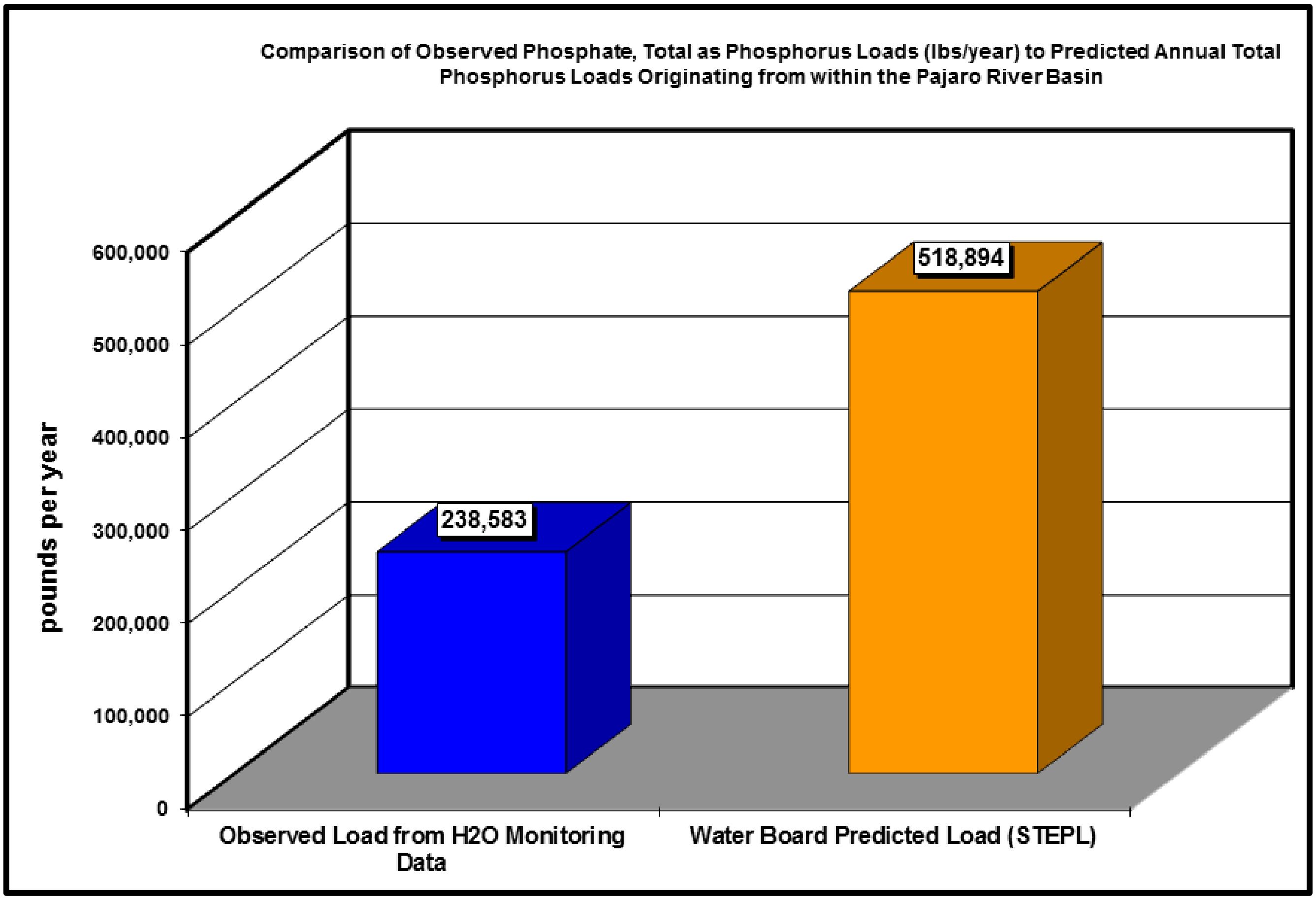


Figure 7-27 illustrates a comparison of the estimated mean annual observed water column phosphate in the Pajaro River at Chittenden to the predicted mean annual phosphorus load derived using the STEPL spreadsheet tool in this report.. The observed water column phosphate as total phosphorus load in the Pajaro River at Chittenden is approximately half of the STEPL estimated river basin phosphorus load. There could be several reasons for the difference in observed water column load versus river basin load. Unlike nitrate, which is soluble, and highly mobile in the environment and in aqueous systems, phosphorus readily binds to sediment and is not as mobile in the environment as nitrogen. As such, measurements of aqueous phosphorus in the water column does not account for phosphorus being transported in detrital matter in the stream bedload, nor does it account for phosphorus that is sequestered within the river basin, in sedimentary materials or organic matter, and which are not necessarily readily transported on an annual basis to downstream watershed outlets. In particular, sediment-sequestered phosphorus loads from headwater reaches may periodically be released from sediments when reduction-oxidation conditions change, or they may be episodically flushed out of the basin during abnormally wet years when large quantities of sediment can be mobilized and transported. Alternatively, the discrepancy between observed load and predicted load could result from inadequate input parameters for the STEPL spreadsheet tool. In particular, STEPL results are quite sensitive to input parameters for nutrient concentrations in runoff. Staff does expect, however, that STEPL provides a plausible gross approximation of *relative* source contributions of phosphorus at the scale of the river basin.

Figure 7-27. Comparison of observed mean annual phosphate as total phosphorus loads in the Pajaro River at Chittenden to a predicted mean annual load from the Central Coast Water Board 2014 STEPL assessment.



8 TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS

8.1 Existing Loading & Loading Capacity

Mean annual existing loads were estimated by a simple averaging technique (for example, see Etchells et al., 2005) where the annual load is calculated as the average concentration of samples multiplied by the mean annual flow. The loading capacity is the greatest amount of a pollutant that a water can receive and still meet water quality standards for that pollutant. Table 8-1 presents a tabulation of estimated mean annual existing nitrate loads and estimated percent reductions from the existing load to attain the loading capacity of the stream. Table 8-2 presents a tabulation of estimated existing dry season (May 1-Oct.30) loads and estimated percent reductions from the existing dry season loads to attain the loading capacity of the stream

Table 8-1. Tabulation of estimated mean annual existing nitrate loads, loading capcity, and percent reductions.

Stream Reach and associated Monitoring Site	Estimated Mean Annual Flow (cfs) ^{A}	Mean Annual Conc. (mg/L)	Mean Annual Existing Load (lbs.)	Mean Annual Loading Capacity (lbs.)	Estimated Load Reduction Necessary (lbs.)	Percent Reduction Goal^B	Nitrate as N Numeric Target Used for Calculating Loading Capacity (mg/L) and Reduction Goal
Carnadero Creek at private property access 305CAR	14.04	8.78	242,032	220,533	21,499	9%	Wet season biostimulation target = 8
Casserly Creek at Paulsen CA2	0.88	5.03	8,724	17,338	0	0%	MUN standard = 10 Anti-degradation requirements apply – maintain existing Water quality
Corralitos Creek at Freedom CORAA-21	16.9	5.31	167,280	252,033	0	0%	Wet season biostimulation target = 8 Anti-degradation requirements apply – maintain existing Water quality
Coward Creek at Carlton Rd CW	0.17	20.4	6,826	3,358	3,468	51%	MUN standard = 10
Furlong Creek at Fraiser Lake Rd 305FUF	0.43	34.13	28,908	6,789	22,119	77%	Wet season biostimulation Target = 8
Green Valley Creek at Green Valley Road GV	0.27	3.84	2,044	4,271	0	0%	MUN standard = 10 Anti-degradation requirements apply – maintain existing Water quality
Green Valley Creek Tributary at Casserly Road GVT	0.40	21.48	16,900	7,884	9,016	53%	MUN standard = 10
Harkins Slough at Harkins Slough Rd 305HAR	2.09	3.18	12,702	32,923	0	0%	Wet season biostimulation Target, total nitrogen as N = 8 Anti-degradation requirements apply – maintain existing Water quality
Hughes Creek at Casserly Road HC	0.07	0.95	146	1,387	0	0%	MUN standard = 10 Anti-degradation requirements apply – maintain existing Water quality
Llagas Creek at Bloomfield Avenue 305LLA	11.94	11.27	249,405	177,062	72,343	29%	Wet season biostimulation target = 8

Stream Reach and associated Monitoring Site	Estimated Mean Annual Flow (cfs) [A]	Mean Annual Conc. (mg/L)	Mean Annual Existing Load (lbs.)	Mean Annual Loading Capacity (lbs.)	Estimated Load Reduction Necessary (lbs.)	Percent Reduction Goal[B]	Nitrate as N Numeric Target Used for Calculating Loading Capacity (mg/L) and Reduction Goal
Llagas Creek at Southside 305LUC	8.84	17.8	309,812	139,248	170,564	55%	Wet season biostimulation target = 8
Pacheco Creek at San Felipe Rd 305PAC	12.70	1.68	42,012	250,062	0	0%	MUN standard = 10 Anti-degradation requirements apply – maintain existing Water quality
Pajaro River at Thurwatcher Rd. 305THU	109.59	5.01	1,081,057	1,726,268	0	0%	Wet season biostimulation target = 8 Anti-degradation requirements apply – maintain existing Water quality
Pajaro River at Chittenden 305CHI	173.1	8.27	2,818,686	2,726,661	92,025	3%	Wet season biostimulation target = 8
Salsipuedes Creek at Hwy 129 downstream of Corralitos Creek 305COR	8.54	3.54	59,532	134,539	0	0%	Wet season biostimulation target = 8 Anti-degradation requirements apply – maintain existing Water quality
San Benito at Y Rd 305SAN	38.60	1.46	110,960	760,040	0	0%	MUN standard = 10 Anti-degradation requirements apply – maintain existing Water quality
San Juan Creek at Anzar 305SJN	1.06	29.13	60,809	16,681	44,128	73%	Wet season biostimulation target = 8
Tequisquita Slough at Shore Rd 305TES	4.23	5.57	46,392	66,613	0	0%	Wet season biostimulation target = 8 Anti-degradation requirements apply – maintain existing Water quality
Tres Pinos Creek at Southside Rd. (305TRE)	18.2	0.42	15,038	358,357	0	0%	MUN standard = 10 Anti-degradation requirements apply – maintain existing Water quality
Watsonville Slough upstream Harkins Slough 305WSA	4.46	10.77	94,572	70,263	24,309	26%	Wet season biostimulation Target, total nitrogen as N = 8

[A] See TMDL report Section 3.4 – Hydrology for source information on flow estimates.

[B] Percent reduction goals are for informational purposes only, and should not be viewed as the TMDL

A tabulation and illustration of the spatial extent of estimate dry season (May 1 to Oct. 31) nitrate as N loading are presented in Table 8-2 (including percent reduction from the existing load to meet the loading capacity of the waterbody).

Table 8-2. Tabulation of estimated mean dry season (May 1 – Oct. 31) existing nitrate loads, dry season loading capcity, and percent reductions.

Stream Reach and associated Monitoring Site	Estimated Mean Dry Season Flow (cfs) [A]	Mean Dry Season Conc. (mg/L)	Mean Dry Season Existing Load (lbs.)	Mean Dry Season Loading Capacity (lbs.)	Estimated Load Reduction Necessary (lbs.)	Percent Reduction Goal [B]	Nitrate as N Biostimulation Numeric Target Used for Calculating the Loading Capacity (mg/L) and Reduction Goal
Carnadero Creek at private property access (305CAR)	1.79	13.59	23,949	3,176	20,773	97%	dry season nitrate as N biostimulation water quality target = 1.8
Carnadero Creek at Highway 25 (site 305CAN)	6.51	14.17	90,817	11,534	79,283	87%	dry season nitrate as N biostimulation water quality target = 1.8
Corralitos Creek at Brown Valley Road (CO-BVR)	6.81	0.13	876	12,063	0	0%	dry season nitrate as N biostimulation water quality target = 1.8
Furlong Creek at Fraiser Lake Rd (305FUF)	1.1	32.67	35,387	1,953	33,434	94%	dry season nitrate as N biostimulation water quality target = 1.8
Llagas Creek at Bloomfield Avenue (305LLA)	2.2	13.01	28,178	3,906	24,272	86%	dry season nitrate as N biostimulation water quality target = 1.8
Llagas Creek at Southside (305LUC)	5.08	17.27	86,377	8,997	77,380	90%	dry season nitrate as N biostimulation water quality target = 1.8
Llagas Creek at Monterey (305MON)	14.09	0.2	2,774	24,966	0	0%	dry season nitrate as N biostimulation water quality target = 1.8
Millers Canal at Frazier Lake Rd (305FRA)	6.72	1.5	9,928	7,282	2,646	27%	dry season total nitrogen as N biostimulation water quality target = 1.1
Pacheco Creek at San Felipe Road (305PAC)	5.83	–	–	Not applicable	0	0%	Biostimulation water quality targets do not apply. Anti-degradation requirements apply – maintain existing water quality.
Pajaro River at Porter (305PJP)	22.83	7,58	170,364	87,655	82,709	49%	dry season nitrate as N biostimulation water quality target = 3.9
Pajaro River at Chittenden Gap (305CHI)	24.2	9.90	235,863	92,911	142,952	61%	dry season nitrate as N biostimulation water quality target = 3.9
Pajaro River at Betabel Rd (305PAJ)	28.45	9.98	377,775	147,624	230,151	61%	dry season nitrate as N biostimulation water quality target = 3.9

Stream Reach and associated Monitoring Site	Estimated Mean Dry Season Flow (cfs) [A]	Mean Dry Season Conc. (mg/L)	Mean Dry Season Existing Load (lbs.)	Mean Dry Season Loading Capacity (lbs.)	Estimated Load Reduction Necessary (lbs.)	Percent Reduction Goal [B]	Nitrate as N Biostimulation Numeric Target Used for Calculating the Loading Capacity (mg/L) and Reduction Goal
Salsipuedes Creek at Hwy 129 (305COR)	5.28	5.28	27,448	9,362	18,086	66%	dry season nitrate as N biostimulation water quality target = 1.8
San Benito at Y Rd (305SAN)	0.4	–	–	Not applicable	0	0%	Biostimulation water quality targets do not apply. Anti-degradation requirements apply – maintain existing water quality.
San Juan Creek at Anzar Rd (305SJN)	1.98	37.57	73,237	6,424	66,813	91%	dry season nitrate as N biostimulation water quality target = 3.3
Tequisquita Slough at Shore Rd (305TES)	0.73	6.72	4,836	1,588	3,248	67%	dry season nitrate as N biostimulation water quality target = 2.2
Tres Pinos Creek at Southside Rd. (305TRE)	2.93	–	–	Not applicable	0	0%	Biostimulation water quality targets do not apply. Anti-degradation requirements apply – maintain existing water quality.
Watsonville Slough upstrm of Harkins Slough (305WSA)	0.5	14.8	7,282	1.040	6,278	86%	dry season total nitrogen as N biostimulation water quality target = 2.1

[A] See TMDL report Section 3.4 – Hydrology for source information on flow estimates.

[B] Percent reduction goals are for informational purposes only, and should not be viewed as the TMDL

8.2 Linkage Analysis

The goal of the linkage analysis is to establish a link between pollutant loads and water quality. This, in turn, supports that the loading capacity specified in the TMDLs will result in attaining the numeric target. The linkage analysis therefore represents the critical quantitative link between the TMDL and attainment of the water quality standards.

The proposed TMDLs will result in the attainment of the biostimulatory substances water quality objective, the water quality objective for unionized ammonia, and the water quality objective for municipal and domestic water supply, and therefore the restoration of beneficial uses of waterbodies in the TMDL project area. This is because the numeric targets are set equal to the nutrient water quality objectives, expressed as concentrations of nutrients that will prevent aquatic plant nuisance in flowing waters. The numeric targets are used directly to calculate the loading capacity (TMDLs). Requiring the responsible parties for nitrogen compounds and orthophosphate loading to reduce nitrate discharges to the numeric water quality objectives and targets will establish a direct link between the TMDL target and sources.

If the Biostimulatory Substances water quality objectives change in the future, the numeric targets would be equal to the new water quality objectives, and a new loading capacity would be calculated to meet the new numeric targets.

8.3 TMDLs & Allocations

Practically speaking, a TMDL is basically a pollutant budget[184] (aka, the "loading capacity"[185] in Clean Water Act terminology) for a surface waterbody. The TMDL distributes, or "allocates" the waterbody's loading capacity among the various sources of that pollutant. Pollutant sources that can be characterized as point sources receive waste load allocations[186], nonpoint sources of pollution receive load allocations[187] . TMDLs also include a margin safety to account for uncertainty.

In these proposed TMDLs, owners and operators of irrigated lands, NPDES–permitted municipal stormwater entities, NPDES–permitted industrial and construction stormwater entities, NPDES–permitted wastewater treatment facilities, golf courses, natural sources, and owners/operators of livestock and domestic animals are assigned unionized ammonia, nitrate, and orthophosphate allocations equal to the water quality numeric targets outlined previously in this staff report.

The proposed TMDLs are concentration–based. This means the TMDLs are equal to the receiving water numeric water quality targets described in the numeric target section above. Unlike a mass load-based TMDL, the concentration-based allocations do not add up to the TMDL because concentrations of individual pollution sources are not additive. Therefore, since the TMDLs are concentration-based, the allocations are not additive. Concentration–based TMDLs are an appropriate expression of TMDLs and meet USEPA requirements for TMDL approval[188]. Concentration-based allocations are also the most appropriate linkage to the loading capacities of streams in the river basin because drinking water and aquatic habitat beneficial uses are supported on the basis of concentration-based thresholds. Therefore, each waste load allocation and load allocation for these TMDLs are equal to the concentration-based nitrate, orthophosphate, and unionized ammonia water quality objective and numeric receiving water targets. However, consistent with USEPA guidance, Central Coast Water Board staff also developed alternative mass load pollutant loading expressions. Mass-based, non-daily load expressions may provide a meaningful connection with on-the-ground implementation efforts where expressions other than receiving water concentrations may provide a basis for water quality-based management strategies.

These TMDLs propose final waste load allocations and load allocations that are to be attained by 25 years after the TMDL is approved by the Office of Administrative Law (OAL). To assess progress towards achieving the final allocations, Central Coast Water Board staff is proposing that some allocations be attained sooner than others. Nitrate allocations protective of the MUN beneficial use and unionized ammonia allocations preventing toxicity shall be attained in 10 years, wet-season nitrate and orthophosphate allocations protective of biostimulatory substances shall be attained in 15 years, and the more stringent dry-season nitrate and orthophosphate allocations protective of biostimulatory substances shall be attained in 30 years.

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[184] See: Water Research Foundation in collaboration with USEPA, 2010*. Drinking Water Source Protection Through Effective Use of TMDL Process.*

[185] Loading capacity – the greatest amount of a pollutant that a water can assimilate and still meet water quality standards.

[186] The portion of a receiving water's loading capacity that is allocated to NPDES-permitted point sources of pollution.

[187] The portion of the receiving water's loading capacity attributed to (1) nonpoint sources of pollution and (2) natural background sources.

[188] According to USEPA guidance, states should report TMDLs on a *daily* time step basis (e.g.,, allowable pounds of pollutant per *day*). Concentration-based TMDLs may be appropriate where there is only limited amounts of daily flow data, which thus limits the ability to calculate a reliable daily time-step allowable pollutant load in stream reaches. There could also be a high degree of error associated with trying to estimate daily flows from limited amounts of instantaneous flow measurements. According to USEPA, the potential for error in flow estimates is particularly pronounced in arid areas, in areas with few USGS stream gages, and in areas where flows are highly modified by human activities (e.g., impoundments, regulated flows, and irrigation return flows). Therefore, according to USEPA TMDLs based on instantaneous concentration-based loads can satisfy the federal guidance to incorporate a daily time-step pollutant load.

8.3.1 Summary of TMDLs

The following TMDLs will result in attainment of water quality standards and are expected to rectify the identified nutrient and nutrient-related impairments. The TMDLs are considered achieved when water quality conditions meet all regulatory and policy requirements necessary for removing the impaired waters from the Clean Water Act section 303(d) list of impaired waters.

The un-ionized ammonia TMDL for all streams of the Pajaro River basin is:

- Un-ionized ammonia concentration shall not exceed 0.025 mg/L-N in receiving waters.

The nitrate TMDL for all streams of the Pajaro River basin required to support MUN beneficial uses is:

- Nitrate concentration shall not exceed 10 mg/L-N in receiving waters.

The nitrate and orthophosphate TMDLs for all reaches of the Pajaro River, including the Pajaro River Estuary are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 3.9 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.14 mg/L in receiving waters, and
- For wet season (November 1 to April 30): Nitrate-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

The nitrate and orthophosphate TMDLs for Corralitos Creek (all reaches) and Salsipuedes Creek (all reaches) are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 1.8 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.14 mg/L in receiving waters, and
- For wet season (November 1 to April 30): Nitrate-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

The nitrate and orthophosphate TMDLs for Beach Road Ditch and McGowan Ditch are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 3.3 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.14 mg/L in receiving waters, and
- For wet season (November 1 to April 30): Nitrate-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

The nitrate and orthophosphate TMDLs for all reaches of Llagas Creek (downstream of Chesebro Reservoir), Carnadero Creek, Uvas Creek, and Furlong Creek are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 1.8 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.05 mg/L in receiving waters, and
- For wet season (November 1 to April 30): Nitrate-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

The nitrate and orthophosphate TMDLs for all reaches of the San Juan Creek and West Branch of San Juan Creek are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 3.3 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.12 mg/L in receiving waters, and
- For wet season (November 1 to April 30): Nitrate-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

The nitrate and orthophosphate TMDLs for Tequisquita Slough are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 2.2 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.12 mg/L in receiving waters, and
- For wet season (November 1 to April 30): Nitrate-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

The total nitrogen and orthophosphate TMDLs for all reaches of Watsonville Slough, Harkins Slough, Gallighan Slough, and Struve Slough are:

- For dry season (May 1 to October 31): total Nitrogen-N concentration shall not exceed 2.1 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.14 mg/L in receiving waters, and
- For wet season (November 1 to April 30): total Nitrogen-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

The total nitrogen and orthophosphate TMDLs for all reaches of Millers Canal are:

- For dry season (May 1 to October 31): total Nitrogen-N concentration shall not exceed 1.1 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.04 mg/L in receiving waters, and
- For wet season (November 1 to April 30): total Nitrogen-N concentration shall not exceed 8.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving waters.

8.3.2 Summary of Allocations

As noted previously, a TMDL is basically a pollutant budget for a surface waterbody. The TMDL distributes, or “allocates” the waterbody’s loading capacity among the various sources of that pollutant. Pollutant sources that can be characterized as point sources receive waste load allocations[189], nonpoint sources of pollution receive load allocations.[190] Table 8-3 presents a summary tabulation of the final waste load allocations (WLAs) and load allocations (LAs) for pollutant source categories associated with relevant stream reaches.

Recognizing that achievement of the more stringent dry season biostimulatory target allocation embedded in Table 8-3 may locally require a significant amount of time to achieve, Table 8-4 therefore presents interim allocations. Interim allocations may be used as benchmarks is assessing TMDL implementation progress and gauging ultimate achievement of the final allocations.

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[189] The portion of a receiving water's loading capacity that is allocated to NPDES-permitted point sources of pollution.

[190] The portion of the receiving water's loading capacity attributed to (1) nonpoint sources of pollution and (2) natural background sources.

Table 8-3. Final waste load allocations and final load allocations (receiving water allocations). Waste load allocations are applicable to NPDES-permitted sources, whereas load allocations are applicable to nonpoint sources of pollution.

FINAL WASTE LOAD ALLOCATIONS[A,B] FOR RECEIVING WATERS

(NPDES-permitted discharges shall attain the following wasted load allocations in receiving surface waters. Attainment of waste load allocations may be assessed using a variety of methodologies as outlined in report Section 9.4.3)

Waterbody[C]	**Party Responsible for Allocation & NPDES/WDR number**	**Receiving Water Nitrate as N WLA (mg/L)** ***Aquatic Habitat***	**Receiving Water Nitrate as N WLA (mg/L)** ***Human Health***	**Receiving Water Orthophosphate as P WLA (mg/L)**	**Receiving Water Total Nitrogen as N WLA (mg/L)**	**Receiving Water Un-ionized ammonia as WLA (mg/L)**
Pajaro River	City of Watsonville (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CAS000004 County of Santa Cruz (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004 City of Watsonville Wastewater Treatment Facility (Wastewater discharges to surface waterbody) NPDES No. CA0048216 South County Regional Wastewater Authority (Wastewater discharges to surface waterbody) NPDES No. CA0049964	3.9 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.14 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round

FINAL WASTE LOAD ALLOCATIONS[A,B] FOR RECEIVING WATERS

(NPDES-permitted discharges shall attain the following wasted load allocations in receiving surface waters. Attainment of waste load allocations may be assessed using a variety of methodologies as outlined in report Section 9.4.3)

Waterbody[C]	**Party Responsible for Allocation & NPDES/WDR number**	**Receiving Water Nitrate as N WLA (mg/L)** ***Aquatic Habitat***	**Receiving Water Nitrate as N WLA (mg/L)** ***Human Health***	**Receiving Water Orthophosphate as P WLA (mg/L)**	**Receiving Water Total Nitrogen as N WLA (mg/L)**	**Receiving Water Un-ionized ammonia as WLA (mg/L)**
All reaches of: Watsonville Slough, Harkins Slough, Gallighan Slough, Struve Slough	City of Watsonville (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CAS000004 County of Santa Cruz (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	Not Applicable	10 Year-round	0.14 Dry season[D] 0.3 Wet season[E]	2.1 Dry season[D] 8.0 Wet season[E]	0.025 Year-round
Corralitos Creek, Salsipuedes Creek	City of Watsonville (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CAS000004 County of Santa Cruz (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	1.8 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.14 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
San Juan Creek, all reaches	San Juan Bautista WWTP (Wastewater discharges to surface waterbody) NPDES No. CA0047902	3.3 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.12 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round

FINAL WASTE LOAD ALLOCATIONS[A,B] FOR RECEIVING WATERS

(NPDES-permitted discharges shall attain the following wasted load allocations in receiving surface waters. Attainment of waste load allocations may be assessed using a variety of methodologies as outlined in report Section 9.4.3)

Waterbody[C]	Party Responsible for Allocation & NPDES/WDR number	Receiving Water Nitrate as N WLA (mg/L) *Aquatic Habitat*	Receiving Water Nitrate as N WLA (mg/L) *Human Health*	Receiving Water Orthophosphate as P WLA (mg/L)	Receiving Water Total Nitrogen as N WLA (mg/L)	Receiving Water Un-ionized ammonia as WLA (mg/L)
Llagas Creek, Little Llagas Creek	City of Gilroy City of Morgan Hill Urbanized areas (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004 County of Santa Clara (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	1.8 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.05 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
Uvas Creek, Carnadero Creek	City of Gilroy City of Morgan Hill (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	1.8 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.05 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
San Benito River	City of Hollister (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	Not Applicable	10 Year-round	Not Applicable	Not Applicable	0.025 Year-round
Any identified impaired waterbody that receives discharges from NPDES-permitted industrial or construction activities within the Pajaro River basin	Industrial stormwater general permit (storm drain discharges from industrial facilities) NPDES No. CAS000001 Construction stormwater general permit (storm drain discharges from construction operations) NPDES No. CAS000002	See specific waterbody for specific WLAs	See specific waterbody for specific WLAs	See specific waterbody for specific WLAs	See specific waterbody for specific WLAs	0.025 Year-round

FINAL LOAD ALLOCATIONS [A,B] FOR RECEIVING WATERS

(Nonpoint source discharges shall attain the following load allocations in receiving surface waters. Attainment of load allocations may be assessed using a variety of methodologies as outlined in report Section 9.3.3)

Waterbody[C]	**Party Responsible for Allocation (Source)**	**Receiving Water Nitrate as N LA (mg/L)** ***Aquatic Habitat***	**Receiving Water Nitrate as N LA (mg/L)** ***Human Health***	**Receiving Water Orthophosphate as P LA (mg/L)**	**Receiving Water Total Nitrogen as N LA (mg/L)**	**Receiving Water Un-ionized ammonia as N LA (mg/L)**
Pajaro River, all reaches, including the Pajaro River Estuary	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	3.9 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.14 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
Corralitos Creek, all reaches Salsipuedes Creek, all reaches	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	1.8 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.14 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
Beach Road Ditch McGowan Ditch	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	3.3 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.14 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					

FINAL LOAD ALLOCATIONS [A,B] FOR RECEIVING WATERS

(Nonpoint source discharges shall attain the following load allocations in receiving surface waters. Attainment of load allocations may be assessed using a variety of methodologies as outlined in report Section 9.3.3)

Waterbody[C]	**Party Responsible for Allocation (Source)**	**Receiving Water Nitrate as N LA (mg/L)** ***Aquatic Habitat***	**Receiving Water Nitrate as N LA (mg/L)** ***Human Health***	**Receiving Water Orthophosphate as P LA (mg/L)**	**Receiving Water Total Nitrogen as N LA (mg/L)**	**Receiving Water Un-ionized ammonia as N LA (mg/L)**
Llagas Creek, all reaches downstream of Chesebro Reservoir, Carnadero Creek, all reaches, Furlong Creek, all reaches	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	1.8 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.05 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
San Juan Creek, all reaches, West Branch San Juan Creek, all reaches	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	3.3 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.12 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
Tequisquita Slough	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	2.2 Dry season[D] 8.0 Wet season[E]	10 Year-round	0.12 Dry season[D] 0.3 Wet season[E]	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
San Benito River	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Not Applicable	10 Year-round	Not Applicable	Not Applicable	0.025 Year-round

FINAL LOAD ALLOCATIONS ^{A,B} FOR RECEIVING WATERS

(Nonpoint source discharges shall attain the following load allocations in receiving surface waters. Attainment of load allocations may be assessed using a variety of methodologies as outlined in report Section 9.3.3)

Waterbody^{C}	**Party Responsible for Allocation (Source)**	**Receiving Water Nitrate as N LA (mg/L)** ***Aquatic Habitat***	**Receiving Water Nitrate as N LA (mg/L)** ***Human Health***	**Receiving Water Orthophosphate as P LA (mg/L)**	**Receiving Water Total Nitrogen as N LA (mg/L)**	**Receiving Water Un-ionized ammonia as N LA (mg/L)**
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
Tres Pinos Creek	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Not Applicable	10 Year-round	Not Applicable	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
Pacheco Creek	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Not Applicable	10 Year-round	Not Applicable	Not Applicable	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					
	No responsible party (Natural sources)					
All reaches of: Watsonville Slough, Harkins Slough, Galligan Slough, Struve Slough	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Not Applicable	10 Year-round	0.14 Dry season^{D} 0.3 Wet season^{E}	2.1 Dry season^{D} 8.0 Wet season^{E}	0.025 Year-round
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)					

<table>
<tr><th colspan="7">FINAL LOAD ALLOCATIONS [A,B] FOR RECEIVING WATERS
(Nonpoint source discharges shall attain the following load allocations in receiving surface waters. Attainment of load allocations may be assessed using a variety of methodologies as outlined in report Section 9.3.3)</th></tr>
<tr><th>Waterbody[C]</th><th>Party Responsible for Allocation (Source)</th><th>Receiving Water Nitrate as N LA (mg/L) <i>Aquatic Habitat</i></th><th>Receiving Water Nitrate as N LA (mg/L) <i>Human Health</i></th><th>Receiving Water Orthophosphate as P LA (mg/L)</th><th>Receiving Water Total Nitrogen as N LA (mg/L)</th><th>Receiving Water Un-ionized ammonia as N LA (mg/L)</th></tr>
<tr><td></td><td>No responsible party (Natural sources)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Millers Canal</td><td>Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)</td><td rowspan="3">Not Applicable</td><td rowspan="3">10 Year-round</td><td rowspan="3">0.04 Dry season[D]
0.3 Wet season[E]</td><td rowspan="3">1.1 Dry season[D]
8.0 Wet season[E]</td><td rowspan="3">0.025 Year-round</td></tr>
<tr><td>Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)</td></tr>
<tr><td>No responsible party (Natural sources)</td></tr>
<tr><td>Any identified impaired waterbody that could receive nutrient discharges from fertilizer applications on golf courses within the Pajaro River basin</td><td>Owners/Operators of Public and Private golf courses in the Pajaro River basin (golf course fertilizer applications)</td><td>See specific waterbody for specific LAs</td><td>See specific waterbody for specific LAs</td><td>See specific waterbody for specific LAs</td><td>See specific waterbody for specific LAs</td><td>0.025 Year-round</td></tr>
</table>

[A] Federal and state anti-degradation requirements apply to all waste load and load allocations.

[B] Achievement of final waste load and load allocations to be determined on the basis of the number of measured exceedances and/or other criteria set forth in Section 4 of the *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List* (the "Listing Policy" – State Water Resources Control Board, Resolution No. 2004-0063, adopted September 2004) or as consistent with any relevant revisions of the Listing Policy promulgated in the future pursuant to Government Code section 11353.

[C] Waterbody name includes all reaches of named waterbody and waterbodies that are tributary to named waterbody.

[D] Dry season is May 1st – October 31st.

Table 8-4. Proposed interim waste load allocations and interim load allocations.

INTERIM WASTE LOAD ALLOCATIONS (WLAs)			
Waterbody	**Party Responsible for Achieving Waste Load Allocation (Source)**	**First Interim WLA**	**Second Interim WLA**
All waterbodies given waste load allocations (WLAs) as identified in Final Waste Load Allocations in Table 8-3	City of Gilroy City of Morgan Hill Urbanized areas (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004 City of Watsonville (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CAS000004 County of Santa Cruz (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004 County of Santa Clara (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004 San Juan Bautista WWTP (Wastewater discharges to surface waterbody) NPDES No. CA0047902 South County Regional Wastewater Authority (Wastewater discharges to surface waterbody) NPDES No. CA0049964	Achieve MUN standard-based and Un-ionized ammonia objective-based allocations: 10 years after effective date of the TMDLs	Achieve Wet Season (Nov. 1 to Apr. 30) Biostimulatory target-based TMDL allocations: Wet Season Allocation/Waterbody combinations as identified in Final Waste Load Allocations in Table 8-3 15 years after effective date of the TMDLs
Any identified impaired waterbody that receives discharges from NPDES-permitted industrial or construction activities within the Pajaro River basin	Entities required to comply with industrial stormwater general permit NPDES No. CAS000001 (storm drain discharges from industrial facilities) and Entities required to comply with Construction stormwater general permit NPDES No. CAS000002 (storm drain discharges from construction operations)	Prevent any further surface water quality degradation and maintain existing surface water quality by continuing or beginning to self-monitor and implement BMPs for manure management or turf management . These sources are currently expected to be achieving interim and final waste load allocations (see report Section 9.5).	Prevent any further surface water quality degradation and maintain existing surface water quality by continuing or beginning to self-monitor and implement BMPs for manure management or turf management . These sources are currently expected to be achieving interim and final waste load allocations (see report Section 9.5).

INTERIM LOAD ALLOCATIONS (LAs)			
Waterbody	**Party Responsible for Achieving Load Allocation (Source)**	**First Interim LA**	**Second Interim LA**
All waterbodies given load allocations (LAs) as identified in Final Load Allocations in Table 8-3	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Achieve MUN standard-based and Un-ionized ammonia objective-based allocations: 10 years after effective date of the TMDLs	Achieve Wet Season (Nov. 1 to Apr. 30) Biostimulatory target-based TMDL allocations: Wet Season Allocation/Waterbody combinations as identified in Final Load Allocations Table 8-3 15 years after effective date of the TMDLs
All waterbodies given load allocations (LAs) as identified in Final Load Allocations Table in Table 8-3	Owners/operators of land used for/containing domestic animals/livestock Owners/operators of public & private golf courses	Prevent any further surface water quality degradation and maintain existing surface water quality by continuing or beginning to self-monitor and implement BMPs for manure management or turf management . These sources are currently expected to be achieving interim and final allocations (see report Section 9.7 and Section 9.8).	Prevent any further surface water quality degradation and maintain existing surface water quality by continuing or beginning to self-monitor and implement BMPs for manure management or turf management These sources are Currently expected to be achieving interim and final allocations (see report Section 9.7 and Section 9.8).

8.3.3 Antidegradation Requirements

It is important to emphasize that state water quality standards, and thus the receiving water-based allocations identified in Table 8-3 are subject to antidegradation requirements. Recall that beneficial uses of waterbodies, water quality objectives, and antidegradation policies collectively constitute water quality standards. For a discussion of antidegradation policies, refer to Section 9.2.3. State and federal antidegradation policies require, in part, that where surface waters are of higher quality than necessary to protect beneficial uses, the high quality of those waters must be maintained unless otherwise provided by the policies. Therefore, antidegradation requirements are a component of every water quality standard. Accordingly, antidegradation requirements apply to the nutrient water quality criteria, and hence to the proposed waste load and load allocations, and can be characterized as follows:

> Wherever the existing quality of water in a stream reach or waterbody is better than necessary***** to support the designated beneficial uses, that water quality shall be maintained and protected, unless and until warranted pursuant to provisions in federal and state antidegradation policies *(See Section II.A, Anti-degradation Policy in the Central Coast Basin Plan)*
>
> ***** *i.e., better-lower than the numeric water quality objective/criteria/allocation*

Practically speaking, this means that, for example, stream reaches or waterbodies that have a concentration-based TMDL allocation of 10 mg/L nitrate as N, and if current or future identified water quality in the stream reach is in fact *well under* 10 mg/L nitrate as N, the allocation does not give license for controllable nitrogen sources to degrade the water resources all the way up to the maximum allocation = 10 mg/L nitrate as N. This is because antidegradation requirements are a part of every water quality standard.

Non-compliance with antidegradation requirements may be determined on the basis of trends in declining water quality consistent with the methodologies provided in Section 3.10 of the California 303(d) Listing Policy (State Water Board, 2004).

8.3.1 Alternative Pollutant Load Expressions to Facilitate Implementation

Central Coast Water Board staff developed alternative pollutant load expressions to facilitate implementation of the concentration-based allocations. Daily allocations, as expressed in this TMDL, are on the basis of daily time-step concentrations (e.g., instantaneous water quality concentrations represented in grab and field samples). Relevant guidance published by the U.S. Environmental Protection Agency pertaining to alternative load expressions is presented below:

> Facilitating Implementation of Waste Load Allocations and Load Allocations:
>
> *"**TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards*.** To facilitate implementation of such a load in water bodies where the applicable water quality standard is expressed in non-daily terms, it may be appropriate for the TMDL documentation to include, in addition to wasteload allocations expressed in daily time increments, wasteload allocations expressed as weekly, monthly, seasonal, annual, or other appropriate time increments. The TMDL and its supporting documentation should clearly explain that the non-daily loads and allocations are implementation-related assumptions of the daily wasteload allocations and are included to facilitate implementation of the daily allocations as appropriate in NPDES permits and nonpoint source directed management measures."*
>
> From: U.S. Environmental Protection Agency, Memorandum, Nov. 15, 2006. Subject: Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, and Implications, for NPDES Permits
>
> ***** emphasis added by Central Coast Water Board staff

In addition, non-daily and alternative load expressions of the concentration-based allocations may be needed to provide a meaningful connection with implementation efforts (such as nonpoint source best management practices) where averaging periods other than daily time steps, or expressions other than receiving water concentration allocations provide the basis for water quality-based control strategies. However, in accordance with USEPA guidance, all final TMDL submissions must contain a daily time-step load component; this requirement is satisfied by the proposed concentration-based TMDLs and allocations (refer to Section 8.3).

Alternative non-daily mass based load expressions and estimated load reductions to facilitate implementation of the TMDLs and allocations are presented in Appendix D. These alternative load expressions shall be considered implementation-related assumptions of the daily time-step concentration-based allocations.

It is important to recognize that there is uncertainty associated with these mass load expressions, as they are in many cases based on limited amounts of instantaneous flow data, or NHDplus modeled flow data and as such reflect coarser temporal load representations (annual and seasonal loads). In the absence of reliable continuous, or daily flow data (i.e., U.S. Geological Survey gages or hydrologic modeling), there could be a high degree of error associated with estimated daily flows from limited amounts of instantaneous flows[191]. According to USEPA, the potential for error is particularly pronounced in arid areas, areas with few U.S. Geological Survey gages, and areas where flows are highly modified by human activities (e.g., impoundments, regulated flows, irrigation return flows)[192]. Therefore, as noted previously, this TMDL and associated load allocation are based on instantaneous concentration-based

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[191] U.S., 2007. Options for Expression Daily Loads in TMDLs. June 22, 2007.

[192] *Ibid.*

loads – this satisfies the USEPA guidance to incorporate a daily time-step load. Also, concentration is generally a more direct linkage to the protection of aquatic habitat, than annual or seasonal mass loads.

8.4 Margin of Safety

The Clean Water Act and federal regulations require that TMDLs provide a margin of safety to account for uncertainty concerning the relationship between pollution controls and water quality responses (see 40 CFR 130.7(c)(1)). These proposed TMDLs provide both implicit and explicit margins of safety to account for several types of uncertainty in the analysis. This section discusses analytical factors that are uncertain and describes how the TMDL provides the requisite margin of safety.

Relationship between algae growth and nutrient loading. Although there is strong evidence of excessive algal growth in summer and some evidence of excessive algal growth in winter, the degree of algae-related impairment in winter and the degree to which nitrogen, phosphorus, or both are limiting factors in algae production throughout the year are uncertain.

The dry season TMDLs and allocations account for this uncertainty by setting conservative numeric target values for nitrate and orthophosphate. Staff review of the available data suggests that there is a closer relationship between nutrient levels and algae production in summer than was observed in the winter. Attainment of these conservative summer target values should ensure that nitrogen and phosphorus are not critical limiting factors in algae production and should result in reductions in algae growth.

The wet season numeric targets, associated TMDLs and allocation are less stringent than the dry season targets and allocations because available data and research studies do not clearly demonstrate that wet season nutrient levels are likely to cause excessive algae growth. The wet season targets and allocations are designed to ensure implementation of the Basin Plan numeric objective for nitrate while acknowledging uncertainty concerning winter algae problems and associated attainment of the narrative objective for biostimulatory effects. The TMDLs account for this winter period uncertainty by incorporating a 20% margin of safety (setting the nitrate numeric target at 8 mg/l instead of 10 mg/l, which is the applicable numeric objective).

Nutrient loading during the wet season period, stream flows, and nutrient loading capacity vary more during the winter period than the summer period because most precipitation related changes in runoff, loads, and flows occurs during the winter period. Wet season period loads and flows change quickly in response to unpredictable precipitation events. High velocity stream flows are likely to scour filamentous algae and carry it out of the watershed; these high flows also flush nutrient compounds through the watershed and into the ocean. Staff has accounted for the uncertainty associated with winter season variability in loads, flows, and loading capacity by setting the winter season TMDLs and allocations on a concentration basis instead of a mass-loading basis.

Staff has outlined a monitoring and assessment plan (see Section 9) to evaluate the effectiveness of implemented management practices and source load reductions. Existing monitoring programs in conjunction with proposed monitoring requirements in these TMDLs can be used synergistically to provide for long-term water quality monitoring and improve our understanding of the relationship between nutrient levels in the watershed and algal growth. Based on results from these data and studies, staff will review and, if necessary, revise the TMDLs, allocations, and/or implementation provisions.

Additional studies of loadings from nonpoint source categories would be warranted in the future to better characterize loadings during wet weather periods from polluted runoff as well as loads associated with septic system operation.

8.5 Critical Conditions & Seasonal Variation

Critical conditions refer to a combination of environmental factors (e.g., flow, temperature, etc.) during which the waterbody is most vulnerable and has the lowest pollutant assimilative capacity. The condition is considered critical because any unknown factor regarding environmental conditions or the calculation of the load allocation could result in not achieving the water quality standard. Therefore, critical conditions are particularly important with load-based allocations and TMDLs. However, this TMDL is a concentration-based TMDL. As such, the numeric targets and allocations are the concentrations equal to the water quality objectives. While critical conditions shall be considered even in concentration-based TMDLs, once the concentration-based allocations are met over all flow conditions, seasonal conditions, or other critical conditions, then there exists no uncertainty as to whether the allocations and TMDLs will result in achieving water quality objectives.

Staff determined there are patterns of seasonal and flow-based variation based on review of the monitoring data. While exceedances were found at monitoring sites year round, temporal and seasonal analysis suggests that many Pajaro River basin streams are subject to higher nitrate and chlorophyll a concentrations during the dry season months (May 1 to Oct. 31) and during low flow conditions – refer back to Section 5.6 and Section 0. Seasonal or flow-based variability is accounted for and addressed by use of the allocations equal to the water quality objectives and concentration-based allocations which assures the loading capacity of the water body be met under all flow and seasonal conditions.

9 IMPLEMENTATION STRATEGY: RECOMMENDED ACTIONS TO CORRECT THE 303(d)-LISTED IMPAIRMENTS

9.1 Introduction

The purpose of the proposed TMDL Implementation Plan is to describe the steps necessary to reduce nutrient loads and to achieve these TMDLs. The TMDL Implementation Plan provides a series of actions and schedules for implementing parties to implement management practices to comply with the TMDL. The TMDL Implementation Plan is designed to provide implementing parties flexibility to implement appropriate management practices and strategies to address nitrate, unionized ammonia and biostimulatory impairments. Implementation consists of 1) identification of parties responsible for taking these actions; 2) development of management/monitoring plans to reduce controllable sources of nitrogen compounds and orthophosphate in surface waters; 3) mechanisms by which the Central Coast Water Board will assure these actions are taken; 4) reporting and evaluation requirements that will indicate progress toward completing the actions; 5) and a timeline for completion of implementation actions.

9.2 Legal & Regulatory Framework

This section presents information on the legal authority and regulatory framework which provides the basis for assigning specific responsibilities and accountability to implementing parties for implementation and monitoring actions. The laws and policies pertaining to point sources and nonpoint sources are identified. The legal authority and regulatory framework are described in terms of the following:

- Controllable Water Quality Conditions
- Manner of Compliance
- Anti-degradation Policies
- Point Source Discharges (NPDES-permitted discharges)
- Nonpoint Source Discharges

9.2.1 Controllable Water Quality Conditions

In accordance with the Water Quality Control Plan for the Central Coast Basin (Basin Plan) Controllable water quality shall be managed to conform or to achieve the water quality objectives and load allocations contained in this TMDL. The Basin Plan defines controllable water quality conditions as follows:

> *"Controllable water quality conditions are those actions or circumstances resulting from man's activities that may influence the quality of the waters of the State and that may be reasonably controlled."*
>
> Source: Water Quality Control Plan for the Central Coast Basin, Chapter 3. Water Quality Objectives, page III-2.

Examples of non-controllable water quality conditions may include atmospheric deposition of nitrogen and phosphorus, and non-controllable natural sources of nutrient compounds.

9.2.2 Manner of Compliance

In accordance with Section 13360 of the Porter-Cologne Water Quality Control Act (California Water Code, Division 7) the Water Board cannot specify or mandate the specific type, manner, or design of on-site actions necessary to reduce nutrient loading, or to meet allocations by the various responsible parties. Specific types of potential management practices identified in this TMDL Report constitute examples or suggestions of management practices known to mitigate or reduce nutrient loading to waterbodies. Stakeholders, local public entities, property owners, and/or resource professionals are in the best position to identify appropriate management measures, where needed, to reduce nutrient loading based on site-specific conditions, with the Water Board providing an oversight role in accordance with adopted permits, waivers, or prohibitions.

9.2.3 Anti-degradation Policies

State and federal anti-degradation policies require, in part, that where surface waters are of higher quality than necessary to protect designated beneficial uses, the high quality of those waters must be maintained unless otherwise provided by the policies. The beneficial uses of waterbodies, water quality objectives, and anti-degradation policies collectively constitute water quality standards. Therefore, anti-degradation requirements are a component of every water quality standard. High quality waters are determined on a "pollutant-by-pollutant"/"parameter-by-parameter" basis, by determining whether water quality is better than the criterion for each parameter using chemical or biological data[193].

Both the U.S. Environmental Protection Agency (40 CFR 131.12) and the State of California (State Board Resolution 68-16) have adopted anti-degradation policies as part of their approach to regulating water quality. Both state and federal anti-degradation policies apply to point source and nonpoint source discharges that could lower water quality (refer to footnote 193). Although there are some differences, where the federal and state policies overlap they are consistent with each other. Further, state anti-degradation policy incorporates the federal policy where applicable. The Central Coast Water Board must ensure that its actions do not violate the federal or State antidegradation policies. These policies acknowledge that minor, or repeated activities, even if individually small, can result in violation of anti-degradation policies through cumulative effects.

➢ Federal Anti-degradation Policy

The federal antidegradation policy, 40 CFR 131.12(a), states in part:

> (1) Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.

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[193] See: State Water Resources Control Board (2008), *Water Quality Standards Academy, Basic Course, Module 14*. Presented by U.S. Environmental Protection Agency, Region 9 – Office of Science and Technology (May 12, 2008).

> (2) …Where the quality of waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located…
>
> (3) Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.

➢ *State Anti-degradation Policy*

Antidegradation provisions of State Water Board Resolution No. 68-16 ("Statement of Policy With Respect to Maintaining High Quality Waters in California") state, in part:

> (1) Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.

Also noteworthy, Section II.A. of the Central Coast Basin Plan explicitly references anti-degradation requirements, and states:

> II.A. Anti-degradation Policy
>
> "Wherever the existing quality of water is **better than the quality of water established herein as objectives**, **such existing quality shall be maintained*** unless otherwise provided by the provisions of the State Water Resources Control Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California," including any revisions thereto."
>
> ***** *emphasis added*

Accordingly, anti-degradation policies apply to the proposed concentration-based waste load and load allocations proposed in these TMDLs, and can be summarized as follows in Text Box 9-1.

Text Box 9-1. Anti-degradation expectations for the TMDLs proposed in this report.

> **Summary of TMDL Anti-degradation Expectations**
>
> Where the quality of water in a stream reach or waterbody is better than necessary (i.e., lower/better than the water quality objective/criteria/allocation) to support the designated beneficial uses, that existing water quality shall be maintained and protected, unless and until a lowering of water quality is warranted pursuant to provisions in federal and state anti-degradation policies

During TMDL implementation, compliance with anti-degradation requirements may be determined on the basis of trends in declining water quality in applicable waterbodies, consistent with the methodologies and criteria provided in Section 3.10 of the California 303(d) Listing Policy (adopted, Sept. 20, 2004, State Water Board Resolution No. 2004-0063). Section 3.10 of the California 303(d) Listing Policy explicitly addresses the anti-degradation component of water quality standards as defined in 40 CFR 130.2(j), and provides for identifying trends of declining water quality as a metric for assessing compliance with anti-degradation requirements.

Section 3.10 of the California 303(d) Listing Policy states that pollutant-specific water quality objectives need not be exceeded to be considered non-compliance with anti-degradation requirements *"if the water* *segment exhibits concentrations of pollutants or water body conditions for any listing factor that shows a trend of declining water quality standards attainment"*[194] (State Water Board, 2004).

Practically speaking, this means that, for example, if a stream reach has a concentration-based TMDL allocation of 10 mg/L nitrate as N and current water quality data or future water quality assessments in the stream reach indicate nitrate as N concentrations are in fact well under 10 mg/L nitrate as N, the allocation does not give license for controllable nitrogen sources to degrade the water resource all the way up to the maximum allocation = 10 mg/L nitrate as N. Data demonstrating trends of declining water quality in these reaches may constitute non-compliance with anti-degradation requirements, where applicable.

9.2.4 Point Sources (NPDES-permitted entities)

The National Pollutant Discharge Elimination System (NPDES) permit is the mechanism for translating waste load allocations (WLAs) into enforceable requirements for point sources. Under Clean Water Act §402, discharges of pollutants to waters of the United States are authorized by obtaining and complying with the terms of an NPDES permit. USEPA policy explicitly specifies NPDES-regulated stormwater discharges are point source discharges and, therefore, must be addressed by the WLA component of a TMDL.[195] The Central Coast Water Board is the permitting authority for NPDES permits in California's central coast region.

USEPA regulations require that a TMDL include WLAs which identify the portion of the loading capacity allocated to existing and future point sources. Thus, the WLA is the maximum amount of a pollutant that may be contributed to a waterbody by point source discharges[196] of the pollutant in order to attain and maintain water quality objectives and restore beneficial uses. 40 CFR 122.44(d)(1)(vii)(B) requires effluent limits to be consistent with the WLAs in an approved TMDL. The State Water Board Office of Chief Counsel has indicated that permit conditions are not necessarily required to contain a literal incorporation of the TMDL's numeric allocations, and that the Regional Boards have discretion to implement the assumptions of a TMDL and its allocations through methodologies other than a direct, literal translation of the numeric WLA, as long as they are "consistent with the assumptions" of the TMDL[197].

According to the U.S. Environmental Protection Agency and the State Water Resources Control Board, all identified NPDES-permitted point sources identified in a TMDL must be given a waste load allocation, even if their current loading to receiving waters is zero[198, 199] otherwise their TMDL allocation is assumed to be zero and no discharges of the identified pollutant(s) would be allowed[200]. Also, a waste load allocation for identified NPDES sources is needed for potential permit renewal issues[201].

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[194] Section 3.10 of the California Impaired Waters 303(d) Listing Policy (adopted, Sept. 20, 2004, State Water Board Resolution No. 2004-0063)

[195] See 40CFR 130.2(g) & (h) and USEPA Office of Water Memorandum (Nov. 2002) *"Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs"*

[196] See 40 CFR 130.2(h). A wasteload allocation is the portion of the receiving water's loading capacity that is allocated to its point sources of pollution.

[197] State Water Resources Control Board, Office of Chief Counsel Memo dataed June 12, 2002. Subject: The Distinction Between a TMDL's Numeric Target and Water Quality Standards.

[198] Personal communication, February 18, 2015, Janet Parrish, Central Coast Regional Liason, U.S. Environmental Protection Agency, Region IX.

[199] Communication, August 2014, Phil Wyels, Assistant Chief Counsel, State Water Resources Control Board.

[200] Personal communication, February 25, 2015, Jamie Marincola, Water Division, U.S. Environmental Protection Agency, Region IX.

[201] Personal communication, February 26, 2015, Janet Parrish, Central Coast Regional Liason, U.S. Environmental Protection Agency, Region IX.

9.2.5 Nonpoint Sources

Nonpoint sources (NPS) refer to pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources are assigned the load allocation component of a TMDL. The load allocation is the portion of the receiving water's pollutant loading capacity attributed to (1) the existing or future nonpoint sources of pollution and (2) natural background sources. Control of nonpoint source pollution is controlled by state programs developed under state law. California's Porter-Cologne Water Quality Control Act applies to both point and nonpoint sources of pollution and serves as the principle legal authority in California for the application and enforcement of TMDL load allocations for nonpoint sources.

In July 2000 the State Water Resources Control Board and the California Coastal Commission developed the Plan for California's Nonpoint Source Pollution Control Program to reduce and prevent nonpoint source pollution in California, expanding the State's nonpoint source pollution control efforts. The NPS Program's long-term goal is to "improve water quality by implementing the management measures identified in the California Management Measures for Polluted Runoff Report (CAMMPR) by 2013. Under the California NPS Program Pollution Control Plan, TMDLs are considered one type of implementation planning tool that will enhance the State's ability to foster implementation of appropriate NPS management measures.

The Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program adopted in August 2004, explains how Water Board authorities granted by the Porter-Cologne Water Quality Control Act will be used to implement the California NPS Program Plan The Nonpoint Source Implementation and Enforcement Policy requires the Regional Water Boards to regulate all nonpoint sources (NPS) of pollution using the administrative permitting authorities provided by the Porter-Cologne Act. Nonpoint source dischargers must comply with Waste Discharge Requirements (WDRs), waivers of WDRs, or Basin Plan Prohibitions by participating in the development and implementation of Nonpoint Source Pollution Control Implementation Programs. NPS dischargers can comply either individually or collectively as participants in third-party coalitions. (The "third-party" Programs are restricted to entities that are not actual discharges under Regional Water Board permitting and enforcement jurisdiction. These may include Non-Governmental Organizations, citizen groups, industry groups, watershed coalitions, government agencies, or any mix of these.) All Programs must meet the requirements of the following five key elements described in the NPS Implementation and Enforcement Policy. Each Program must be endorsed or approved by the Regional Water Board or the Executive Officer (if the Water Board has delegated authority to the Executive Officer).

Key Element 1:	A Nonpoint Source Pollution Control Implementation Program's ultimate purpose must be explicitly stated and at a minimum address NPS pollution control in a manner that achieves and maintains water quality objectives.
Key Element 2:	The Program shall include a description of the management practices (MPs) and other program elements dischargers expect to implement, along with an evaluation program that ensures proper implementation and verification.
Key Element 3:	The Program shall include a time schedule and quantifiable milestones, should the Regional Water Board require these.
Key Element 4:	The Program shall include sufficient feedback mechanisms so that the Regional Water Board, dischargers, and the public can determine if the implementation program is achieving its stated purpose(s), or whether additional or different MPs or other actions are required (See Section 12, Monitoring Program).
Key Element 5:	Each Regional Water Board shall make clear, in advance, the potential consequences for failure to achieve a Program's objectives, emphasizing that it is the responsibility of

individual dischargers to take all necessary implementation actions to meet water quality requirements.

9.3 Implementation for Discharges from Irrigated Lands

Owners and operators of irrigated agricultural land must comply with the Conditional Waiver of Waste Discharge Requirements for Irrigated Lands (Order R3-2012-0011; the "Agricultural Order") and the Monitoring and Reporting Programs in accordance with Orders R3-2012-0011-01, R3-2012-0011-02, and R3-2012-0011-03, or their renewals or replacements, to meet load allocations and achieve the TMDLs. The requirements in these orders, and their renewals or replacements in the future, will implement the TMDLs and rectify the impairments addressed in the TMDLs.

Current requirements in the Agricultural Order that will achieve the load allocations include:

A. Implement, and update as necessary, management practices to reduce nutrient loading.
B. Maintain existing, naturally occurring riparian vegetative cover in aquatic habitat areas.
C. Develop/update and implement Farm Plans.
D. Properly destroy abandoned groundwater wells.
E. Develop and initiate implementation of an Irrigation and Nutrient Management Plan (INMP) or alternative certified by a Professional Soil Scientist, Professional Agronomist, or Crop Advisor certified by the American Society of Agronomy, or similarly qualified professional.

The current Agricultural Order provides the requirements necessary to implement this TMDL. Therefore, no new requirements are proposed as part of this TMDL.

Central Coast Water Board staff will conduct a review of implementation activities as monitoring and reporting data are submitted as required by the Agricultural Order, or when other monitoring data and/or reporting data are submitted outside the requirements of the Agricultural Order. Central Coast Water Board staff will pursue modification of Agricultural Order conditions, or other regulatory means, if necessary, to address remaining impairments resulting from nitrogen compounds or orthophosphate during the TMDL implementation phase.

9.3.1 Implementing Parties

Table 9-1 presents the implementing parties responsible for implementation load allocations for discharges of nutrients from irrigated lands.

Table 9-1. Implementing Parties for Discharges of nutrients from irrigated lands.

Source Category	Implementing Parties
Irrigated lands	Owners/operators of irrigated lands

9.3.2 Priority Areas & Priority Pollutant

The Agricultural Order should prioritize implementation and monitoring efforts in impaired subwatersheds, stream reaches, or areas where:

1) Water quality data and land use data indicate the largest magnitude of nutrient loading and/or impairments;
2) Reductions in nutrient loading, reductions in-stream nutrient concentrations, and/or implementation of improved nutrient management practices that will have the greatest benefit to aquatic habitat and/or human health in receiving waters and also with consideration to mitigation of downstream impacts;
3) Crops that are grown that require high fertilizer inputs;

4) Other information such as proximity to waterbody; soils/runoff potential; irrigation and drainage practices, or relevant information provided by stakeholders, resource professionals, and/or researchers indicate a higher risk of nutrient and/or biostimulatory impacts to receiving waters.

Based on information developed for this project report, such as average annual nutrient yields (refer back to Table 7-31 on page 326), staff provisionally anticipates that the following areas will need high prioritization of mitigation efforts:

- *Upper Pajaro River and Lower Llagas Creek subwatersheds*

On the basis of nutrient loading estimates, nutrient yield estimates, land use, and water quality information, implementation and monitoring efforts should prioritize the Upper Pajaro River subwatershed and the Lower Llagas Creek subwatershed for implementation efforts (refer back to Figure 3-4 on page 13 for a map of subwatersheds in the Pajaro River basin).

- *Lower Pajaro River and Watsonville Slough subwatersheds*

On the basis of nutrient loading estimates, nutrient yield estimates, land use, and water quality information, implementation and monitoring efforts should prioritize the Lower Pajaro River subwatershed and the Watsonville Slough subwatershed areas in the Pajaro Valley for implementation efforts (refer back to Figure 3-4 on page 13 for a map of subwatersheds in the Pajaro River basin).

- *San Juan Valley subwatershed*

On the basis of nutrient loading estimates, nutrient yield estimates, land use, and water quality information, implementation and monitoring efforts should prioritize the San Juan Valley subwatershed[202] for implementation efforts (refer back to Figure 3-4 on page 13 for a map of subwatersheds in the Pajaro River basin).

- *Priority Pollutant*

With regard to pollutant prioritization, reporting by Tetra Tech, Inc. indicates that currently control of nitrogen in streams of the California central coast region may be considerably more important than control of phosphorus. Tetra Tech scientists found that streams in the California chaparral and oak nutrient subecoregion (subecoregion III-6) are more often limited by nitrogen than by phosphorus[203]. Accordingly, staff maintains that at this time the focus of resources and implementation should be directed with respect to nitrogen loading reduction.

However, as reported by USEPA (2007b), while controlling one nutrient may potentially prevent productivity, control of both nutrients (nitrogen and phosphorus) in upstream waters can also provide additional assurance that excess productivity will remain in control. For example, under conditions of nitrogen limitation, even if local excess primary productivity is ultimately controlled to a large extent by nitrogen reduction alone, there will be resultant export of the excess nutrient, phosphorus, because the excess of that nutrient would not have the opportunity for uptake into biomass. The larger the excess of phosphorus in upstream systems is, the greater the contribution to potential phosphorus-sensitive downstream systems. Therefore, concurrent reduction of both nitrogen and phosphorus in a basin is often warranted in order to protect downstream use. More recently, USEPA provided further guidance on why the development of dual numeric criteria for both nitrogen and phosphorus can be an effective tool to protect beneficial uses of the nation’s streams, lakes, estuaries, and coastal systems (USEPA, 2015).

Also, noteworthy is that research has shown that in some areas of the nearby Salinas Valley, phosphorus-fertilization is ineffective in improving lettuce growth in areas that have high phosphorus content, rendering the need for P-fertilization unnecessary:

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[202] In the Watershed Boundary Dataset convention, they 12-digit hydrologic unit associated with the San Juan Valley is designated the “San Juan Canyon” hydrologic unit (subwatershed).

[203] See TetraTech (2004). *2004 Overview of Nutrient Criteria Development and Relationship to TMDLs*

> *“P fertilization was ineffective in improving lettuce growth in either field 1 or 2. Both fields had soil test P > 50 PPM (bicarbonate, or ‘Olsen’, extraction procedure), above the agronomic response threshold we established in prior research in the Salinas Valley (Johnstone et al., 2005). These results provide additional evidence to convince growers that P fertilization of soils at or above 50 PPM Olsen P is not necessary for lettuce production. Whole leaf sampling at mid-season showed leaf P concentration in the no-P treatment to be 0.52 and 0.65% in field 1 and 2, respectively; this was well above the 0.43% sufficiency threshold established in earlier research (Hartz et al., 2007), and statistically equal in both fields to the treatment receiving P application.*
>
> From: *“Reducing nutrient loading from vegetable production”* (field trials – Salinas Valley).
> UC-Davis and Univ. of Calif. Cooperative Extension – Project Leaders: T.K. Hartz, R. Simth and M. Cahn. 2007.

9.3.3 Determining Progress & Attainment of Load Allocations

Load reductions are proposed for discharges of nitrogen compounds and orthophosphate from irrigated lands. It is estimated that nutrient loads from irrigated lands overwhelmingly comprise the largest source category of nutrient loading to waterbodies in the Pajaro River basin (refer back to Section 7). Therefore, implementation of management measures will be needed to implement the proposed load allocations for irrigated lands.

Load allocations will be achieved through a combination of implementation of management practices and strategies to reduce nitrogen compound and orthophosphate loading, and water quality monitoring. For nonpoint source load allocations, USEPA guidance generally expects that the State’s, Territory’s, or authorized Tribe’s Clean Water Act Section 319 nonpoint source management programs will be the basis for implementing load allocations[204]. California’s Nonpoint Source Pollution Control Program was previously described in Section 9.2.5. In practical terms, this means load allocations are addressed though the implementation of management practices (e.g., land, irrigation and nutrient management practices)[205]. It is important to note that although load allocations are typically addressed by adoption of specific management practices, it is not always easy to evaluate the effectiveness of management practices. As this TMDL is heavily dependent on nonpoint source loading reductions through load allocations, long-term watershed water quality monitoring is proposed to evaluate the effectiveness of implemented management practices and nonpoint source load reductions. Existing monitoring programs in conjunction with proposed monitoring requirements in this TMDL can be used synergistically to provide for long-term water quality monitoring.

Biostimulatory impairments result from nutrients acting in combination with other factors to contribute to dissolved oxygen and algal biomass problems and degradation of aquatic habitat. The proposed nitrate and orthophosphate allocations to address biostimulation are predictors of the nutrient water quality level necessary to restore beneficial uses. However, it should be recognized that the main concern with biostimulatory impairments is a need to restore dissolved oxygen and algal biomass to acceptable levels consistent with designated beneficial uses, and to mitigate downstream biostimulatory nutrient impacts to receiving waterbodies. As such, nutrient-response indicator targets (dissolved oxygen, chlorophyll *a*, microcystin) proposed in this TMDL can be used to assess water quality standards attainment over the long term. Staff is proposing flexibility in allowing owners/operators from irrigated lands to demonstrate compliance with load allocations; additionally, staff is aware that not all implementing parties are necessarily contributing to or causing surface water impairments. However, it is important to recognize that impacting shallow groundwater with nutrient pollution may also impact surface water quality via baseflow loading contributions to streams.

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[204] See USEPA, “Establishing and Implementing TMDLs” at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/TMDL-ch3.cfm

[205] See USEPA, Protocol for Developing Nutrient TMDLs. EPA 841-B-99-007 (November, 1999)

To allow for flexibility, compliance with load allocations can be demonstrated and determined in several ways, using one or a combination of the following:

Text Box 9-2. Demostrating progress towards and attainment of load allocations.

Water Board staff will assess progress towards and attainment of load allocations using one or a combination of the following:

a) attaining the nutrient load allocations in the receiving water;

b) attaining receiving water TMDL numeric targets for nutrient-response indicators (i.e., dissolved oxygen water quality objectives, chlorophyll *a* targets and microcystin targets) and mitigation of downstream nutrient impacts to receiving waterbodies may constitute a demonstration of attainment of the nitrate, nitrogen and orthophosphate-based seasonal biostimulatory load allocations. Note that implementing parties are strongly encouraged to maximize overhead riparian canopy, where and if appropriate, using riparian vegetation, because doing so could result in achieving nutrient-response indicator targets before allocations are achieved (resulting in a less stringent allocation);

c) owners/operators of irrigated lands may be deemed in compliance with load allocations by implementing management practices that are capable of achieving interim and final load allocations identified in this TMDL;

d) demonstrating quantifiable receiving water mass load reductions;

e) owners/operators of irrigated lands may provide sufficient evidence to demonstrate that they are and will continue to be in compliance with the load allocations; such evidence could include documentation submitted by the owner/operator to the Executive Officer that the owner/operator is not causing waste to be discharged to impaired waterbodies resulting or contributing to violations of the load allocations.

9.4 Implementation for Discharges from MS4 Stormwater Entities

Waste load allocations for this source category will be implemented by NPDES MS4 stormwater permits. Municipal separate storm sewer systems (MS4s) are considered relatively minor loads of nitrogen compounds and orthophosphate in the Pajaro River basin based on the source analysis presented in Section 7.2 However, because these sources can potentially have a significant localized effect on water quality they are allocated wasteload allocations. The Central Coast Water Board will address nitrogen compounds and orthophosphate discharged from municipal separate storm sewer systems (MS4s) by regulating the MS4 entities under the provisions of the State Water Resource Control Board's General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems (General Permit, Water Quality Order No. 2013-0001-DWA, NPDES CAS000004), or subsequent General Permits. To address the MS4 waste load allocations, the Central Coast Water Board will require MS4 enrollees that discharge to surface waterbodies impaired by excess nutrients or by biostimulation to address these impairments by developing and implementing a Waste Load Allocation Attainment Program. The elements of a Waste Load Allocation Attainment Program are described in report section 9.4.2 and in Text Box 9-3. Report section 5.16 contains maps and tables identifying the stream reaches impaired by excess nutrients and biostimulation.

MS4 entities that discharge to surface waterbodies that are currently not impaired by nutrients and biostimulation are presumed to be meeting their waste load allocations at this time, and thus would not be required to develop a Waste Load Allocation Attainment Program for nutrients. However, because anti-degradation is an element of all water quality standards (refer back to report Section 4, Section 4.3, and Section 9.2.3), these entities should continue to implement their stormwater programs and comply with the General Permit or any subsequent permits with the goal of maintaining existing nutrient water quality and helping to prevent any further water quality degradation.

The Central Coast Water Board will require MS4 entities to develop and submit for Executive Officer approval a Waste Load Allocation Attainment Program consistent with the requirements of the General Permit, or with any subsequent General Permits. The Waste Load Allocation Attainment Program shall include descriptions of the actions that will be taken by the MS4 entity to attain the TMDL waste load allocations. Specifics of the Waste Load Allocation Attainment Program are detailed in Section 9.4.2.

9.4.1 Implementing Parties

Table 9-2 presents the implementing entities responsible for implementation of waste load allocations for the municipal stormwater source category. In the context of this report, TMDL implementation refers to actions to correct impaired surface waters, as well as to actions to address anti-degradation concerns and maintain existing water quality. Not all implementing parties are expected to need to develop Waste Load Allocation Attainment Plans (refer back to report Section 9.4).

Table 9-2. Implementing Parties for Discharges from MS4 Entities.

Owner/Operator Name	Type	General Permit Status
City of Watsonville	Phase II Small MS4	Active
City of Gilroy	Phase II Small MS4	Active
City of Morgan Hill	Phase II Small MS4	Active
City of Hollister	Phase II Small MS4	Active
County of Monterey	Phase II Small MS4	Active
County of Santa Clara	Phase II Small MS4	Active
County of Santa Cruz	Phase II Small MS4	Active

9.4.1 Priority Areas and Priority Pollutant

Stakeholders in the municipal stormwater entities and local resource professionals are in the best position to ultimately assess implementation priorities and problem areas. Unfortunately, Central Coast Water Board staff did not have municipal storm drain outfall water quality data for urban areas of the Pajaro River basin. Based on information developed in this report, Central Coast Water Board staff at this time expects that areas that are currently impaired from nutrient pollution, such as urbanized areas of the lower Llagas Creek subwatershed, the Lower Pajaro River subwatershed, and the Watsonville Slough subwatershed, would be a focus of priority for municipals stormwater implementing parties. Regional and national municipal stormwater runoff data suggest that exceedances of proposed nutrient water quality criteria may be localized, but not pervasive in urbanized areas.

➢ Priority Pollutant

With regard to pollutant prioritization, reporting by Tetra Tech, Inc. indicates that currently control of nitrogen in this system may be considerably more important than control of phosphorus. Tetra Tech scientists found that streams in the California chaparral and oak nutrient subecoregion (subecoregion III-6) are more often limited by nitrogen than by phosphorus[206]. Accordingly, as a practical matter staff maintains that at this time the focus of resources and implementation should be directed with respect to nitrogen. However, as previously articulated in report Section 9.3.2, controlling both nitrogen and phosphorus discharges can also provide additional assurance that excess aquatic biological productivity will remain in control.

9.4.2 Implementation Actions

The overall goal of developing a Waste Load Allocation Attainment Program is to Implement management practices capable of achieving interim and final Wasteload Allocations identified in this

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[206] See TetraTech (2004). *2004 Overview of Nutrient Criteria Development and Relationship to TMDLs*

TMDL. The Central Coast Water Board will require the Wasteload Allocation Attainment Program to include descriptions of the actions that will be taken by the MS4 entity to attain the TMDL wasteload allocations, and specifically address:

A. Development of an assessment and implementation strategy;
B. Source identification and prioritization;
C. Best management practices (BMP) identification, prioritization, implementation schedule, analysis, and effectiveness assessment;
D. Monitoring and reporting program development and implementation. Monitoring program goals shall address: (1) assessment of stormwater discharge and/or receiving water quality; (2) assessment of BMP effectiveness; and (3) demonstration and progress towards achieving interim goals and waste load allocations;
E. Coordination with stakeholders; and
F. Other pertinent factors.

The Wasteload Allocation Attainment Program will be required by the Central Coast Water Board to address each of these TMDLs that occur within the MS4 entities' jurisdictions. MS4 entities will submit Waste Load Allocation Attainment Programs in consistent with current, of future conditions specified in the General Permit (Water Quality Order No. 2013-0001-DWA, NPDES CAS000004), or subsequent General Permits.

The Waste Load Allocation Attainment Programs shall include the elements identified in Attachment G of the General Permit (Water Quality Order No. 2013-0001-DWQ, NPDES CAS000004), as reproduced below in Text Box 9-3.

Text Box 9-3. Required components of Waste Load Allocation Attainment Programs.

1. A detailed description of the strategy the MS4 will use to guide BMP selection, assessment, and implementation, to ensure that BMPs implemented will be effective at abating pollutant sources, reducing pollutant discharges, and achieving wasteload allocations according to the TMDL schedule.
2. Identification of sources of the impairment within the MS4's jurisdiction, including specific information on various source locations and their magnitude within the jurisdiction.
3. Prioritization of sources within the MS4's jurisdiction, based on suspected contribution to the impairment, ability to control the source, and other pertinent factors.
4. Identification of BMPs that will address the sources of impairing pollutants and reduce the discharge of impairing pollutants.
5. Prioritization of BMPs, based on suspected effectiveness at abating sources and reducing impairing pollutant discharges, as well as other pertinent factors.
6. Identification of BMPs the MS4 will implement, including a detailed implementation schedule. For each BMP, identify milestones the MS4 will use for tracking implementation, measurable goals the MS4 will use to assess implementation efforts, and measures and targets the MS4 will use to assess effectiveness. MS4s shall include expected BMP implementation for future implementation years, with the understanding that future BMP implementation plans may change as new information is obtained.
7. A quantifiable numeric analysis demonstrating the BMPs selected for implementation will likely achieve, based on modeling, published BMP pollutant removal performance estimates, best professional judgment, and/or other available tools, the MS4's wasteload allocation according to the schedule identified in the TMDL. This analysis will most likely incorporate modeling efforts. The MS4 shall conduct repeat numeric analyses as the BMP implementation plans evolve and information on BMP effectiveness is generated. Once the MS4 has water quality data from its monitoring program, the MS4 shall incorporate water quality data into the numeric analyses to validate BMP implementation plans.
8. A detailed description, including a schedule, of a monitoring program the MS4 will implement to assess discharge and receiving water quality, BMP effectiveness, and progress towards any interim targets and ultimate attainment of the MS4s' wasteload allocation. The monitoring program shall be designed to validate BMP implementation efforts and quantitatively demonstrate attainment of interim targets and wasteload allocations.
9. If the approved TMDL does not explicitly include interim targets, the MS4 shall establish interim targets (and

dates when stormwater discharge conditions will be evaluated) that are equally spaced in time over the TMDL compliance schedule and represent measurable, continually decreasing MS4 discharge concentrations or other appropriate interim measures of pollution reduction and progress towards the wasteload allocation. At least one interim target and date must occur during the five-year term of this Order. The MS4 shall achieve its interim targets by the date it specifies in the Wasteload Allocation Attainment Program. If the MS4 does not achieve its interim target by the date specified, the MS4 shall develop and implement more effective BMPs that it can quantitatively demonstrate will achieve the next interim target.

10. A detailed description of how the MS4 will assess BMP and program effectiveness. The description shall incorporate the assessment methods described in the CASQA Municipal Storm water Program Effectiveness Assessment Guide.
11. A detailed description of how the MS4 will modify the program to improve upon BMPs determined to be ineffective during the effectiveness assessment.
12. A detailed description of information the MS4 will include in annual reports to demonstrate adequate progress towards attainment of wasteload allocations according to the TMDL schedule.
13. A detailed description of how the MS4 will collaborate with other agencies, stakeholders, and the public to develop and implement the Wasteload Allocation Attainment Program.
14. Any other items identified by Integrated Report fact sheets, TMDL Project Reports, TMDL Resolutions, or that are currently being implemented by the MS4 to control its contribution to the impairment.

9.4.3 Determining Progress & Attainment of Waste Load Allocations

USEPA guidance[207] states that if the State or USEPA establishes a TMDL for impaired waters that include wasteload allocations for stormwater discharges, permits for MS4 discharges must contain effluent limits and conditions consistent with the requirement and assumptions of the WLAs in the TMDL. [208] Compliance with waste load allocations can be demonstrated in several ways; the permitting authority (Water Board) has the discretion to express the effluent limitations in the applicable stormwater permits as numeric water quality-based limits consistent with the waste load allocations (if and where feasible), or the effluent limitations may be expressed as a measureable, objective Best Management Practices (BMPs) that are anticipated to be capable of achieve the waste load allocation[209]. USEPA states that where a BMP-based approach to permit limitations is selected, the BMPs required by the permit will be sufficient to implement applicable waste load allocations, including adequate monitoring, numeric benchmarks, or specific protocols to determine if the BMPs are performing as necessary.

Biostimulatory impairments result from nutrients acting in combination with other factors to contribute to dissolved oxygen and algal biomass problems and degradation of aquatic habitat. The proposed nitrate and orthophosphate allocations to address biostimulation are predictors of the nutrient water quality level necessary to restore beneficial uses. However, it should be recognized that the main concern with biostimulatory impairments it to restore dissolved oxygen and algal biomass to acceptable levels consistent with designated beneficial uses, and to mitigate downstream biostimulatory nutrient impacts to receiving waterbodies. As such, nutrient-response indicator targets (dissolved oxygen, chlorophyll *a*, microcystin) proposed in this TMDL can be used to assess water quality standards attainment over the long term. Accordingly, to allow for flexibility, compliance with waste load allocations can be demonstrated and determined in several ways, as follows:

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[207] USEPA Memorandum, Nov. 12, 2010, *Revisions to the November 22, 2002 Memorandum "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) from Storm Water Sources and NPDES Permit Requirements Based on Those WLAs"*

[208] See 40 CFR 122.44(d)(1)(vii)(B).

[209] USEPA Memorandum, Nov. 26, 2014, *Revisions to the November 22, 2002 Memorandum "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) from Storm Water Sources and NPDES Permit Requirements Based on Those WLAs".*

Text Box 9-4. Demostrating progress towards and attainment of waste load allocations.

Water Board staff will assess progress towards and attainment of waste load allocations using one or a combination of the following:

a) Attaining the waste load allocations in the receiving water;
b) Attaining receiving water TMDL numeric targets for nutrient-response indicators (i.e., dissolved oxygen water quality objectives, chlorophyll a targets and microcystin targets) and mitigation of downstream nutrient impacts to receiving waterbodies may constitute a demonstration of the attainment of the nitrate, nitrogen, and orthophosphate-based seasonal biostimulatory waste load allocations. Note that implementing parties are strongly encouraged to maximize overhead riparian canopy using riparian vegetation, where and if appropriate, because doing so could result in achieving nutrient-response indicator targets before allocations are achieved (resulting in a less stringent allocation);
c) Demonstrate compliance by measuring concentrations in stormdrain outfalls;
d) Demonstrate compliance by demonstrating load reductions on mass basis at stormdrain outfalls;
e) MS4s may be deemed in compliance with waste load allocations through implementation and assessment of pollutant loading reduction projects and assessment of BMPs capable of achieving interim and final waste load allocations identified in this TMDL in combination with water quality monitoring for a balanced approach to determining program effectiveness; and
f) Any other effluent limitations and conditions which are consistent with the assumptions and requirements of the waste load allocations.

9.5 Implementation for Industrial & Construction Stormwater Discharges

Based on evidence and information provided in this TMDL report (refer back to report Section 7.3), NPDES stormwater-permitted industrial facilities and construction sites in the Pajaro River basin would not be expected to be a significant risk or cause of the observed nutrient water quality impairments, and these types of facilities are generally expected to be currently meeting proposed waste load allocations. Therefore, at this time, additional regulatory measures for this source category are not warranted.

To maintain existing water quality and prevent any further water quality degradation, these permitted industrial facilities and construction operators shall continue to implement and comply with the requirements of the statewide Industrial General Permit (Order No. 97-03-DWQ, NPDES No. CAS000001 or Order No. 2014-0057-DWQ, NPDES No. CAS000001) or the Construction General Permit (Order No. 2012-0006-DWQ, NPDES No. CAS000002, or any subsequent Construction General Permit), respectively.

Available information does not conclusively demonstrate that stormwater from all industrial facilities and construction sites are meeting waste load allocations. More information will be obtained during the implementation phase of these TMDLs to further assess the level of nutrient contributions to surface waters from these source categories, and to identify any actions needed to reduce nutrient loading.

9.6 Implementation for Municipal Wastewater Treatment Facilities

Based on available data, discharges of treated wastewater from municipal wastewater treatment facilities are expected to generally be a relatively minor source of nutrient pollution to surface waters of the Pajaro River basin. However, according to the U.S. Environmental Protection Agency and the State Water Resources Control Board, all NPDES-permitted point sources identified in a TMDL must be given a waste load allocation, even if their current load to receiving waters is zero.

Watsonville Wastewater Treatment Facility's (Order No. R3-2014-0006 NPDES No. CA0048216) uses an ocean discharge point in Monterey Bay and these coastal marine waters are outside the scope of these TMDLs. Therefore further regulatory measures in the context of these TMDLs for this facility is not warranted. This facility will be given a generic waste load allocation, to reserve discharge capacity if there is a need for future discharge points for this facility into surface waters of the Pajaro Valley. As noted above, all NPDES-permitted point sources identified in a TMDL must be given a waste load allocation, even if they are not currently contributing loads to receiving waters, otherwise their allocation is assumed to be zero and no discharges of the identified pollutant(s) are allowed now or in the future.

It should be noted that legal guidance from the State Water Resources Control Board's Office of Chief Counsel contemplates flexibility in the context of translating waste load allocations identified in a TMDL, to effluent limits in an NPDES permit – see the text box below:

> *While the EPA might have required WQBELs [water quality based effluent limitations] to be identical to a discharger's wasteload allocation, it did **not** do so. The EPA instead opted to **provide the states the latitude** to determine how to achieve the end results dictated by the TMDL. Accordingly, the regulations require that the WQBELs be **"consistent with the assumptions and requirements of"** rather than **"identical to"** or "not less stringent than" wasteload allocations.*
>
> From: State Water Resources Control Board, Office of Chief Counsel, January 26, 2001, Memo entitled: *Guidance Regarding the Extent to Which Effluent Limitations Set Forth in NPDES Permits Can Be Relaxed in Conjunction with a TMDL*
>
> emphasis, and parenthetical clarification in brackets added by Central Coast Water Board staff

The above legal guidance is noteworthy in that effluent limits in an NPDES permit need to be "consistent with the assumptions" of a waste load allocation, but are not necessarily required to be "identical to" the waste load allocation. Thus, in the context of NPDES effluent limits, the states have some latitude in determining how to achieve the end results of the TMDL and its associated waste load allocations.

The South County Wastewater Treatment Facility (Order No. R3-2010-0009, NPDES No. CA0049964), is permitted to discharge treated wastewater to the Pajaro River, but only under certain flow conditions. Based on available information, the existing effluent limitations and conditions in Order No. R3-2010-0009 would be expected to be capable of implementing and attaining the proposed waste load allocations identified in these TMDLs. Based on discussions between the Central Coast Water Board's NPDES staff and TMDL staff, the orthophosphate waste load allocations can potentially be implemented by actions and numeric limitations in the existing NPDES permit[210]

Available information does not conclusively demonstrate that the South County Wastewater Treatment Facility permitted treated wastewater discharge to the Pajaro River poses no threats to aquatic habitat, and thus during the TMDL implementation phase the Central Coast Water Board may use its Water Code §13267 authorities to have the South County Regional Wastewater Authority estimate their current or future nutrient loading contribution to the Pajaro River, and the Central Coast Water Board may subsequently assess what, if any, modifications to the nutrient effluent limitations are needed to those currently specified in Order No. R3-2010-0009.

The City of San Juan Bautista Wastewater Treatment Facility (Order No. R3-2009-0019 NPDES No. CA0047902) is permitted to discharge up to treated wastewater to an unnamed drainage ditch that is

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[210] The existing South County Regional Wastewater Authority NPDES permit contains numeric effluent and/or receiving water limits for nitrogen compounds, dissolved oxygen, and biostimulatory substances. Collectively these effluent and receiving water limits are expected, at this time, to minimize biostimulation, protect beneficial uses, and meet the intent of the TMDLs, without necessarily requiring a numeric orthophosphate effluent limit. As noted previously in this TMDL report (Section 9.4.1), existing research indicates that biostimulation in California central coast streams is largely being driven by excess nitrogen. However, USEPA recommends dual nutrient criteria for both nitrogen and phosphorus in nutrient TMDLs, as a way to provide additional assurance against the risk of biostimulation. Therefore, while phosphorus reduction is a secondary goal of the proposed TMDLs, Central Coast Water Board staff recommend at this time that implementation, regulatory efforts, and permit requirements treat nitrogen as the priority pollutant in the context of the proposed TMDLs.

tributary to the San Juan Creek. At this time, the hydraulic connectivity of this ditch with other creeks and drainages of the San Juan Valley is uncertain; however, elevated nutrient concentrations on the treated wastewater discharged to the ditch appear to be generally exceeding water quality numeric targets identified in these TMDLs. Central Coast Water Board may use its Water Code §13267 authorities to have the City of San Juan Bautista estimate their nutrient loading contribution, and nutrient-related water quality impacts to downstream receiving waters. On the basis of this, and other information collected during TMDL implementation, the Central Coast Water Board will incorporate effluent and receiving water limitations for the surface water discharge at the San Juan Bautista Wastewater Treatment Facility.

9.7 Implementation for Livestock & Domestic Animals

Based on available information, it is generally expected that owners and operators of livestock and domestic animals on grazing lands or in rural residential areas are currently achieving proposed nutrient load allocations. As such, new regulatory measures, and formal regulatory oversight not warranted for this source category.

To maintain existing water quality and prevent any further water quality degradation, owners and operators of unconfined livestock on rangelands or confined livestock and domestic animals in rural residential areas which do not drain to a municipal separate stormwater sewer system should begin or continue to self-assess, self-monitor and make animal management and manure management decisions which comport with accepted rangeland management practices or manure management practices recommended or published by reputable resource professionals or local agencies.

It is important to note that the Pajaro River basin is in fact currently subject to a Domestic Animal Waste Discharge Prohibition and livestock owners are subject to compliance with an approved indicator bacteria TMDL load allocation[211]. Implementation efforts by responsible parties to comply with this prohibition and with indicator bacteria load allocations will, as a practical matter, also reduce the risk of nitrogen and phosphorus loading to surface waters from domestic animal waste.

It should be noted that information developed in this TMDL Report does not conclusively demonstrate that discharges from all livestock facilities are meeting proposed load allocations. More information will be obtained during the implementation phase of these TMDLs to further assess the level of nutrient contributions to surface waters from these source categories, and to identify any actions needed to reduce nutrient loading.

9.8 Implementation for Public & Private Golf Courses

Use of fertilizer on golf courses could conceivably be a source of nutrients to surface waters in any given watershed. Available data from golf course creeks in the Pajaro River basin, as well as information on regional and national golf course water quality data suggest that golf courses would be expected to be meeting load allocations protective of designated beneficial uses in streams of the Pajaro river basin, and thus formal regulatory actions or regulatory oversight of golf courses to implement these TMDLs is unwarranted. Because anti-degradation is an element of all water quality standards, owners and operators of public and private golf courses should continue to implement turf management practices which help to protect and maintain existing water quality and to prevent any further surface water quality degradation.

Available information does not conclusively demonstrate that all golf courses in the Pajaro River basin are currently meeting proposed nutrient load allocations for discharges to surface waters. The Central Coast Water Board will obtain more information, if merited, during the implementation phase of the TMDLs to further assess the levels of nutrient contribution from this source category, and to identify any actions if necessary to reduce nutrient loading to surface waters.

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[211] Central Coast Water Board Resolution No. R3-2009-0008 (March 2009).

9.9 Potential Management Measures

9.9.1 Potential Management Measures for Agricultural Sources

The State Water Board, California Coastal Commission and other State agencies have identified management measures (MMs) to address agricultural sources of nutrient pollution that affect State waters. These are provided here for informational value; they are not provided as examples of current or anticipated requirements, nor are they an exhaustive list of all possible, effective management measures.

The agricultural MMs include practices and plans installed under various NPS programs in California, including systems of practices commonly used and recommended by the U.S. Department of Agriculture as components of Resource Management Systems (RMS), Water Quality Management Plans and Agricultural Waste Management Systems. These RMSs are planned by individual farmers and ranchers using an objective-driven planning process outlined in the NRCS National Planning Procedures Handbook.

As described in Section 9.2.2, the Water Board cannot specify the specific type or design of onsite actions necessary to reduce nutrient loading to waterbodies; however the California Nonpoint Source Pollution Control Program contains information on the general expectations and types of MMs (see Management Measure 1C – Nutrient Management) that will reduce nutrient loading; this information may be viewed at the following link:

http://www.swrcb.ca.gov/water_issues/programs/nps/docs/cammpr/cammpr_agr.pdf

Further, the State Water Board's Nonpoint Source Management Program provides an on-line reference guide designed to facilitate a basic understanding of nonpoint source (NPS) pollution control and to provide quick access to essential information from a variety of sources. The purpose of this on-line resource guide is to support the implementation and development of NPS total maximum daily loads (TMDLs) and watershed (action) plans with a goal of protecting high-quality waters and restoring impaired waters. Relevant information from the State Water Board Nonpoint Source (NPS) – Encyclopedia for nutrient management is available online at:

http://www.swrcb.ca.gov/water_issues/programs/nps/encyclopedia.shtml

The California Department of Food and Agricultural Fertilizer Research and Education Program (FREP) funds and coordinates research to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. FREP serves growers, agricultural supply and service professionals, extension personnel, public agencies, consultants, and other interested parties. FREP is guided by the Technical Advisory Subcommittee (TASC) of the Fertilizer Inspection Advisory Board (FIAB). This subcommittee includes growers, fertilizer industry professionals, and state government and university scientists. The TASC directs FREP activities, and reviews, selects and (after peer review) recommends to the FIAB funding for FREP research and education projects. Information on FREP and nutrient management research and education can be found at: http://www.cdfa.ca.gov/is/ffldrs/frep.html

➢ *Nutrient Management Plans*

Where needed and appropriate, implementation of nutrient management plans voluntarily or if and as consistent with requirements of the Agricultural Order (or future revisions of the Order), may be an effective management option to reduce nitrate loads to waters of the State. The California Nonpoint Source Pollution Control Program states that development and implementation of a nutrient management plan should include the following goals:

1) Apply nutrients at rates necessary to achieve realistic crop yields,
2) Improve the timing of nutrient application, and
3) Use agronomic crop production technology to increase nutrient use efficiency.

The California Nonpoint Source Pollution Control Program states that core components of a nutrient management plan should include:

- Farm and field maps with identified and labeled: acreage and type of crops, soil surveys, location of any environmental sensitive areas including any nearby water bodies and endangered species habitats.
- Realistic yield expectations for the crop(s) to be grown based primarily on the producer's yield history, State Land Grant University yield expectations for the soil series, or USDA NRCS Soils-5 information for the soil series.
- A summary of the nutrient resources available to the producer, which (at a minimum) include (a) soil test results for pH, phosphorus, nitrogen, and potassium; (b) nutrient analysis of compost, sludge, mortality compost (birds, pigs, etc.), or effluent (if applicable); (c) nitrogen contribution to the soil from legumes grown in rotation (if applicable); and (d) other significant nutrient sources (e.g., irrigation water).
- An evaluation of the field limitations and development of appropriate buffer areas, based on environmental hazards or concerns such as (a) sinkholes, shallow soils over fractured bedrock, and soils with high leaching potential; (b) lands near or draining into surface water; (c) highly erodible soils; and (d) shallow aquifers.
- Use of the limiting nutrient concept to establish a mix of nutrient sources and requirements for the crop based on realistic yield expectations.
- Identification of timing and application methods for nutrients to (a) provide nutrients at rates necessary to achieve realistic yields, (b) reduce losses to the environment, and (c) avoid applications as much as possible to frozen soil and during periods of leaching or runoff.
- Provisions for the proper calibration and operation of nutrient application equipment.
- Provisions to ensure that, when compost from confined animal facilities (excluding CAFOs) is to be used as a soil amendment or is disposed of on land, subsequent irrigation of the land does not leach excess nutrients to surface or ground waters.
- Vegetated Treatment Systems are discussed in Management Measure 6C of the NPS Recent peer-reviewed literature has examined the efficacy and efficiency of agricultural solutions to reducing nitrogen pollution. As reported in Davidson et al. (2012), many existing mitigation strategies[212] for farms have been demonstrated to potentially reduce nitrogen losses within the existing agricultural system by 30 to 50% or more. However, Davidson et al. (2012) note that improved fertilizer management, better education and training of crop advisors, and willingness by farmers to adopt these practices are needed. An ecologically intensive approach that integrates complex crop rotations, cover crops, perennials could also reduce nitrogen loses by as much as 70 to 90%.

9.9.2 Potential Management Measures for Urban Sources

Potential management measures are provided here for informational value; they are not provided as examples of current or anticipated requirements, nor are they an exhaustive list of all possible, effective management measures. As described in Section 9.2.2, the Water Board cannot specify or mandate the specific type or design of onsite actions (e.g., best management practices) necessary to reduce nutrient loading to waterbodies; however the California Nonpoint Source Pollution Control Program[213] contains information on the general expectations and types of MMs that will reduce urban nutrient loading; this information may be viewed at the following link:

http://www.swrcb.ca.gov/water_issues/programs/nps/docs/cammpr/cammpr_urb.pdf

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[212] Davidson et al. (2012) define existing mitigation strategies as those that could be accomplished under the current agricultural subsidy system.

[213] While MS4 permitted municipal stormwater is considered a "point source" requiring WLAs under EPA regulation, urban runoff management measures are identified in California's Nonpoint Source Pollution Plan.

Further, the State Water Board's Nonpoint Source Management Program provides an on-line reference guide designed to facilitate a basic understanding of nonpoint source (NPS) pollution control and to provide quick access to essential information from a variety of sources The purpose of this on-line resource guide is to support the implementation and development of NPS total maximum daily loads (TMDLs) and watershed (action) plans with a goal of protecting high-quality waters and restoring impaired waters. Relevant information from the State Water Board Nonpoint Source (NPS) – Encyclopedia for nutrient management is available online at:

http://www.swrcb.ca.gov/water_issues/programs/nps/encyclopedia/3_0_urb.shtml

The International Stormwater BMP Database is a comprehensive source of BMP performance information. The BMP Database is comprised of carefully examined data from a peer reviewed collection of studies that have monitored the effectiveness of a variety of BMPs in treating water quality pollutants for a variety of land use types. The Stormwater BMP Database is available online at:

http://www.bmpdatabase.org/

9.10 Recommended Water Quality Monitoring

There is a relatively large quantity of surface water quality samples in the Pajaro River basin being collected by multiple entities, with reasonably good spatial and temporal variation. Thus, at this time Central Coast Water Board staff are not recommending additional receiving water quality monitoring above and beyond what is currently being collected. The plethora of current monitoring efforts in the Pajaro River basin, including the Central Coast Ambient Monitoring Program, the Cooperative Monitoring Program, the City of Watsonville, the Watershed Council, the Pajaro Valley Water Management Agency, and others may be used synergistically by implementing parties to help demonstrate progress towards and attainment of water quality standards.

The Agricultural Order, and any renewals or revisions thereof, shall include monitoring and reporting requirements that assess progress toward achieving load allocations (refer back to Section 9.3 for a description of implementation of load allocations). It should be noted that the Cooperative Monitoring Program (CMP) - the entity that collects data on behalf of growers - currently is collecting samples on a monthly basis at Pajaro River basin monitoring sites. At this time, staff anticipates that the current CMP monitoring efforts are adequate to assess receiving water quality and TMDL progress on behalf of irrigated agriculture.

Applicable NPDES-permitted entities that have waste load allocations associated with this TMDL need to incorporate effluent limits, conditions, and monitoring and reporting elements consistent with the requirements and assumptions of the wasteload allocations in the TMDL (refer back to 9.4.3 for information on implementation of waste load allocations).

➢ *Total Nitrogen Monitoring in the Watsonville Slough Subwatershed & Millers Canal*

Staff are proposing that total nitrogen (rather than nitrate) be monitored and used as a water quality target for surface waters of the Watsonville Slough subwatershed, and for Millers Canal, for the following reason:

While monitoring of nitrate is recommended for most Pajaro River basin stream reaches, ***monitoring of total nitrogen is recommended for the coastal slough environment of the Watsonville Slough subwatershed.*** *This is because water column nitrate in these coastal slough environments generally do not adequately represent the collective total amount of water column nitrogen that is potentially available* *to contribute to internal loading via nitrogen cycling in this stream reach*[214]*. Similarly,* ***numeric criteria developed here for Millers Canal are based on total nitrogen targets.*** *Nitrate is only a very small percentage of total nitrogen in the canal waters, possibly as a result of high levels of observed chlorophyll a in the canal, suggesting elevated biological uptake of nitrate.*

Note that is widely recognized by researchers that locally, waterbodies can have low levels of bioavailable nutrients (nitrate, orthophosphate) in the water column but still have high levels of biomass because the bioavailable nutrient is assimilated in the algae. These nutrients can later become biologically available upon decay or release. Indeed, one of the scientific peer reviewers for a recent Central Coast Water Board TMDL project provided comment which conceptually highlights this well-established understanding of nutrient cycling:

> *"While orthophosphate is the biologically available form of phosphorus, it does not account for phosphorus in organic matter or bound to inorganic particulates, which can be biologically available upon decay or release. Water can have low orthophosphate, yet contain substantial algal biomass which has assimilated most of the available orthophosphate."*
>
> *Dr. Marc Beutel, Washington State University,*
> *Scientific Peer Review Comments provided to Water Board Staff, 3 May 2012., TMDLs for Nitrogen Compounds and Orthophosphate for the Lower Salinas River and Reclamation Canal Basin, and the Moro Cojo Slough Subwatershed, Resolution No. R3-2013-0008.*

Also, from an efficacy standpoint for MS4 entities, implementation of source control measures for solids (e.g., total phosphorus) typically have lower unit costs and are more cost effective than biorention strategies generally anticipated for dissolved phosphorus (e.g., orthophosphate) – (personal communication, Brandon Steets, P.E., Geosyntec Consultants, September 25, 2012). Also, USEPA and researchers often recommend collection of total phosphorus data to demonstrate attainment or non-attainment of water quality standards. Therefore, it may ultimately be prudent in the future to revise waste load allocations on the basis of total phosphorus rather than orthophosphate waste load allocations, assuming adequate total phosphorus water quality data becomes available. This will require the more systematic and routine collection of total phosphorus water quality data, as current monitoring programs focus on dissolved phosphorus (orthophosphate) – refer back to 6.3.1 for an explanation of the use of orthophosphate as water quality targets in this TMDL.

Additionally, while microcystin water quality targets have been identified in this project report, to limit the burden of monitoring, staff are not recommending that responsible parties conduct microcystin monitoring. Responsible parties may voluntarily collect microcystin data if they choose to do so. The State Water Resources Control Board and the Central Coast Water Board may fund additional collection of baseline microcystin data for the central coast region as the need arises.

9.11 Timeline & Milestones for TMDL Implementation

Discharges of nitrogen compounds and orthophosphate are occurring at levels which are impairing a wide spectrum of beneficial uses and, therefore, constitute a serious water quality problem. As such, implementation should occur at a pace to achieve the allocations and TMDL in the shortest time-frame feasible. Central Coast Water Board staff recognizes that immediate compliance with water quality standards is not feasible, and are proposing milestones as follows.

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[214] Monitored lagoons and estuaries of the central coast region appear to indicate that nitrate is generally only about half or less of all water column total nitrogen. See: Total Maximum Daily Loads for Nitrogen Compounds and Orthophosphate for the Lower Salinas River and Reclamation Canal Basin, and the Moro Cojo Slough Subwatershed (California Central Coast Water Board, Resolution No. R3-2013-0008).

Table 8-4 presents temporal interim water quality benchmarks to demonstrate progress towards achievement of the final wasteload allocations and load allocations previously presented in Table 8-3. These benchmarks can be summarized as follows:

- First Interim Waste Load and Load Allocations: Achieve the nitrate MUN nitrate standard (10 mg/L nitrate as N in receiving waters that are designated MUN) and the unionized ammonia water quality objective-based allocations within 10 years of the effective date of the TMDL (which is upon approval by the Office of Administrative Law);
- Second Interim Waste Load and Load Allocations: Achieve the less stringent wet-season (Nov. 1 to Apr. 30) biostimulatory target-based allocations within 15 years of the effective date of the TMDL;
- Final Interim Waste Load and Load Allocations: Achieve the more stringent dry-season (May 1 to Oct. 31) biostimulatory target-based allocations within 25 years of the effective date of the TMDL;

In 2005, the Pajaro River Nitrate TMDL (Resolution No. R3-2005-0131) identified a 20 year time frame to achieve the human health (MUN) nitrate standard, and therefore the expectation was achievement of the water quality standard by the year 2025. Consistent with the timeframe established in the 2005 Nitrate TMDL, staff are identifying a ten year timeframe for the achievement of the MUN nitrate standards and the Basin Plan objective for unionized ammonia, thus attainment of these water quality standards could be expected by the year 2025. The ten year timeframe is also based on the expectation that nearly all landowners and operators of irrigated agricultural activities should have completed Farm Water Quality Plans and should have been implementing management practices by the end of the first five-year Agricultural Order cycle, back in the year 2012. These efforts should be continuing. Water quality benefits resulting from implementing nutrient-control management measures (e.g., grass swales and riparian buffers, etc.) may take a few years to be realized. Central Coast Water Board staff believes 10 years for the first interim waste load and load allocations is a reasonable timeframe to implement management measures and reduce nitrate levels consistent with the allocations and the numeric target. The 10 year benchmark is also consistent with making progress towards the Water Board's vision for the central coast region of healthy, functioning watersheds by the year 2025.

The 15 year timeframe to achieve the second interim waste load and load allocations (which are based on the less stringent wet-season biostimulatory targets) was identified as a reasonable time frame and intermediate benchmark prior to achieving the final, more-stringent final allocations. The basis for this timeline is that source controls (nutrient and irrigation efficiency improvements) and surface water treatment (e.g., constructed wetlands, buffer strips) are anticipated to result in improvements to surface water quality more rapidly that mitigation measures to reduce nitrate pollution in shallow groundwater. As noted previously, shallow groundwater is a contributing source of nutrients to surface waters; shallow groundwater moves slowly; and shallow groundwater will require longer time frames to respond to the full effects of source control measures.

The 25-year timeline to meet more-stringent dry-season biostimulatory substances allocations are based on the estimate that legacy nutrient loads, which are unrelated to current practices and are originating from groundwater and baseflow, may locally continue to contribute elevated nutrients to some Pajaro River basin streams over a substantial period of time.[215,216] Therefore, staff anticipates that it will take a

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[215] For example, the U.S. Geological Survey (U.S. Geological Survey) reports that in spite of many years of efforts to reduce nitrate levels in the Mississippi River Basin, concentrations have not consistently declined during the past two decades. U.S. Geological Survey concludes that elevated nitrate in groundwater are a substantial source contributing to nitrate concentrations in river water. Because nitrate moves slowly through groundwater systems to rivers, the full effect of management strategies designed to reduce loading to surface waters and groundwaters may not be seen in these rivers for decades. (see *"No Consistent Declines in Nitrate Levels in Large Rivers of the Mississippi River Basin"* U.S. Geological Survey News Release dated 08/09/2011).

significant amount of time for legacy pollutant loads in shallow groundwater, and the subsequent baseflow pollutant loads to stream reaches, to attenuate. Refer back to Section 3.9 for information on groundwater quality, shallow groundwater, and residence time of baseflow in the subsurface.

Evaluating progress towards these milestones and the attainment of load allocations and wasteload allocations will be consistent with the benchmarks and methodologies previously identified in Section 9.3.3 and Section 9.4.3.

9.12 How We Will Evaluate TMDL Implementation Progress

For specific types of pollutant discharge source categories, methodologies for implementing parties to measure and demonstrate progress towards attainment of water quality standards were outlined previously in report Section 9.3.3 and report Section 9.4.3. It is also worth recognizing there are uncertainties including, but not limited to, extreme inter-annual variability in pollutant loading to surface waters based on climatic conditions, flows, water management practices, uncertainties about the nexus between receiving water pollutant concentrations and leachate concentrations, etc. Measures of TMDL implementation progress will not necessarily be limited to receiving water column concentration-based metrics and/or time-weighted average concentrations of water column pollutants. Some information and literature are available suggesting that decreasing nutrient loads to creeks by improving agricultural management practices may actually locally raise instream nutrient concentrations[217,218,219]. Thus, locally there could be a possibility that implementation of improved management practices could, in the short term, result in non-attainment of water quality standards. Cahn and Hartz (2010) noted that concentration data in creeks of agricultural watersheds may not always accurately reflect the progress individual farmers are making towards achieving water quality goals.

Therefore, the approach proposed in these TMDLs is to strive for pollutant load reduction strategies while continuing to collect additional data on receiving water concentrations, while recognizing that there may not always be a direct linkage between mass-based load reductions and instream concentrations of pollutants in grab samples. Regardless of the short or intermediate–term effects on instream flows and instream pollutant concentrations, pollution control efforts, such as improved nutrient and irrigation management, will ultimately have environmental and water quality benefits.

In recognition of the uncertainties highlighted above, other metrics that can provide insight on interim progress to reduce nutrient pollution may be utilized, for example:

- assessments of mass-based load reductions (e.g., tons of pollutant load reduced per year);
- improvements in flow-weighted concentrations;
- estimates of the scope and extent of implementation of improved management practices capable of ultimately achieving load allocations;

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[216] In a recent national study USGS researchers reported that legacy nutrients present in shallow groundwater may sustain high nitrate levels in some streams which are characterized by substantial groundwater inputs for decades to come (see Tesoriero, Duff, Saad, Spahr, and Wolock, 2013, *Vulnerability of Streams to Legacy Nitrate Sources.* Environmental Science and Technology, 2013, 47(8), pp. 3623-3629.).

[217] Pilot-scale field trials in Monterey County suggests that while substantial reduction in nitrogen loss from cropland are achievable with BMPs, there was not a corresponding reduction in nitrate leachate on a concentration (ppm) basis. Source: Michael Cahn, 2010, University of California Cooperative Extension, Monterey County, *Optimizing Irrigation and Nitrogen Management in Lettuce for Improving Farm Water Quality, Northern Monterey County*, Grant No. 20080408 project report.

[218] In a Utah TMDL, Tetra Tech, Inc. hypothesized that decreasing total dissolved solids (TDS) loads might actually raise instream TDS concentrations as a result of less dilution from surface return flows or more concentrated TDS in shallow groundwater (see Tetra Tech, Inc. 2002, *Uinta River, Deep Creek and Dry Gulch Creek TMDLs for Total Dissolved Solids*, prepared for: USEPA Region 8, State of Utah Department of Environmental Quality, and Ute Indian Tribe).

[219] Central Coast Water Quality Preservation, Inc. has noted that *"Reductions in farm discharges may first show reduced loading in tributaries, with reduced concentrations only in higher order streams"* (see CCWQP, 2012).

- improvements in receiving water nutrient-response indicators (i.e., dissolved oxygen, chlorophyll *a*, microcystins), independent of nutrient concentrations.

Water Board staff may conclude in future reviews that ongoing implementation efforts may be insufficient to ultimately achieve the allocations and numeric target. If this occurs, Water Board staff will recommend revisions to the implementation plan. Water Board staff may conclude and articulate in the reviews that implementation efforts and results are likely to result in achieving the allocations and numeric target, in which case existing and anticipated implementation efforts should continue. If allocations and numeric targets are being met, Water Board staff will recommend the waterbody be removed from the 303(d) list.

9.13 Optional Special Studies & Reconsideration of the TMDLs

Additional monitoring and voluntary optional special studies would be useful to evaluate the uncertainties and assumptions made in the development of these TMDLs. The results of special studies may be used to reevaluate waste load allocations and load allocations in these TMDLs. Implementing parties may submit work plans for optional special studies (if implementing parties choose to conduct special studies) for approval by the Executive Officer. Special studies completed and final reports shall be submitted for Executive Officer approval. Additionally, eutrophication is an active area of research. Consequently, ongoing scientific research on eutrophication and biostimulation may further inform the Water Board regarding waste load or load allocations that are protective against biostimulatory impairments, implementation timelines, and/or downstream impacts. At this time, staff maintains there is sufficient information to begin to implement these TMDLs and make progress towards attainment of water quality standards and the proposed allocations. However, in recognition of the uncertainties regarding nutrient pollution and biostimulatory impairments, staff proposes that the Water Board reconsider the waste load and load allocations, if merited by optional special studies and new research, ten years after the effective date of the TMDLs, which is upon approval by the OAL. A time schedule for optional studies and Central Coast Water Board reconsideration of the TMDL is presented in Table 9-3.

Further, the Central Coast Water Board may also reconsider these TMDLs, the nutrient water quality criteria, or other TMDL elements on the basis of potential future promulgation of a statewide nutrient policy for inland surface waters in the State of California.

Based on relevant future information, data, and research, the Water Board has the discretion to conduct a water quality standards review which may potentially include one or more of the following:

- The Water Board may designate critical low-flow conditions below which numerical water quality criteria do not apply, as consistent with federal regulations and policy[220].
- The Water Board may authorize lowering of water quality to some degree if and where appropriate, if the Water Board finds water quality lowering to be necessary to accommodate important economic or social development. In authorizing water quality lowering the Water Board shall make any such authorizations consistent with the provisions and requirements of federal and state anti-degradation policies.
- The Water Board may authorize revision of water quality standards, if appropriate and consistent with federal and state regulations, to remove a designated beneficial use, establishing subcategories of uses, establishing site specific water quality objectives, or other modification of the water quality standard[221]. When a standards action is deemed appropriate, the Water Board shall follow all applicable requirements, including but not limited to those set forth in part 131 of

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[220] See: U.S. Environmental Protection Agency, Water Quality Handbook, March 2012. EPA-823-8-12-002.

[221] See: Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options. California State Water Resources Control Board, June 16, 2005. Adopted by Resolution 2005-0050.

Title 40 of the Code of Federal Regulations and Article 3 of Division 7, Chapter 4 of the California Water Code.

Table 9-3. Proposed time schedule for optional studies and Water Board reconsideration of waste load allocations and load allocations.

Proposed Actions	Description	Time Schedule-Milestones
Optional studies work plans	Implementing parties shall submit work plans for optional special studies (if implementing parties choose to conduct special studies) for approval by the Executive Officer	By four years after the effective date of the TMDL
Final optional studies	Optional studies completed and final report submitted for Executive Officer approval.	By six years after the effective date of the TMDL
Reconsideration of TMDL	If merited by optional special studies or information from ongoing research into eutrophication issues, the Water Board will reconsider the Wasteload and Load allocations and/or implementation timelines adopted pursuant to this TMDL.	By eight years after the effective date of the TMDL

9.14 TMDL Achievement & Future Delisting Decisions

Achieving surface water nutrient reductions of the scale identified in this TMDL and in an agricultural watershed is necessarily subject to uncertainties.

Staff maintains it is prudent to allow for flexibility, adaptation, and re-assessment as appropriate. It also should be noted that immediate compliance with water quality objectives are not contemplated or required by TMDLs. Staff are proposing interim waste load and load allocations and benchmarks, and periodic re-consideration of the TMDL and appropriateness of the biostimulatory numeric water quality targets based on new research and information.

In terms of ultimately assessing TMDL achievement in waterbodies, evaluating exceedances of TMDL numeric targets identified herein (refer back to Section 6) and assessing future de-listing decisions to remove waterbodies from the CWA Section 303(d) list, staff will use the de-listing criteria and methodologies identified in Section 4 (California Delisting Factors) of the State Water Resources Control Board's *Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List* (i.e., "Listing Policy", State Water Board, 2004), or as consistent with any relevant revisions of the Listing Policy promulgated in the future pursuant to Government Code section 11353.

9.14.1 An Important Note about Nutrient Water Quality Targets & Allocations

The proposed nutrient water quality biostimulatory targets developed in this TMDL are predictions of the nutrient concentration levels necessary to be protective against biostimulation <u>*based on current conditions*</u>. However, recall that biostimulation is the result of a *combination of factors* (nutrients, flow and aeration, shading, canopy, etc.). Therefore, note that increased canopy shading, increased flow and aeration of stream water, and better water management can potentially achieve the same goal (better dissolved oxygen conditions, flushing of algae, etc.) regardless of whether the predicted biostimulatory nutrient targets and allocations herein are achieved. In other words, it is not necessary to be singularly focused on attempting to achieve the nutrient numeric water column concentration targets proposed in this TMDL, while disregarding other important factors that can limit the risk of biostimulation. In other words, a holistic approach to improve aquatic habitat and water quality can have corollary benefits in reducing the risk of biostimulation.

A goal of this TMDL is to address and mitigate biostimulatory impairments (as expressed by dissolved oxygen imbalances, excess algal biomass, and associated downstream impacts). In the future, if watershed conditions change (increased riparian canopy shading, better aeration of water column, better dissolved oxygen conditions in the water columns), it will be prudent to potentially reconsider proposed nutrient numeric targets proposed herein. Less stringent nutrient numeric targets are generally merited in cases where increased canopy shading and/or water column aeration in a stream are attained[222].

Additionally, attainment of receiving water TMDL numeric targets for nutrient-response indicators (i.e., dissolved oxygen water quality objectives, chlorophyll *a* targets and microcystin targets) may constitute a proxy demonstration of the attainment of the nitrate, nitrogen and orthophosphate-based seasonal biostimulatory wasteload and load allocations.

9.15 Success Stories, Case Studies, & Existing Implementation Efforts

Protecting California's water resources depends on the proactive engagement of citizens, land owners, researchers, and businesses. Proactive efforts by citizens in the Pajaro River basin that may result in improved water quality protection are commendable and should be recognized.

9.15.1 Pajaro River Basin Irrigation & Nutrient Management Grant Program

The purpose of this Proposition 50 water quality grant project was to implement agricultural irrigation and nutrient best management practices (BMPs) through technical, permitting, and cost-share assistance to serve as a model for agricultural BMP project development in the Pajaro River basin region. The project was a partnership between growers, private landowners, the Resource Conservation District of Santa Cruz County, the University of California Cooperative Extension, and others and implemented between the years 2010–2014 (Santa Cruz RCD, 2014). In an effort to target high priority watersheds, implementation sites were located in the Uvas Creek watershed, the Llagas Creek watershed, the Lower Pajaro River subwatershed, and the Watsonville Slough subwatershed. Overall, practices were implemented on 15 sites comprising a combined area of 108 acres. Implementation achieved average nitrogen load reductions of 47% and irrigation efficiency was improved by an average of 17% resulting in an average 13.3 pounds per acre reduction in nitrogen load per irrigation season. Further, all participating growers indicated they would be incorporating the successful management practices over their entire farms in the future.

9.15.2 Environmental & Water Quality Improvements, Watsonville Slough Subwatershed

Landowners, growers, and local stakeholders have been instrumental in achieving significant environmental and water quality improvments over the last decade in the Watsonville Slough system, as articulated below by Mr. Ross Clark, director of the Central Coast Wetlands Group:

> *Watsonville Slough, a rising star in wetland restoration*
> *By Ross Clark, Santa Cruz Sentinel, March 7, 2013*
>
> *Up until the 1990s, Watsonville Slough was treated as a burden, being ditched, drained, and filled by farms and urban development alike. Today, more than 450 acres of wetlands are protected and the slough is a natural centerpiece from which both farmer and urban dweller alike go about their business. This environmental success story traces back to the combined actions of many environmental partners and a number of early conservation and restoration efforts.*

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[222] Regardless of the levels of nutrients are appropriate protect against biostimulation and downstream biostimulatory impacts, nitrate water quality objectives must still be met to protect other beneficial uses (e.g., MUN-drinking water standards, GWR-groundwater recharge)

The Watsonville Slough Enhancement Plan, completed under the guidance of Donna Bradford, who works for Santa Cruz County, set the stage for today's success and spelled out many wetland restoration and property acquisition projects that have now come to completion. Twenty years ago I participated in one of the first wetland restoration projects on the Watsonville Slough, successfully converting 75 acres in the Hanson Slough from poor-quality farmland back into a freshwater wetland. That same year Watsonville Wetland Watch was founded to protect restore and educate the public on the environmental values of the slough.

Recently the Santa Cruz Land Trust made the significant purchase of a 450-acre working farm in the middle of the slough. The purchase ensures that the center of the slough will be protected from future development. The previous owners agreed to forgo their dreams of luxury homes and a golf course to ensure that agriculture and rural boundaries were maintained and that wetland and upland habitats were restored.

The Santa Cruz Land Trust purchase came with guarantees that the property would remain a working farm, with rental proceeds redirected back into the property and watershed for future conservation. All but 26 acres of the farm is organically farmed, with crops rotating between strawberries and leafy greens. Bryan Largay with the trust pointed out that, "at any time, 180 acres are in production and produce enough strawberries and leafy greens for 30,000 people to enjoy every day of year." The least productive 16 acres of farmland will be returned to wetlands.

Read more at:
http://www.santacruzsentinel.com/homeandgarden/ci_22739980/ross-clark-earth-matters-watsonville-slough-rising-star

9.15.3 Reducing Nutrient Loading From Vegetable Production (Field Trials)

This project was implemented by UC –Davis and University of California Cooperative Extension (project leaders: T.K. Hartz,, R Smith, and M. Cahn) and included three field trials conducted in drip-irrigated lettuce fields in northern Monterey County during the summer and fall of 2007. This project was undertaken to demonstrate the potential for reducing N and P fertilization rates in lettuce production while maintaining high yield and quality. Given the rapid adoption of drip irrigation in central coast vegetable production, and the fertilizer and irrigation efficiency that can be gained with this technology, all trials were conducted in drip-irrigated fields.

These trials documented that improved fertilizer management practices previously demonstrated in sprinkler-irrigated fields are equally applicable to drip-irrigated culture. The highly efficient drip irrigation scheduling done by the cooperating growers was an encouraging sign of improved management that could significantly reduce off-site nutrient loss. Such real-world examples of efficient irrigation management are helpful in our educational efforts with industry groups. The potential for significant reduction in fertilizer usage demonstrated in these trials suggests that continued grower education is required to convince the industry that current fertilization practices can be improved without risk of crop loss.

9.15.4 Integrated Regional Water Management Plan

The 2007 Pajaro River Watershed Integrated Regional Water Management Plan (IRWM) is a collaborative effort by the Pajaro Valley Water Management Agency, San Benito Water District, and the Santa Clara Valley Water District to identify regional projects and resource management strategies for the benefit of the Pajaro River Watershed. The water quality objectives identified in the Pajaro River Watershed IRWM include:

1. Meet or exceed all applicable groundwater, surface water, wastewater, and recycled water quality regulatory standards;
2. Protect or improve the quality of water supply sources;
3. Meet or exceed water quality targets established by stakeholders;
4. Aid in meeting TMDLs for the Pajaro River Watershed; and
5. Minimize impacts from stormwater through implementation of established Best Management Practices or other stormwater management plans.

The IRWM includes planning and implementation strategies to protect drinking water quality, agricultural water quality, improve nutrient management, and to protect and restore ecological systems, including preserving the environmental health of the Pajaro River Watershed by identifying opportunities to restore and enhance natural resources of streams, watersheds, wetland, and the Monterey Bay.

9.15.5 Pajaro Valley Water Management Agency Irrigation Efficiency Webpage

The Pajaro Valley Water Management Agency maintains a webpage with copious amounts of information and educational materials pertaining to irrigation efficiency and agricultural water management. The webpage is located at:

http://www.pvwma.dst.ca.us/conservation/agriculture.php

9.15.6 Santa Clara Valley Water District Fertilizer Management Fact Sheets

The Santa Clara Valley Water District in conjunction with the Monterey County Water Resources Agency has published fact sheets on the following topics:

Fact Sheet 1- Fertilizer Management for Cool-Season Vegetables
Fact Sheet 2- On Farm Handling of Fertilizers
Fact Sheet 3- Water Management for Cool-Season Vegetables
Fact Sheet 4- Using Nitrate Present in Soil/Water in Fertilizer Calculations
Fact Sheet 5- On Farm Nitrogen Determination Sap, Soil and Water

These fact sheets are available online from the Pajaro Valley Water Management Agency at:

http://www.pvwma.dst.ca.us/conservation/agriculture.php

9.15.7 Pajaro Valley Community Water Dialogue

This is a community forum consisting of Pajaro Valley stakeholders whose goal, in part, is to identify and implement sustainable agricultural land management and irrigation best practices. Pilot projects include precision irrigation practices and soil moisture monitoring currently utilized by some prominent berry growers in the Pajaro Valley.

http://www.pajarowatershed.org/Content/10111/CommunityWaterDialogue.html

9.15.8 California Farm Water Success Stories (Pacific Institute)

The Pacific Institute (a non-profit research and policy analysis organization) has created an interactive database and map, which contains more than 30 case studies of reported farm water quality success stories in California. The database is searchable by location, production type, irrigation method, and stewardship practice. The online database may be accessed at:
http://www.agwaterstewards.org/index.php/case-studies

These California farm water success stories are highlighted and articulated by Dr. Juliet Christian-Smith of the Pacific Institute, as shown below:

> *"Farmers, irrigation districts, and local organizations are finding innovative ways to protect water quantity and quality, saving energy and saving money, augmenting stream flows, and storing water for inevitable drought periods," said the Pacific Institute's Dr. Juliet Christian-Smith. "To claim it can't be done, or that there isn't more we can do, just doesn't make sense. These case studies show how, and are a great practical resource."*
>
> *http://pacinst.org/publication/california-farm-water-success-stories-2/*

9.16 Cost Estimates

9.16.1 Preface

Note that in the case of this TMDL, impairments due to exceedances of *existing* State water quality objectives are being addressed. Although the State must consider a variety of factors in establishing the different elements of a TMDL, considering the economic impact of the required level of water quality is not among them. The State Water Board Office of Chief Counsel notes that the economic impact was already previously determined when the water quality standard was adopted[223] consistent with Water Code Section 13241 and pursuant to the basin planning process. The statutory directive under the federal Clean Water Act to adopt TMDLs to "implement the applicable water quality standards" is not qualified by the predicate "so long as it is economically desirable to do so." This conclusion is not altered when a TMDL is established to implement a narrative water quality objective (State Water Board, Office of Chief Counsel, 2002). Therefore, not only would an in-depth economic analysis be redundant, it would be inconsistent with federal law (State Water Board, Office of Chief Counsel, 2002). Further, the State Water Board Office of Chief Counsel states that under the Porter-Cologne Water Quality Control Act §13141 (i.e., implementation of agricultural water quality control programs), the Regional Boards "are not required to do a formal cost-benefit analysis" under the statute. This statute focuses only on costs and financing sources (State Water Board, Office of Chief Counsel, 1999).

9.16.2 Cost Estimates for Irrigated Agriculture

In accordance with §13141 of the Porter-Cologne Water Quality Control Act, prior to implementation of any agricultural water quality control program the Water Boards are required to estimate the *total* cost of such a program and potential sources of funding (see Section 9.17 for an outline of potential funding sources). It should be noted that the statute does not require the Water Boards to do, for example, a cost-benefit analysis or an economic analysis (refer back to Section 9.16.1).

Load allocations for irrigated cropland are proposed to be implemented using an existing regulatory tool – the Agricultural Order. As such, the extent this TMDL would incur incremental costs – if any – above and beyond what is already required in the Agricultural Order is necessarily subject to significant uncertainty.

Further, it is should be recognized that implementation measures to reduce nutrient pollution from irrigated agriculture are already required in the Pajaro River basin by compliance with an existing regulatory program [Agricultural Order No. R3-2012-0011 including any pending and future renewals of the Order]. Compliance with these implementation measures are required *with or without* the TMDL and are therefore not attributable to TMDL implementation As outlined in Section 9.3, this TMDL is relying on the Agricultural Order for TMDL implementation, and this TMDL is not proposing the adoption of new regulatory tools for irrigated cropland. To a significant extent, the proposed TMDL can be considered an informational tool to focus and facilitate implementation, and assist the Central Coast Water Board in making its plan to implement state water quality standards.

Also noteworthy, the cost estimates in TMDLs do not require economic cost-benefit analysis (see §13141 of the Porter-Cologne Water Quality Control Act; and State Water Board, Office of Chief Counsel, 1997). These estimates thus constitute gross expenses which do not contemplate potential net cost-savings associated with TMDL implementation measures (for example long-term savings associated with improved irrigation and nutrient efficiency).

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[223] State Water Resources Control Board, Office of Chief Counsel, memo June 12, 2002: *"The Distinction Between a TMDL's Numeric Targets and Water Quality Standards"*

In addition, some of the implementation costs likely will not constitute direct out-of-pocket expenses to growers, as the state and federal government have made funding sources, incentive payments, and grants available to address nonpoint sources of pollution and to implement TMDLs – see Section 9.17. For example, recently just one grant funding source (i.e., the Proposition 50 Agricultural Water Quality Grant Program) made $1,250,000 available to assist growers with irrigation and nutrient management in the Pajaro River basin.

Indeed, the State Water Resources Control Board recently issued a draft Water Quality Order explicitly concluding that generally, TMDL implementation does not incur additional costs above and beyond what is already in the Agricultural Order:

> *"[A] discharger's implementation of the Agricultural Order will constitute compliance with certain applicable TMDLs.* ***In other words, the TMDL provision does not lead to any costs above and beyond what is already required by the Agricultural Order. In addition, the Agricultural Order is simply the implementation vehicle for TMDL compliance**** *– it does not require dischargers to do anything more than would be required of them under the applicable TMDLs"*
>
> ** emphasis added*
>
> *From: California State Water Resources Control Board, Draft Water Quality Order, Change Sheet #1 (Circulated 09/19/12) In the Matter of the Petitions Of Ocean Mist Farms And Rc Farms; Grower-Shipper Association Of Central California, Grower-Shipper Association Of Santa Barbara And San Luis Obispo Counties, And Western Growers For Review of Conditional Waiver of Waste Discharge Requirements Order No. R3-2012-0011 Discharges from Irrigated Lands*

However, because of the magnitude and scope of nutrient pollution in the Pajaro River basin, staff anticipates a higher degree and scope of nutrient pollution mitigation measures will occur in the river basin - either voluntarily, due to targeted grant funding, or due to TMDL implementation - relative to other areas of California's central coast region. Therefore, staff concludes it would be prudent to develop estimates associated with potential incremental costs pertaining to attainment of water quality standards for nutrients and TMDL implementation.

Cost estimates to comply with the existing Agricultural Order have previously been developed (Central Coast Regional Water Quality Control Board, 2011). It should be noted that these were scoping level assessments because it is difficult to estimate precise costs because of the absence of information about the current extent of management practices implementation, and how the costs of the Agricultural Order would represent incremental increases above current costs. Water Board Agricultural Program staff therefore applied best professional judgment and conservative assumptions in constructing an estimate of total cost for management practice implementation for the Agricultural Order. The assumptions and information that went into developing the Agricultural Order cost estimates can be found in: *Central Coast Regional Water Quality Control Board. 2011. Technical Memorandum: Cost Considerations Concerning Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands; in: Appendix F – Staff Recommendations for Agricultural Order (March, 2011).* Table 9-4 presents the cost estimates to implement the Agricultural Order throughout the entire Central Coast Region.

Table 9-4. Cost estimates to implement Agricultural Order for CENTRAL COAST REGION (2011).

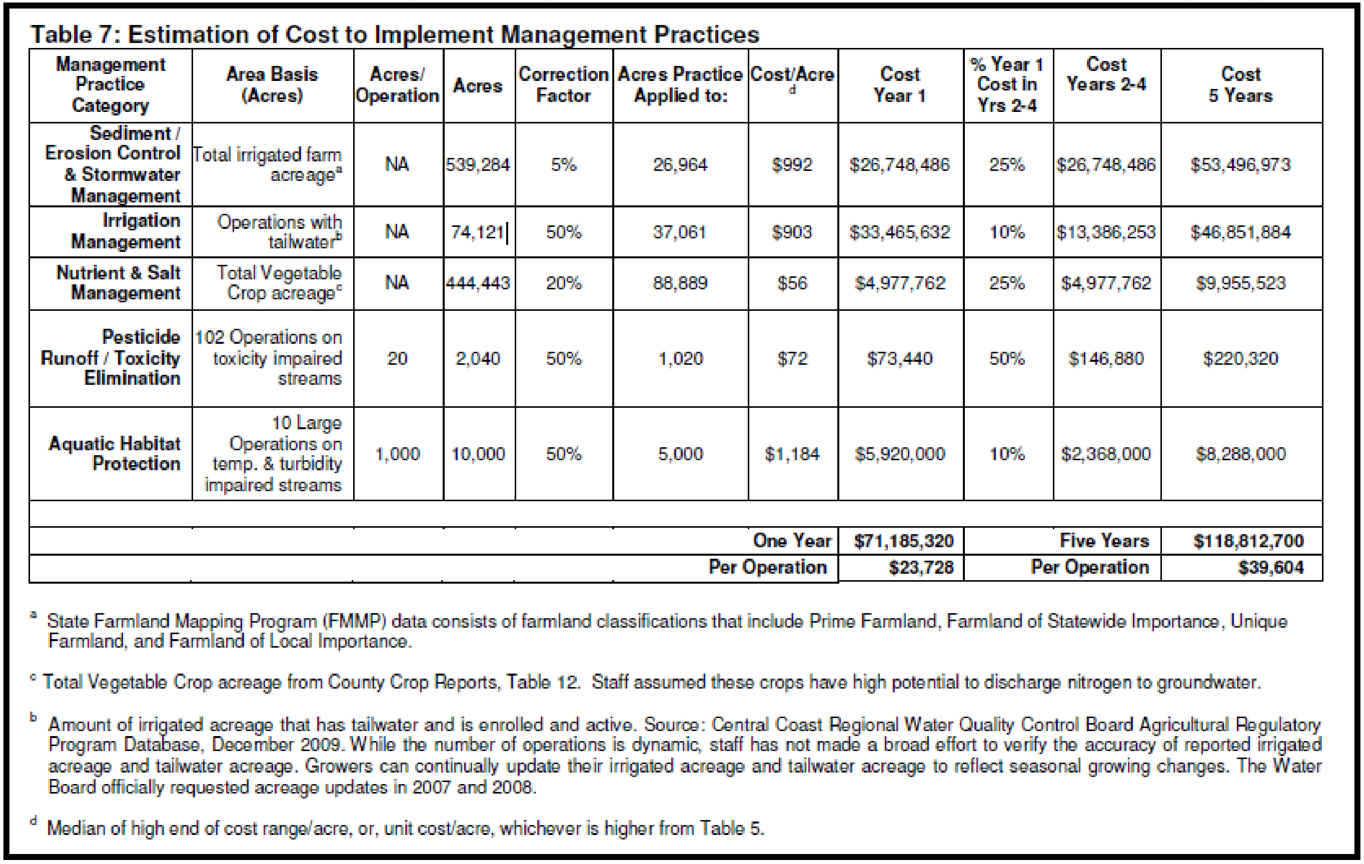

Table 7: Estimation of Cost to Implement Management Practices

Management Practice Category	Area Basis (Acres)	Acres/ Operation	Acres	Correction Factor	Acres Practice Applied to:	Cost/Acre [d]	Cost Year 1	% Year 1 Cost in Yrs 2-4	Cost Years 2-4	Cost 5 Years
Sediment / Erosion Control & Stormwater Management	Total irrigated farm acreage[a]	NA	539,284	5%	26,964	$992	$26,748,486	25%	$26,748,486	$53,496,973
Irrigation Management	Operations with tailwater[b]	NA	74,121	50%	37,061	$903	$33,465,632	10%	$13,386,253	$46,851,884
Nutrient & Salt Management	Total Vegetable Crop acreage[c]	NA	444,443	20%	88,889	$56	$4,977,762	25%	$4,977,762	$9,955,523
Pesticide Runoff / Toxicity Elimination	102 Operations on toxicity impaired streams	20	2,040	50%	1,020	$72	$73,440	50%	$146,880	$220,320
Aquatic Habitat Protection	10 Large Operations on temp. & turbidity impaired streams	1,000	10,000	50%	5,000	$1,184	$5,920,000	10%	$2,368,000	$8,288,000
						One Year	**$71,185,320**		**Five Years**	**$118,812,700**
						Per Operation	**$23,728**		**Per Operation**	**$39,604**

[a] State Farmland Mapping Program (FMMP) data consists of farmland classifications that include Prime Farmland, Farmland of Statewide Importance, Unique Farmland, and Farmland of Local Importance.

[c] Total Vegetable Crop acreage from County Crop Reports, Table 12. Staff assumed these crops have high potential to discharge nitrogen to groundwater.

[b] Amount of irrigated acreage that has tailwater and is enrolled and active. Source: Central Coast Regional Water Quality Control Board Agricultural Regulatory Program Database, December 2009. While the number of operations is dynamic, staff has not made a broad effort to verify the accuracy of reported irrigated acreage and tailwater acreage. Growers can continually update their irrigated acreage and tailwater acreage to reflect seasonal growing changes. The Water Board officially requested acreage updates in 2007 and 2008.

[d] Median of high end of cost range/acre, or, unit cost/acre, whichever is higher from Table 5.

Staff endeavored to estimate incremental costs associated with implementing the proposed TMDLs, by using the cost estimate information in Table 9-4. Accordingly staff: (1) scaled acreage in Table 9-4 requiring implementation down to the scale of the Pajaro River basin; and (2) staff scaled up some of the correction factors[224] found in Table 9-4 in recognition of the fact that the magnitude of nutrient pollution in the Pajaro River basin exceeds most other areas of the central coast region and likely will require more concerted and sustained efforts to address, and thus is not necessarily comparable to an "average" estimate for the central coast region at large. These scalar modifications are presented in Table 9-5.

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[224] Correction factors are an estimate of the ratio of irrigated acres that might be subject to actual management to reduce pollutant discharges.

Table 9-5. Farmland acreage and correction factors for Central Coast Region vs. TMDL project area.

	Amount of farmland[A] (acres)	Central Coast Regional Correction Factor[B] Used for Agricultural Order	Correction Factor used for Pajaro River Basin	Basis for Scaling Up Correction Factor in Pajaro River Basin
Central Coast Region (Region 3)	738,429	50%	**50%**	Not scaled up: Pajaro River basin growers have reportedly already substanitally improved irrigation efficiency in recent years.
Pajaro River Basin	97,114	20%	**60%**	Scaled up by factor of 3 Magnitude of nutrient pollution in surface waters and groundwater in the Pajaro River basin will require more concerted efforts to address than in many other central coast watersheds.
Farmland Acreage Ratio: Farmland in Pajaro River Basin compared to all of Region 3	13% Ratio: TMDL Project Area compared to Region 3	50%	**100%**	Scaled up by factor of 2 Magnitude of nutrient pollution in surface waters and groundwater in the TMDL project area will require more concerted efforts to address than in many other central coast watersheds.

[A] source: DWR Farmland Mapping and Monitoring Program, 2008

[B] correction factors are an estimate of the ratio of irrigated acres that might be subject to actual management to reduce pollutant discharges.

Based on geographically scaling the 2011 Agricultural Order's regional compliance costs estimates to the scale of the Pajaro River basin, as outlined above, Table 9-6 presents the estimated compliance costs associated with the Agricultural Order that may be incurred for farmland within the Pajaro River basin.

Table 9-6 illustrates estimated summed costs are that are associated with compliance with the Agricultural Order, plus incremental costs potentially attributable to TMDL implementation.

Table 9-6. Cost estimates associated with Agricultural Order compliance and nutrient TMDL implementation in the Pajaro River (2011 dollars).

Management Practice Category	Area Basis (Acres)[A]	Acres	Correction Factor	Acres Practice Applied to:	Cost per Acre	Cost - Year 1 of TMDL Implementation	% Year 1 Cost in Yrs 2-5	Cost Years 2-5	Compliance Cost 5 Years
Irrigation Management	12% of corresponding acreage from Table 9-4	9,635	50%	4,817	$903	$4,349,751	10%	$1,739,900	$6,089,651
Nutrient Management	12% of corresponding acreage from Table 9-4	57,778	60%	34667	$56	$1,941,341	25%	$1,941,341	$3,882,682
Aquatic Habitat Protection	12% of corresponding acreage from Table 9-4	1,300	100%	1,300	$1,184	$1,539,200	10%	$615,680	$2,154,880

[A] The 13% fraction in this column is the ratio (%) of farm acres in the Pajaro River basin to farm acres in all of the central coast region

Based on the information presented in Table 9-6, the total costs associated with agricultural order compliance and TMDL implementation for a period of five years is approximately 12 million dollars. As discussed previously, this estimate is subject to significant uncertainty, however staff endeavored to use available information to develop these estimates in an effort to inform the interested public and decisions makers.

Based on information in the 2011 technical documentation for the Agricultural Order and information developed in this section, an estimated cost attributable to compliance with the Agricultural Order and TMDL implementation in the Pajaro River basin over 5 years is approximately **$12 million.** This represents, on average, an estimated unit-area gross cost of **$125 per acre of farmland*** (2011 dollars) in the Pajaro River basin over a period of five years of compliance and implementation.

***** *as represented by the Calif. Dept. of Water Resource's 2010 farmland mapping and monitoring spatial dataset*

9.16.3 Cost Estimates of BMPs for MS4 Entities

Anticipating incremental costs attributable specifically to TMDL implementation with any accuracy is challenging for several reasons. Many of the actions, such as review and revision of policies and ordinances by a governmental agency, could incur no significant costs beyond the program budgets of those agencies. However, other actions, such as establishing nonpoint source implementation programs and establishing assessment workplans carry discrete costs.

Cost estimates are further complicated by the fact that some implementation actions are necessitated by other regulatory requirements (e.g., Phase II Stormwater) or are actions anticipated regardless of whether or not the TMDL is adopted. Therefore assigning all of these costs to TMDL implementation would be inaccurate. It also is important to note that reported MS4 program costs are not all attributable to compliance with MS4 permits. Many program components, and their associated costs, existed before any MS4 permits were issued. For example, street sweeping and trash collection costs cannot be solely or even principally attributable to MS4 permit compliance, since these practices have long been implemented by municipalities. Therefore, true program cost resulting from MS4 permit requirements is some fraction of reported costs,

Guidance and information on preparing scoping-level cost estimations were provided to staff by Brandon Steets, P.E. of Geosyntec Consultants. Geosyntec Consultants is an engineering firm with substantial experience assisting MS4 entities in California with TMDL implementation. Estimated BMP capital and O&M costs are available in Technical Appendix C of the Strategic BMP Planning and Analysis Tool (SBPAT)[225]. SBPAT is a public domain, water quality analysis tool intended to facilitate the selection of BMP project opportunities and technologies in urban watersheds. These estimated unit BMP capital costs and annual maintenance costs are presented in Figure 9-1 and Figure 9-2, respectively. These tables are from the SBPAT technical appendix C.

Unit-area costs are based on cost per treated acre for a specific management practice. It would be highly speculative for staff to identify what percentage of the area of the MS4 footprint would require implementation, and what percentage of this area will receive implementation with or without a TMDL, due to to permits which exist independent of the TMDL and/or other ongoing environmental projects. Implementation over 100% of the MS4 footprint is clearly impractical and cost-prohibitive. Implementation will undoubtedly be focused on areas or land uses that are identified as water quality risks and require implementation. Therefore, it is presumed that implemenation, on a unit-area basis, will occur over catchement areas that are substantially smaller than the footprint of the MS4.

Geosyntec consultants suggested that for urban nutrient pollution control, Water Board staff should primarily focus on unit-area costs associated with bioretention and wetland treatement strategies (refer again to Figure 9-1 and Figure 9-2). Some these management strategies could represent entirely new practices associated with TMDL implementation that might not occur under existing permit requirements or as associated with other non-regulatory watershed improvement projects. Therefore, some unit-area costs potentially associated with strategies to implement the TMDL can be estimated. This approach is consistent with legal guidance from the State Water Resources Control Board's Office of Chief Counsel, whom have stated that economic considerations in a TMDL should determine: 1) what methods of

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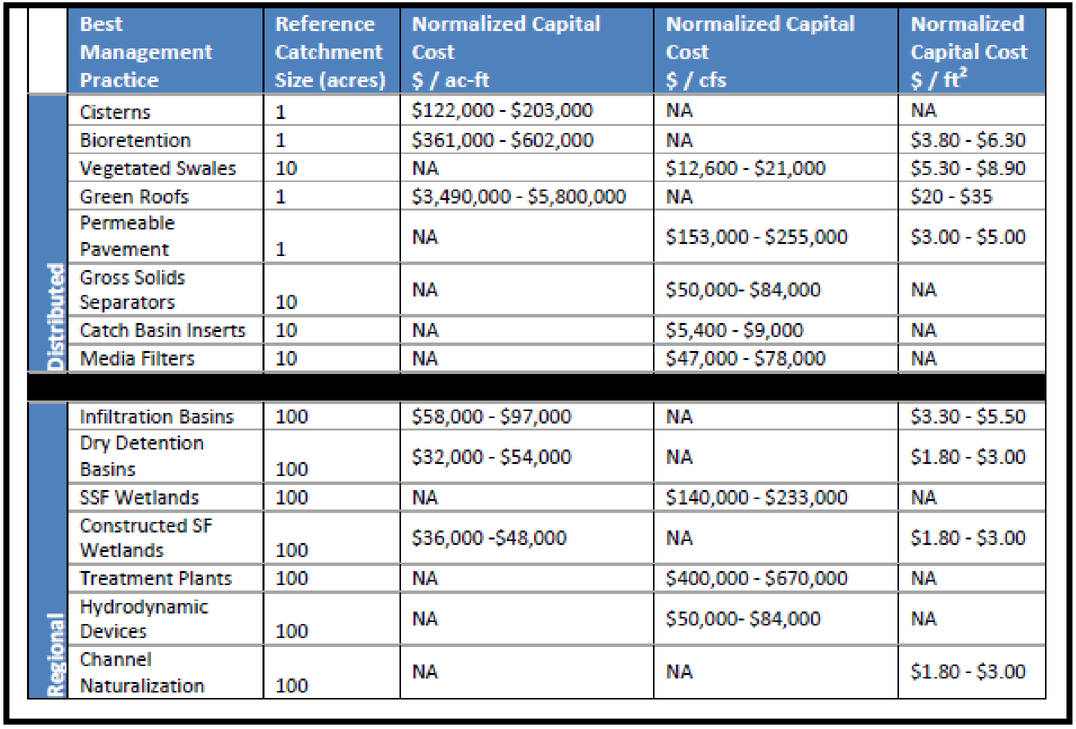
[225] Online linkage: http://www.sbpat.net/

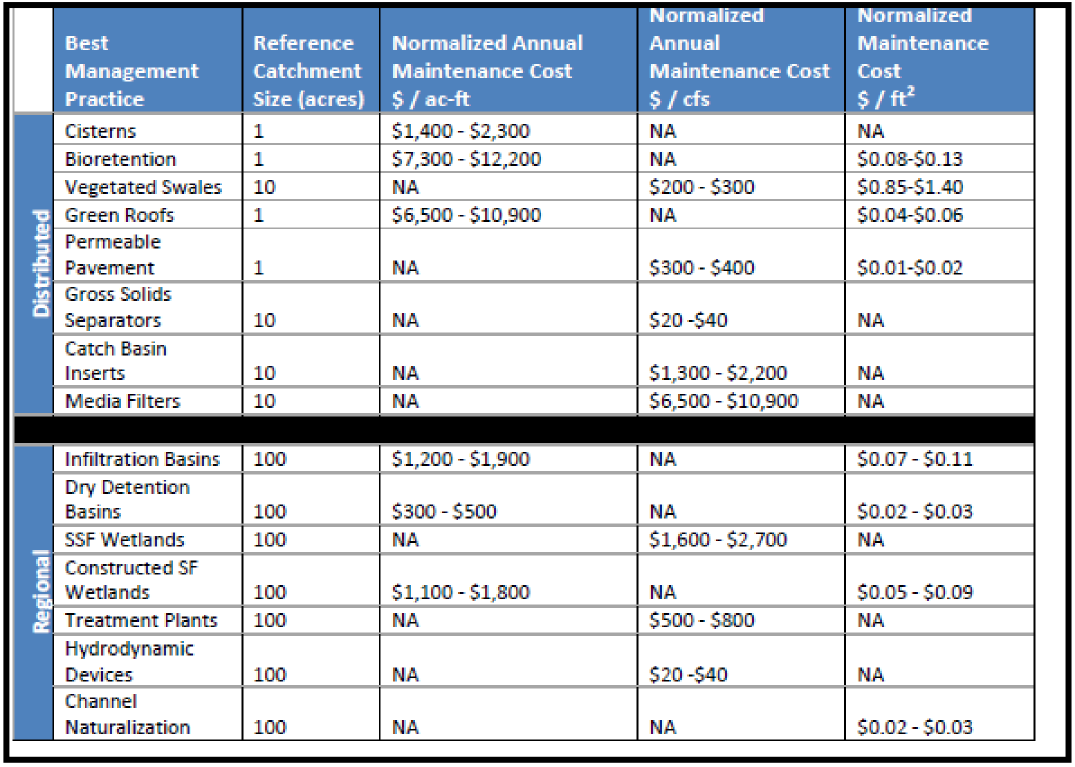
compliance are reasonably foreseeable to attain the allocations; and 2) what are the *costs of these methods* (State Water Board, 1999b).

Figure 9-1. Estimated unit BMP capital costs by design volume, flow rate, and footprint area (2008 dollars).



	Best Management Practice	Reference Catchment Size (acres)	Normalized Capital Cost $ / ac-ft	Normalized Capital Cost $ / cfs	Normalized Capital Cost $ / ft²
Distributed	Cisterns	1	$122,000 - $203,000	NA	NA
	Bioretention	1	$361,000 - $602,000	NA	$3.80 - $6.30
	Vegetated Swales	10	NA	$12,600 - $21,000	$5.30 - $8.90
	Green Roofs	1	$3,490,000 - $5,800,000	NA	$20 - $35
	Permeable Pavement	1	NA	$153,000 - $255,000	$3.00 - $5.00
	Gross Solids Separators	10	NA	$50,000- $84,000	NA
	Catch Basin Inserts	10	NA	$5,400 - $9,000	NA
	Media Filters	10	NA	$47,000 - $78,000	NA
Regional	Infiltration Basins	100	$58,000 - $97,000	NA	$3.30 - $5.50
	Dry Detention Basins	100	$32,000 - $54,000	NA	$1.80 - $3.00
	SSF Wetlands	100	NA	$140,000 - $233,000	NA
	Constructed SF Wetlands	100	$36,000 -$48,000	NA	$1.80 - $3.00
	Treatment Plants	100	NA	$400,000 - $670,000	NA
	Hydrodynamic Devices	100	NA	$50,000- $84,000	NA
	Channel Naturalization	100	NA	NA	$1.80 - $3.00

Figure 9-2. Estimated unit BMP annual maintenance costs by design volume, flow rate, and footprint area (2008 dollars).



	Best Management Practice	Reference Catchment Size (acres)	Normalized Annual Maintenance Cost $ / ac-ft	Normalized Annual Maintenance Cost $ / cfs	Normalized Maintenance Cost $ / ft²
Distributed	Cisterns	1	$1,400 - $2,300	NA	NA
	Bioretention	1	$7,300 - $12,200	NA	$0.08-$0.13
	Vegetated Swales	10	NA	$200 - $300	$0.85-$1.40
	Green Roofs	1	$6,500 - $10,900	NA	$0.04-$0.06
	Permeable Pavement	1	NA	$300 - $400	$0.01-$0.02
	Gross Solids Separators	10	NA	$20 -$40	NA
	Catch Basin Inserts	10	NA	$1,300 - $2,200	NA
	Media Filters	10	NA	$6,500 - $10,900	NA
Regional	Infiltration Basins	100	$1,200 - $1,900	NA	$0.07 - $0.11
	Dry Detention Basins	100	$300 - $500	NA	$0.02 - $0.03
	SSF Wetlands	100	NA	$1,600 - $2,700	NA
	Constructed SF Wetlands	100	$1,100 - $1,800	NA	$0.05 - $0.09
	Treatment Plants	100	NA	$500 - $800	NA
	Hydrodynamic Devices	100	NA	$20 -$40	NA
	Channel Naturalization	100	NA	NA	$0.02 - $0.03

Therefore, for implementation of these TMDLs by MS4 entities, a range of unit costs to implement bioretention and vegetated and wetland treatments strategies are estimated to range as shown in Table 9-7.

Table 9-7. Unit costs for MS4 TMDL implementation (2008 dollars)

Implementation Strategy Methods	Costs of Method
SSF wetlands (subsurface flow wetlands)	➢ Estimated Normalized Capital Costs ($/cfs): $140,000 - $233,000 ($/cfs) to treat 100 acres of catchment size. ➢ Estimated Annual Maintenance Cost ($/cfs): $1,600 - $2,700 ($/cfs) to treat 100 acres of catchment size.
Constructed SF wetlands (surface flow wetlands)	➢ Estimated Normalized Capital Costs ($/ft^2): $1.80 - $3.00 ($/ft^2) to treat 100 acres of catchment size. ➢ Estimated Annual Maintenance Cost ($/ft^2): $0.05 to $0.09 ($/ft^2) to treat 100 acres of catchment size.
Channel Naturalization	➢ Estimated Normalized Capital Costs ($/ft^2): $1.80 - $3.00 ($/ft^2) to treat 100 acres of catchment size. ➢ Estimated Annual Maintenance Cost ($/ft^2): $0.02 to $0.03 ($/ft^2) to treat 100 acres of catchment size

9.17 Sources of Funding

In accordance with §13141 of the Porter Cologne Water Quality Control Act, prior to implementation of any agricultural water quality control program the Water Board is required to identify potential sources of funding. Accordingly, in this section, staff provides some examples of funding sources. Potential sources of financing to TMDL implementing parties include the following:

9.17.1 Regional Conservation Partnership Program (2014 Federal Farm Bill)

According to a news release from the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS), funding is availalble to landownders in the Pajaro Valley pursuant to the Regional Conservation Partnership Program newly created in the 2014 Farm Bill. The project will provide assistance to local growers to implement conservation practices that reduce groundwater pumping, increase aquifer recharge, and protect surface water quality by reducing nitrate leaching into groundwater. Interested growers and landowners can contact Mr. Rich Casale, District Conservationist, at the Santa Cruz County USDA NRCS office at (831) 475-1967 or Richard.casale@ca.usda.gov. *Note that NRCS services are available free of charge and are non-regulatory. All information is kept confidential.*

9.17.2 State Water Resources Control Board - 319(h) Grant Program

The Division of Financial Assistance administers water quality improvement programs for the State Water Board. The programs provide grant and loan funding to reduce nonpoint source pollution discharge to surface waters. The Division of Financial Assistance currently administers two programs that improve water quality—the Agricultural Drainage Management Loan Program and the Agricultural Drainage Loan Program. Both of these programs were implemented to address the management of agricultural drainage into surface water. The Agricultural Water Quality Grant Program provides funding to reduce or eliminate the discharge of nonpoint source pollution from agricultural lands into surface and groundwater. It is currently funded through bonds authorized by Proposition 84. The State Water Pollution Control State Revolving Fund Program also has funding authorized through Proposition 84. It provides loan funds to a wide variety of point source and nonpoint source water quality control activities. The State Water Board also administers Clean Water Act funds that can be used for agricultural water quality improvements.

More information about the 319(h) Grant Program is available from the California State Water Resources Control Board site at SWRCB 319(h) NPS Grant Program, or contact Mathew Freesel, State Board Division of Water Quality, 319(h) Grants Program at (916) 341-5485.

9.17.3 Agricultural Water Quality Grant Program

The Agricultural Water Quality Grant Program provides funding for projects that reduce or eliminate non-point source pollution discharge to surface waters from agricultural lands. Funding from Propositions 40 and 50 were administered through two solicitations, most recently the 2005-2006 Consolidated Grants Process. Additional funds will be made available in the future through Proposition 84. More information on the Agricultural Water Quality Grant Program is available from the State Water Resources Control Board

9.17.4 Proposition 1 (2014 Water Bond)

Proposition 1 authorized billions of dollars for water projects including surface and groundwater storage, ecosystem and watershed protection and restoration, and drinking water protection. The State Water Resources Control Board will administer Proposition 1 funds for five programs. Stakeholders specifically interested in ecosystem and watershed restoration and protection aspects of Prop 1, should consider the Ocean Protection Council (OPC), State Coastal Conservancy, Wildlife Conservation Board, and Department of Fish and Wildlife administered funds.

9.17.5 Other Sources of Funding for Growers and Landowners

The local Resource Conservation District offices can provide access to and/or facilitate a land owners application for federal cost-share assistance through various local, state and federal funding programs. For certain projects the RCD may also be able to apply for other grant funds on behalf of a cooperating landowner, grower or rancher. More information is available from the Santa Cruz County Resource Conservation District, the Loma Prieta Resource Conservation District, the San Benito Resource Conservation District, or the Monterey County Resource Conservation District.

7 PUBLIC PARTICIPATION

7.1 Public Meetings & Stakeholder Engagement

Public outreach and public involvement are a part of TMDL development and the basin planning process. Over the past three years, staff of the Central Coast Regional Water Quality Control Board (Central Coast Water Board) implemented a process to inform and engage interested persons about this TMDL project. We provided regular TMDL updates and solicited public feedback via our stakeholder email subscription list consisting of over 350 stakeholders representing a wide range of interests. We periodically posted interim TMDL progress reports on the Central Coast Water Board's website with the intent of sharing our progress with stakeholders as we moved forward with TMDL development. We conducted public workshops in the City of Watsonville in August 2012, December 2013, and in the City of Gilroy on April 2, 2015, and Central Coast Water Board staff engaged with stakeholders during the development of the TMDL through email correspondence and telephone contact. Individuals and entities Central Coast Water Board staff engaged with during public workshops or during TMDL development included representatives of the following:

- Pajaro Valley Water Management Agency staff
- Central Coast Water Quality Preservation, Inc.
- County of Santa Cruz staff
- Representatives of South County Regional Wastewater Authority
- City of Watsonville staff
- City of Gilroy staff

- City of Hollister staff
- Central Coast Ag Water Quality Coalition
- U.S. Department of Agriculture, Natural Resources Conservation Service staff
- Representatives of the Santa Clara County Division of Agriculture
- Representatives of commercial farms, vineyards, nurseries, and ranches
- Agricultural consultants
- Consultants representing County of Santa Clara's stormwater program
- U.S. Environmental Protection Agency staff
- Fisheries biologists from San Jose State University and the National Marine Fisheries Service
- Coastal Watershed Council
- Friends of Pinto Lake
- Other individuals and local residents interested in Pajaro River basin water quality

Central Coast Water Board staff conducted a California Environmental Quality Act (CEQA) stakeholder scoping meeting on December 17, 2013. Central Coast Water Board staff addressed questions and comments from attendees.

In particular, staff would like to thank the Pajaro Valley Water Management Agency, the City of Watsonville, and the Cooperative Monitoring Program for providing data we used to supplement TMDL development. We acknowledge the data and commend the efforts of many other entities, groups, researchers, and volunteers involved in water quality monitoring in the Pajaro River basin. Special thanks also go to Robert Ketley City of Watsonville, Joel Casagrande National Marine Fisheries Service, and Dr. Jerry Smith San Jose State University, for feedback and for photo documentation.

Central Coast Water Board staff's efforts to inform and involve the public included a public comment period. The staff report, resolution, basin plan amendment, and TMDL report were made available for a 45-day public comment period commencing on **March 11, 2015.** This provided interested parties an opportunity to provide comment prior to any Central Coast Water Board hearing regarding these TMDLs. Staff solicited public comments from a wide range of stakeholders including owners/operators of agricultural operations, representatives of the agricultural industry, representatives of environmental groups, academic researchers and resource professionals, representatives of local, state, and federal agencies, representatives of municipal wastewater treatment facilities, representatives of city and county stormwater programs, representatives of NPDES–permitted industrial and construction facilities, ranchers and representatives of the livestock industry, managers and representatives of local golf courses, representatives of Native American tribal groups, representatives of environmental justice groups, and other individuals and groups interested in the water quality of streams in the Pajaro River basin.

Central Coast Water Board staff received two comment letters from:

1. Mr. Saeid Vaziry, P.E., Environmental Programs Manager, South County Regional Wastewater Authority, Gilroy, in an email attachment received April 22, 2015.
2. Ms. Janet Parrish, TMDL Liaison, U.S. Environmental Protection Agency Region IX, San Francisco, in an email attachment received April 23, 2015.

The public comments received and Central Coast Water Board staff responses are included in in the documentation of this TMDL project. Central Coast Water Board staff appreciates the comments provided by these interested parties. Some of the comments prompted us to clarify and improve information and narrative in the TMDL project documents.

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