California Regional Water Quality Control Board
Central Coast Region

Total Maximum Daily Loads for Nitrogen Compounds and Orthophosphate

for the

Lower Salinas River and Reclamation Canal Basin, and the Moro Cojo Slough Subwatershed, Monterey County, California

Final Project Report

Prepared January 8, 2013
for the
January 31−February 1, 2013 Water Board Meeting

Adopted by the
California Regional Water Quality Control Board
Central Coast Region
on ______________, 2013

and the
United States Environmental Protection Agency
on ________________, 2013

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http://www.waterboards.ca.gov/centralcoast/water_issues/programs/tmdl/docs/salinas/nutrients/index.shtml

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List of Acronyms and Abbreviations

This report contains numerous acronyms and abbreviations. In general, staff wrote an acronym or abbreviation in parentheses following the first time a title or term was used. Staff wrote the acronym/abbreviation in place of that term from that point throughout this report. The following alphabetical list of acronyms/abbreviations used in this report is provided for the convenience of the reader:

Basin Plan	Water Quality Control Plan for the Central Coast Region
BMP	Best Management Practice
CCAMP	Central Coast Ambient Monitoring Program
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CMP	Cooperative Monitoring Program
CSUMB	Calif. State University-Monterey Bay
CWA	Clean Water Act
DFG (or CDFG)	Calif. Dept. of Fish and Game
DHS	California Department of Health Services
DO	Dissolved oxygen
DWR	California Department of Water Resources
ESNERR	Elkhorn Slough National Estuarine Research Reserve
FMMP	Farmland Mapping and Monitoring Program
GWAVA	Ground-Water Vulnerability Assessment (USGS)
HSG	Hydrologic Soil Group
HUC	Hydrologic Unit Code
LA	Load allocation
LOBO	Land/Ocean Biogeochemical Observatory
MBARI	Monterey Bay Aquarium Research Institute
MMs	Management measures
MS4	Municipal Separate Storm Sewer System
NASS	National Agricultural Statistics Service
NCDC	National Climatic Data Center
NHD	National Hydrography Dataset
NMFS	National Marine Fisheries Service (NOAA)
NOAA	National Oceanic and Atmospheric Administration
NO3	Nitrate
NO3-N or NO3 as N	Nitrate as Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
OSDS	Onsite Waste Disposal System
PO4	Phosphate
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RCD	Resources Conservation District
SCCC-ESU	South-central California Coast Evolutionary Significant Unit
SSURGO	Soil Survey Geographic Database
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWRCB	State Water Resources Control Board (State Board)
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TP	Total phosphorus
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
Water Board	California Central Coast Regional Water Quality Control Board
WLA	Waste load allocation

1 INTRODUCTION

1.1 Clean Water Act Section 303(d) List

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 water on the Central Coast's "303(d) Impaired Waters List", the California 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 which 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. In addition to creating this list of waterbodies not meeting water quality standards, the Clean Water Act mandates each state to develop TMDLs for each waterbody listed. The Central Coast Regional Water Quality Control Board is the agency responsible for protecting water quality consistent with the Basin Plan, including developing TMDLs and programs of implementation for waterbodies identified as not meeting water quality objectives pursuant to Clean Water Act Section 303(d) and the Porter-Cologne Water Quality Control Act §13242.

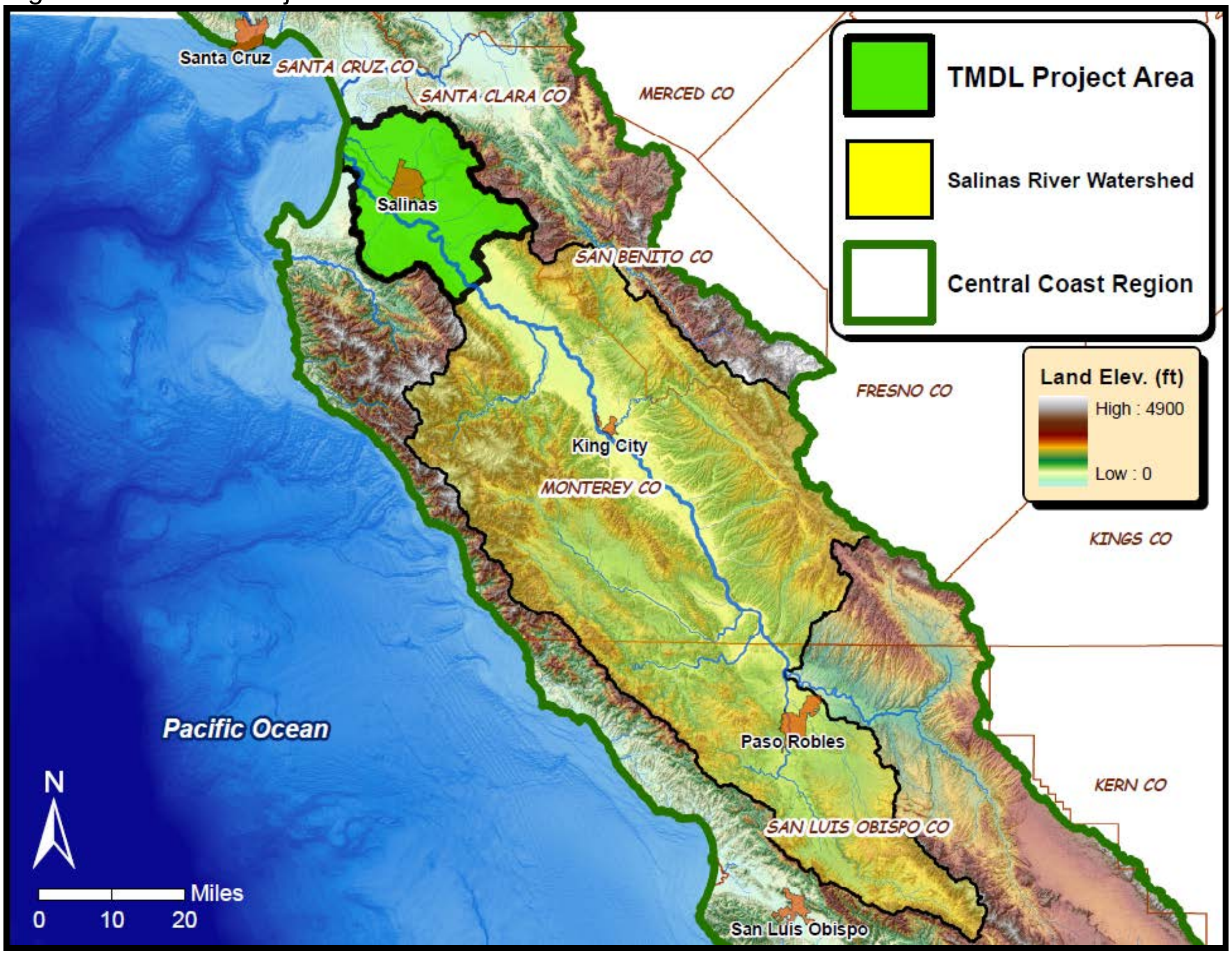
1.2 Project Area

The proposed geographic scope of this TMDL encompasses approximately 405 square miles of the Lower Salinas Valley in northern Monterey County, including the Lower Salinas River, the Salinas Reclamation Canal, Tembladero Slough and their tributaries (see Figure 1-1).

The project area is comprised of two major drainages, identified here as the Reclamation Canal watershed[1] (following the watershed-naming convention of Casagrande and Watson, 2006), and the Lower Salinas River watershed. The Reclamation Canal watershed drains to the Old Salinas River and contains Tembladero Slough, the Reclamation Canal, and their upstream tributaries Merrit Ditch, Espinosa Slough, Santa Rita Creek, Gabilan Creek, Natividad Creek, and Alisal Creek. The Moro Cojo Slough subwatershed is also included in the project area. Moro Cojo slough is not directly hydrologically connected to the Lower Salinas River watershed or the Reclamation Canal watershed, but does ultimately drain to the same receiving water body – Moss Landing Harbor. As a management and TMDL implementation strategy it is prudent to include this subwatershed in the TMDL project area.

[1] The Salinas Reclamation Canal (i.e., Reclamation Canal) as listed in the Basin Plan, is the same waterbody that is sometimes identified locally as the Reclamation Ditch.

Figure 1-1. TMDL Project area - lower Salinas River and Reclamation Canal basin.



The lower Salinas River watershed drains to the Salinas River Lagoon[2], and contains the lower Salinas River and its tributaries: Blanco Drain, Toro Creek, Quail Creek, Esperanza Creek, and Chualar Creek. The Reclamation Canal watershed contains Tembladero Slough, the Reclamation Canal, and their tributaries. Waters from both the Reclamation Canal watershed and the Lower Salinas River watershed ultimately drain into Moss Landing Harbor, which is the receiving water located at the center of Monterey Bay.

There is a limited hydrologic connection between the Reclamation Canal watershed and the Lower Salinas River watershed where the Salinas River Lagoon (North) periodically drains into the Old Salinas River through a slide gate at the northwest end of the Salinas River Lagoon (North). In the winter, the slide gate is often closed to prevent flooding in low-lying agricultural lands surrounding the Old Salinas River, and the inflows into the Salinas Lagoon are typically discharged directly into Monterey Bay through a breached sand bar at the mouth of the lagoon. Table 1-1 shows the downgradient receiving water bodies and the tributaries to these receiving water bodies. Figure 1-2 illustrates the project area waterbodies and their connectivity[3].

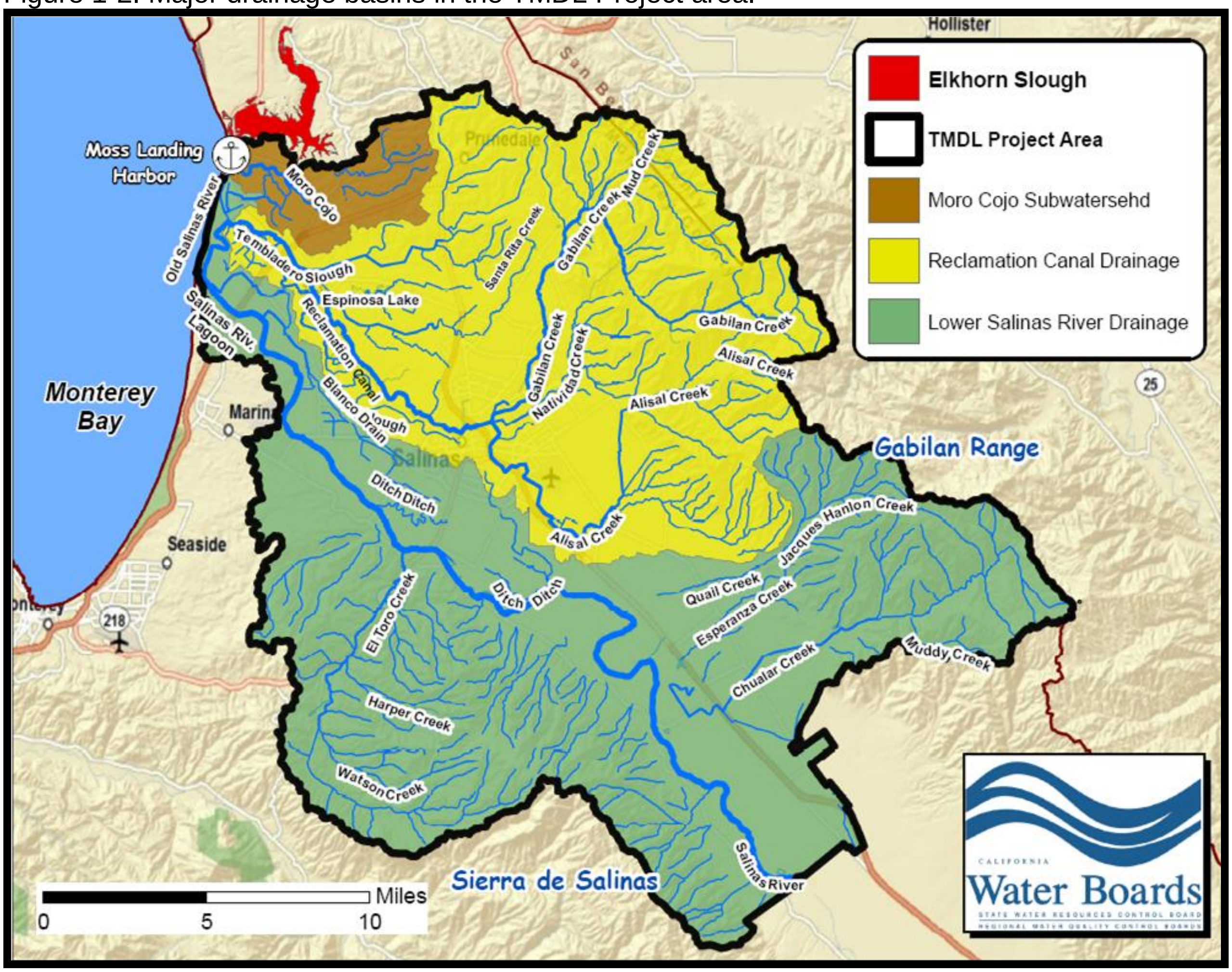
[2] Salinas River Lagoon is the same waterbody as Salinas River Lagoon (North), as listed in the Basin Plan. The two names are used interchangeably throughout this report.

[3] In this TMDL project report, the lower Salinas River drainage, the Reclamation Canal-Tembladero Slough drainage, Morro Cojo Slough, and all tributaries thereof are often collectively referred to as the "TMDL project area".

Table 1-1. Receiving waterbodies and tributaries of the Project area.

Coastal Confluence Receiving Water Bodies:		
Salinas River Lagoon	**Old Salinas River**	**Moss Landing Harbor**
Upstream Tributaries Discharging to the Above Receiving Water Bodies:		
Lower Salinas River	Tembladero Slough	Moro Cojo Slough
El Toro Creek	Salinas Reclamation Canal	
Blanco Drain	Santa Rita Creek	
Quail Creek	Gabilan Creek	
Chualar Creek	Alisal Creek	
Esperanza Creek	Espinosa Slough	

Figure 1-2. Major drainage basins in the TMDL Project area.



1.3 Pollutants Addressed and Their Environmental Impacts

The pollutants addressed in this TMDL are nitrate, un-ionized ammonia, low dissolved oxygen, and chlorophyll *a*. In addition, to protect waters from biostimulatory substances, orthophosphate is included as a pollutant. Nitrate and un-ionized ammonia pollution of both surface waters and groundwater has long been recognized as a problem in the lower Salinas valley. Elevated levels of nitrate or un-ionized ammonia can degrade municipal and domestic water supply, groundwater, and also can impair freshwater aquatic habitat. Many surface waterbodies in the lower Salinas Valley routinely exceed the water quality objective for nitrate in drinking water and may therefore degrade drinking water supplies (MUN) and impair designated groundwater recharge (GWR) beneficial uses[4]. The Water Quality Control Plan for the Central Coast Region (Basin Plan) explicitly requires that the GWR beneficial use of surface waters be maintained to protect the water quality of the underlying groundwater resources[5]. It is noteworthy that CEC and Moss Landing Marine Laboratories (1994) report that sections of the nitrate-polluted lower Natividad Creek and Gabilan Creek may be one of the best aquifer recharge areas in the lower Salinas Valley. Private wells are often more vulnerable to higher levels of nitrate because they draw water from shallower groundwater aquifers. While the actual number of polluted wells and people affected are unknown; protecting public health and ensuring safe drinking water are among the highest priorities for the Water Board.

Regarding nitrate-related health concerns, it has been well-established that infants below six months who are fed formula made with water containing nitrate in excess of the U.S. Environmental Protection Agency's safe drinking water standard (i.e., 10 milligrams of nitrate-N 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.[6] The well-established linkage between nitrate and methemoglobinemia alone should be sufficient to warrant TMDL development. High nitrate levels may also affect the oxygen-carrying ability of the blood of pregnant women[7]. 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 addressed in this TMDL which is associated with nutrients is biostimulation. Biostimulation can result in eutrophication of the waterbody. 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 which have adverse impacts on water quality; for example when they cause toxicity or eutrophication. Eutrophication is the excessive and undesirable growth of algae and aquatic plants that may be caused by excessive levels of nutrients. Eutrophication effects typically occur at somewhat lower nutrient concentrations than toxic effects. Either of these modes of water quality impairment 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. Additionally, several stream reaches in the project area are impaired by elevated levels of unionized ammonia in the water column. Unionized ammonia (a nitrogen compound) is highly toxic to aquatic species. Reducing the amount of nutrients that enters a water body will help to preserve and maintain the aquatic beneficial uses.

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[4] "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.
[5] See Basin Plan, Chapter 2 Beneficial Use Definitions, page II-19
[6] U.S. Environmental Protection Agency: http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm
[7] California Department of Public Health www.cdph.ca.gov/certlic/drinkingwater/Pages/Nitrate.aspx

In addition to detrimental 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 (HABs) reported in the United States and worldwide is due to one group of algae, cyanobacteria (CyanoHABs, or 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[8]. 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, algal toxins have been implicated in the deaths of central California southern sea otters according to recent findings (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 (source: Dr. Wayne Carmichael of the Wright State University-Department of Biological Sciences, as reported in NBC News, 2009). Section 3.7.3 of this report presents available information and data on algal toxins in the TMDL project area.

Also noteworthy is that TMDL development intended to address nitrate pollution risks to human health and address degradation of aquatic habitat is consistent with the Water Board's highest identified priorities. The Water Board's two highest priority missions[9] (listed in priority order) are presented below:

Water Board Top Two Priorities (July 2012)
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"*

The U.S. Environmental Protection Agency (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[10]. Over half of the nation's streams, including most steams in the lower Salinas Valley, have medium to high levels of nitrogen and phosphorus. According to USEPA, nitrate drinking water standard violations have doubled nationwide in eight years, and it has been widely demonstrated that drinking water supplies in the Salinas Valley have been substantially impacted by nitrate. Algal blooms, resulting from the biostimulatory effects of nutrients, are steadily on the rise nationwide; related toxins have potentially serious health and ecological effects. Biostimulation of surface waters in the lower Salinas Valley are documented in this report; these water quality impairments are also having significant adverse downstream

[8] California Department of Public Health website
[9] See Staff Report for the July 11, 2012 Water Board meeting.
[10] U.S. Environmental Protection Agency: Memorandum from Acting Assisstant 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".

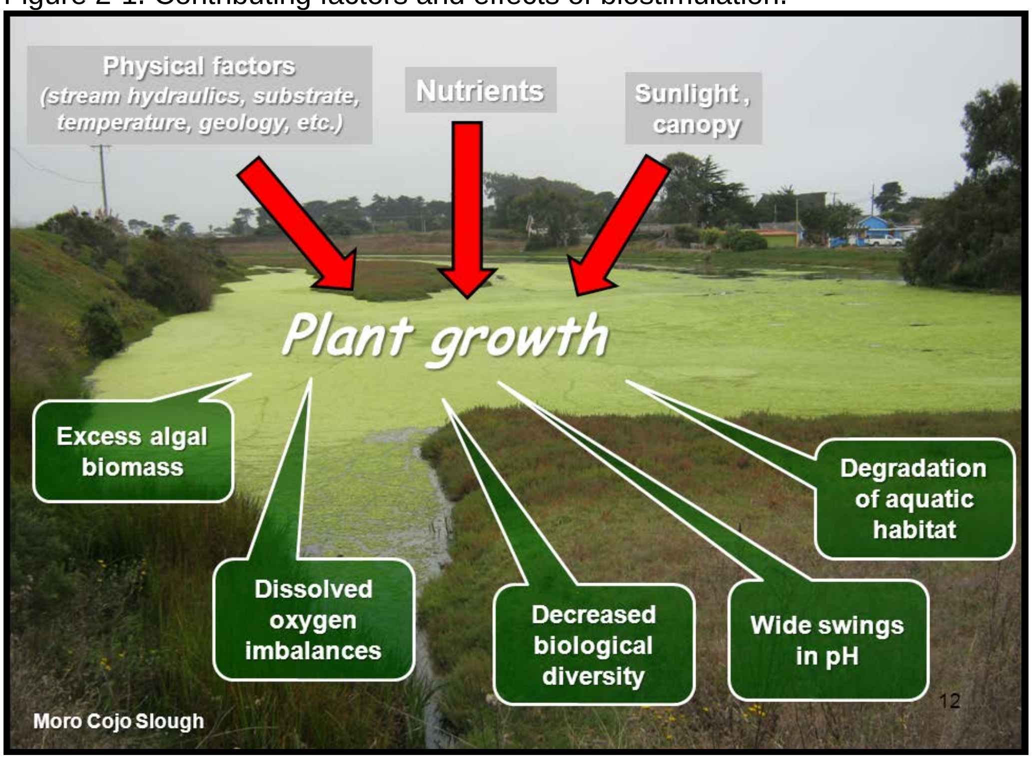
impacts to the ecologically sensitive Elkhorn Slough estuary as demonstrated by estuarine researchers and the peer-reviewed scientific literature (refer to Section 3.11.2).

2 PHYSICAL SETTING & WATERSHED DESCRIPTION

2.1 Introduction

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 (TetraTech, 2006). TetraTech (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 2-1).

Figure 2-1. Contributing factors and effects of biostimulation.



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

Additionally, agricultural stakeholders have requested that staff review whether the nutrient impairments in surface waters of the lower Salinas Valley could possibly be due simply to natural inputs:

> *"Included in your assessment, we encourage review of whether the impairment is caused by environmental sources, such as the natural background and atmospheric deposition which isn't listed under the regulation. Is it possible that those inputs alone exceed the TMDL goals?"*
>
> *Abby Taylor-Silva, Vice President, Grower-Shipper Assoc. of Central California*
> *Norm Groot, Executive Director, Monterey County Farm Bureau*
> *Benny Jefferson, Chairman, Salinas River Channel Coalition*
>
> *In a letter to Water Board Staff dated Nov. 3, 2011*

For all the aforementioned reasons, staff endeavored to characterize the watershed 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.

- ***A Note on Spatial Datasets Used in this TMDL Project***

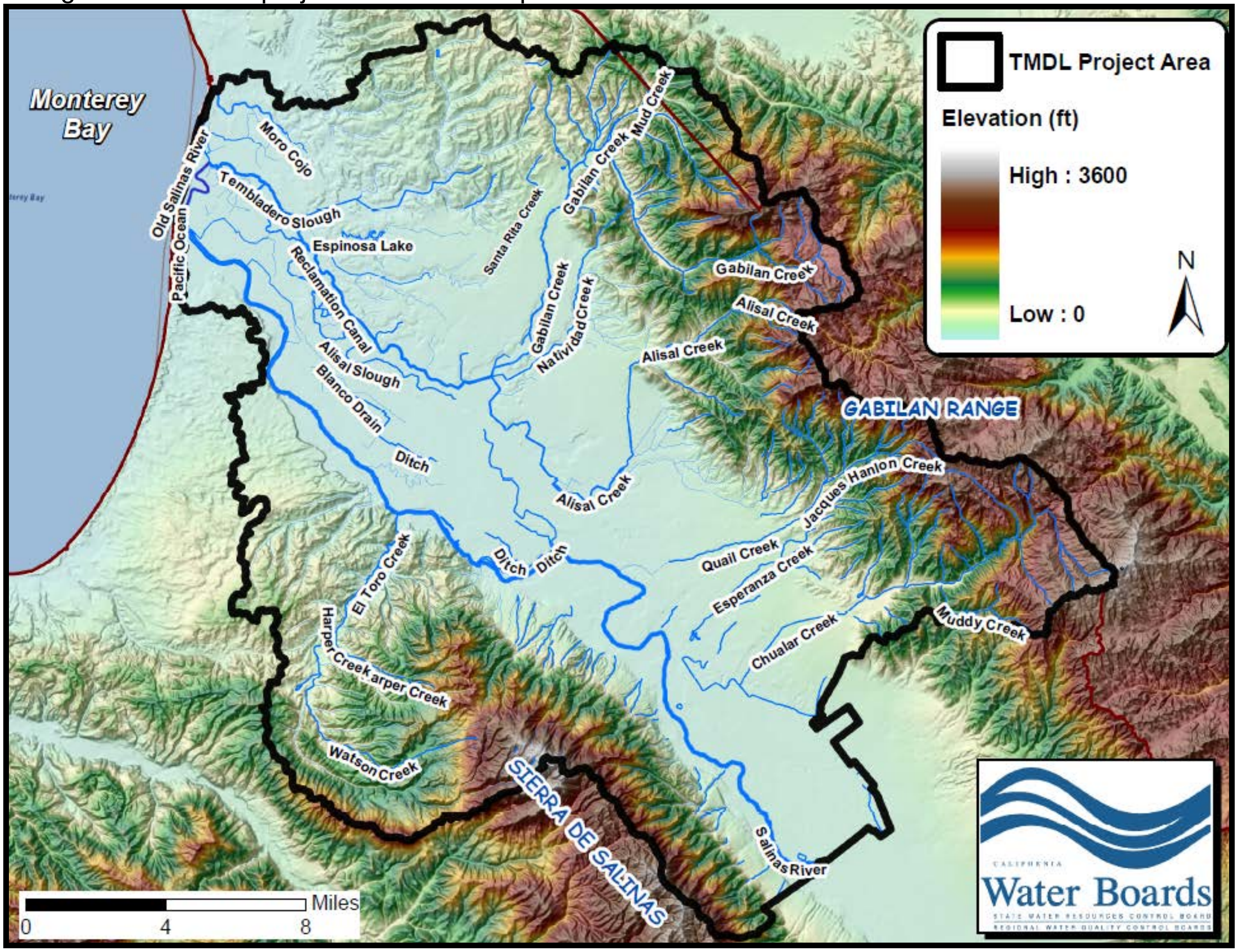
Staff endeavored to use the best available spatial datasets from reputable scientific and public agency sources to render and assess physical, hydrologic, and biologic conditions in the TMDL project area. Spatial data of these types are routinely used in TMDL development and watershed studies nationwide. 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 U.S. Environmental Protection Agency 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 are proposed to be conducted during TMDL implementation.

2.2 Project Area Description

The project area is located in a 405 square mile, southeast-northwest trending watershed in northern Monterey County which drains an alluvial valley and surrounding uplands and mountains (see Figure 2-2). The watershed is comprised of an alluvial intermontane valley bounded by the Gabilan Range to the northeast and by the Sierra De Salinas to the southwest; and includes the contributing watershed area beginning at the town of Gonzales (approximately at Salinas River mile 35) and extending downstream to Old Salinas River Estuary. The Salinas River Lagoon, the Old Salinas River Estuary and Moss Landing Harbor are the receiving water bodies at the downstream outlet of the project area.

Agriculture is the current dominant land use in the project area, with increasing transition to urban use. The City of Salinas, and other urbanized areas account for approximately 8 percent of the watershed's land use. Grassland, shrubland and forest also comprise substantial parts of the upland reaches of the watershed within an ecosystem characterized oak woodland, chamise-redshank chaparral, and coastal scrub (source: National Land Cover Dataset, 2001; Calif. Dept. of Forestry and Fire Protection, 1977).

Figure 2-2. TMDL project area relief map and waterbodies.



2.3 Watershed Delineation

ESRI™ ArcMap® 9.2 was used to create watershed layers for the project area. Drainage boundaries within the project area were delineated on the basis of 1) the Watershed Boundary Dataset[11], which contain digital hydrologic unit boundary layers at the subwatershed scale (12-digit hydrologic unit code); and 2) elevation-derived catchments (drainage areas) available digitally from the National Hydrography Dataset Plus (NHDPlus).

Hydrologic Unit Codes (HUC) were developed by the United States Geological Survey (USGS) to identify all the drainage basins of the United States. NHDplus catchments are drainage features, typically at a smaller scale than 12-digit hydrologic units, and are produced using a drainage enforcement techniques by the USGS, and the U.S. Environmental Protection Agency (USEPA).

[11] 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 soley upon science-based principles, not favoring any administrative boundaries. Online linkage: http://datagateway.nrcs.usda.gov/

The initial selection and delineation of the project area, and associated subwatersheds, was accomplished by digitally clipping the following 12-digit hydrologic units (HUC 12s) which are located within the Lower Salinas River valley (see Table 2-1):

Table 2-1. Project Area HUC 12 subwatersheds.

HUC 12	HUC 12 NAME or NUMBER
180600051503	Limekiln Creek-Salinas River
180600051507	180600051507
180600051504	Chualar Creek
180600051506	Quail Creek
180600051509	Alisal Creek-Salinas River
180600110101	Mud Creek-Gabilan Creek
180600110102	Nativdad Creek-Gabilan Creek
180600110103	Alisal Slough-Tembladero Slough
180600110202	Bennet Slough-Frontal Monterey Bay (Moro Cojo Slough)

Within each HUC 12, higher resolution subwatershed delineation of project area stream reaches and associated drainage areas were accomplished by using NHDplus catchment shapes as masks, and dissolving them together into larger polygons. Smoothed NHDplus catchment shape files can be downloaded from the National Hydrography Dataset at: http://www.horizon-systems.com/nhdplus/download.

Lastly, as a final refinement step, a 30-meter resolution digital elevation model (DEM) of the project area was created. Digital elevation data is available via the National Elevation Database (NED) developed by the USGS. DEM data is routinely used to derive slope and hydrologic attributes. Hydrologic attributes may be derived using the Hydrology Spatial Analyst tool extension available in ESRI™ ArcMap® 9.2. NED data is available from the U.S. Department of Agriculture Natural Resources Conservation Service, National Cartography & Geospatial Center at: http://datagateway.nrcs.usda.gov/

In this project, the DEM was used primarily to refine subwatershed delineations located in very low-gradient valley floor areas, whose drainage catchments may not always adequately represented by the aforementioned HUC 12 and NHDplus catchment shape files.

Based on the available information as complied by staff, Figure 2-3 illustrates the individual subwatersheds developed for the project area. Table 2-2 tabulates the names and the areal sizes of the subwatersheds. It should be noted that at higher-resolution spatial scales (individual parcels), site specific engineering can result in parcel-scale drainage that runs counter to topographic elevation direction. These higher resolution drainage patterns may not be represented at localized parcel scales by these subwatershed delineations presented herein.

Figure 2-3. Map of subwatersheds in TMDL project area.

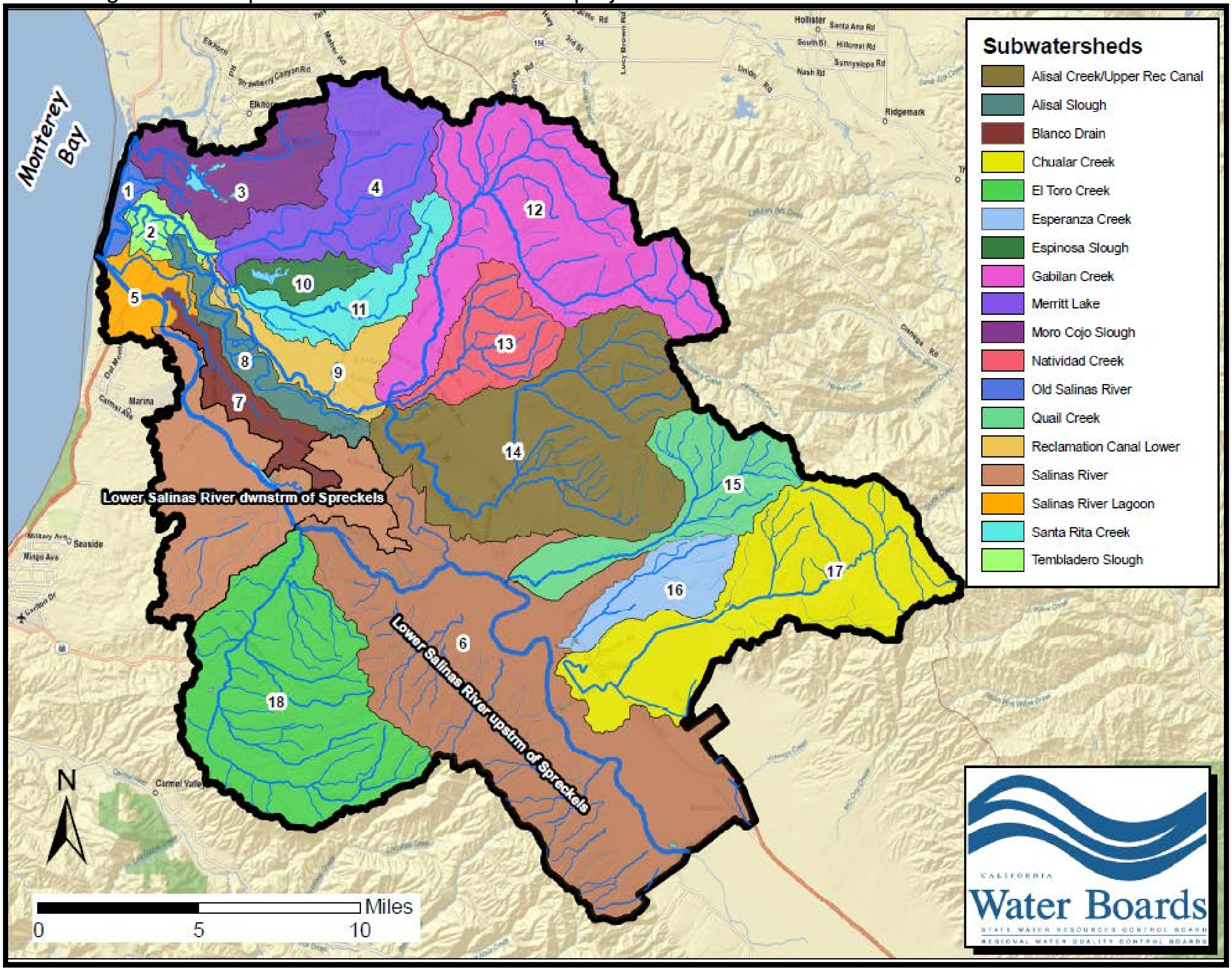


Table 2-2. Tabulation of subwatershed sizes (acres - mi²).

Watershed ID	Watershed		Acres	Square Miles
1	Old Salinas River		1,492	2.3
2	Tembladero Slough		2,154	3.4
3	Moro Cojo Slough		9,836	15.4
4	Merritt Lake		14,236	22.2
5	Salinas River Lagoon		3,837	6.0
6	Lower Salinas River[A]	Lower Salinas River upstrm of Spreckels	50,422	78.8
		Lower Salinas River dwnstrm of Spreckels	19,352	30.2
7	Blanco Drain		4,442	6.9
8	Alisal Slough		4,621	7.2
9	Reclamation Canal, Lower		5,729	9.0
10	Espinosa Slough		2,655	4.1
11	Santa Rita Creek		6,348	9.9

Watershed ID	Watershed	Acres	Square Miles
12	Gabilan Creek	27,957	43.7
13	Natividad Creek	7,337	11.5
14	Alisal Creek/Reclamation Canal, Upper[B]	29,656	46.3
15	Quail Creek	11,097	17.3
16	Esperanza Creek	5,687	8.9
17	Chualar Creek	**25,**422	39.7
18	El Toro Creek	27,062	42.3
TOTAL		**259,342**	**405**

[A] The total Lower Salinas River watershed drainage area downstream of Gonzalez is 69,774 acres.
[B] The lower reach of Alisal Creek has been channelized and is now known as the Reclamation Canal downstream of Hartnell Road. In this project report the "upper Reclamation Canal" refers the reach of the canal downstream of Alisal Creek at Hartnell Road and upstream of Carr Lake. The "lower Reclamation Canal" (Watershed ID 9) refers to the reach of the canal downstream of Carr Lake.

2.4 Land Use and Land Cover

Land use and land cover in the project area can be evaluated from digital data provided by the California Department of Conservation Farmland Mapping and Monitoring Program (FMMP). The FMMP maps are updated every two years with the use of aerial photographs, a computer mapping system, public review, and field reconnaissance. For this data analysis report, the 2008 FMMP mapping data for Monterey County was used.

FMMP data is available for download from:
http://www.consrv.ca.gov/DLRP/fmmp/index.htm

Figure 2-4 illustrates land use and land cover in the project area. Table 2-3 tabulates the distribution of land use in the project area.

Figure 2-4. Project area land use – land cover.

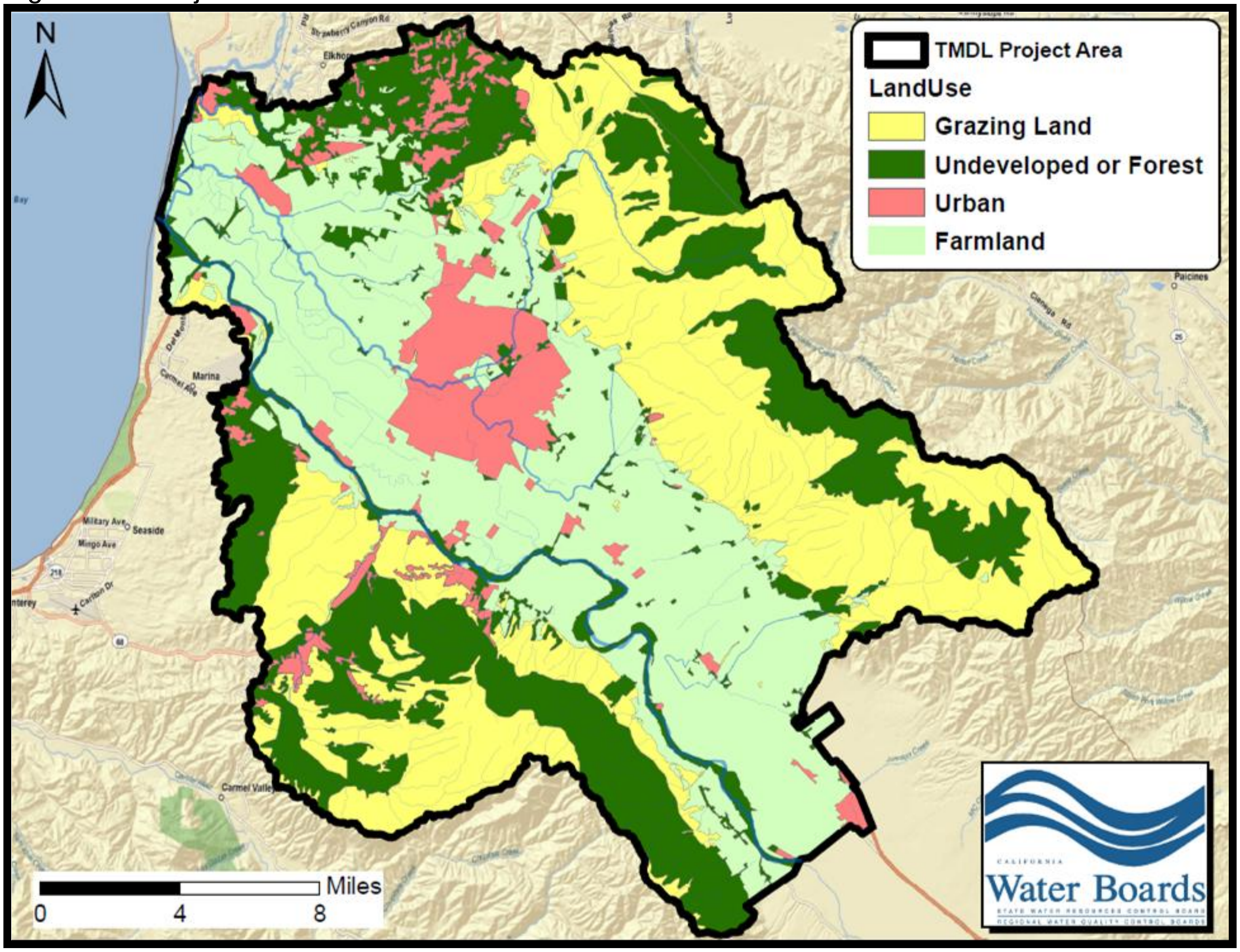


Table 2-3. Tabulation of land use/land cover in project area.

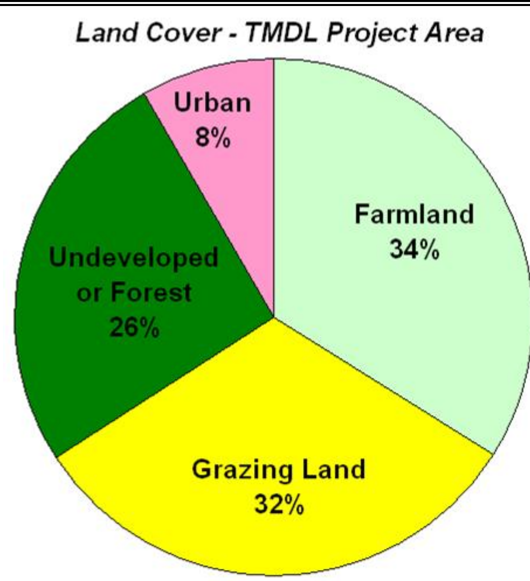
Land Cover	Acres	Land Cover Pie Chart
Urban	21,463	
Farmland	88,139	
Grazing Land	82,307	
Forest, Undeveloped, or Restricted	67,330	
Water	102	
Total	259,341	

Table 2-4 presents acreage estimates of land use-land cover acreage in all the TMDL project areas subwatersheds.

Table 2-4. Land use - land cover by subwatershed.[A]

Subwatershed		Farmland	Urban	Undeveloped, Forest, or Restricted	Grazing Lands	Total
Alisal Creek/Upper Rec Canal		10,135	3,796	3,000	12,724	29,656
Alisal Slough		3,884	705	32	0	4,621
Blanco Drain		4,374	64	1	0	4,439
Chualar Creek		7,737	123	4,051	13,511	25,422
El Toro Creek		26	1,333	10,137	15,566	27,062
Esperanza Creek		2,922	0	513	2,252	5,687
Espinosa Slough		2,158	37	460	0	2,655
Gabilan Creek		2,497	1,705	9,117	14,638	27,957
Merritt Lake		3,707	2,457	6,611	1,461	14,236
Moro Cojo Slough		3,185	1,478	4,585	487	9,735
Natividad Creek		1,476	1,002	364	4,494	7,337
Old Salinas River		1,058	44	353	37	1,492
Quail Creek		2,705	114	4,570	3,709	11,097
Reclamation Canal Lower		3,124	2,544	48	13	5,729
Lower Salinas River	Total	30,104	4,532	22,503	12,635	69,774
	upstream of Spreckels	*23,590*	*2,114*	*16,270*	*8,449*	*50,423*
	downstream of Spreckels	*6,514*	*2,418*	*6,235*	*4,185*	*19,352*
Salinas River Lagoon		2,485	34	810	508	3,837
Santa Rita Creek		4,769	1,143	154	281	6,348
Tembladero Slough		1,784	345	24	1	2,155

[A] Land use-Land cover dataset: Calif. Dept. of Conservation Farmland Mapping and Monitoring Program (2008)

2.5 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 project area (i.e., the Lower Salinas River watershed) encompasses over four thousand square miles (refer back to Figure 1-1). However, much of the runoff and precipitation generated throughout the entire Salinas River watershed is impounded in reservoirs, and periodically released for groundwater recharge, irrigation, or other purposes.

California central coast streams tend to have flashy hydrologic conditions with short durations of high flows following precipitation events, followed by long, extended periods of low or no flows. Low flow, baseflow conditions, or dry conditions (in ephemeral drainages) characterize stream reaches of the project area between rainy periods and throughout the dry season (May through October). Broadly speaking, many of the low-gradient, valley floor stream reaches and coastal confluence water bodies have perennial or near-perennial flows. This is attributable to the fact that these stream reaches receive base flow and/or discharges of urban and agricultural runoff during the dry season. The Salinas Reclamation Canal, Tembladero Slough, the Salinas River Lagoon, and the Old Salinas River are perennial; summer flows in these bodies of water are attributed to groundwater and irrigation sources. Because the Salinas River is a highly regulated water body, and flows are to a some extent, tied to dam releases, the Lower Salinas River was dry during the late summer months upstream of Davis Road (near the City of Salinas). Flow records from the USGS gage at Spreckles and the USGS gage at Chualar Bridge, indicate that the Salinas River in these reaches, have measurable flow approximately 60% of the year. More recently, flow patterns and flow management have changed on the Salinas River due to construction of a rubber dam upstream of Highway 1 and other management changes, which are intended to facilitate improved water and fisheries management.

In contrast, many stream reaches located higher up (topographically upgradient) on the alluvial plain or in lower order headwater reaches (where there is less flow contribution from urban or agricultural runoff), flows tend to be intermittent or ephemeral (e.g., reaches of Gabilan Creek upstream of Hebert Rd). Also, these stream reaches may typically be underlain by deep alluvial deposits or fractured bedrock having high permeability; consequently surface flows tend to percolate into the subsurface. Note however, that in some cases lower order project area headwater reaches appear to have flow that are intermittent, or near-perennial (e.g., Towne Creek) based on the observation that water quality data has been collected throughout the year (including dry months) at monitoring sites associated with these reaches). These relatively more sustained headwater reach flows may potentially be due to baseflow, spring sources, and/or relatively impermeable bedrock (e.g., granitic bedrock in the Gabilan Range) which limit subsurface percolation of the surface flows.

Figure 2-5 and Table 2-5 illustrate mean annual discharge estimates within the project area, based on USGS flow gage data and NHDplus estimates of mean annual flow[12]. Figure 2-6 illustrates the estimated hydrologic stream channel classifications in the project area. The source of these hydrologic stream classification attributes is from the USGS's high resolution National Hydrography Dataset Plus (NHDplus)[13], supplemented with input from local stakeholders and information published in Casagrande and Watson (2006). 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.

[12] USGS gages provide measured daily flow records (online linkage: http://ca.water.usgs.gov/). NHDplus provies modeled mean annual flow estimates; staff used values for the attribute "MAFlowU". MAFflowU 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 "MAFlowV" are based on methods from Vogel et al., 1999. NHDplus uses two flow estimation procedures, both developed by using the HydroClimatic 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.

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

Figure 2-5. Estimated mean annual discharge, acre-feet/year.

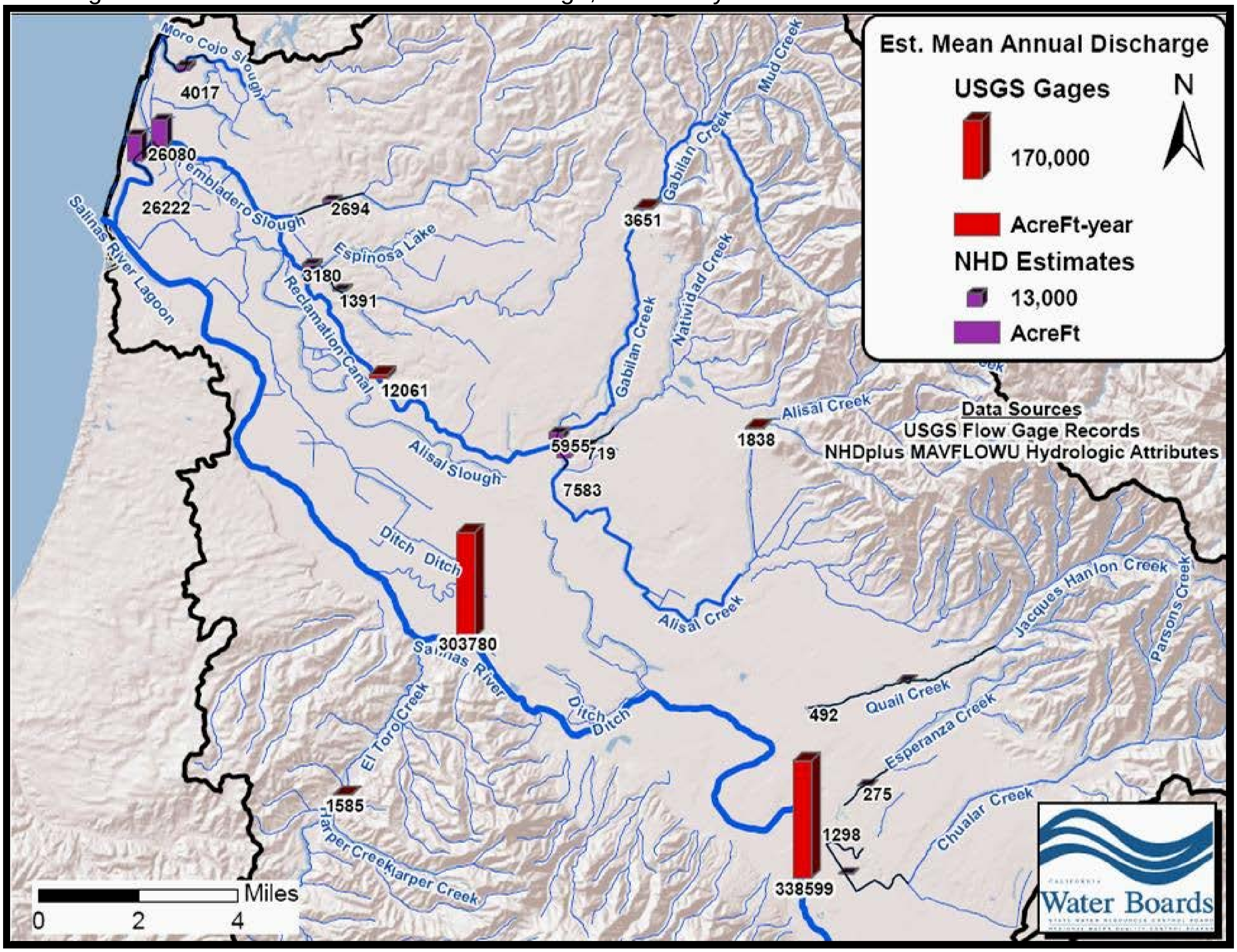


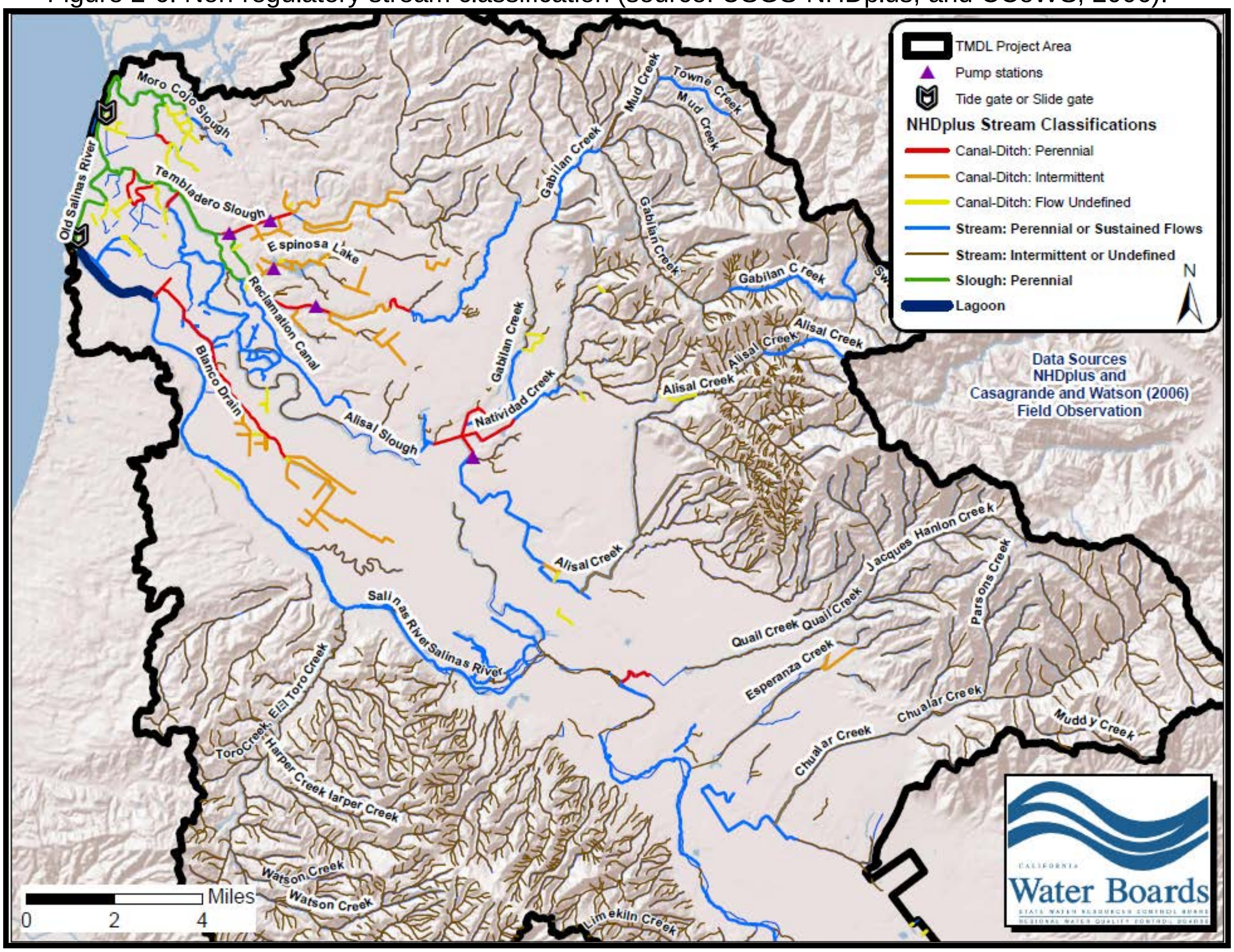
Table 2-5. Estimated mean annual discharge (units = acre-feet per year)

Receiving Waterbody	Mainstem Tributaries	Mean Annual Discharge	Flow Data Source	Lower Order Tributaries	Mean Annual Discharge[A]	Flow Data Source
Salinas River Lagoon	**Salinas Riv. @ Spreckels**	303,779	*USGS Gage (1942-2011)*	Chualar Creek	1,298	*NHDplus*
				Esperanza Creek	275	*NHDplus*
				Quail Creek	492	*NHDplus*
	Salinas Riv. @ Highway 1	253,400	*NHDplus*	El Toro Creek	1,585	*USGS Gage (1963-2001)*
				Blanco Drain	2.200	*Monterey County Water Resources Agency (1978)*
Old Salinas River Estuary-Moss Landing Harbor	**Old Salinas Riv. @ Monterey Dunes Way**	26,222	*NHDplus*	*Salinas River Lagoon outflow via slide gate*	-	*NHDplus*
	Tembladero Slough @	26,080	*NHDplus*	Reclamation Canal @ San Jon Rd.	12,061	*USGS Gage (1971-2011)*

Receiving Waterbody	Mainstem Tributaries	Mean Annual Discharge	Flow Data Source	Lower Order Tributaries	Mean Annual Discharge[A]	Flow Data Source
	Molera Rd			Upper Reclamation Canal-Alisal Creek	7,583	*NHDplus*
				Natividad Creek	719	*NHDplus*
				Gabilan Creek	5,955	*NHDplus*
				Santa Rita Creek-Espinosa Slough	3,180	*NHDplus*
				Merrit Ditch	2.694	*NHDplus*
Moss Landing Harbor	**Moro Cojo Slough @ Hwy 1**	4,017	*NHDplus*	-	-	*NHDplus*

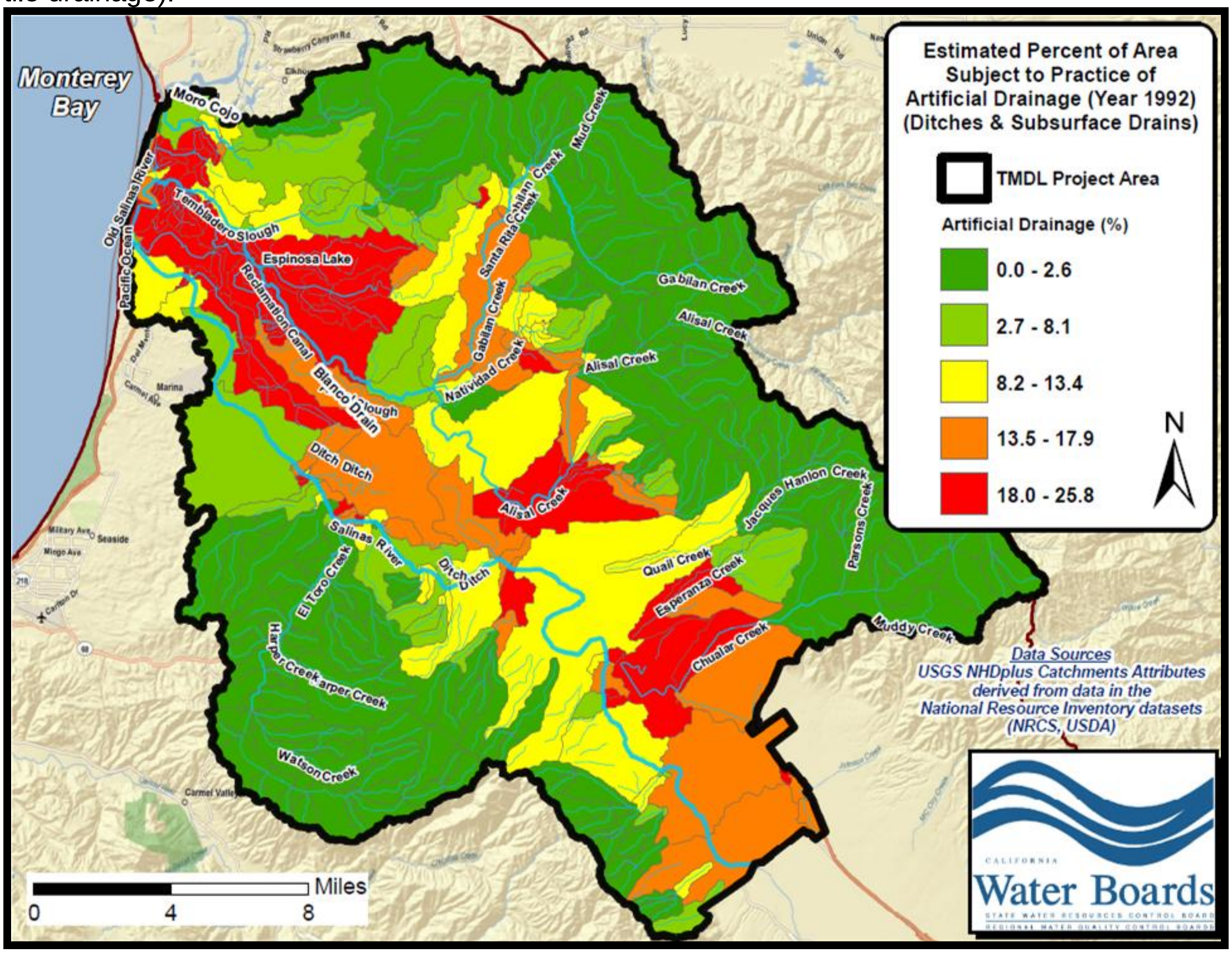
[A] Units are mean acre-feet per year. Mean acre- ft/yr can be converted to mean annual flow (in cubic feet/sec) by dividing the number of acre-feet by 724**.**

Figure 2-6. Non-regulatory stream classification (source: USGS-NHDplus, and CCoWS, 2006).



As noted previously, artificial drainage, such as agricultural runoff, is an important contributor to flows in some project area waterbodies. In watersheds dominated by agriculture, artificial drainage systems can act as efficient conveyance systems to 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 2-7 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 USGS NHDplus catchment attribute datasets, are intended for informational value only, are based on data derived by the National Resource Inventory conducted by the NRCS for the year 1992[14], and are presumed to represent a plausible gross approximation of the current percentage of land area subject to artificial drainage practices[15]. The data indicates that artificial drainage is most intensive in the lower (downgradient) portions of the project area (e.g. Tembladero Slough, Reclamation Canal, Blanco Drain), as well as in localized areas around lower Alisal Creek-upper Reclamation Canal, and lower Chualar Creek.

Figure 2-7. Estimated percentage of land area subject to artificial drainage practices (ditches & tile drainage).



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[14] 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 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.

[15] It should be noted that agricultural stakeholders report that significant efforts have been made in the Monterey Bay area since 1992 to improve water quality management practices; as such, the information is this figure should be considered very qualitative and substantital changes at local scales may have occurred since 1992.

Due to the nature and scope of artificial drainage, regulated flows and the Mediterranean climate in the TMDL project area, dry season flow patterns can vary substantially from patterns observed from mean annual flow patterns (refer back to Figure 2-5 for mean annual flow patterns). 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 USGS gages in the project area, various monitoring programs[16] have collected over 1,000 instantaneous flow measurements in the project area in recent years (See Appendix B – Flow Duration Record Summary and Instantaneous Flow Records). Because of the large size of this flow dataset, taking the means of May-October instantaneous flow measurements from selected stream reaches can provide a plausible approximation of average dry season flow, measured as cubic feet per second. Additionally, 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 instantaneous flow measurements are reasonably representative of the full range of dry season flow conditions.

Figure 2-8 illustrates estimated dry season (May 1 – Oct. 31) flow patterns in the project area. Note that at the downstream outlets of the project area, flows from the Tembladero Slough and Reclamation Canal drainage represent a significantly larger proportion of the dry season flows leaving the project area and entering Moss Landing Harbor, relative to dry season flows from the Old Salinas River/Lagoon via the slide gate at the Old Salinas River (see Table 2-6). Also, dam-regulated flows on the Salinas River are designed to recharge the Salinas Valley groundwater basin, thus mean dry season surface flows on the Salinas River substantially drop between Chualar and Davis Road. Consequently, flows in the lowermost Salinas River, downstream of Davis Road and above the Lagoon, are primarily attributable to inputs from the Blanco Drain and nonpoint sources of surface flow inputs.

[16] Data sources: Cooperative Monitoring Program; CCAMP; and Central Coast Watershed Studies

Figure 2-8. Estimated mean dry season flows (May-Oct.); units = cubic feet/second.

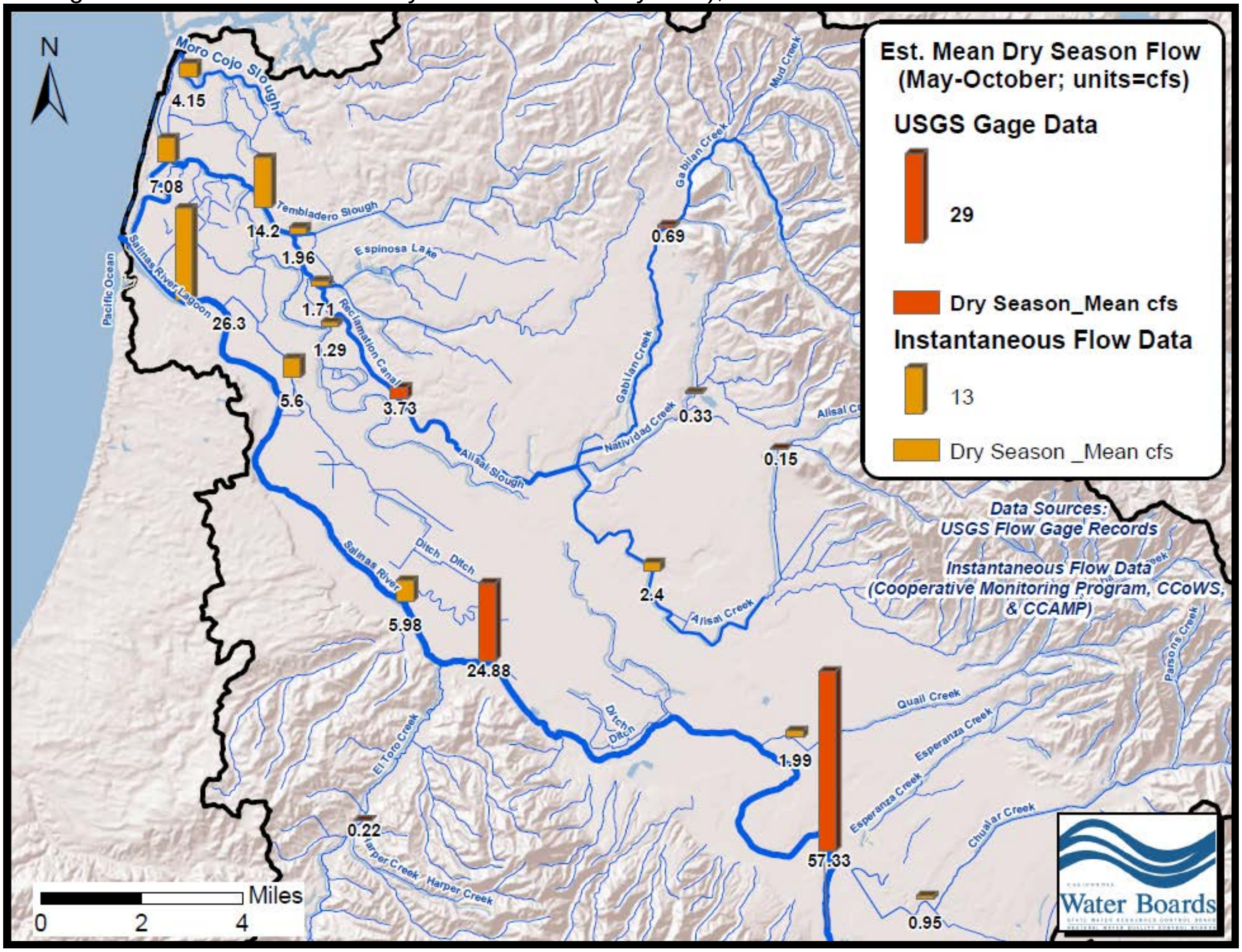


Table 2-6. Estimated mean dry season flows (May-Oct.) (units = cubic feet per second)

Receiving Waterbody	Mainstem Tributaries	Mean Dry Season Flow	Flow Data Source	Lower Order Tributaries	Mean Dry Season Flow	Flow Data Source
Salinas River Lagoon	**Salinas Riv. @ Chualar**	57.33	*USGS Gage*	Chualar Creek	0.95	*Instantaneous flow data*
	Salinas Riv. @ Spreckels	24.88	*USGS Gage*	Quail Creek	1.99	*Instantaneous flow data*
	Salinas Riv. @ Davis Rd.	5.98	*Instantaneous flow data*	El Toro Creek	0.22	*USGS Gage*
	Salinas Riv. @ Hwy. 1 (site 309SBR)	26.3	*Estimate derived from Jones and Snyder (1984)[A]*	Blanco Drain	5.6	*Instantaneous flow data*

Receiving Waterbody	Mainstem Tributaries	Mean Dry Season Flow	Flow Data Source	Lower Order Tributaries	Mean Dry Season Flow	Flow Data Source
Old Salinas River Estuary-Moss Landing Harbor	**Old Salinas River** @ **Monterey Dunes Way**	7.08	*Instantaneous flow data*	*OSR originates @ Salinas River Lagoon via lagoon outflow @ slide gate*	-	-
	Tembladero Slough @ **Haro Rd**	14.2	*Instantaneous flow data*	Alisal Creek @ USGS 11152570	0.15	*USGS Gage*
				Reclamation Canal @ La Guardia	2.4	*Instantaneous flow data*
				Reclamation Canal @ San Jon Rd.	3.73	*USGS Gage*
				Natividad Creek @ 309NAD	0.33	*Instantaneous flow data*
				Gabilan Creek @ USGS 11152600	0.69	*USGS Gage*
				Espinosa Slough	1.71	*Instantaneous flow data*
				Merrit Ditch	1.96	*Instantaneous flow data*
Moss Landing Harbor	**Moro Cojo Slough** @ **Hwy 1**	4.15	*Instantaneous flow data*	-	-	-

[A] *Jones and Snyder (1984). "Potential Effects of Sewage Effluent Removal on the Lower Salinas River Riparian System". . In: California Riparian Systems: Ecology, Conservation and Productive Management. Edited by R. E. Warner and K. M. Hendrix. University of California Press (1984).* Authors estimated that 11% surface inflow to Salinas River Lagoon is attributable to the Blanco Drain, and that of the surface inflow attributable to other nonpoint sources of flow to the river is approx.. 3.7 times larger than the Blanco Drain contribution. Therefore, estimated mean dry season flow at 309SBR = Blanco Drain contribution + (3.7 x Blanco Drain contribution) = 5.6 + (3.7 x 5.6) = 26.3 cfs.

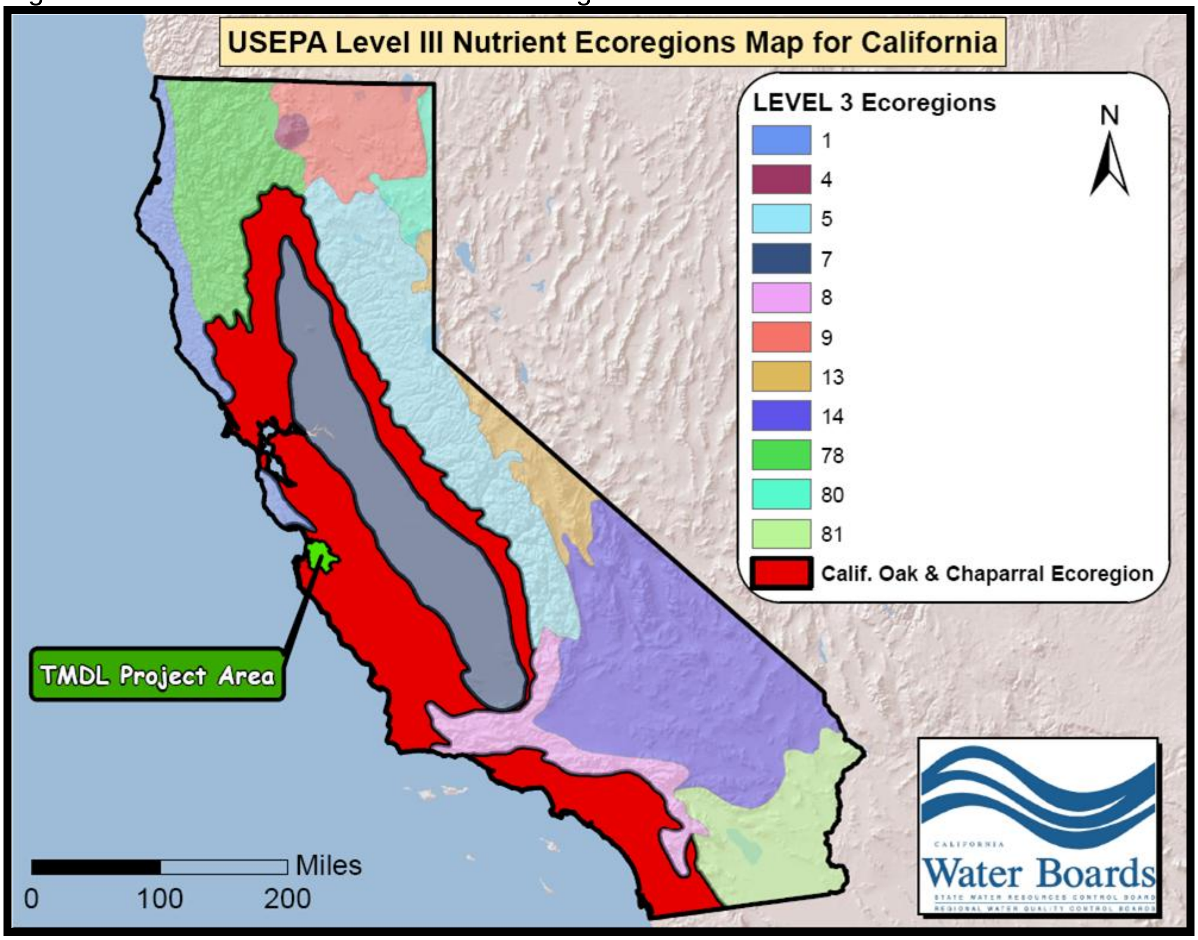
2.6 Nutrient Ecoregions

Nutrient ecoregions are USEPA designations for subregions of the United States that denote areas with ecosystems that are generally similar (e.g., physiography, climate, geology, soils, land use, hydrology). The project area is located in Ecoregion III subecoregion 6 – Southern and Central California Chaparral and Oak Woodlands[17] (see Figure 2-9). 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 of pine are found at higher elevations. Most of the region 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.

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 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 Project Report will reference to nutrient water quality conditions in Ecoregion III subecoregion 6 (i.e., Calif. Oak and Chapparal subecoregion).

[17] Also referred to throughout this report more concisely as "Nutrient Subecoregion 6".

Figure 2-9. California Level III nutrient ecoregions.



In 2000, the USEPA published ambient numeric criteria to support the development of State nutrient criteria in rivers and streams of Nutrient Ecoregion 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 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. 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 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 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.*

Note that USEPA 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."*

EPA proposed that the 25th percentiles of all nutrient 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. These 25th percentile values were characterized as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000a). However, EPA also noted that States and Tribes may "need to identify with greater precision the nutrient levels that protect aquatic life and recreational uses."

For reference, USEPA's 25th percentiles (representing unimpacted reference conditions) for the California Oak and Chapparal Subecoregion (i.e., nutrient subecoregion 6) are presented in Table 2-7.

Table 2-7. 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

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 difference geographic scales and at higher spatial resolution.

To establish reference conditions appropriate locally, staff applied the USEPA reference stream methodology (75th percentile approach) for water quality data from natural or lightly-disturbed headwater and tributary reaches in the Salinas River basin. The 75th percentile was chosen by

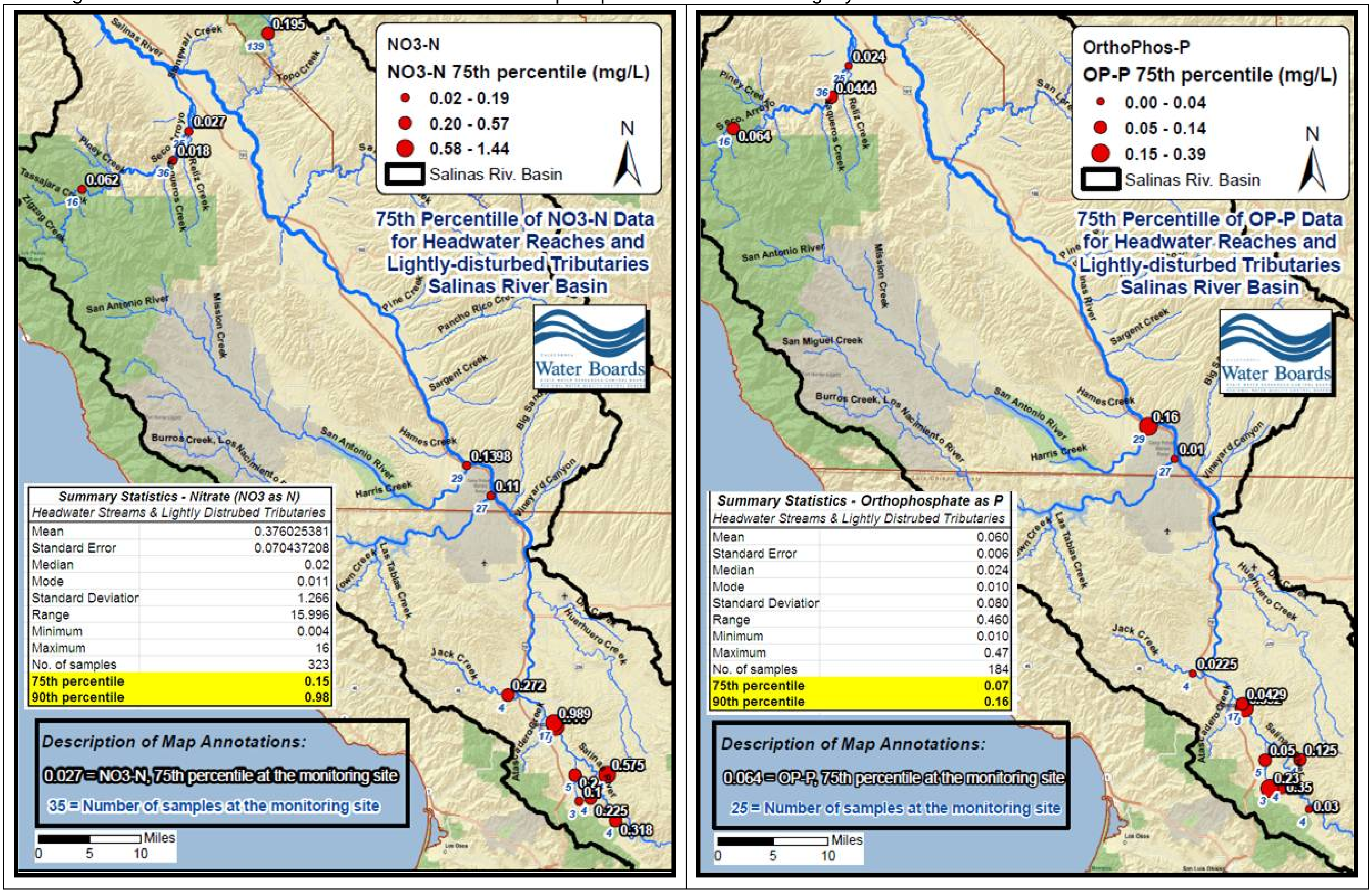
USEPA since it is likely associated with minimally impacted conditions, and will be protective of designated uses. Staff also calculated the 90th percentiles of nitrate and orthophosphate in these reaches to assess what plausible high-end concentrations of these constituents might be expected in lightly-disturbed areas.

Figure 2-10 illustrates the range and statistics of nitrate (as N) and orthophosphate (as P) concentrations in headwater reaches and lightly disturbed tributaries of the Salinas River basin. Note that the 75th percentiles for this population of stream data are 0.15 mg/L nitrate-N, and 0.07 mg/L orthophosphate-P[18]. For comparative purposes, note that these concentrations appear to comport reasonably well with the USEPA's 25th percentile reference conditions for subecoregion 6 previously shown in Table 2-7.

Also noteworthy is that the 90th percentile of nitrate-N in Salinas River basin reference streams is 0.98 mg/L. This suggests that nitrate-N in reference stream conditions typically never exceeds about 1 mg/L except in outlier or anomalous conditions.

[18] These values could underestimate the total nitrogen and total phosphorus, since nitrate and orthophostate are molecules that often represent a fraction of total water column nitrogen and phosphorus, respectively. However, in central coast inland streams, nitrate typically appears to comprise the largest faction of total water column nitrogen.

Figure 2-10. Reference conditions for nitrate and orthophosphate in headwater & lightly-disturbed stream reaches of the Salinas River basin.



2.7 Climate and Precipitation

Precipitation data can be used, in conjunction with other physical metrics, to estimate flow for ungaged streams. For example the California State Water Resources Control Board (SWRCB) uses a precipitation-based proration method to estimate flow at ungaged streams (SWRCB, 2002). Further, having a good estimate of precipitation is also a necessary input parameter of the USEPA STEPL source analysis spreadsheet tool staff used for source assessment (see Section 5.1).

Precipitation data in the project watershed is available from the National Oceanographic and Atmospheric Administration - Western Regional Climate Center (http://www.wrcc.dri.edu), and from California Department of Water Resources - California Irrigation Management Information Systems website (http://wwwcimis.water.ca.gov). The Lower Salinas Valley has a Mediterranean climate, with the vast majority of precipitation falling between November and April (see Table 2-8).

Table 2-8. Project Area precipitation records.

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Salinas Airport[A] **(1930-2008)**	Average Total Precipitation (in.)	2.66	2.41	2.14	1.12	0.32	0.09	0.03	0.05	0.13	0.58	1.39	2.38	**13.29**
Salinas 2[A] **(1958-2008)**	Average Total Precipitation (in.)	2.89	2.68	2.33	1.13	0.3	0.1	0.03	0.06	0.24	0.62	1.76	2.46	**14.58**
Spreckels[A] **(1907-1988)**	Average Total Precipitation (in.)	2.83	2.27	2.17	1.14	0.35	0.11	0.03	0.04	0.22	0.55	1.44	2.29	**13.45**
Fort Ord[A] **(1968-1978)**	Average Total Precipitation (in.)	0.91	2.7	2.28	1.4	0.12	0.09	0.06	0.13	0.13	0.68	2.06	2.33	**14.89**
Castroville #19[B] **(1983-2007)**	Average Total Precipitation (in.)	2.94	3.33	2.13	0.98	0.67	0.35	0.31	0.21	0.37	0.68	1.76	2.70	**16.26**

A: Western U.S. COOP weather station (Source: NOAA Western Regional Climate Center)
B: California Dept. of Water Resources CIMIS station (Source: Calif. DWR-Irrigation Management Information System)

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).

Therefore, mean annual precipitation estimates for the project area may be assessed using the Parameter-elevation Regressions on Independent Slopes Model (PRISM)[19]. 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

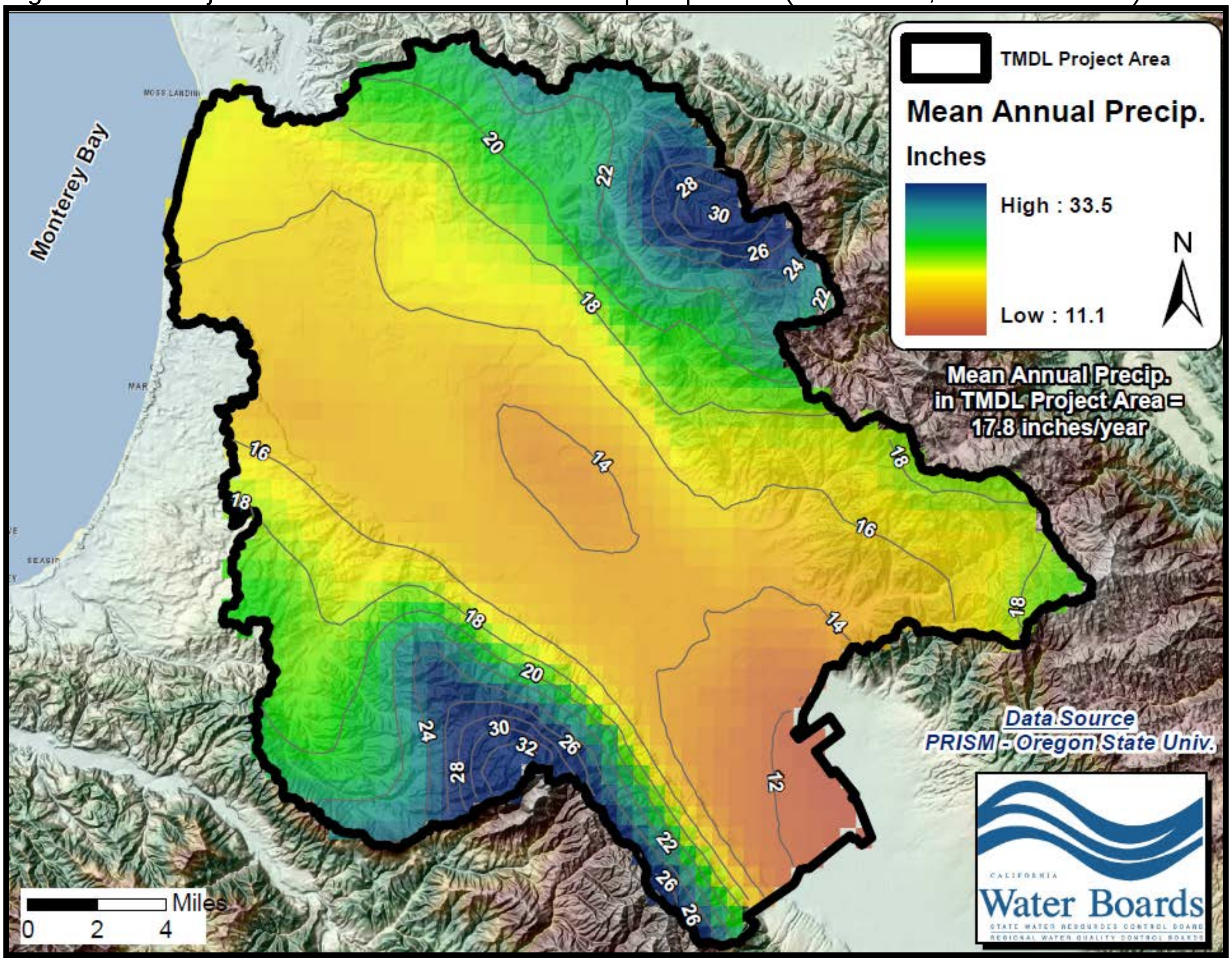
[19] The PRISM dataset was developed by researchers at Oregon State University, and uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of climatic parameters. The dataset incorporates a digital elevation model, and expert knowledge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

Service to spatially interpolate rainfall frequency estimates. An isohyetal map for estimated mean annual precipitation in the project area is presented in Figure 2-11.

Based on the statistical summary as calculated by ArcMap® 9.2 for the digitally clipped PRISM grid, average precipitation in the in the TMDL project area can be summarized as follows:

Average annual precipitation within the TMDL project area, accounting for orographic effects:
17.8 inches per year (period of record 1971-2000)

Figure 2-11. Project area estimated mean annual precipitation (1971-2000, source: PRISM).



2.8 Tree Canopy and Vegetation

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. Tree canopy and shading can vary from zero percent, particularly along coastal sloughs and water conveyance structures, to significantly higher in other types of water bodies (see Figure 2-12).

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 for canopy as a parameter influencing sunlight availability (refer to Section 4.3).

Figure 2-12. Project Area tree canopy - % (source: NLCD 2001 canopy raster)

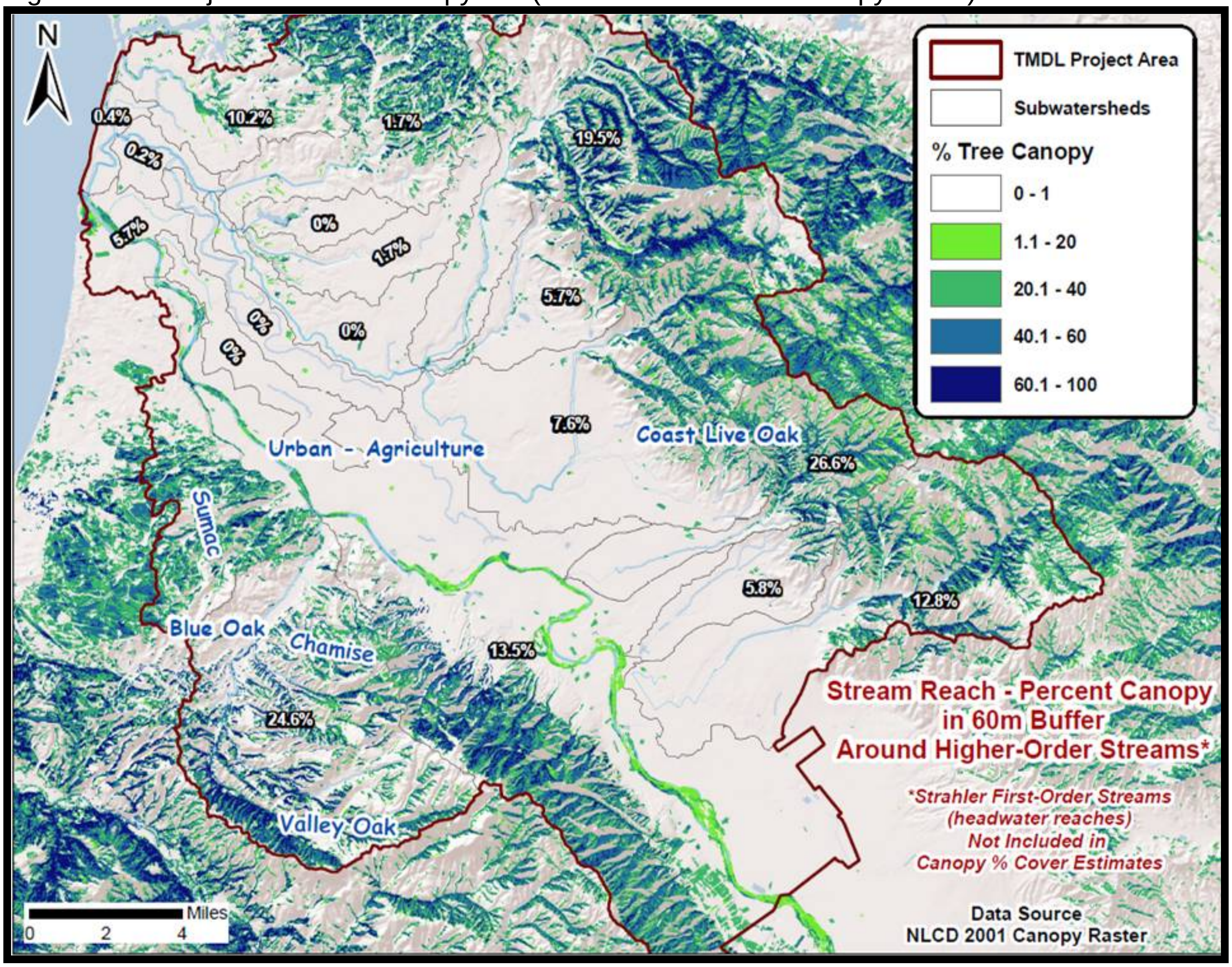


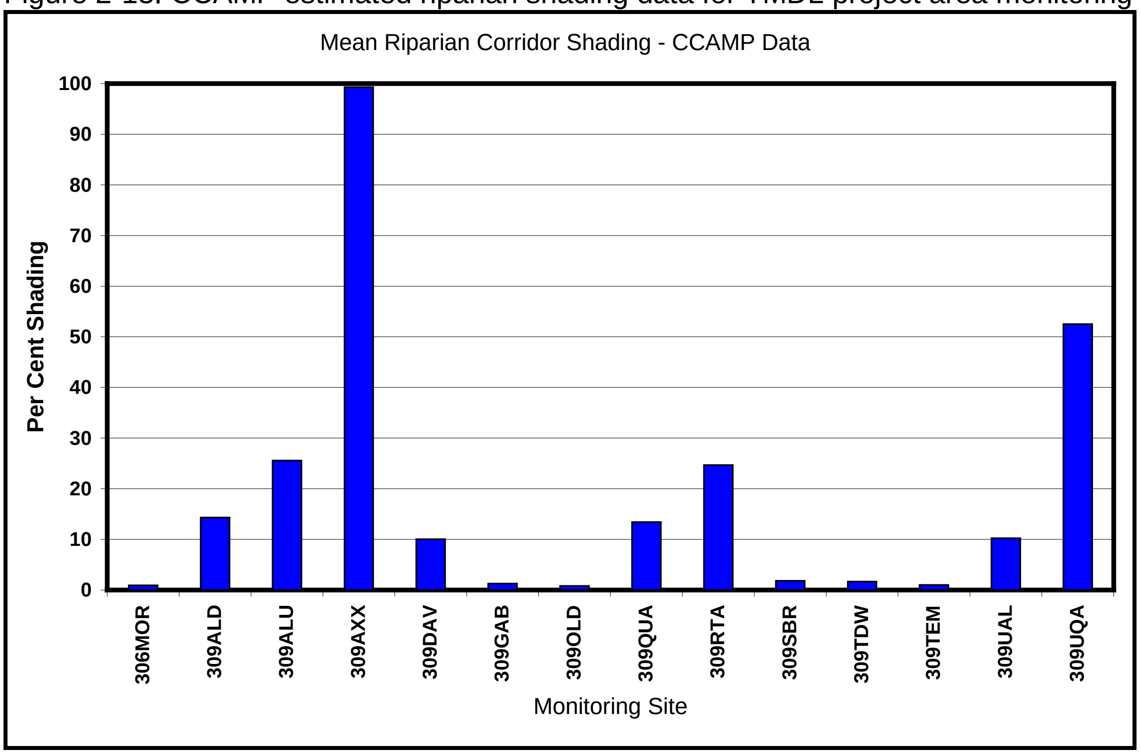
Table 2-9 presents estimates of canopy cover for project area stream reaches. Riparian shading estimates in Table 2-9 are from a regional NLCD raster (2001); available at http://www.mrlc.gov/. It is presumed that mean riparian canopy is a plausible surrogate for percent shading along riparian corridors. To obtain these estimates, 60 meter buffers (at the pixel-scale) around representative stream reaches were used to mask and clip the canopy raster data. The clipped canopy data was used to derive an approximation of the mean amount of canopy in the riparian corridors at the reach and subwatershed-scale. Figure 2-13 compiles CCAMP field observation data for estimates of riparian corridor shading at specific monitoring sites. These site-specific data comport reasonably well with reach-scale estimates derived from the NLCD canopy raster data in Table 2-9; i.e., percent canopy shading in TMDL higher strahler order TMDL project area stream reaches are relatively low, generally on the order of 10 or 20 percent at best.

Table 2-9. Estimated tree canopy (%) for TMDL project area stream reach buffers.

Waterbody	Tree Canopy in Representative Higher Strahler Order Stream Reaches*	
	Area-Weighted Mean Canopy[A] (%)	*Strahler Stream Order(s)
Gabilan Creek	19.5%	3 to 4
Old Salinas River	0.4%	4
Salinas Lagoon	5.7%	6
Salinas River	13.5%	6
Chualar Creek	12.8%	2 to 3
Quail Creek	26.6%	2 to 3
Esperanza Creek	5.8%	1 to 2
Natividad Creek	5.7%	2 to 3
Alisal Creek	7.6%	2 to 3
Santa Rita Creek	1.7%	1 to 2
Reclamation Canal	0%	4
Alisal Slough	0.02%	1 to 2
Blanco Drain	0.2%	1 to 2
Tembladero Slough	0.15%	1 to 4

[A] canopy raster data from NLCD (2001).

Figure 2-13. CCAMP estimated riparian shading data for TMDL project area monitoring sites.



2.9 Groundwater

Groundwater (as baseflow) can be a source of nutrient loads to surface waters (USEPA, 1999). In addition, although TMDLs do not directly address groundwater quality problems, many surface waters are in fact designated for groundwater recharge beneficial use in the Basin Plan. Excessive nutrient concentrations in surface waters can potentially contribute to elevated nitrate concentrations in groundwater via percolation and recharge; also nutrients in groundwater can contribute to nutrients in surface waters. Conceptually, this well-established phenomena is described by the U.S. Geological Survey:

> *"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"

The aforementioned concepts and information are presented in graphical format in Figure 2-14.

Figure 2-14. Streams are intimately connected to the ground water system.

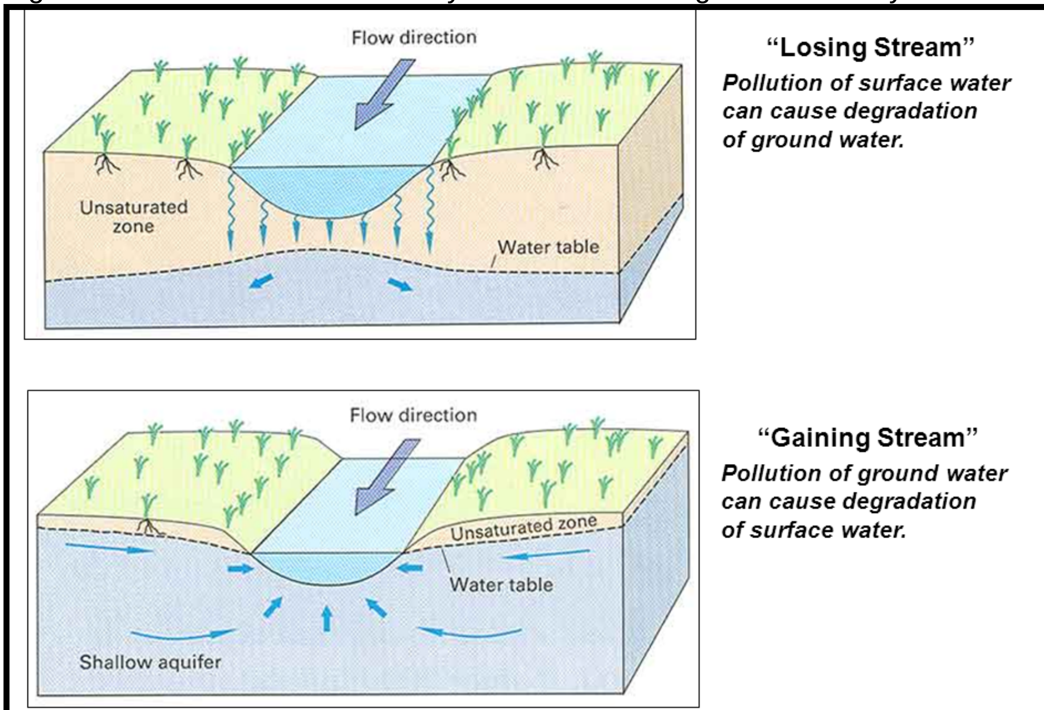
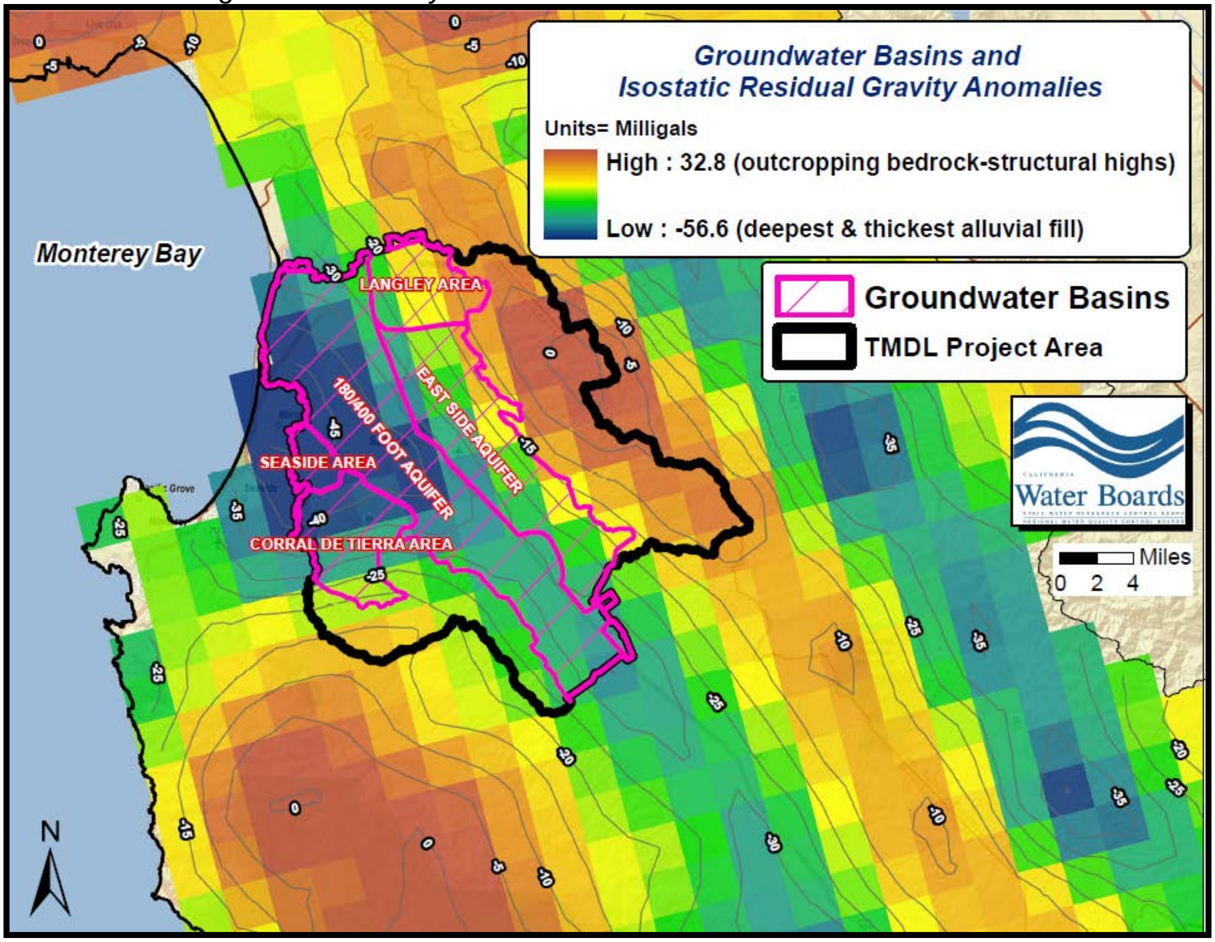


Photo credits: University of Wyoming, Dept. of Geology and Geophysics
http://www.gg.uwyo.edu/content/laboratory/groundwater/gw-streams/intro.asp?callNumber=23165&SubcallNumber=0&color=873F8A&unit=

Groundwater pollution by nitrate is a well-known and serious problem in the lower Salinas Valley, and has been recently studied and documented (University of California-Davis, 2012). Alluvial groundwater basins of the project area with isostatic residual gravity anomalies overlay[20] are illustrated in Figure 2-15. As suggested by the gravity data, 180/400 foot aquifer occurs within the depocenter of the deepest and thickest section of alluvial fill underlying the lowermost Salinas River and associated coastal confluence areas.

[20] Isostatic gravity anomaly data are a geophysical attribute that measures density contrasts, and can be used as a proxy to assess the presence and depth/thickness of alluvial fill. Data source: U.S. Geological Survey, *Isostatic residual gravity anomaly data grid for the conterminous U.S.*, 1999.

Figure 2-15. Groundwater basins in the TMDL project area with isostatic residual gravity anomalies color gradation overlay.



In addition, shallow groundwater or perched groundwater zones can provide base flows to streams and can be a major source of surface water flows during the summer 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 base flow to stream reaches in the TMDL project area.

An additional reason for developing groundwater data for this TMDL project is that many nutrient loading models (e.g., STEPL, refer to Section 5.1) require data input for shallow groundwater nutrient concentrations to allow for baseflow load estimates to surface waters. Indeed, shallow groundwater zones and perched groundwater are known to exist in the Salinas Valley:

> *"Recent Alluvium is present in the more established drainages, and typically has low to moderate permeability. Recent Alluvium also **includes perched groundwater zones*** that have not generally been affected by seawater intrusion, but have, in some cases, been impacted by percolation from agriculture."*
>
> *Monterey County Groundwater Management Plan, Salinas Valley Groundwater Basin, May 2006. Prepared for the Monterey County Water Resources Agency.*
>
> ***** *emphasis added*

Stream baseflow resulting from these shallow water-bearing hydrogeologic zones can contribute to nutrient loading to streams. Figure 2-16 illustrates the estimated nitrate as nitrogen concentration in project area shallow, recently-recharged groundwater (data source: USGS GWAVA model[21]), and phosphorus concentrations observed in groundwater from wells and from springs (data source: USGS NURE database).

Nitrate groundwater concentrations are not uniform throughout the project area, and to a significant extent are related to land use/land cover. Source assessment tools used by staff (see Section 5) require inputs of nitrate concentrations in shallow groundwater for specific land use categories. Therefore, these paired land use/groundwater concentration estimates are presented in

Figure 2-17 and Figure 2-18. As expected, 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. It is noteworthy that as shown in Figure 2-18 representative nitrate concentrations in groundwaters underlying the City of Salinas[22] comport reasonably with a study that reported average measures of nitrate concentrations in groundwaters underlying urban-dominated basins in the United States (USGS, 2000) – 1.63 mg/L nitrate-N (city of Salinas) compared to 1.8 mg/L nitrate-N (U.S urban areas), respectively.

[21] 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.usgs.gov/GIS/metadata/usgswrd/XML/gwava-s_out.xml

[22] Source: GAMA geotracker environmental monitoring wells. It should be noted that the State Water Resources Control Board's Geotracker database indicate a bulk fertilizer handling facility in the city of Salinas that has locally contaminated shallow groundwater with high nitrate concentrations. This facility is regulated and has implemented groundwater cleanup measures as required by permit. Available data indicate the nitrate groundwater impacts from this facility appear to be highly localized and not representative of urban groundwater conditions more broadly in the city of Salinas.

Figure 2-16. Nutrient concentrations in shallow groundwater – (A) NO3-N; and (B) Phosphate.

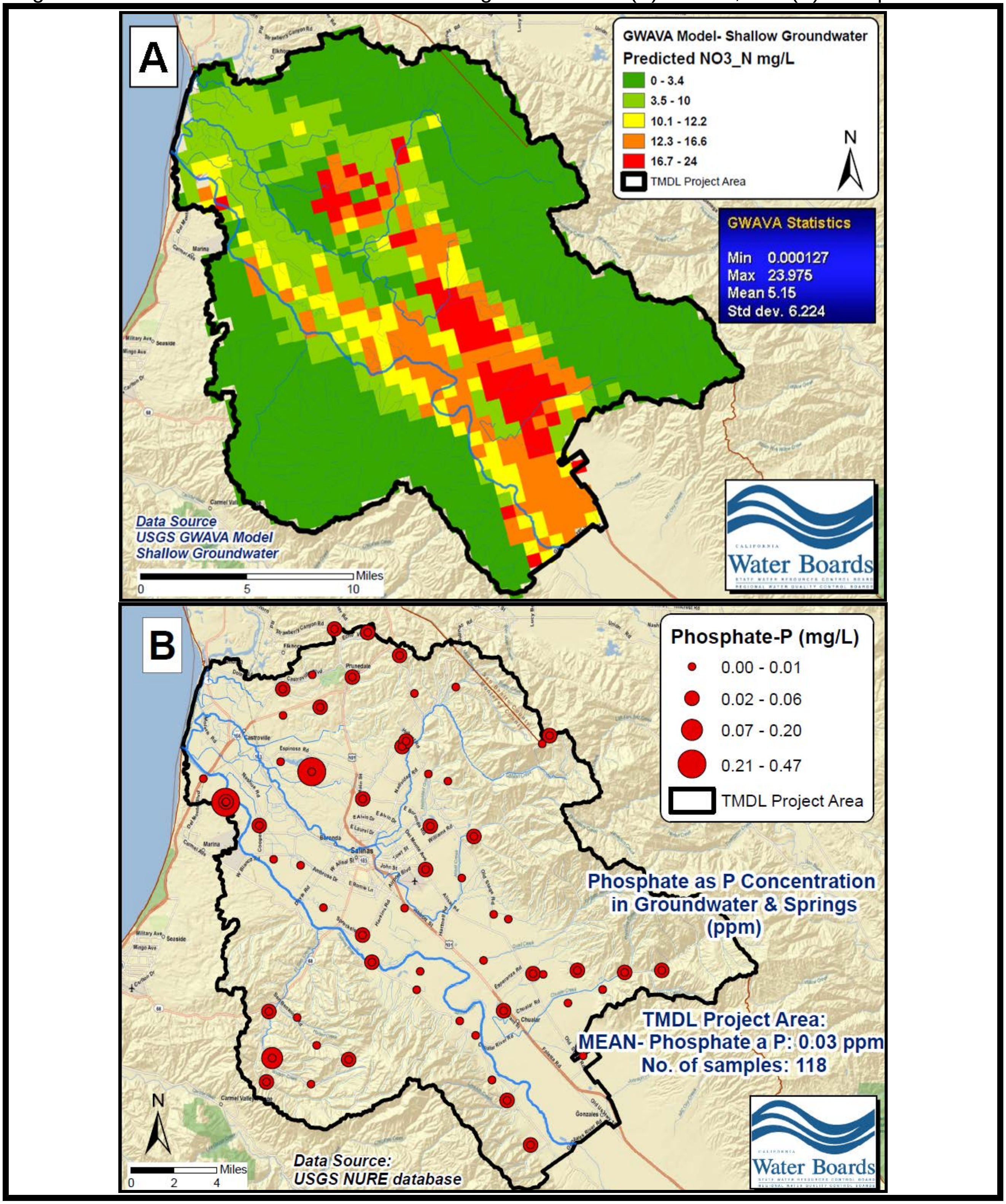


Figure 2-17. Estimated NO3-N concentrations (mg/L) and averages in shallow groundwaters of (A) the alluvial basin floor areas; and (B) the upland regions of the TMDL project area.

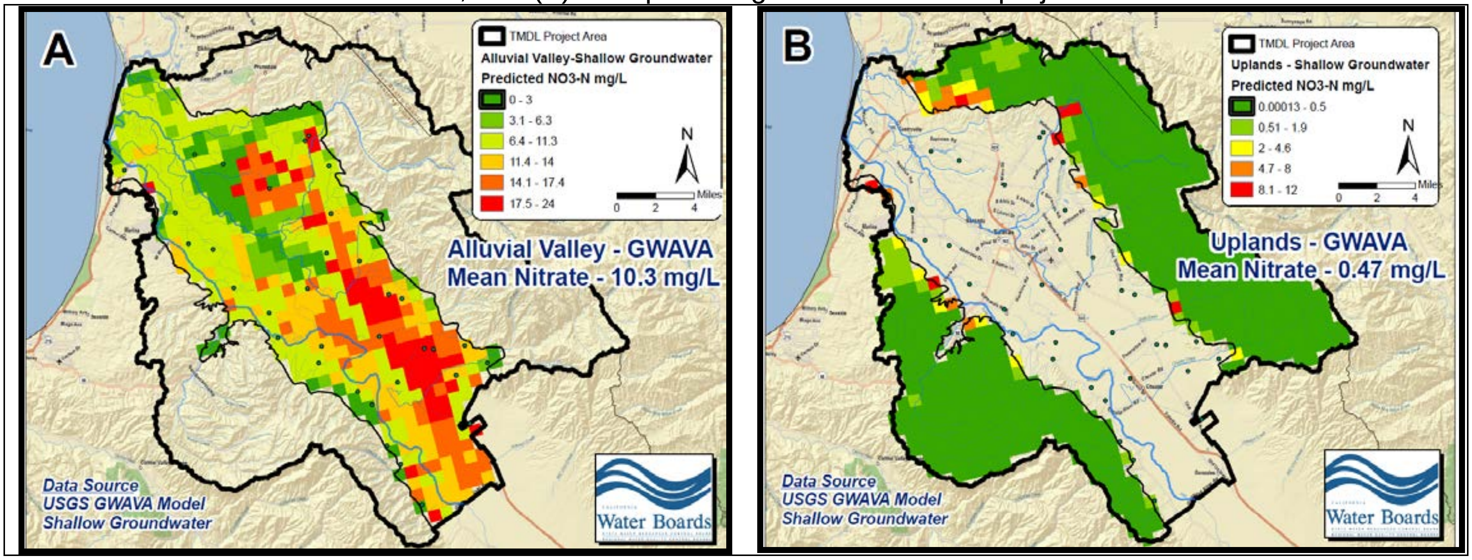
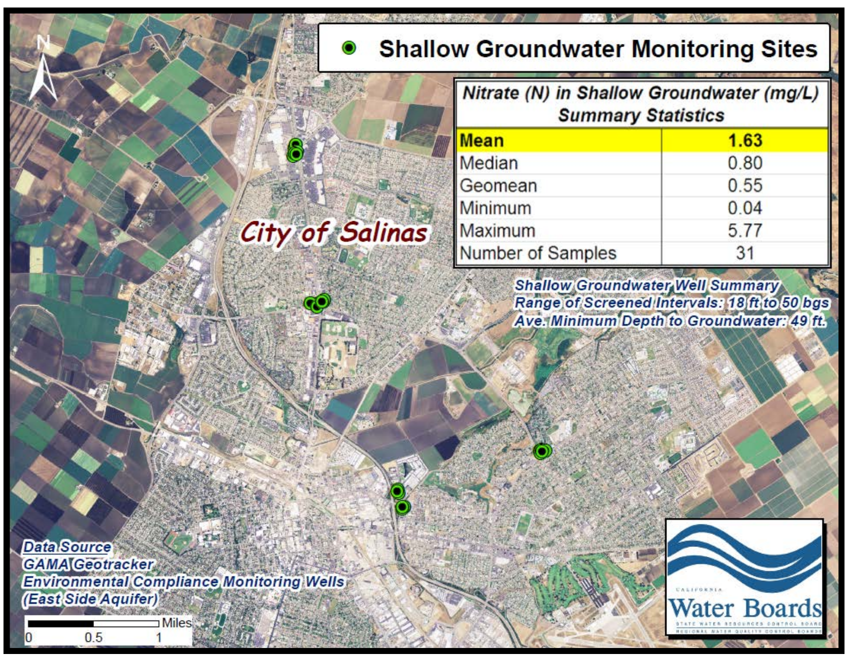


Figure 2-18. Measured NO3-N concentrations and average measures of nitrate in shallow groundwaters beneath City of Salinas (map, period of record 2005-2012), and in U.S. urbanized areas (table – source NAWQA studies 1991-1998)).



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.

Also noteworthy is 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[23] of the TMDL Project area can be approximated using data obtained by Moran et al., 2011 in the lowermost Arroyo Seco River Watershed 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[24,25].

Based on the aforementioned information, estimated shallow groundwater nitrate-N concentrations in the TMDL project area can be summarized as follows:

- **ALLUVIAL VALLEY AMBIENT BACKGROUND:** *Ambient natural background nitrate concentration that would be expected in unimpacted shallow groundwater underlying the alluvial valley floor:*
  - **1.21 mg/L**
- **AGRICULTURAL AREAS:** *Average, shallow groundwater concentration expected to underlie agricultural areas of the lower Salinas Valley:*
  - **10.3 mg/L**
- **URBAN AREAS:** *Average, shallow groundwater concentration attributable to urban influence that would be expected to underlie urban areas of the lower Salinas Valley:*
  - **1.8 mg/L**[26]
- **WOODLAND, RANGELAND & UPLAND REACHES:** *Average, shallow groundwater concentration that would be expected in bedrock aquifers and alluvial fill underlying woodland and rangeland in upland ecosystems of the TMDL project area:*
  - **0.47 mg/L**

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 alluvial and fluvial systems, the shallow subsurface stratigraphic architecture of the lower Salinas Valley is highly heterogeneous both laterally and vertically (see Figure 2-19). Perched or shallow groundwater systems are likely to occur in shallow, laterally discontinuous permeable zones (sands and gravel), which are nested within or interfinger with fine-grained aquitard strata (silts and clays).

[23] 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 in the Salinas Valley would interact with soil nitrogen during infiltration and recharge.

[24] The estimate that natural, background nitrate in alluvial valley groundwater is approximately an order of magnitude lower than anthropogenic nitrate in groundwater underlying agicultural 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”.

[25] Moran et al. (2011) report nitrate as NO3; however staff chose to report this value as nitrate-N herein, because in staff’s judgement and based on the body of scientific literature, 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 human impacts. Further, staff endeavored to develop biostimulatory targets that would not be infeasible to achieve because of plausible background conditions.

[26] Average of national median values, refer back to table in Figure 2-18

Figure 2-19. Geostatistical heterogeneity model of lower Salinas Valley shallow subsurface.

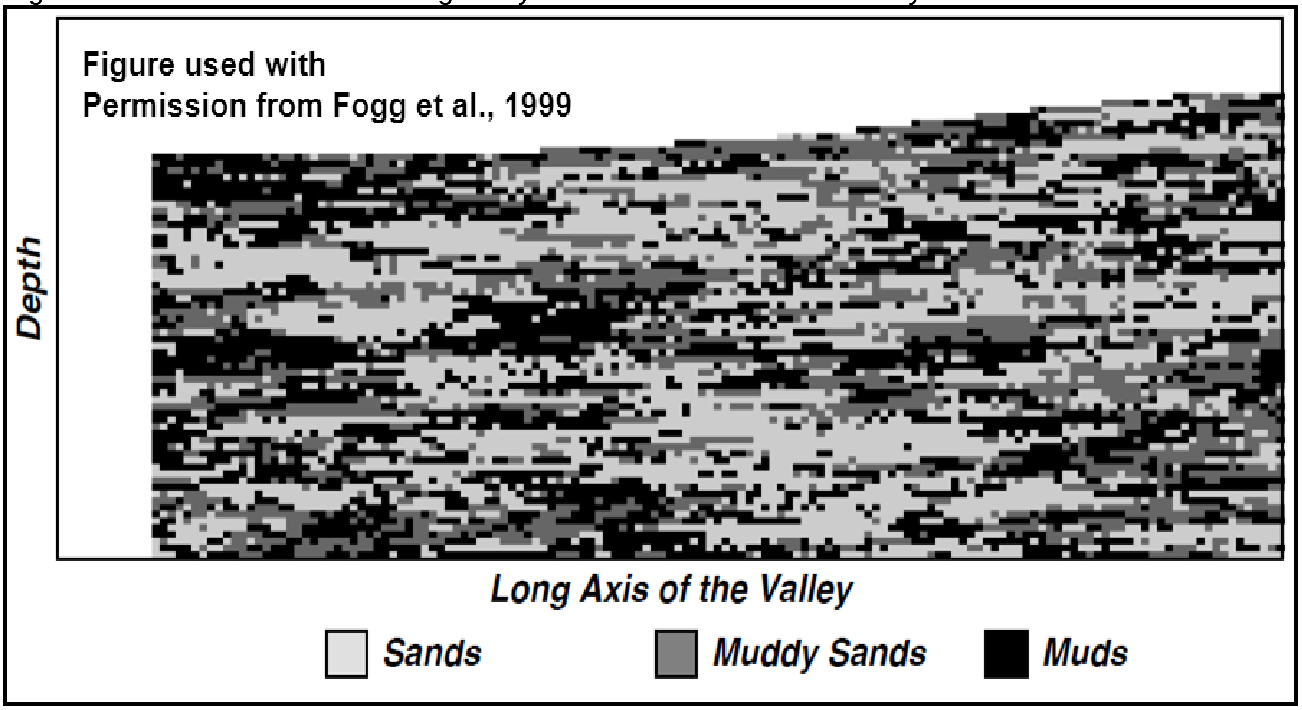
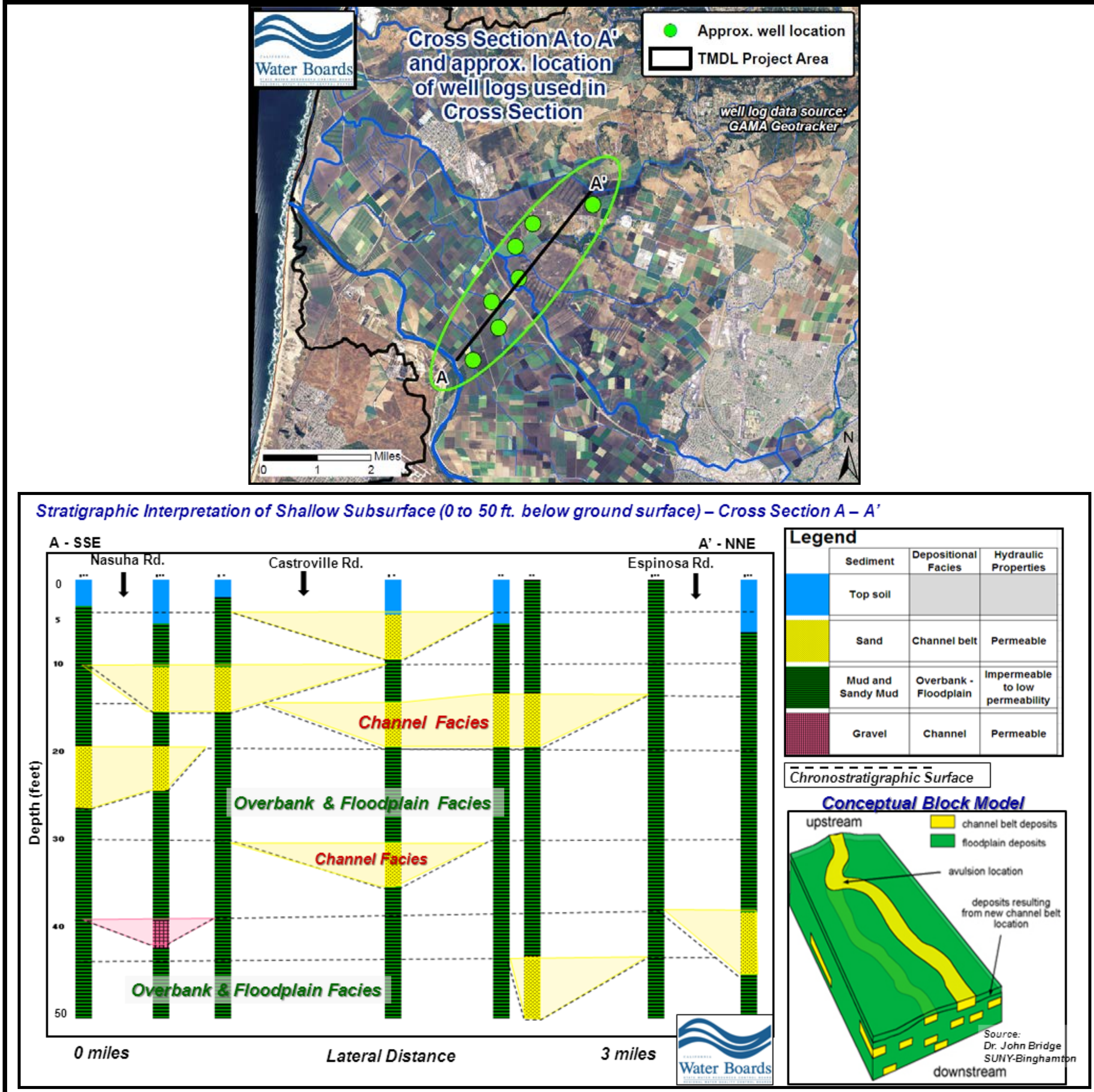


Figure 2-20 illustrates that shallow, laterally-discontinuous high permeability facies (channel belt sands and gravels) locally occur at very shallow depths (5 to 20 feet below ground surface) in the basin floor reaches of the lowermost Salinas Valley. These shallow, discontinuous permeable strata would be expected to be potential zones for perched groundwater horizons, and conduits for shallow groundwater flow and baseflow contributions to streams.

Figure 2-20. Shallow subsurface stratigraphy, cross section A – A', lower Salinas Valley.

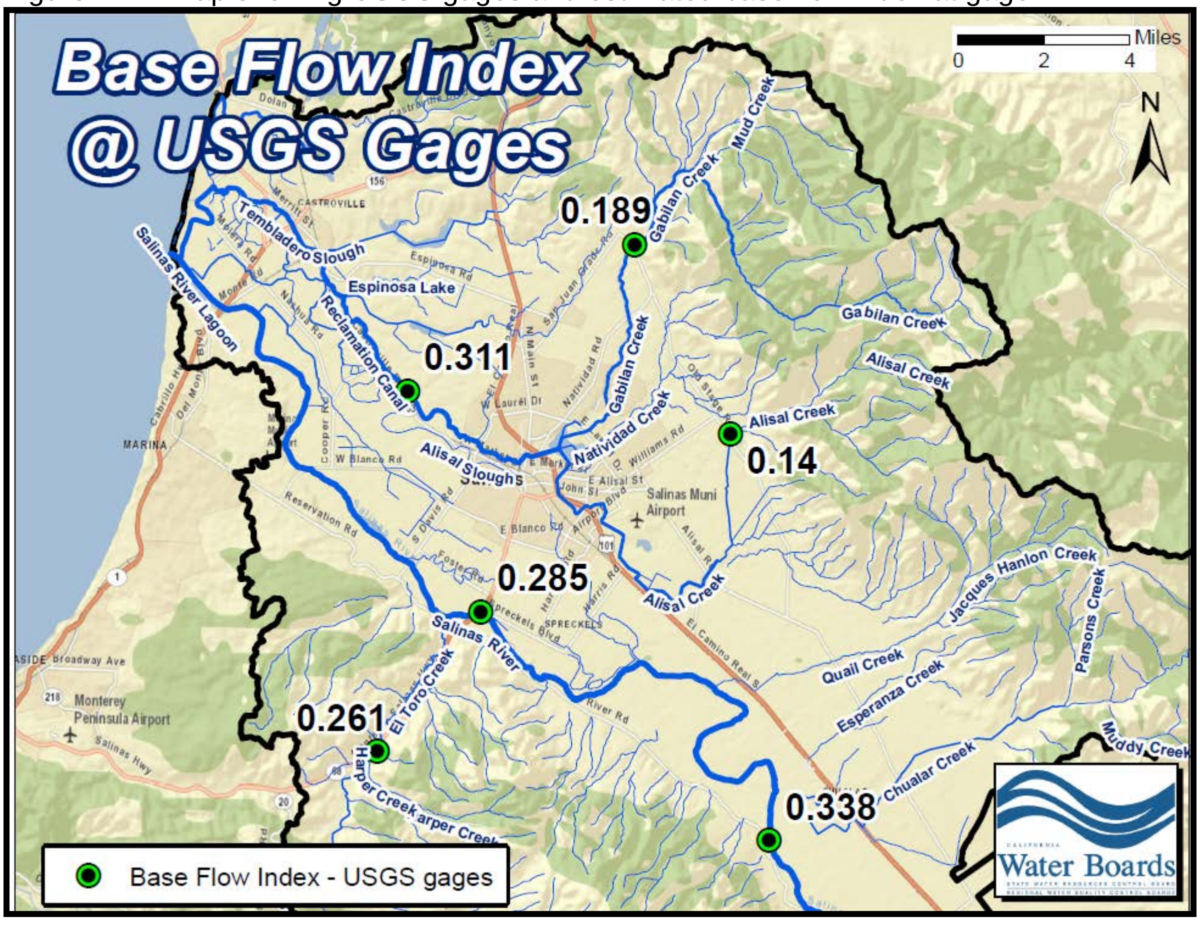


Adapted and interpreted from well log data published in Kenddey/Jenks Consultants (2004) and well log data from GAMA Geotracker.

Further, a cursory review of well log stratigraphy from logs[27] proximal to the Reclamation Canal locally indicate the presence of shallow, perched groundwater horizons that exist vertically above the main zone of saturation, as well as shallow, highly-impermeable strata including fat clays (classification = CH in the Unified Soil Classification System) and caliche stringers. These types of shallow subsurface hydrogeologic conditions suggest that shallow groundwater, perched saturated horizons, and shallow, highly-impermeable strata are present and may influence baseflow processes in adjacent stream reaches.

Additionally, flow separation analyses[28] on project area USGS gages indicate baseflow[29] indices which range from of 14% to 34% (see Figure 2-21 and Figure 2-22). As would be expected, stream gages located in the alluvial basin floor and flood plain reaches (Reclamation Canal, Salinas River) receive a substantially larger proportion of base flow contributions relative to stream reaches located upgradient on the alluvial fan reaches of the project area (Gabilan Creek, El Toro Creek, Alisal Creek). These flow separation analyses suggest that baseflow locally can be a significant hydrologic process in project area stream reaches.

Figure 2-21. Map showing USGS gages and estimated base flow index at gage

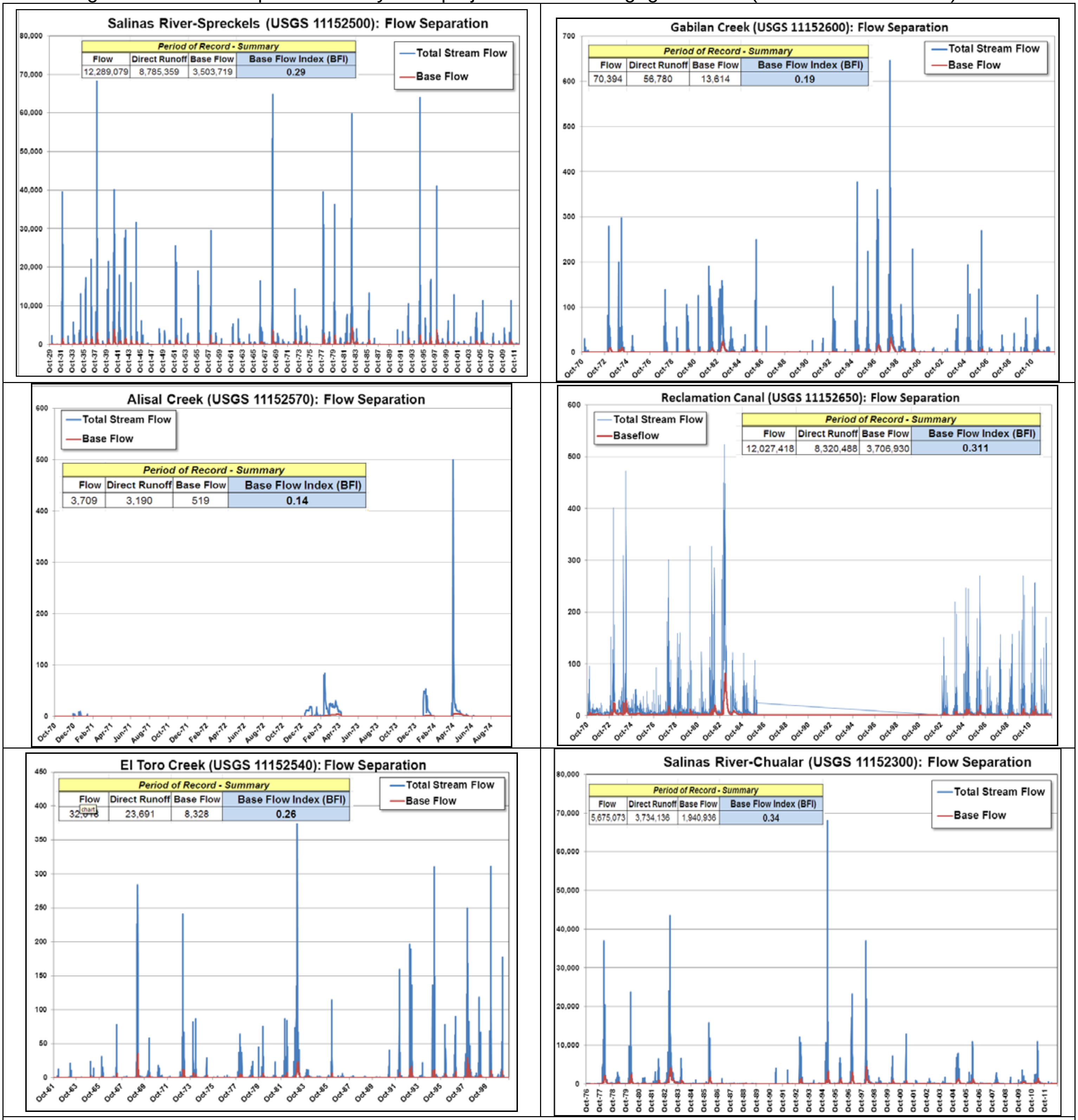


[27] Well logs and ground water depths are available at State Water Resourced Control Board's GAMA-Geotracker Regulator website. Due to confidentiality provisions in the California Water Code pertaining to well completion reports, staff cannot show or publish well logs evaluated for this project report.

[28] Flow separation was accomplished using the Web-based Hydrograph Analysis Tool (W.H.A.T.) developed by the Purdue University engineering department.

[29] Base flow is the component of stream flow over the period of record that is attributable to groundwater discharge into the stream .

Figure 2-22. Flow separation analysis of project area stream gage records (units = cubic feet/sec).



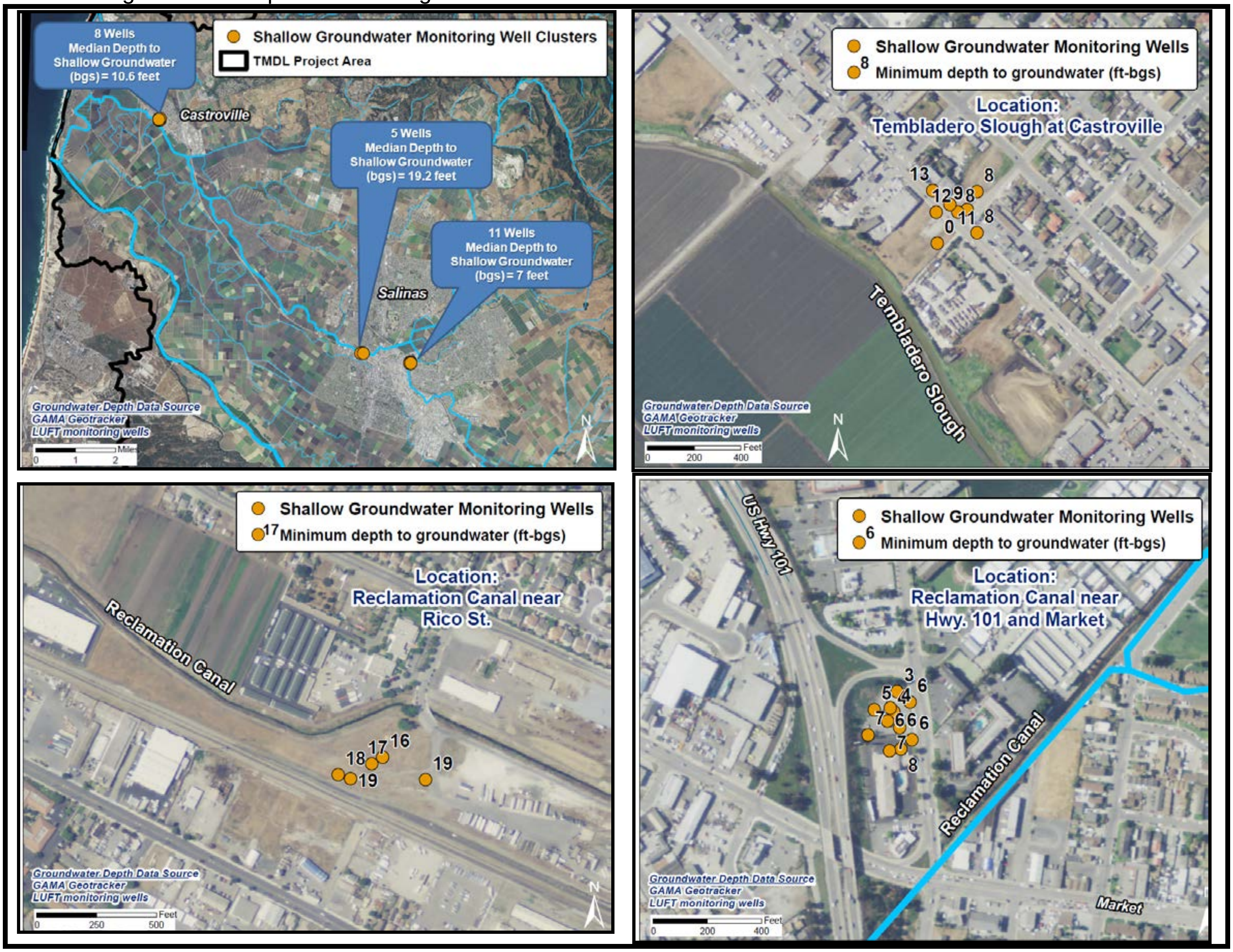
Flow separation was accomplished using the Web-based Hydrograph Analysis Tool (W.H.A.T.) developed by the Purdue University engineering department using the Recursive Digital Filter Method, with BFImax calibrated to be equivalent to base flow indices reported by the U.S. Geological Survey (2003*), Flow characteristics at U.S. Geological Survey streamgages in the conterminous United States* – USGS Open File Report 03-146.

To reiterate, localized zones of saturation (perched zones or shallow groundwater horizons) can exist vertically above the main water table, and may potentially contribute to groundwater seepage into creeks. The potential for baseflow from shallow groundwater is also illustrated from information contained in Figure 2-23. This figure shows depth to shallow groundwater from selected clusters of monitoring wells[30] in close proximity (200 to 500 feet) to the Reclamation Canal and Tembladero Slough. First-encountered shallow groundwater depths (feet below ground surface at well location) from these well clusters indicate that shallow groundwater can be encountered within a few feet (zero to twenty feet) below the ground surface in these lower alluvial valley floor areas.

It should be emphasized that these depths are measured in feet below ground at the well location; the relative elevation of proximal stream beds will be lower than land elevation at well locations Based on the depths of these shallow groundwater zones, direct hydraulic communication between stream beds and proximal shallow groundwater locally is a virtual certainty.

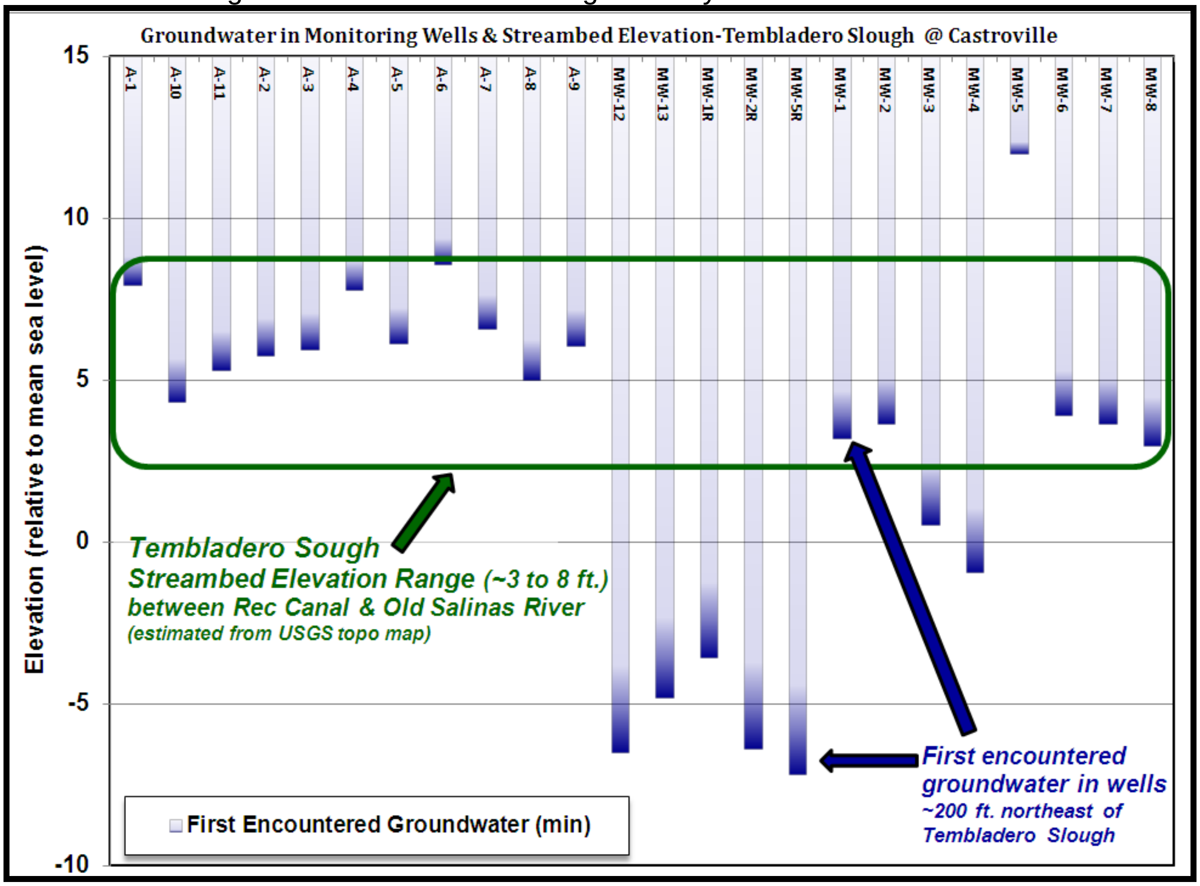
[30] Groundwater depth data from environmental monitoring well records available from SWRCB Geotracker database.

Figure 2-23. Depth to shallow groundwater at selected locations.



Additionally, well data from a cluster of monitoring wells in Castroville (refer back to Figure 2-23) located adjacent to Tembladero Slough also suggest hydraulic connectivity, locally, between streambeds and shallow groundwater. Figure 2-24 illustrates that first-encountered groundwater, locally, is at or near the stream bed elevation of Tembladero Slough at Castroville, indicating the potential for direct hydraulic communication between surface waters and subsurface waters.

Figure 2-24. First encountered groundwater in monitoring well cluster at Castroville with Tembladero Slough streambed elevation range overlay.



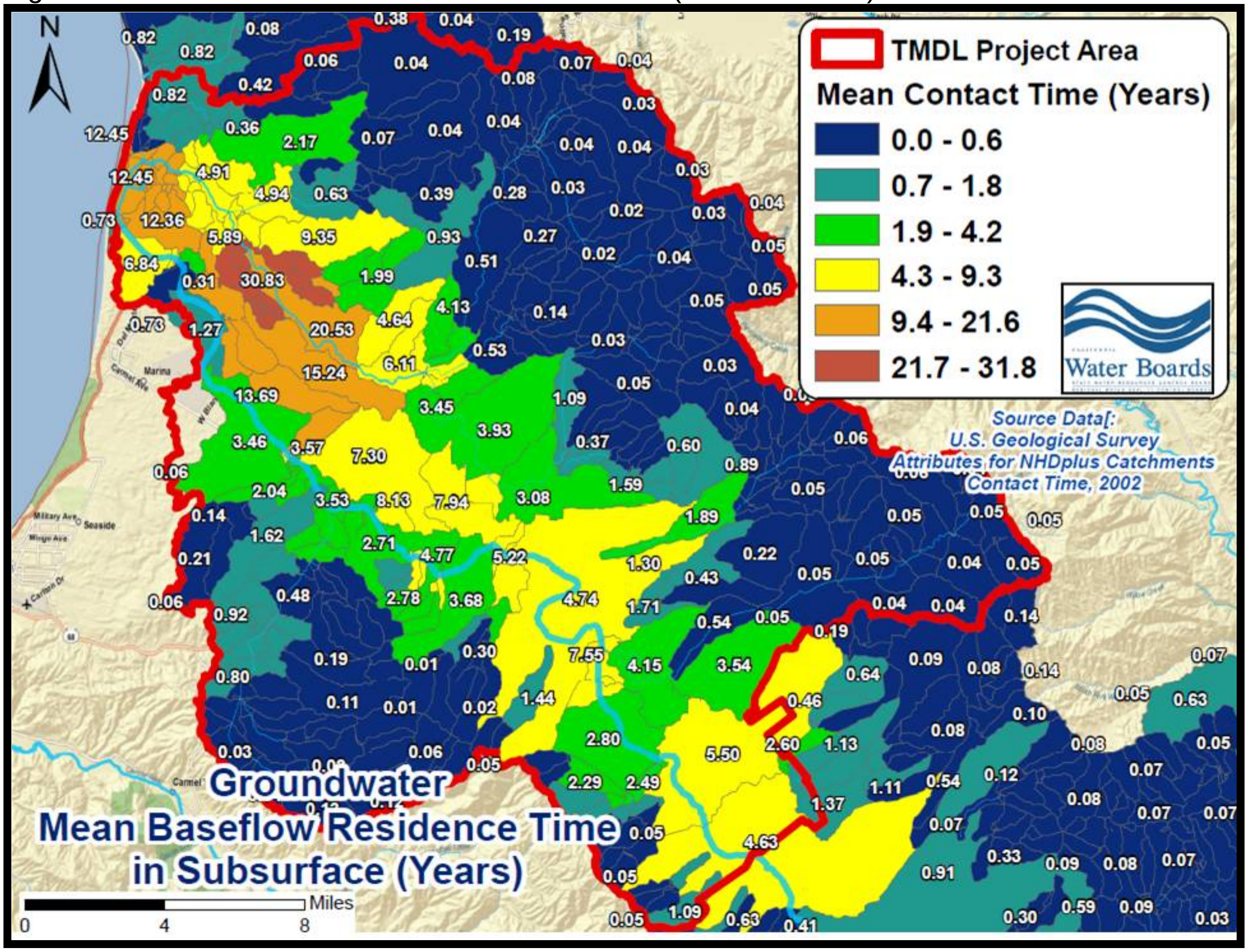
Finally, it may be important to consider the possibility of existing legacy pollution of shallow groundwater, and the residence time in the subsurface before the groundwater is expressed as baseflow. Legacy pollution (associated with long-residence times in groundwater) may be unrelated to current land 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 2-25 illustrates estimated mean groundwater baseflow residence time in the subsurface[31] on the basis of NHD catchments. It should be noted that Contact Time, as defined by the U.S. Geological Survey (USGS) metadata for this dataset represents an "average" amount of time groundwater is in the subsurface before being expressed as stream baseflow; it should not be considered a "maximum" contact time for shallow groundwater within the catchment. Based on site-specific conditions, locally contact time could be longer than the NHD catchment mean contact times.

Note that in the alluvial basin floor reaches of the lower Salinas valley (lower Reclamation Canal, Blanco Drain, Alisal Slough, etc.), local soils have very low permeability and average groundwater baseflow residence times can be on the order of decades. In contrast, stream reaches located on the alluvial fan and upland areas of the project area have shorter baseflow

[31] 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.

residence times. If shallow groundwater, or perched groundwater systems have legacy pollution issues and if baseflow is a load contributor to streams, any reasonable implementation strategy or timeline may have to consider that legacy pollution coming from baseflow and which is unrelated to current activities may take decades to dissipate.

Figure 2-25. Estimated baseflow mean contact time (source: USGS).



Collectively, the USGS 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[32] may locally be partially attributable to legacy pollution.

2.10 Geology

Geology may have a significant influence on natural, background concentrations of nutrients. Stein and Kyonga-Yoon (2007) report that catchment geology was the most influential environmental factor on variability in water quality from natural areas in undeveloped stream reaches located in Ventura, Los Angeles, and Orange counties, California. As such, in evaluating the effect of anthropogenic activities on nutrient loading, it is also relevant to consider the potential impact on water quality which might result from local geology and rock geochemistry.

[32] e.g., Blanco Drain, Alisal Slough, lower Reclamation Canal, and/or Tembladero Slough.

The project area of the lower Salinas Valley lies in a southeast to northwest-trending intermontane trough filled principally by unconsolidated alluvial sediments. The valley is bounded by mountains which are formed by uplift and tranpressional tectonic forces and which are underlain by consolidated sedimentary assemblages, igneous rocks and metamorphic rocks.

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. The mean annual average of nutrient concentrations (wet weather plus dry weather samples), as shown in Table 7 of Stein and Kyonga-Yoon (2007), indicates undeveloped stream reaches underlain by igneous rock had mean nutrient concentrations of: total nitrogen=1.12 mg/L, total phosphorus = 0.03 mg/L. In contrast, undeveloped stream reaches underlain by sedimentary rock in contrast had mean nutrient concentrations of: total nitrogen = 1.36 mg/L, total phosphorus = 0.06 mg/L.

<u>Nitrogen Geochemistry</u>

It is important to note that while the aforementioned researchers indicated that catchment geology can influence “nutrient” concentrations, for clarity’s sake in fact 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[33]. Nitrogen-enriched minerals are rare, and are only found in nitrate minerals formed in highly-arid evaporative environments[34]. The TMDL project area of the lower Salinas River watershed does not contain nitrate-enriched evaporative sedimentary rocks.

With regard to non-mineralogical forms of nitrogen, organic nitrogen is more abundant in sedimentary rocks than in igneous or metamorphic rocks. Nitrogen in sedimentary rocks is typically associated with organic matter, which is commonly deposited with sedimentary strata, mostly marine shales and mudstones (University of California-Davis, 2012). Some organic-rich marine shales can contain 600 ppm nitrogen on average (USGS, 1985). Note that in contrast, organic material is only an infrequent and trace component in most igneous or metamorphic rocks. The TDML project area is largely comprised of igneous, metamorphic, and sandy-silty sedimentary rock assemblages, and available data does not indicate the presence of significant amounts of organic-rich mudstones or shales deposited in marine depositional environments (see Figure 2-26). Consequently, there does not appear to be a significant geologic reservoir in the project area that could contribute to elevated nitrogen loads to surface waters.

Indeed, from the nitrogen-cycling perspective, 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 TMDL project area 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.

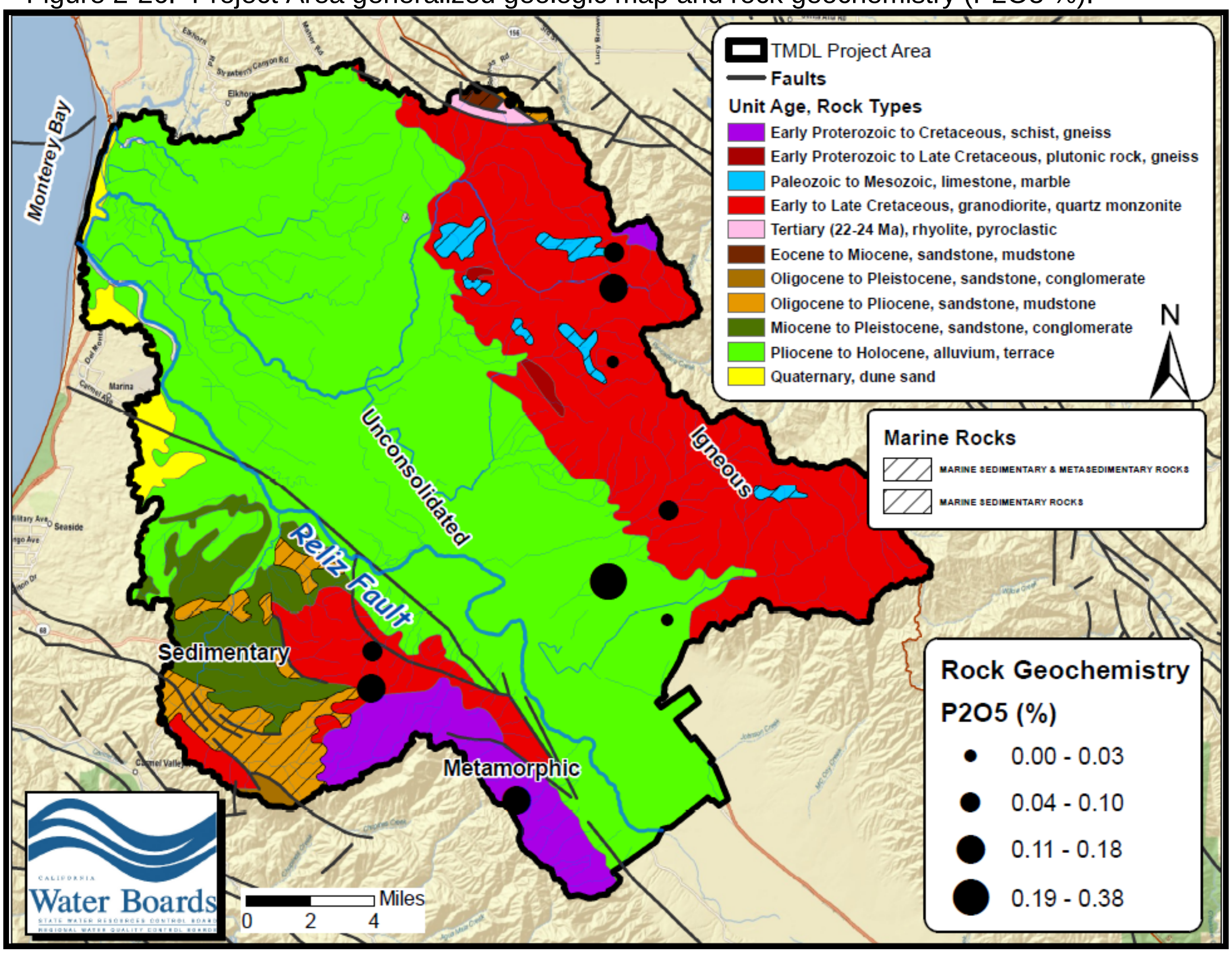
[33] For example, the average nitrogen content of igneous rocks is reported to be 46 part per million (ppm). By comparison, the trace elements cesium, lanthanum, vanadium, and neodymium are reportedly more abundant in igneous rocks than nitrogen (see: USGS, 1985, *Study and Interpretation of the Chemical Characteristics of Natural Water.* USGS Water-Supply Paper 2254).

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

<u>Phosphorus Geochemistry</u>

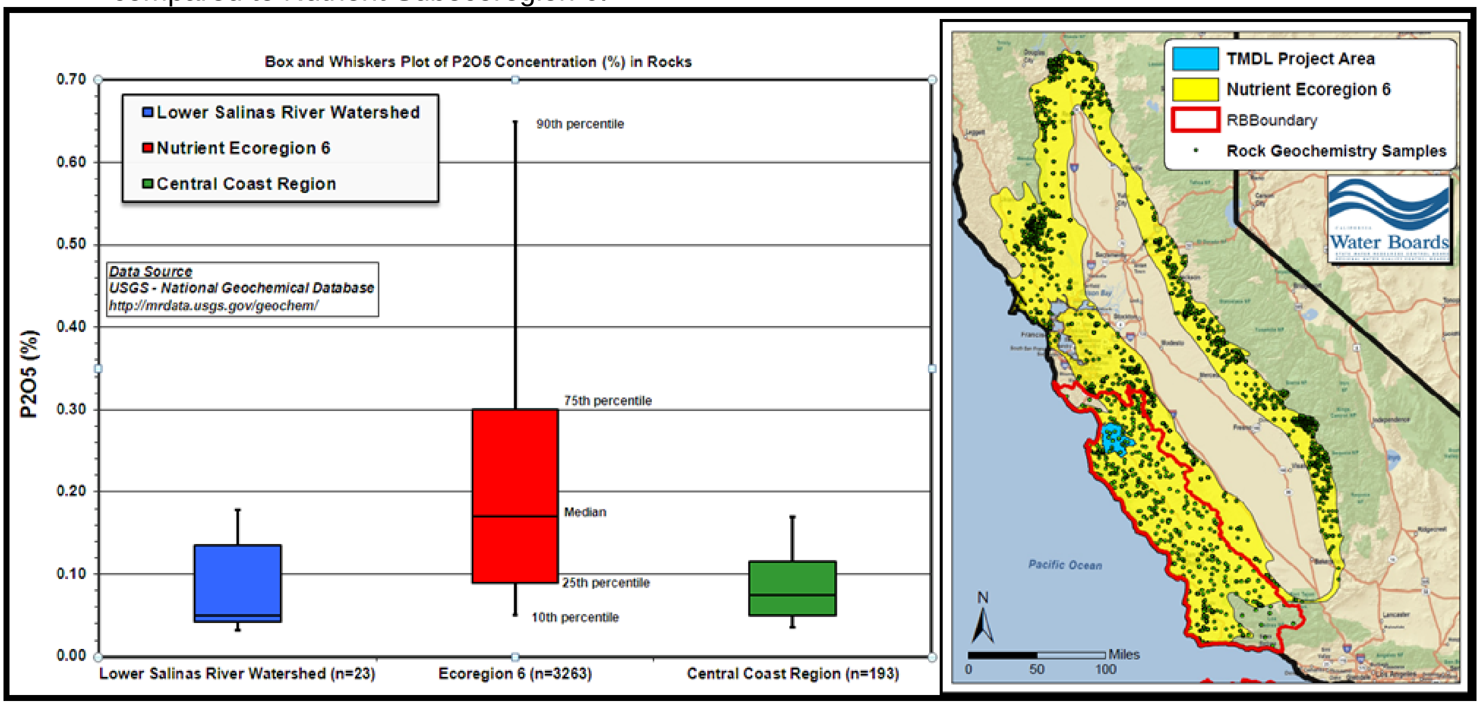
Rocks and natural phosphatic deposits are the main natural reservoirs of phosphorus inputs to aquatic systems (USEPA, 1999). The potential for these natural phosphorus inputs may be assessed using digital data for California geology and rock geochemistry available from the U.S. Geological Survey's Mineral Resources On-line Spatial Data webpage and National Geochemical Database (http://mrdata.usgs.gov/). Figure 2-26 depicts the geology of the project area. Generally, headwater reaches in the Gabilan Range (northeastern side of project area) drain stream reaches underlain largely by granitic (igneous) rock. Headwater reaches draining the Sierra de Salinas Range (southwestern side of project area) drain reaches that are underlain by a mix of sedimentary, igneous, metamorphic rocks. According to the USGS digital lithology dataset, there are no significant amounts of phosphate-enriched rocks such as phosphatic shales, or phosphatic cherts in the project area. Overall, igneous rock is the dominant lithology draining the natural areas and headwater reaches of the project area. As noted previously, igneous lithology is identified in the Stein and Kyonga-Yoon (2007) study as contributing relatively lower natural levels of phosphorus to aquatic systems.

Figure 2-26. Project Area generalized geologic map and rock geochemistry (P2O5 %).



Additionally, limited amounts of rock geochemistry (% P_2O_5) are available for the project area (see Figure 2-26 and Figure 2-27)[35]. The limited amounts of geochemical data suggest that rocks in the project area are not enriched in phosphate, and evidently are not a particularly significant source of phosphate to project area streams. As shown in the box and whiskers plot of Figure 2-27 rocks in the project area and the central coast region apparently have relatively low concentrations of phosphorus (%P2O5[36]) on average relative to all rock geochemical samples more broadly from across Nutrient Subecoregion 6.

Figure 2-27. Rock geochemistry (P2O5 %) in TMDL Project Area and central coast region compared to Nutrient Subecoregion 6.



Also, as noted previously, available data indicate that granite and sandstone are the dominant lithologies in the TMDL project area, with subsidiary amounts of mudstone. The worldwide average phosphorus composition of these rock types is presented in Table 2-10.

Table 2-10. Global average phosphorus content (P2O5 wt. %) of selected rock types.

Rock Type	Worldwide Average P2O5 composition (Weight %)	Scientific Source
Granite	0.12%	Blatt and Tracy, 1997
Sandstone	0.16%	Pettijohn et al. 1987[A]
Shale (mudstone)	0.15%	NASC = North American Shale Composite[B]

[A] average of sandstone compositions reported in Table 2-7 of Pettijohn et al., 1987
[B] as reported by Mannan, 2002

Comparing these global averages to the ranges of P2O5 compositions in the lower Salinas Valley and the Central Coast region (refer back to Figure 2-27) indicates that rocks of the TMDL project area do not significantly deviate - nor are elevated - relative to global average phosphorus content reported for granite, sandstones and shales. This constitutes a further line

[35] Data source: U.S. Geological Survey, mineral resources and geochemistry online spatial data. Online linkage: http://mrdata.usgs.gov/
[36] P2O5 = phosphorous pentoxide..

of evidence that project area geology is not likely to be a significant contributor of phosphorus to surface waters.

An additional line of evidence is available based on information published by the U.S. Geological Survey. In the central coast region of California, most phosphate-enriched rocks are associated with Miocene-aged marine sedimentary rocks; specifically Miocene mudstones and phosphatic shales (USGS, 2002). Phosphatic facies have been reported in the literature to exist in the Miocene-age Monterey and Santa Margarita formations (USGS, 2002). 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 to late Miocene Epoch, approximately ~ 7 to 15 million years ago (White, undated PowerPoint presentation).

Consequently, note that Figure 2-28 illustrates the distribution of Miocene-aged marine sedimentary rocks of the northern central coast region; these distributions constitute areas where there is presumably potential for phosphate-enriched mudstones and shales. An additional independent line of supporting evidence pertaining to this hypothesis is available from rock geochemical data[37]. Of 193 rock phosphorus geochemical samples available for the central coast region, rocks that were sampled within areas associated with Miocene sedimentary rocks have, on average (arithmetic mean) almost twice as much phosphorus (on a weight percentage basis) as rock geochemical samples in areas *not* associated with Miocene sedimentary rocks (see Table 2-11). Addtionally, the maximum observed rock phosphorus content in areas associated with Miocene sedimentary rocks is almost three times as high as the maximum phosphorus content in areas *not* associated with Miocene sedimentary rocks.

The map data in Figure 2-28 indicate that there are no significant amounts of phosphate-prone marine sedimentary rocks in the TMDL project area. In particular, there are virtually no phosphate-prone Miocene marine sedimentary rocks in areas draining to the Reclamation Canal watershed.

Outside the TMDL project area it should be noted that Figure 2-28 indicates that a major upstream tributary (the San Antonio River) in the upper reaches of the Salinas River does drain areas containing substantial amounts of phosphorus-prone Miocene sedimentary rocks. Indeed, water column orthophosphate in the lower San Antonio River is generally elevated (monitoring site 309SAN: orthophosphate-P mean = 0.131 mg/L; maximum = 0.281 mg/L)[38] relative to regional ambient reference conditions. However, the San Antonio River phosphorus contributions to the Salinas River are likely diluted by volumetrically larger flow inputs from low-phosphorus waters of the Nacimiento River[39] and other Salinas River tributaries – indeed, orthophosphate concentrations in the Salinas River downstream of its confluence with the San Antonio River are relatively low (e.g., Salinas River at King City, orthophosphate-P mean = 0.060 mg/L; maximum= 0.150 mg/L). This suggests that phosphorus inputs to the Salinas River from the San Antonio River tributary are evidently diluted and likely have no significant detrimental effect on phosphorus water column concentrations within the downstream Salinas River reaches of the TMDL project area.

[37] U.S. Geological Survey: The national geochemical survey database.
[38] Water quality data source: Central Coast Ambient Monitoring Program website. Online linkage: http://www.ccamp.org/.
[39] According to the Monterey County Water Resources Agency reservoir release schedule, average annual releases for the year 2012 were 234 cfs for the Nacimento dam compared to 88 cfs for the San Antonio dam.

Collectively, all of the aforementioned information indicates that geology and rock composition in the TMDL project area evidently are not likely to be a significant reservoir or contributing factor to the highly elevated phosphorus concentrations found locally in surface waters of the lower Salinas valley.

Figure 2-28. Distribution of Miocene marine sedimentary rocks in northern Central Coast region.

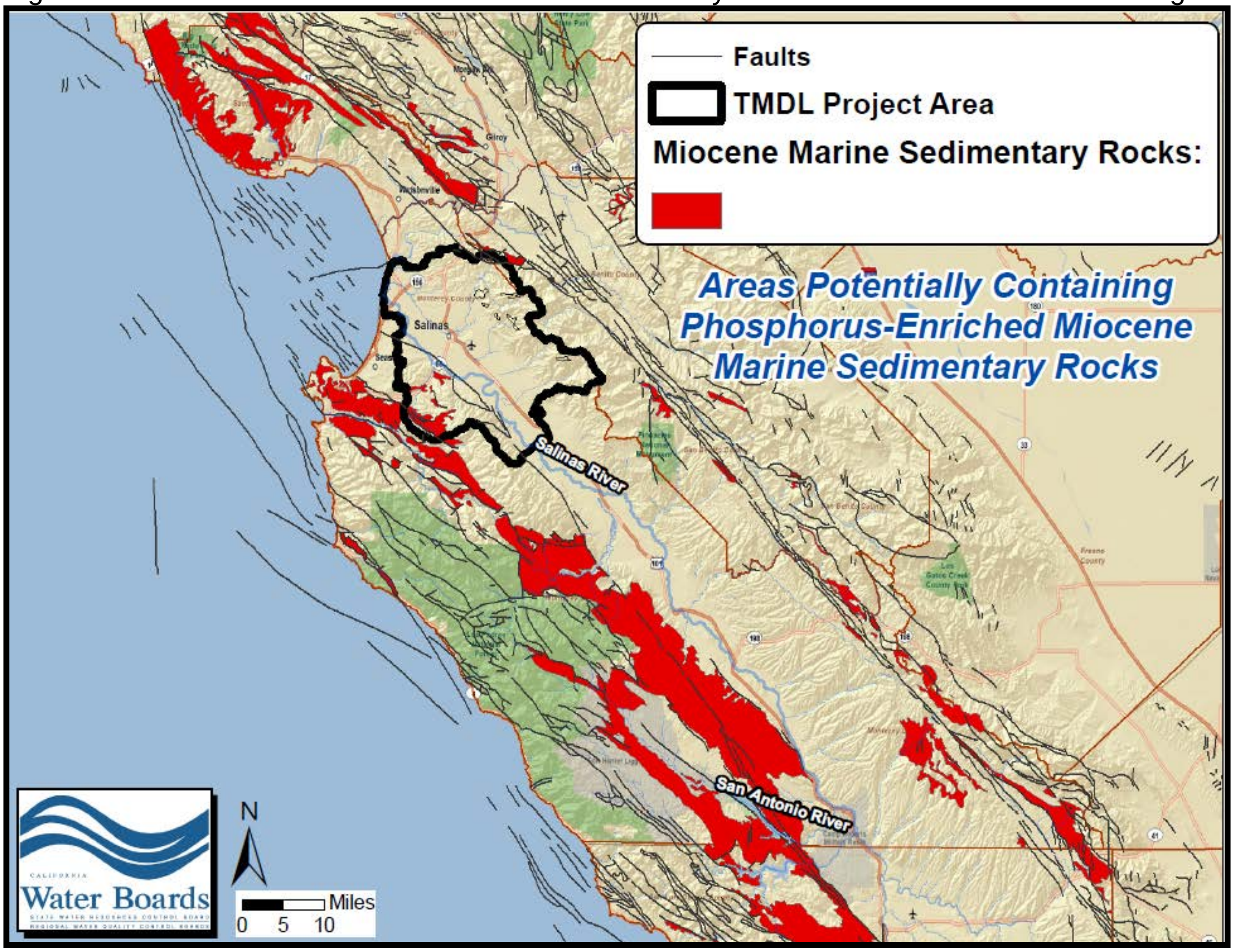


Table 2-11. Central Coast Region rock geochemistry samples: Comparison of phosphorus content of samples from areas with Miocene sedimentary rocks, and areas excluding Miocene sedimentary rocks.

Central Coast Region: Observed Rock P2O5 content (weight %) in Samples Associated with Miocene Sed Rocks									
No. of Samples	**Min**	**10th percentile**	**25th percentile**	**Median**	**Geomean**	**Mean**	**75th percentile**	**90th percentile**	**Max**
32	0.005	0.041	0.069	0.090	0.095	0.155	0.148	0.210	1.185
Central Coast Region: Observed Rock P2O5 content (weight %) in Samples NOT Associated with Miocene Sed Rocks									
No. of Samples	**Min**	**10th percentile**	**25th percentile**	**Median**	**Geomean**	**Mean**	**75th percentile**	**90th percentile**	**Max**
161	0.006	0.035	0.050	0.070	0.071	0.086	0.105	0.150	0.380

source data: USGS on-line geologic spatial map data- *Preliminary integrated databases for the United States – Western States: California, Nevada, Arizona, and Washington*, and the USGS National Geochemical Survey database (attribute P-ICP40).

2.11 Soils and 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; Kellog et al., 2006). The relationship between nutrient export (loads) and soil texture are illustrated in Figure 2-29 and Figure 2-30. 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.

An additional reason for developing soils data for this TMDL project is because the STEPL source estimation spreadsheet tool used in this project report requires input for soil conditions (refer to 5.1). Accordingly, this section of the project report summarizes relevant soils information.

Figure 2-29. Median annual Total N and Total P export for various soil textures.

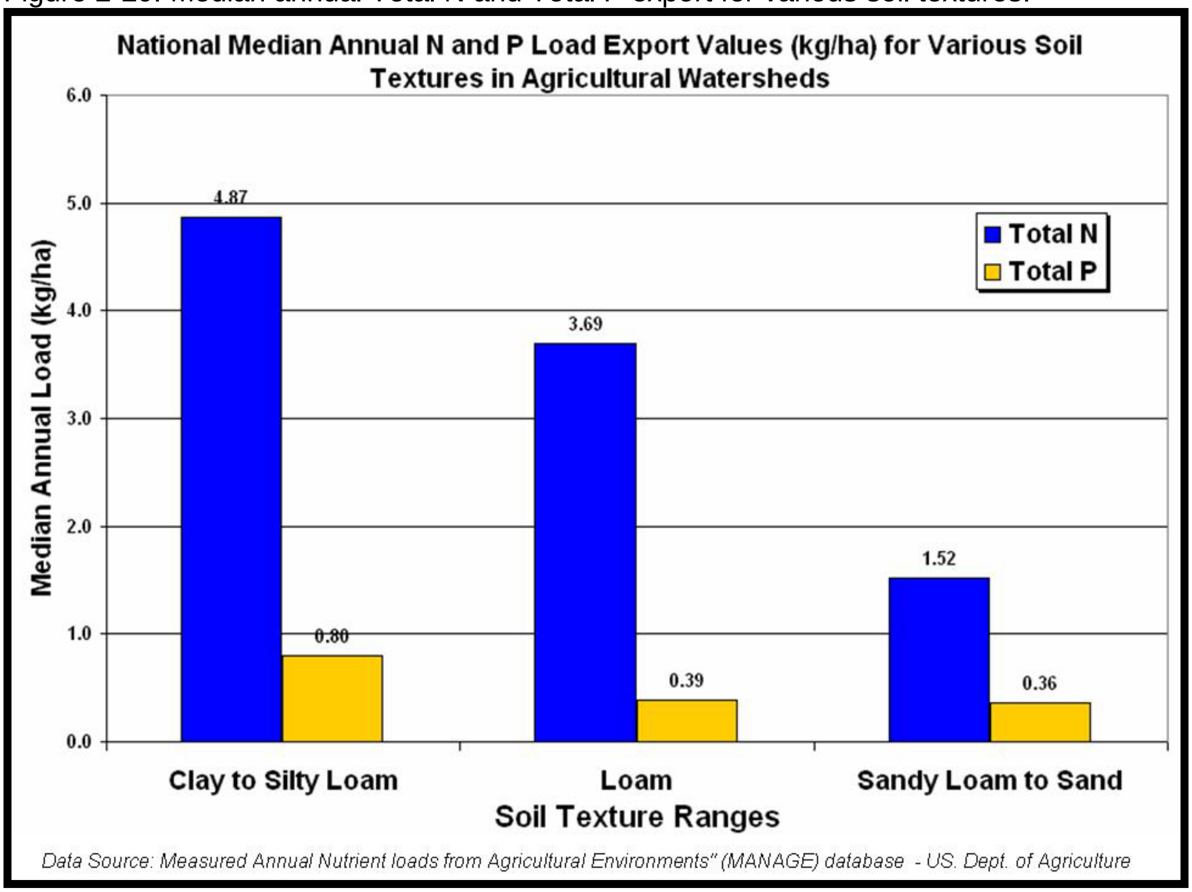
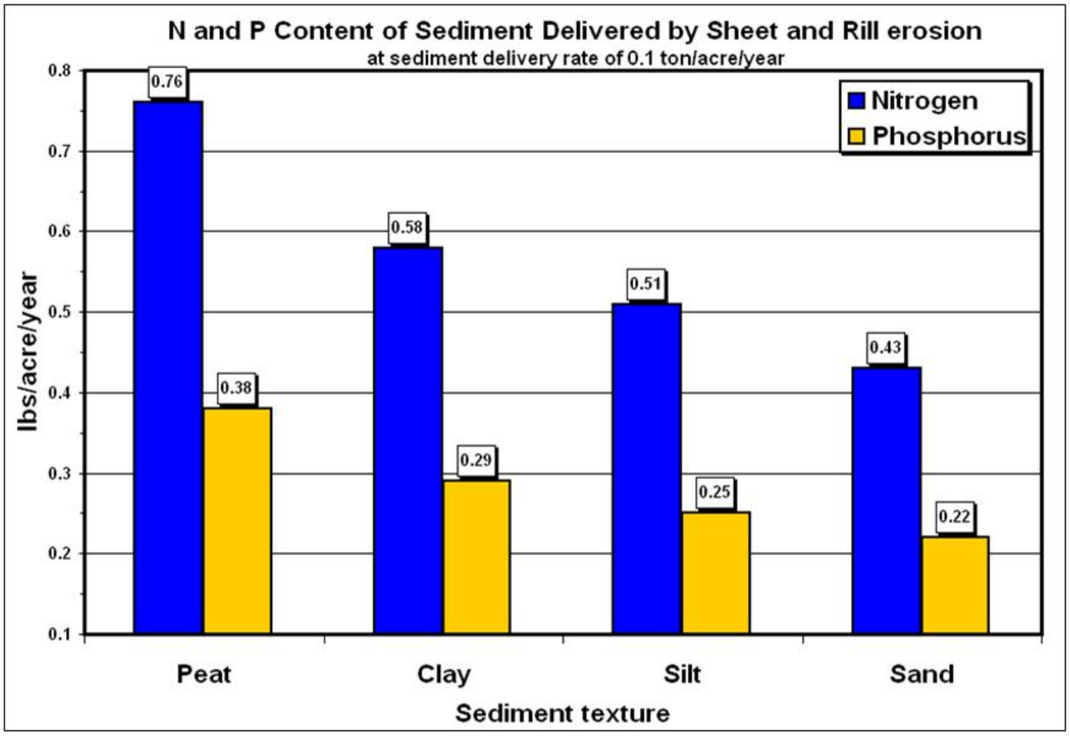


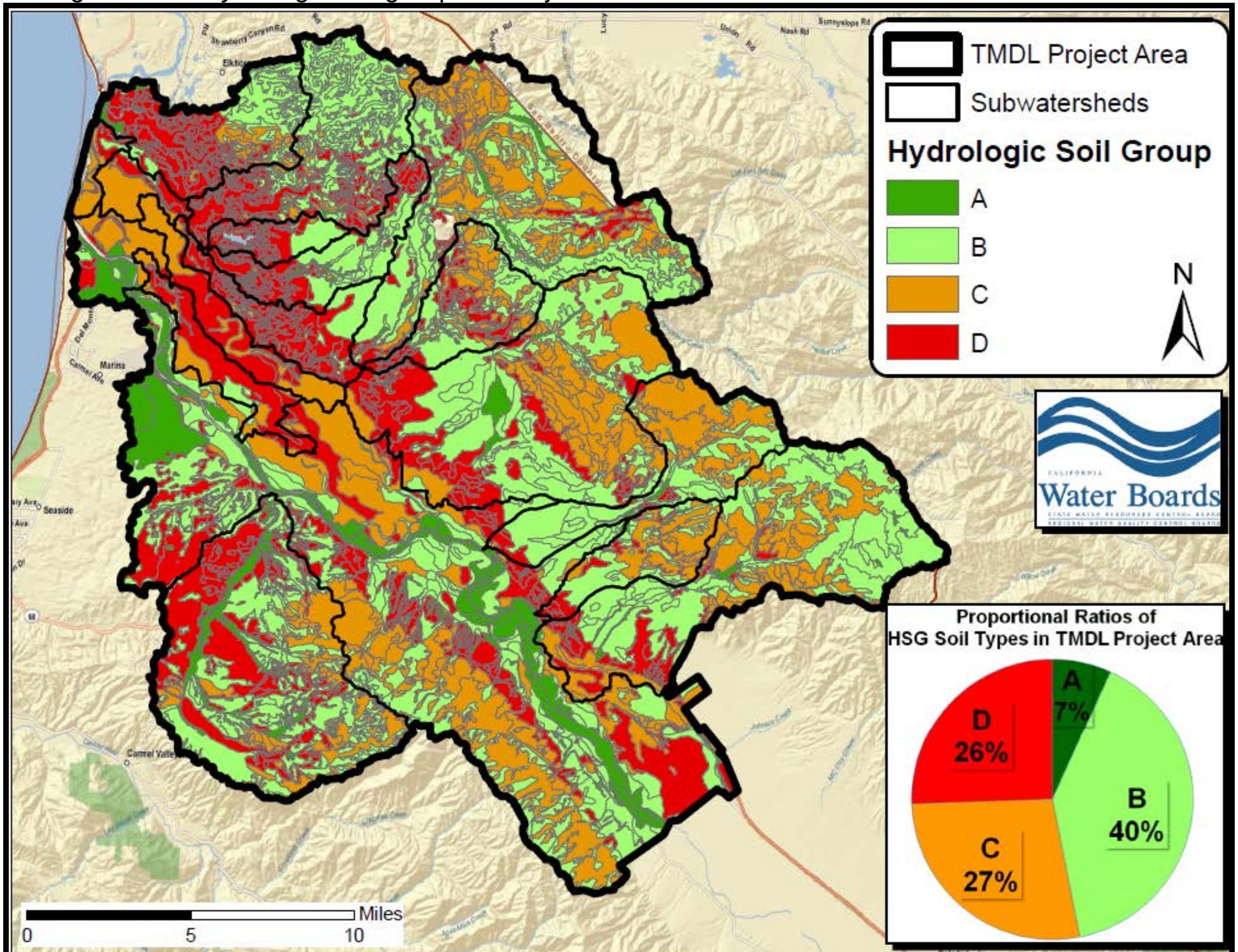
Figure 2-30. N and P content of sediment delivered by sheet and rill erosion.



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.*

The soil survey for Monterey County was compiled by the U.S. Department of Agriculture National Resources Conservation Service (NRCS) and 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. Figure 2-31 illustrates the distribution of hydrologic soil groups in the project area along with a tabular description of the soil group's hydrologic properties.

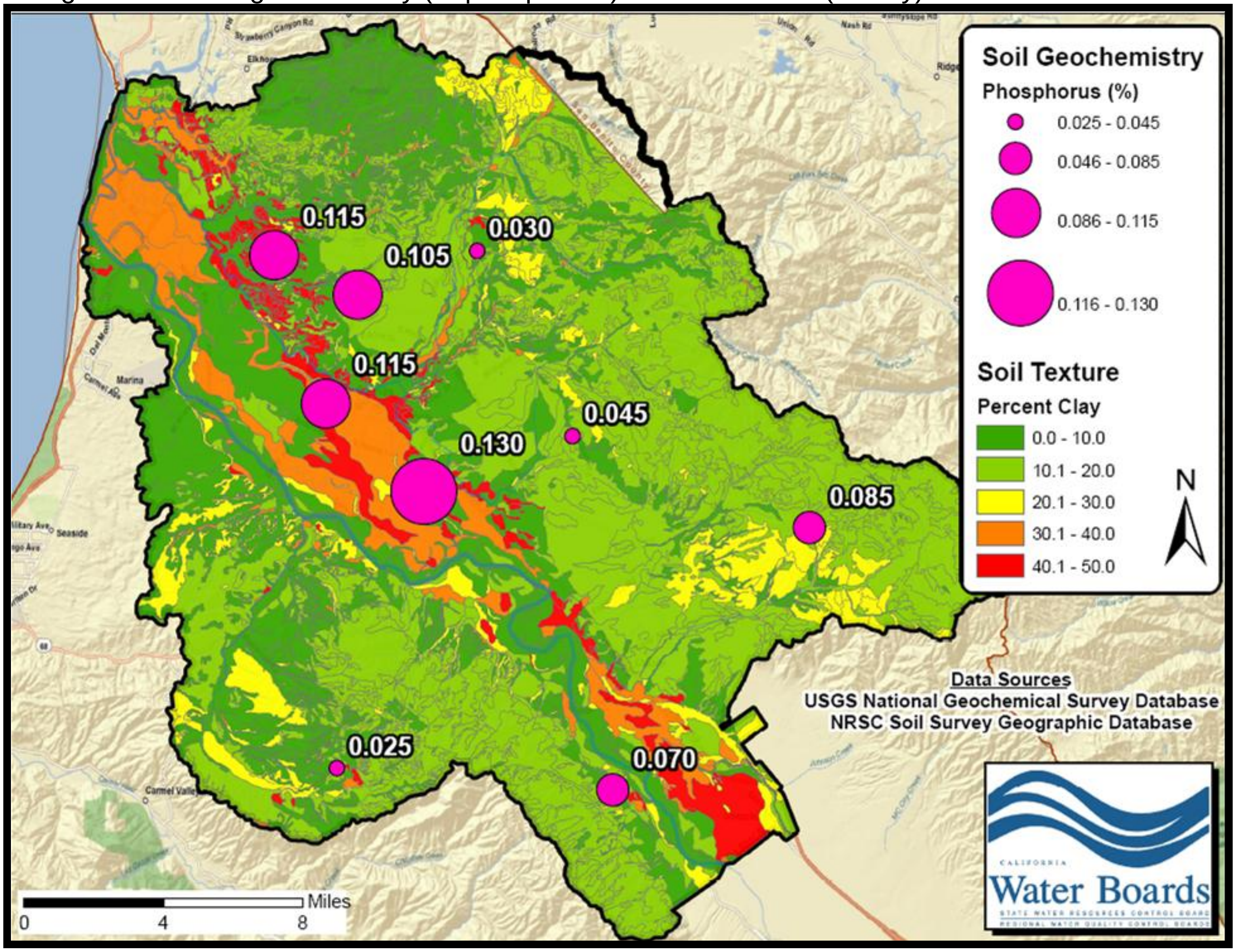
Figure 2-31. Hydrologic soil groups in Project Area.



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)

Available soil geochemistry data from the USGS National Geochemical Survey indeed indicates that soils in project area agricultural and urbanized valley floor areas, and/or areas comprised of clay-enriched soils in the lower Salinas River watershed are higher in phosphorus content relative to generally coarser grained soils in upland or headwater reaches (see Figure 2-32). This is broadly consistent with the observations, as previously illustrated in Figure 2-29 that the risk of nutrient export is typically higher with finer-grained or clay-rich soils.

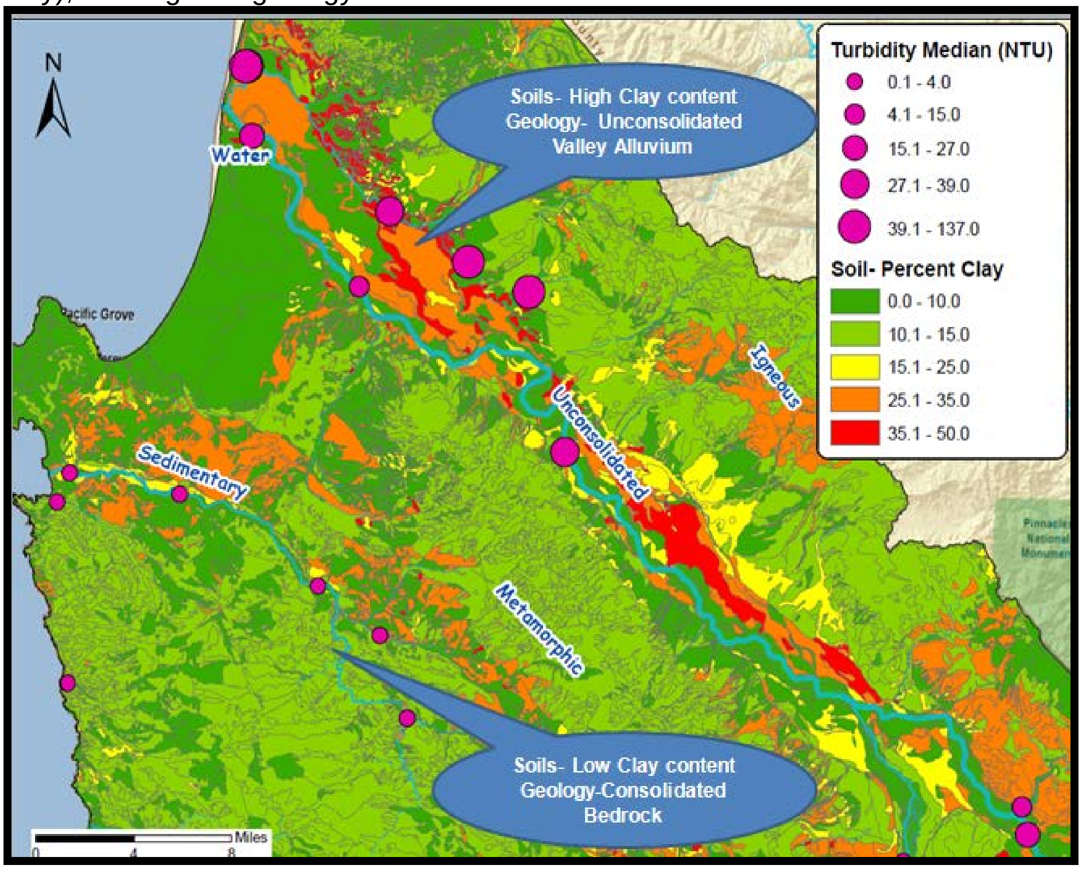
Figure 2-32. Soil geochemistry (% phosphorus) and soil texture (% clay).



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 water column turbidity, soil conditions, and regional geology illustrate the substantial variability in ambient conditions even at reach-scale or watershed-scale. Figure 2-33 illustrates that in northern Monterey County, turbidity conditions in an agricultural alluvial valley, with clay-rich soils and substrates will likely have substantially different ambient turbidity conditions relative to stream reaches in upland areas, or 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 2-33. Northern Monterey County, water column turbidity (median NTU), soil texture (% clay), and regional geology.



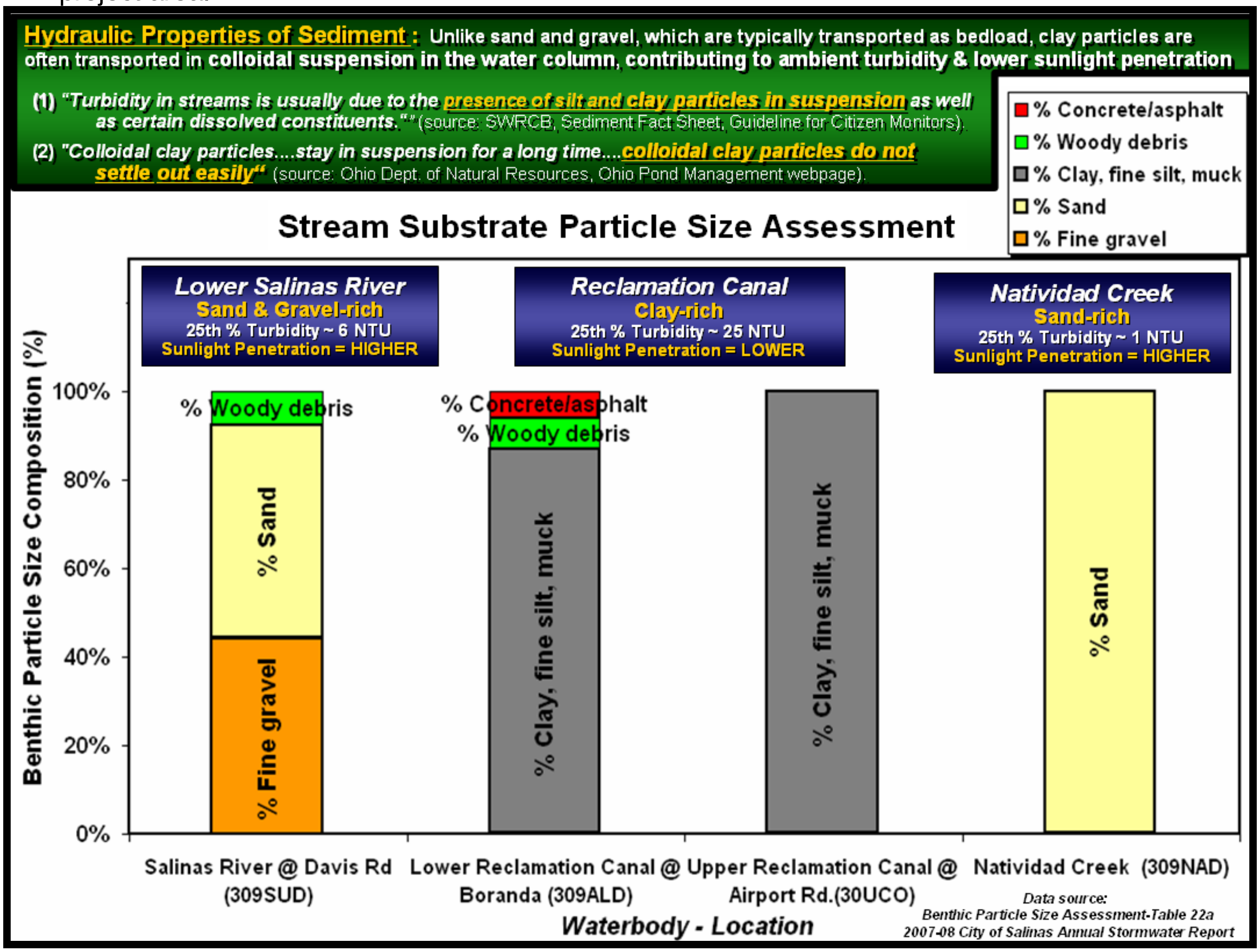
Further, some biocriteria modeling tools used to assess nutrient targets (e.g., California NNE benthic biomass model tool) require input of turbidity information to calculate the water column light extinction coefficient. As noted above, turbidity, to a large extent, may result from the magnitude of suspended fine-grained particulate matter such as clay and fine silt in the water column[40]. Consequently, staff considered whether local soil physical characteristics available via SSURGO mapping databases (as shown, for example in soil texture spatial data in Figure 2-32 and) represent an approximation of the physical characteristics of soil particle-size distributions found in proximal stream substrates. Presumably, local mapped soil properties (e.g., the quantity and spatial distribution of clay, silt, sand) are a proxy that reasonably reflects the particle size distribution expected in adjacent stream substrates. Staff validated these presumptions, as follows.

Stream transects performed on behalf of the City of Salinas stormwater monitoring program has reported and quantified the physical composition of stream substrates from several stream reaches in the TMDL project area (see Figure 2-34). Data from field transects in these stream reaches indicate that stream substrate composition in the TMDL project area indeed reasonably reflect the physical composition of local soil conditions which are associated geographically with a stream reach. For example, local soil conditions proximal to the Reclamation Canal based on SSURGO data indicate a predominance of clays, clay-loams, and silty-clays, while in contrast local soil conditions proximal to the lower Salinas River are dominated by coarser-grained

[40] SWRCB, Surface Water Ambient Monitoring Program. Sediment Sources and Transport, and Impacts. Fact Sheet 5.2.1.0

material like sand. Consistent with these observations of local soil conditions, the Reclamation Canal benthic substrate (based on field transects) is indeed dominated by clay and fine-grained particulate matter, while the Lower Salinas River benthic substrate is overwhelmingly comprised of sand and coarser-grained material (see Figure 2-34).

Figure 2-34. Benthic particle size distribution from several stream reach substrates in TMDL project area.



2.12 Geomorphology

Project area geomorphology was incorporated into the development of nutrient numeric water quality targets (refer to Section 4.3). Because eutrophication is generally assumed to be limited to slow-moving waters in low gradient streams, lakes, ponds, estuaries and bays, a review of project area 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 TetraTech (2006), Dodds et al. (2002) report a negative correlation of benthic chlorophyll a to gradient, consistent with Biggs (2000) work on scour/accrual effects. Also high gradient streams in steeper terrains keep water aerated diminishing the potential for anoxic zones (USEPA, 2001). 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.

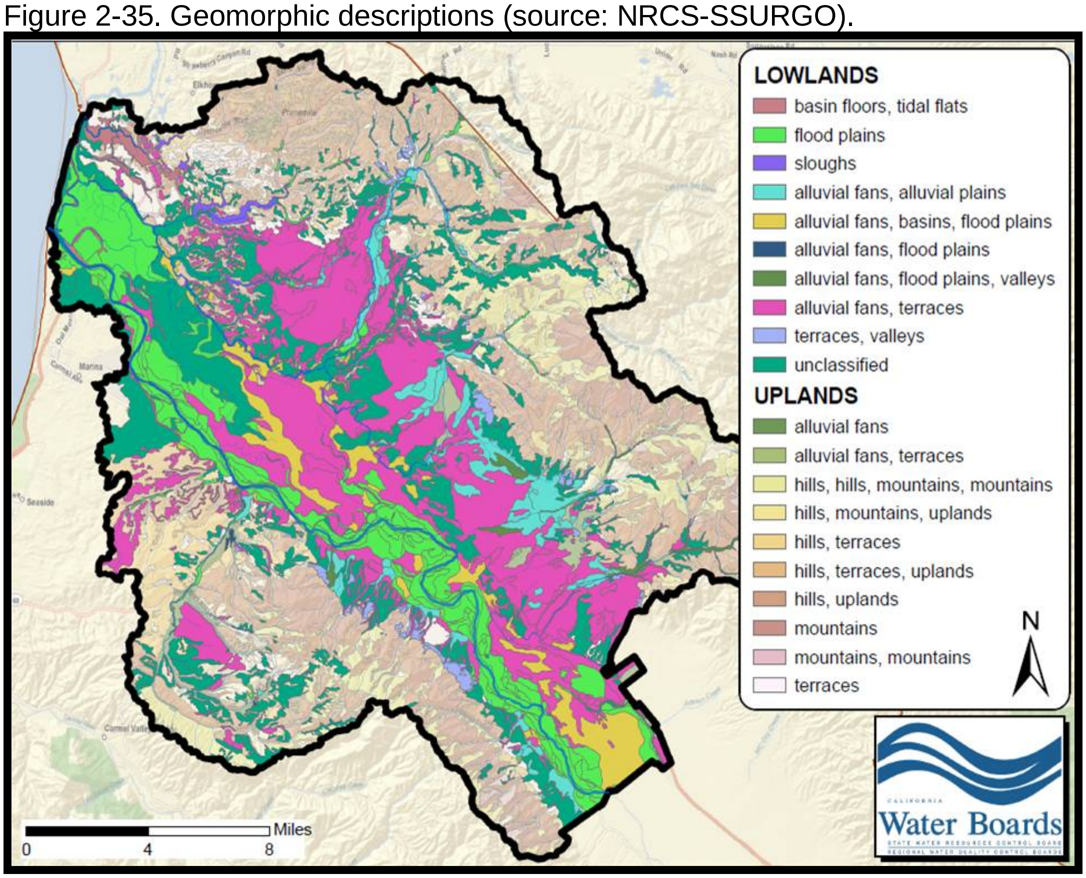
As such, the nutrient concentration that results in impairment in a high-gradient, shaded stream may be much different from the one that results in impairment in a low-gradient, unshaded stream (TetraTech, 2006) However, it is important to note that it is generally presumed that excess nutrients in head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

Further, California central coast researchers have reported a linkage between geomorphology and biostimulatory impairments:

> "*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 2-35 illustrates the geomorphology of the project area; 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, relative to higher gradient, higher canopy, and non-perennial flow upland areas.

Figure 2-35. Geomorphic descriptions (source: NRCS-SSURGO).



An additional reason for assessing geomorphic conditions in the watershed is that geomorphic conditions can potentially be used in grouping streams into categories as consistent with nutrient water quality target development guidance from USEPA (see Section 4.3).

2.13 Flow Travel Times and Denitrification

It may be important to consider the potential for instream attenuation of nutrients and denitrification because these processes pertain to the fate of nitrate in streams and can potentially reduce the loading of nitrate to streams. Denitrification converts nitrate to nitrogen or nitrous oxide gas, and could potentially mitigate nitrate loading to streams and groundwater. Dentrification occurs naturally were certain geochemical conditions are met. Other process can affect the fate of nitrogen in streams including biological uptake, and nitrogen losses to groundwater in the losing reaches of streams. Denitrification in shallow groundwater systems was previously discussed in Section 2.9. Valigura et al. (2001) reported total nitrogen in-stream loss rates for drainages of major estuaries of the conterminous United States. The data Valigura et al. provided indicates that all stream flow travel times of ≤ one day result a range of nominal (less than 8%) to negligible (near zero %) in-stream total nitrogen loss (see Figure 2-36). According to the data published by Valigura et al. (2001), in-stream travel times longer than one day begin to exhibit progressively increasing in-stream loss of the original nitrogen load. Figure 2-37 and Figure 2-38 illustrate estimated mean annual flow travel times in the TMDL project area. These estimates indicate that at the subwatershed-scale, flow times to the downstream outlet of the subwatersheds is, on average, less than one day. Flow travel times at the basin-scale for waters in all inland stream reaches to the downstream outlets of the TMDL project area are expected to be, on average, less than about two days. These estimated travel times are insufficient to expect substantial in-stream losses of nitrogen. In fact, for major stream reaches in the TMDL project area, nitrate concentrations typically increase in a downstream direction (refer back to Figure 3-8 in Section 3.7.3) suggesting that in-stream nitrogen loss, attenuation, and denitrification are not occurring at rates that would offset nitrogen loading to surface waters and downstream receiving waters.

Further, some scientific literature suggests that natural denitrification in a small agricultural stream can indeed marginally contribute to nitrogen retention with the catchment; but the denitrification however is not of such a scale to remove most of the nitrogen prior to export to downstream receiving waters (Jansson et al., 1994). A study in southern Sweden of denitrification and nitrogen retention in a 7-kilometer reach of a small agricultural stream (River Råån) and a small pond located within the catchment indicates that less than 3% of the total nitrogen transported is retained in the catchment over the period of the study. Higher nitrogen retention was observed during low flow periods in the summer (20 to 50% retention), with the retention in the pond was greater than in the rest of the river. On an annual basis denitrification was estimated to be responsible for 30-40%[41] of observed total nitrogen retention in the River Råån. Assuming flow travel times in this 7-km reach of the River Råån are on the order of less than a day to two days (depending on flow conditions), there estimates of nitrogen retention are reasonably consistent with the results of Valigura et al. (2001) shown in Figure 3-27.

[41] Thus, based on the information provided by Jansson et al. (1994), denitrification is responsible for less than 1% to at most 20% of the in-stream loss (retention) of nitrogen within this reach of farmland stream prior to export out of the basin, depending largely on discharge and flow conditions.

Figure 2-36. Total Nitrogen Loss Rates Based on Stream Flow Travel Time for select major U.S. drainage basins (data from Table 7 in Valigura et al., 2001).

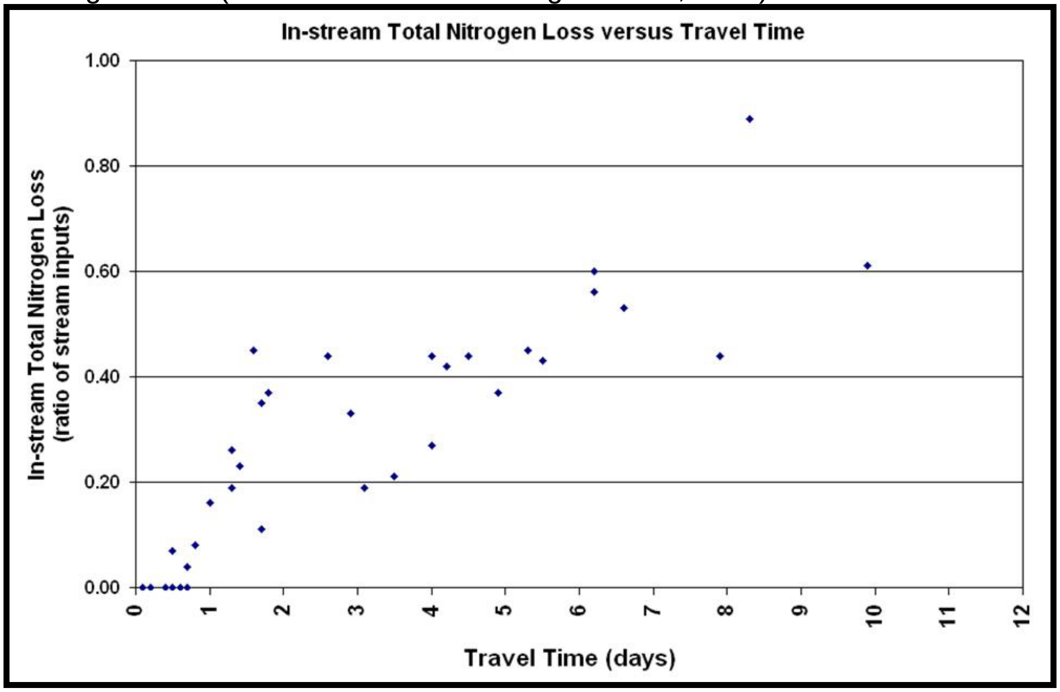


Figure 2-37. Estimated mean annual flow travel times in Project Area stream reaches.

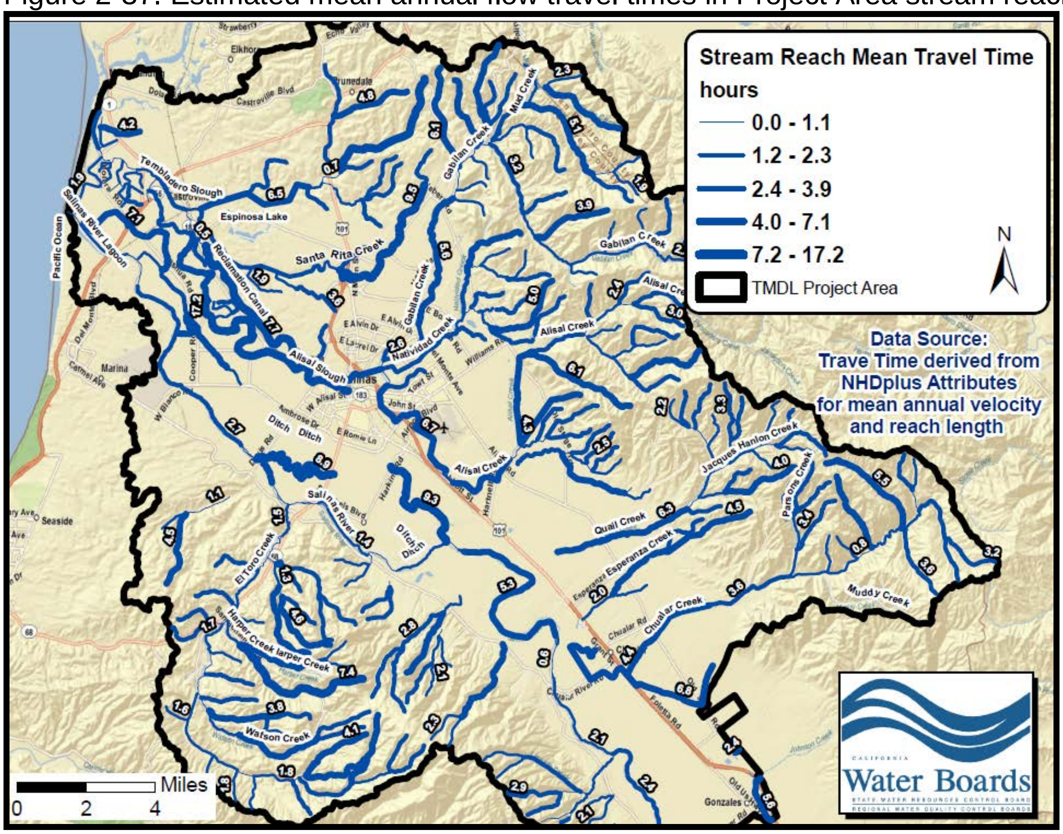
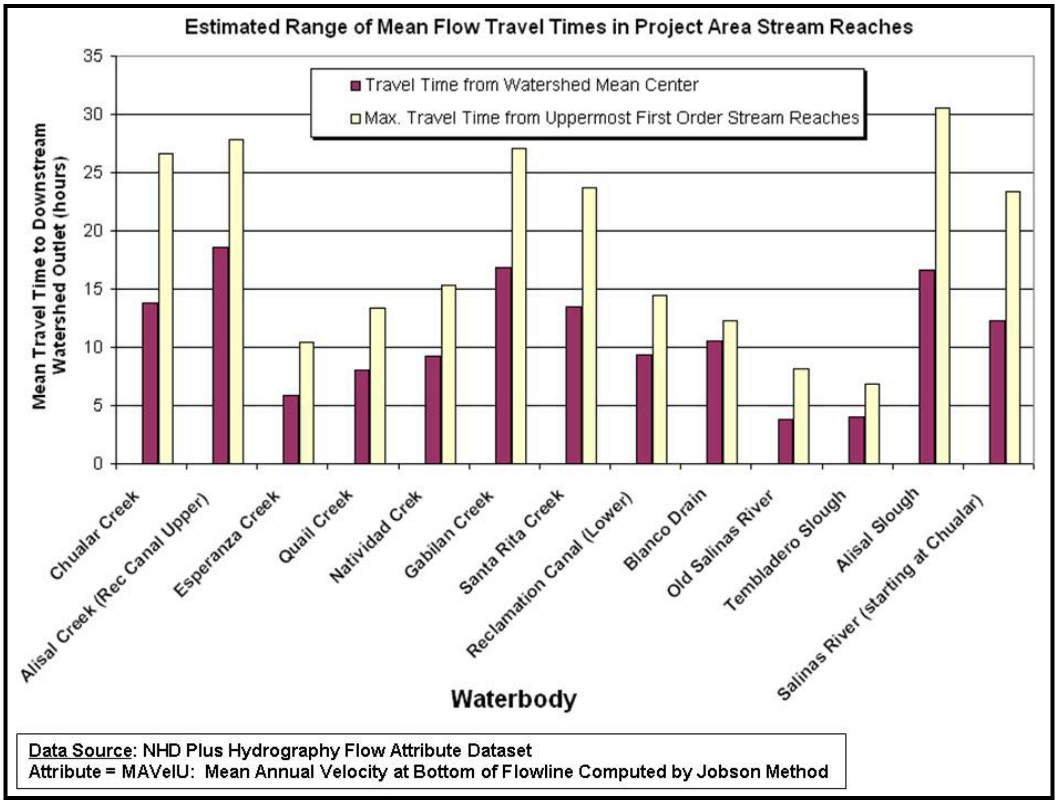


Figure 2-38. Bar graph of estimated ranges of mean flow travel times in Project Area stream reaches.



Collectively, all the aforementioned information appears to suggest that denitrification and retention of nitrogen in the lower Salinas Valley do not occur rates that would substantially mitigate the risk of nitrogen loading to surface waters and to affected downstream receiving waters.

2.14 Fish Habitat and Distribution

Water quality plays an important role in fish habitat. A number of the designated aquatic habitat beneficial uses for project area waterbodies (refer to Section 3.3 and Table 3-2) may be adversely affected by higher than natural nutrient levels and associated water quality stressors (wide DO and pH swings) that occur within the project area. 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 project area. 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 Monterey County area, the cumulative effect of human activities in the last century has severely degraded, reduced and restricted viable fresh water habitat in the TMDL project area (personal communication, Ross Clark, Director of the Central Coast Wetlands Group at Moss Landing Marine Labs). Viable fresh water aquatic habitat is critical for numerous bird, fish, and invertebrate species Also, the California Department of Fish and Game 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).

Also, it has long been recognized that eutrophication, excess nutrients, and water quality degradation has substantially degraded aquatic habitat locally in stream reaches of the TMDL project area. For example, over 20 years ago ABA Consultants (1991) reported extremely low faunal densities in Moro Cojo Slough which were far below any possible normal seasonal change patterns and noted that eutrophication, anoxia, as well as flow patterns had resulted in habitat degradation. Additionally, 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.

Special Status Aquatic Species (Fish and Amphibians)

The TMDL project area provides habitat to five special-status aquatic species[42] (fish and amphibians) listed under the federal Endangered Species Act (ESA), and include:

- South-central California Coast (S-CCC) steelhead DPS (Federal Status: threatened);
- Tidewater goby (Federal Status: endangered); (observed in Moro Cojo Slough)
- California red-legged frog (threatened);
- California tiger salamander (Federal Status: endangered for region-specific DPS)
- Santa Cruz long-toed salamander (Federal and State Status: endangered)

The tidewater goby is listed as an endangered fish species under the ESA and is reported to have historically existed in the Salinas River lagoon; however this fish is currently considered to be extirpated (locally extinct) from the lagoon. Photographic documentation and information from the California Natural Diversity Database indicate that tidewater goby currently can be found in the Moro Cojo Slough.

Aquatic Species of Special Concern (Fish and Turtle)

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 Game (DFG)[43] "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 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, the TMDL project area provides habitat for the following aquatic Species of Special Concern that do not currently have special status legal protection:

- Monterey roach (fish), which is designated by DFG as a Class 3 watch list species.
- Pacific lamprey (fish), which is classified by DFG as a Class 4 species *(population status apparently secure, but population is in decline).*
- Monterey Hitch (fish), which is classified by DFG as a Class 4 species *(population status apparently secure, but population is in decline and Calif. Dept. of Fish and Game noted that this species probably deserves to be on the Class 3 Watch List).*
- Western pond turtle, which is designated by DFG as a special concern species,

[42] Source: Calif. Dept. of Fish and Game – California Natural Diversity Database
[43] See DFG species of special concern webpage, accessed June 2012, online linkage: http://www.dfg.ca.gov/wildlife/nongame/ssc/

Clusters of Fish Recommended for Coordinated Ecosystem-Level Management

The California Department of Fish and Game (DFG) have recommended coordinated special ecosystem management strategies for regional clusters of potentially endangered species with similar environmental requirements (Moyle et al., 1995). These DFG-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. DFG 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 TMDL project area:

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

Fish Resources in Project Area

Historically, Snyder (1913) as reported in MCWRA, 2001) described 12 species of fish inhabiting the rivers and tributary streams of the Salinas River basin including steelhead, Pacific lamprey, three-spine stickleback, coast range sculpin, riffle sculpin, prickly sculpin, Sacramento sucker, Sacramento pikeminnow, California roach, hitch, tule perch, and dace. Of the 12 species of fish reported by Snyder in 1913, eight have been recorded as still present. These include the Pacific lamprey, Sacramento sucker, Sacramento blackfish, hitch, steelhead, stickleback, speckled dace, and prickly sculpin (MCWRA, 2001). In addition to the aforementioned Snyder (1913) reporting, a literature review by Kukowski (1972) identified reported occurrences for 21 fish species in the Salinas River.

Recently, Casagrande et al. (2003) presented field research and compilations of existing studies on the fish resources of the Salinas River Basin, including waterbodies in the TMDL project area. Additionally, fish resources of the Moro Cojo Slough subwatershed have been reported by Coastal Conservation and Research, Inc. (2008). Table 2-12 presents the native fish species observed or reported in the project area by Casagrande et al. (2003) and Coastal Conservation and Research, Inc. (2008), or reported by MCWRA (2001). Hager (2001) also reported sightings of common carp and California roach fish species in the Reclamation Canal, and rainbow trout in upper Gabilan Creek.

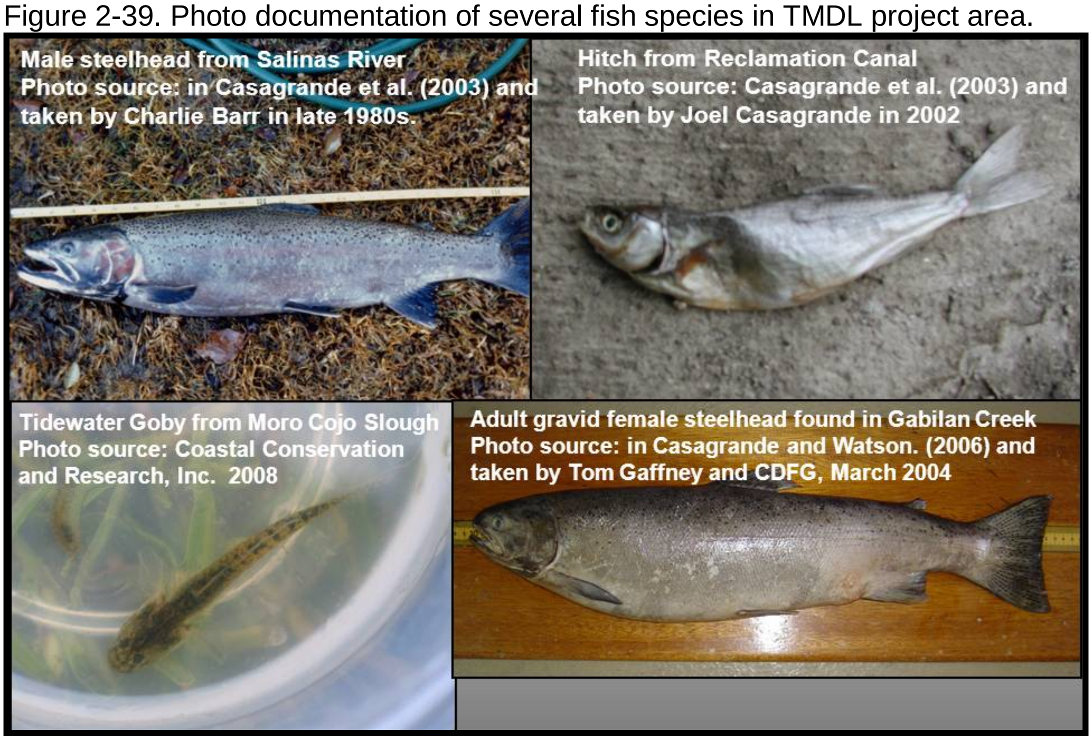
Figure 2-39 presents photo documentation of several fish species in the TMDL project area. Figure 2-40 illustrates the current and historical extent of tidewater goby critical habitat in relation to the TMDL project area. It is noteworthy that there is photographic evidence of tidewater goby in the Morro Cojo slough subwatershed, which is within the TMDL project area (see Figure 2-39).

Casagrande et al. (2003) noted that aquatic habitat in the Salinas Watershed needs to be studied in greater detail. They concluded that Sacramento perch, tule perch, and tidewater goby could all potentially be reintroduced into the Salinas Watershed if aquatic habitat is improved and maintained.

Table 2-12. Native fish species observed or reported in Salinas River, Reclamation Canal/Gabilan Creek, and Moro Cojo Slough.

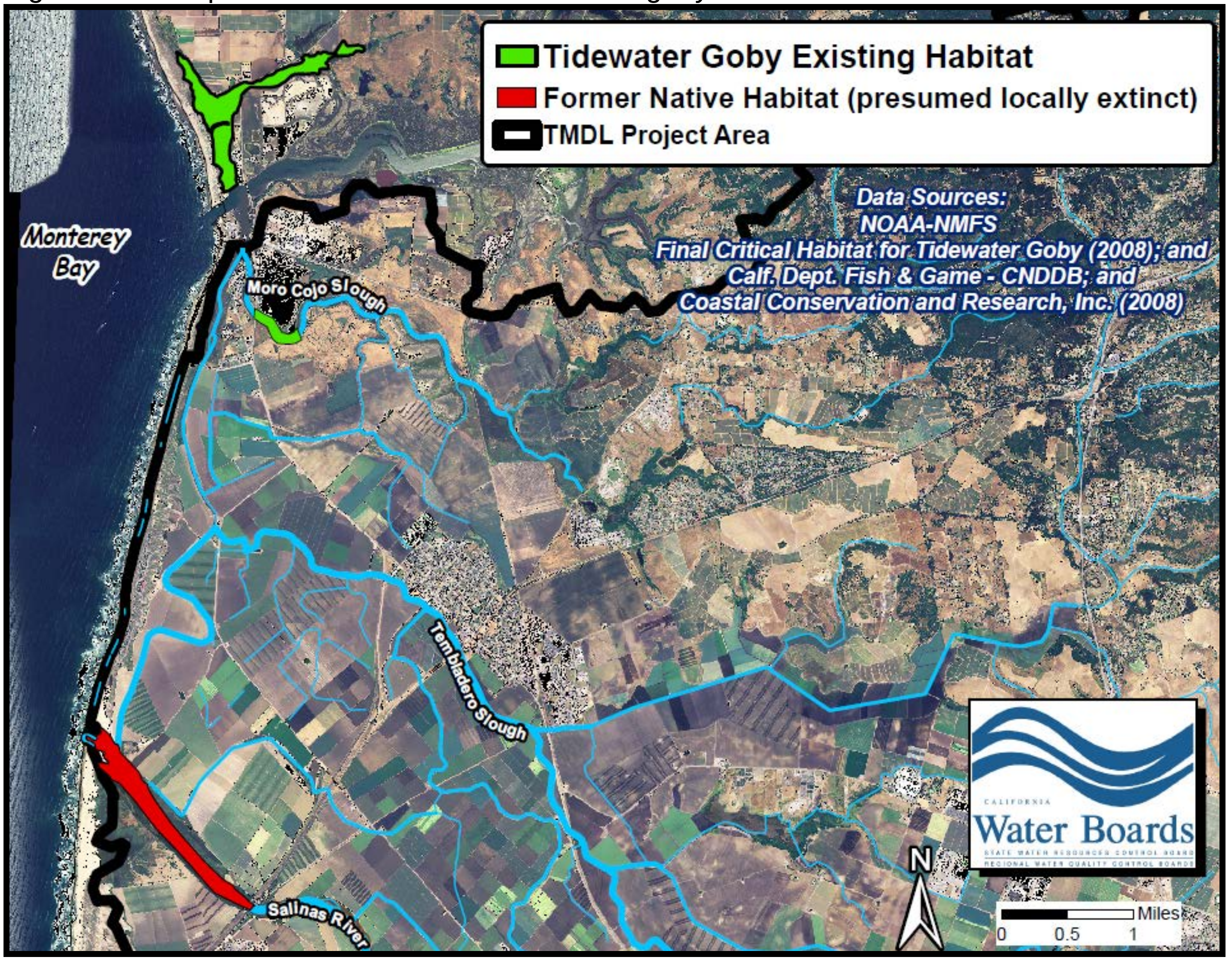
Fish Species (common name)	Scientific Name	Moro Cojo Slough	Reclamation Canal/Gabilan Creek	Salinas River
Rainbow Trout	*Oncorhynchus mykiss*	X	X	X
Sac. Pikeminnow	*Ptychocheilus grandis*		X	
Sacramento Sucker	*Catostomus occidentalis*		X	X
Monterey Roach	*Lavinia symmetricus subditus*		X	X
Speckled Dace	*Rhinichthys osculus*			X
Hitch	*Lavinia exilicauda*		X	X
Threespine Stickleback	*Gasterosteus aculeatus*	X		X
Pacific Lamprey	*Lampetra tridentate*			X
Tidewater Goby	*Eucyclogobius newberryi*	X		Historically present in Salinas River lagoon but considered extirpated.
Sacramento Perch	*Archoplites interruptus*			Historically present but considered extirpated.
Tule Perch	*Hysterocarpus traskii*			Historically present but considered extirpated.
Arrow Goby	*Clevelandia ios*	X		
Longjaw Mudsucker	*Gillichthys mirabilis*	X		

Figure 2-39. Photo documentation of several fish species in TMDL project area.



Note that Table 2-12 pertains primarily to riverine freshwater fish and does not include comprehensive tabulations of estuarine and brackish water fish known to occur in the Salinas River Lagoon, which is also part of the TMDL project area, and is the receiving water for the lower Salinas River and Blanco Drain. Resource professionals and federal fisheries biologists identify the Salinas River Lagoon as an important natural resource (see, for example RMC, 2006). The lagoon provides habitat for not only freshwater fish, but also for brackish, estuarine, and marine fish assemblages. Additionally the lagoon reportedly provides habitat for a large diversity of vertebrate species; habitat in and around the lagoon support over 280 species of fish and wildlife, including at least 38 rare, threatened, or endangered species[44]. The lagoon's close proximity to the biologically-rich Elkhorn Slough estuary and Monterey Bay underscores the lagoon's value for wildlife and aquatic habitat. The Salinas Valley Integrated Water Management Functionally Equivalent Plan Update (RMC, 2006) noted the need to improve and protect Salinas River Lagoon habitat.

Figure 2-40. Reported habitat areas for tidewater goby.



Non-native fish species reported in the Salinas River and/or the Reclamation Canal drainage include: carp, mosquito fish, black bullhead, white bass, and black crappie among others (Page, 1995 as reported in MCWRA, 2001).

In a recent fish-count report from Salinas river mile 2.73[45] (Cuthbert et al. 2011), 23 steelhead passage events (consisting of 13 total adult steelhead) occurred between January 22, 2011 and February 17, 2011. Other aquatic species passages tabulated during this period included

[44] Salinas Valley *Integrated Regional Water Management Functionally Equivalent Plan Summary Document.* May 2006. Prepared by RMC for the Monterey County Water Resources Agency.
[45] Location of the Salinas River Weir

catfish, carp, Sacramento pikeminnow, Sacramento sucker, striped bass, beavers, muskrats, and a bat ray.

A large fish kill (> 2,000 fish) was observed and reported in the Old Salinas River, Tembladero Slough and the Reclamation Canal in July of 2002 which killed many carp along with other species (Casagrande et al., 2003) – see Figure 2-41. Casagrande and Watson (2006) reported that the cause of the large fish kill was never determined; however water and tissue samples collected by DFG indicated that pesticides were unlikely to be the culprit. Casagrande and Watson (2006) hypothesized that low oxygen levels in the water may have caused the fish kill; however DFG was unable to collect dissolved oxygen concentration data reportedly due to equipment failure. However, note that regarding this fish kill the Monterey County Farm Bureau and the Monterey County Water Resources Agency stated conclusively that the *"cause at Tembladero was found to be low DO"* (see .Casagrande and Watson, 2006-Chapter 10, Appendix A Stakeholder Comments). Casagrande and Watson (2006) also reported observing evidence of a smaller fish kill in the Reclamation Canal at San Jon Road on October 21, 2003; the dead species observed were carp and hitch.

Figure 2-41. Fish kill (reportedly due to low dissolved oxygen) in Tembladero Slough (photo: Joel Casagrande, 2002).

The Salinas River and some tributaries provide migration and/or spawning habitat for steelhead trout, a federally listed endangered species. Figure 2-42 illustrates steelhead presence or absence in the project area. 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. The data is based on the South-central California Coast Evolutionary Significant Unit (SCCC-ESU) and was compiled by the National Marine Fisheries Service (NOAA Fisheries) Southwest Regional Office (SWR) in an effort to designate Critical Habitat for Steelhead in California. There is also reportedly some anecdotal evidence that Chinook salmon once inhabited the watershed, but this has not been confirmed (Franklin, 1999 as reported in Casagrande et al. 2003). Note that the existence of a steelhead run in wet years in the Reclamation Canal-Gabilan Creek drainage is currently uncertain (Casagrande and Watson, 2006).

It should be noted that spawning and migratory habitat in the project area is generally rated as poor to fair by the SCCC-ESU. Seasonal drying of river sections influences species dispersal, abundance, and distribution. Structural/hydraulic barriers also influence dispersal. The South-Central California Coast Steelhead Recovery Planning Area Conservation Action Planning (CAP) Threats Assessment (Hunt and Associates Biological, 2008) rated overall habitat conditions for steelhead as “poor” in the Salinas River watershed, largely because the valley-floor mainstem stream reaches have been substantially altered by human activities (e.g., physical, hydraulic, and water quality modifications and changes). Habitat conditions in the Salinas River itself are not suitable for steelhead/rainbow trout spawning because of the broad, sandy nature of the river; however steelhead populations elsewhere in the basin (e.g., Arroyo Seco River) are believed to use the lower Salinas River and lagoon as a migration corridor when adequate flows are present (Entrix, 2009). It is generally thought that most steelhead spawning that currently remains in the Salinas Basin likely occurs in reaches of the Arroyo Seco River with the Salinas River mainstem providing migratory habitat (Cuthbert et al., 2010).

Casagrande et al. (2003) reported that in some project area headwater reaches, stream aquatic habitat is in good to excellent condition. Gabilan Creek was officially designated as Critical Habitat for steelhead by NOAA Fisheries in 2005 as part of the South-Central California Coast Evolutionary Significant Unit (ESU) (as reported in Casagrande and Watson, 2007). The habitat listing was based on Gabilan’s proximity to the Salinas River drainage, the presence of *O. mykiss* in upper Gabilan Creek, and the finding of the dead adult gravid female. It is currently unknown whether or not an anadromous population exists in the Gabilan Creek subwatershed. While spawning and rearing habitat exists in the upper subwatershed (Hager, 2001) there are limiting factors including migration barriers on the creek, low stream flow duration during migration, and water quality degradation in lower reaches of the watershed.

It is noteworthy and commendable, however that local landowners in the upper reaches of Gabilan Creek (Gabilan Cattle Company) have reportedly been working with U.S. Fish and Wildlife Service and California Department of Fish and Game to improve native steelhead runs in Gabilan Creek, and improve riparian habitat for this species (Gabilan Cattle Company website, accessed August, 2011) at http://www.gabilanranch.com/ranchhistory.html.

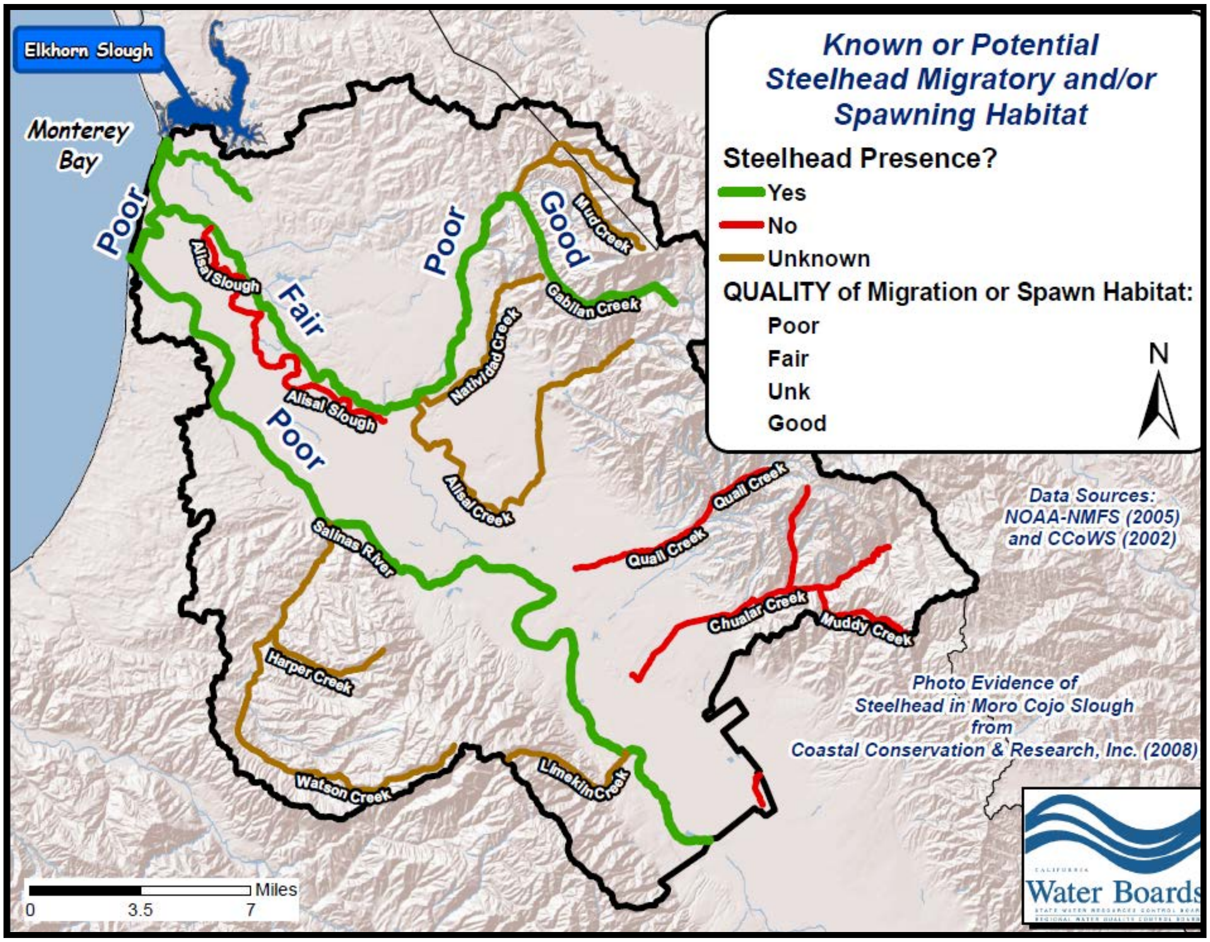


Figure 2-42. Steelhead distribution – presence or absence (source: NOAA)

The Center for Ecosystem Management and Restoration (Becker et al., 2010) has published reports which summarize California Dept. of Fish and Game (DFG) and National Marine Fisheries Service (NMFS) reports, memos, and notes on steelhead/rainbow trout habitat in the TMDL project area, which are reproduced below:

> *As part of the 1965 state fish and wildlife plan, DFG prepared an inventory of anadromous salmonids. According to the inventory, about 404 mile of steelhead habitat, "much of which is of very poor quality," exists in the Salinas River system. At the time of the inventory the Salinas steelhead run was estimated to consist of about 500 individuals. The plan states, "The most critical factors are the lack of water and the need to develop what water there is for agriculture".*
>
> *Current steelhead habitat restoration efforts include an inflatable dam that is planned for construction at about river mile 4.0 on the Salinas River, as part of the Salinas Valley Water Project. The project includes a fishway and a steelhead population and habitat monitoring program, and has been tied to re-operation of the Nacimiento and San Antonio rivers reservoirs to facilitate steelhead passage (NMFS 2007, as reported by Becker et al., 2010. The Salinas Valley Water Project's Biological Opinion identified an "Upper Salinas" O. mykiss population consisting of resident rainbow trout that "co-occur" with steelhead (Becker et al., 2010).*
>
> *Historically, DFG has considered Gabilan Creek to be a tributary to Tembladero Slough. A 1959 DFG survey report reported that steelhead spawning could occur in upper Gabilan Creek during wet years Resident rainbow trout, likely descended from planted O. mykiss was said to be "fairly successful" in the creek. In a 1960 memo DFG states, "…Gabilan Creek…supports a small trout fishery. It is not known whether the existent trout fishery involves young steelhead or resident rainbow" (DFG 1960a). Gabilan Creek was surveyed in 2000. The survey found*

multiple age classes of steelhead. An adult steelhead was collected from Gabilan Creek in 2004.

Additionally, A 2002 DFG letter states, "Natividad Creek is known as a migration route for steelhead trout" (DFG 2002). However, the basis for the statement was not provided.

As part of a steelhead range contraction study, NMFS staff visited El Toro Creek 2003. It was found to be dry and therefore not capable of supporting O. mykiss. Watson Creek, a tributary of El Toro Creek, appears on an undated list of Monterey County streams with historical steelhead populations. The basis for inclusion is not provided.

At present it is still unknown as to whether or not the species can still use Gabilan Creek as a spawning ground. However, Casagrande (2001) reported that:

"The Gabilan Cattle Company, owners of the headwaters of Gabilan Creek, are currently working with the U.S. Fish and Wildlife Service and the California Department of Fish and Game on a program that will improve the chance for steelhead runs in Gabilan Creek."

The NOAA-National Marine Fisheries Service (NMFS) provided information on aquatic habitat in the project area to Water Board staff in a letter dated November 10, 2011[46]. NMFS reported to Water Board staff that the Salinas River was designated as critical habitat for SCCC steelhead on September, 2, 2006. On January 5, 2006, the SCCC steelhead DPS was reaffirmed listed as threatened under the Federal Endangered Species Act.

NMFS also indicated to Water Board staff that the most recent status review concluded that populations of SCCC-DPS steelhead are likely to become extinct in the next 50 years without intervention (Good et al., 2005 as reported by NMFS staff, personal communication, Nov. 10.2011).

Habitat components for the survival and recovery of SCCC steelhead include, but are not limited to, uncontaminated estuarine areas and substrate and sufficient water quality to support growth and development. NMFS 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. NMFS states that water carrying excess nutrients and algal material exacerbates negative effects to the quality of habitat conditions for fish in the Salinas River Lagoon, as reproduced below:

"*Water carrying excess nutrients and algal material exacerbates negative effects to the quality of habitat conditions for fish in the Salinas Lagoon. The lagoon stratisfies due to seasonal temperature differences caused by poor water circulation and solar heating of the less saline and dense upper water column. The impaired water entering the lagoon from upstream carries detrital algal matter which settles into the cooler, deeper water of the lagoon and causes the dissolved oxygen levels in this biologically important zone to reach low levels as the algae decays (Bond 2006). This leads to the loss of an important temperature zone for rearing juvenile steelhead for periods of time."*

-Steven A. Edmondson, NOAA-NMFS, Southwest Regional Habitat Manager, in a letter to the Central Coast Water Board dated Nov. 10, 2011

Regarding the Salinas River Lagoon, staff includes here an additional independent line of evidence illustrating algae-related dissolved oxygen problems, based on reporting from researchers at the Watershed Institute at California State University, Monterey Bay. These

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

researchers reported that dissolved oxygen problems in the water column in the Salinas River Lagoon during the summer and fall months are locally indicative of moderate to extremely high algal productivity:

> *"The high DO fluctuations at sites except those immediately adjacent to the ocean are indicative of extremely high algal production and associated respiration, and possible risk of crashes in dissolved oxygen levels… "Of the three monitoring events during the warmer months, conditions in October were indicative of extremely high algal production, while July and August monitoring suggested more moderate production."*
>
> *from: Casagrande et al. (2002) – The Watershed Institute at California State University, Monterey Bay -- Salinas River Lagoon water quality monitoring results*

Finally, it should be noted that recent studies have also documented other important aspects of biological resources dependent on aquatic habitat in the project area, including benthic aquatic invertebrates, amphibians, reptiles, birds and mammals. For example, see Casagrande and Watson (2006), and Harris et al. (2007). It is important to recognize that the Water Board is required to protect, maintain, or restore aquatic habitat beneficial uses of waters of the State broadly for the full spectrum of species dependent on aquatic habitats, for example: vegetation, fish or wildlife, including invertebrates (refer to Section 3.2.4).

3 PROBLEM IDENTIFICATION

3.1 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[47]." 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. Beneficial uses, relevant water quality objectives, and anti-degradation requirements that pertain to this TMDL are presented below in Section 3.2, Section 3.3, and Section 3.4 respectively. For a detailed discussion of anti-degradation policies, please refer to Section 7.2.3.

3.2 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.

[47] Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.) Title 1, Section 101.(a)

The California Central Coast Water Board is required under both State Federal Law to protect and regulate beneficial uses of waters of the state.

The Basin Plan 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 Water Board has interpreted this general statement of beneficial uses to encompass the beneficial uses of REC-1 and REC-2, 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 Central Coast Basin Plan the 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 Basin Plan 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 (SWRCB) 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, SWRCB, Order WQO 2002-0015). The 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 dischargers or stakeholders present evidence that the uses are not existing 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.

Table 3-1. Basin Plan designated beneficial uses for inland waters.

Waterbody Names	MUN	AGR	PROC	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	COMM	SHELL
Old Salinas River Estuary						X	X	X	X	X	X	X	X	X	X		X	X
Salinas River Lagoon (North)						X	X	X	X	X	X	X	X		X		X	X
Tembladero Slough						X	X	X		X		X		X	X		X	X
Espinosa Lake						X	X	X		X							X	
Espinosa Slough						X	X	X		X							X	
Salinas Reclamation Canal						X	X	X		X							X	
Gabilan Creek	X	X			X	X	X	X		X		X					X	
Alisal Creek	X	X			X	X	X	X	X	X		X					X	
Blanco Drain						X	X	X		X							X	

Waterbody Names	MUN	AGR	PROC	IND	GWR	REC1	REC2	WILD	COLD	WARM	MIGR	SPWN	BIOL	RARE	EST	FRESH	COMM	SHELL
Moro Cojo Slough					X	X	X	X	X	x		X	X	X	X		X	X
Salinas River, dnstr of Spreckels Gage	X	X				X	X	X	X	X	X					X	X	
Salinas River, Spreckels Gage-Chualar	X	X	X	X	X	X	X	X	X	X	X						X	

MUN: Municipal and domestic water supply.
AGR: Agricultural supply.
PRO: Industrial process 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 project area surface waters which are most likely to be potentially at risk of impairment by water column nutrients are presented below.

3.2.1 Municipal and 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[48] nitrate as nitrogen (see Basin Plan, Table 3-2). This level is established to protect public health (refer back to Section 1.3 for a description of health risks related to nitrate).

3.2.2 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.)*

The groundwater recharge (GWR) beneficial use is recognition 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. Most surface waters and ground waters of the central coast region are both designated with the MUN beneficial use. The MUN nitrate water quality

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

objective (10 mg/L) therefore applies to *both* the stream waters, and to the underlying groundwater. This numeric water quality objective and the MUN designation of underlying groundwater is relevant to the extent that portions project area 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 beneficial use of the underlying ground water resource. Indeed, protection of the GWR beneficial use of surface waters has been recognized in approved California TMDLs[49]. 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 (SWRCB, 2004). Section 3.7.5 of this project report presents data, lines of evidence, and assessments regarding whether or not project area designated GWR beneficial uses are currently being supported.

3.2.3 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 of the agricultural supply beneficial of waters of the State use 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[50]. 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) 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[51]. For example, according to Ayers and Westcot (1985)[52] 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

[49] for example, see RWQCB-Los Angeles Region, Calluguas Creek Nitrogen Compounds TMDL, 2002. Resolution No. 02-017, and approved by the State of California Office of Adminstrative Law, OAL File No. 03-0519-02 SR.
[50] 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 Univ. 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.
[51] 1 mg/L NO3-N in irrigation water = 2.72 pounds of nitrogen per acre foot of applied water.
[52] R.S. Ayers (Soil and Water Specialist, Univ. of Calif.-Davis) and D.W. Westcot (Senior Land and Water Resources Specialist – Calif. Central Valley Regional Water Quality Control Board) published in UN-FAO Irrigation and Drainage Paper 29 Rev.1

the grain weight. 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[53] especially when the concentration exceeds 10 mg/L nitrate as N[54]. Should this be ignored, the resulting excess input of nitrogen could cause problems such as excessive vegetative growth and contamination of groundwater[55].

Further, the Basin Plan provides water quality objectives for nitrate which are protective of the AGR beneficial uses for livestock watering. While nitrate (NO3) itself is relatively non-toxic to livestock, ingested nitrate is broken down to nitrite ($NO2^-$); 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[56]. Death can occur when blood hemoglobin has fallen to one-third normal levels. Resource professionals[57] 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-N for purposes of livestock watering at 100 mg/L[58].

Also noteworthy is that the AGR beneficial use of surface water not only applies to several stream reaches of the project area, but can 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 3.2.2).

3.2.4 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.

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.

[53] 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.

[54] 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

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

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

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

[58] 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).

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 is most relevant to nutrient pollution[59] is the biosimulatory 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.

3.2.1 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."

[59] 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 heatlh 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 1.3) 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[60] (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.

3.3 Water Quality Objectives & Criteria

The Central Coast Region's Water Quality Control Plan (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 criteria are established to protect beneficial uses and are compiled in Table 3-2.

3.4 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. Also, see Section 7.2.3 for a full description of anti-degradation requirements.

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

Table 3-2. 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 objective	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 4.3	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)*

3.5 California CWA Section 303(d) Listing Policy

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 protective water quality standards. In accordance with the Water Quality Control Policy for developing California's Clean Water Act (CWA) Section 303(d) List (SWRCB, 2004), water body and pollutants that exceed protective water quality standards are placed on the State's 303(d) List of impaired waters. The 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 (Listing Policy, Table 3.2). The minimum number of measured exceedances for toxicants is displayed in Table 3-3 and for conventional and other pollutants in Table 3-4.

With regard to the water quality constituents addressed in this TMDL, it is important to note that unionized ammonia and nitrate[61] are considered a toxicants, low dissolved oxygen, chlorophyll a and pH, are conventional pollutants. Thus, impairments by nitrate and unionized ammonia are assessed on the basis of Table 3-3, while impairments by dissolved oxygen and chlorophyll a are assessed on the basis of Table 3-4.

Table 3-3. . 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 β < 0.2 and where |α - β| 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,	

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

Table 3-4. 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 β < 0.2 and where |α - β| 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	

3.6 CWA Section 303(d) Listings

The final 2010 Update to the 303(d) List and 303(d)/305(b) Integrated Report for the Central Coast showing waterbodies with nutrient or potential nutrient-related impairments in the lower Salinas River watershed are shown in Table 3-5. Figure 3-1 presents these 2010 303(d) listings in map view.

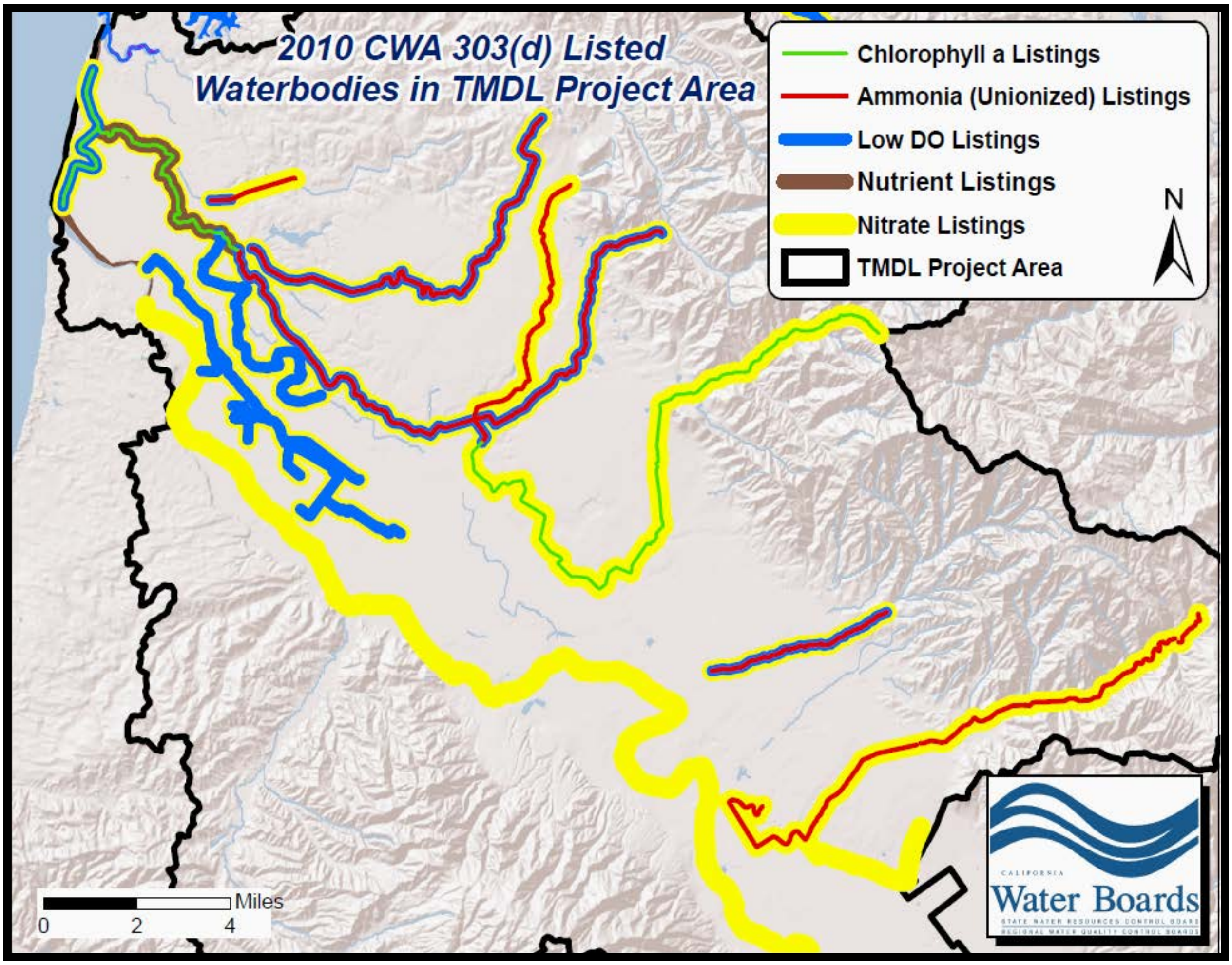
Table 3-5. 303(d) listed waterbodies.

HU*	WATER BODY NAME	POLLUTANT NAME	LIST STATUS
309	Alisal Creek (Monterey County)	Nitrate	TMDL Required
309	Alisal Slough (Monterey County)	Low Dissolved Oxygen	TMDL Required
309	Alisal Slough (Monterey County)	Nitrate	TMDL Required
309	Alisal Creek	Chlorophyll-a	TMDL Required
309	Blanco Drain	Low Dissolved Oxygen	TMDL Required
309	Blanco Drain	Nitrate	TMDL Required

HU*	WATER BODY NAME	POLLUTANT NAME	LIST STATUS
309	Chualar Creek	Ammonia (Unionized)	TMDL Required
309	Chualar Creek	Nitrate	TMDL Required
309	Chualar Creek	pH	TMDL Required
309	Esperanza Creek	Nitrate	TMDL Required
309	Espinosa Slough	Ammonia (Unionized)	TMDL Required
309	Espinosa Slough	Nitrate	TMDL Required
309	Espinosa Slough	pH	TMDL Required
309	Gabilan Creek	Ammonia (Unionized)	TMDL Required
309	Gabilan Creek	Nitrate	TMDL Required
309	Gabilan Creek	pH	TMDL Required
306	Moro Cojo Slough	Low Dissolved Oxygen	TMDL Required
306	Moro Cojo Slough	pH	TMDL Required
306	Moro Cojo Slough	Ammonia (Unionized)	TMDL Required
309	Merrit Ditch	Ammonia (Unionized)	TMDL Required
309	Merrit Ditch	Low Dissolved Oxygen	TMDL Required
309	Merrit Ditch	Nitrate	TMDL Required
309	Natividad Creek	Ammonia (Unionized)	TMDL Required
309	Natividad Creek	Low Dissolved Oxygen	TMDL Required
309	Natividad Creek	Nitrate	TMDL Required
309	Natividad Creek	pH	TMDL Required
309	Old Salinas River	Chlorophyll-a	TMDL Required
309	Old Salinas River	Low Dissolved Oxygen	TMDL Required
309	Old Salinas River	pH	TMDL Required
309	Old Salinas River	Nitrate	TMDL Required
309	Quail Creek	Ammonia (Unionized)	TMDL Required
309	Quail Creek	Low Dissolved Oxygen	TMDL Required
309	Quail Creek	Nitrate	TMDL Required
309	Salinas Reclamation Canal	Ammonia (Unionized)	TMDL Required
309	Salinas Reclamation Canal	Low Dissolved Oxygen	TMDL Required
309	Salinas Reclamation Canal	Nitrate	TMDL Required
309	Salinas Reclamation Canal	pH	TMDL Required
309	Salinas River (lower, estuary to near Gonzales Rd crossing)	pH	TMDL Required
309	Salinas River (lower, estuary to near Gonzales Rd crossing)	Nitrate	TMDL Required
309	Salinas River Lagoon (North)	Nutrients	TMDL Required
309	Salinas River Refuge Lagoon (South)	pH	TMDL Required
309	Santa Rita Creek (Monterey County)	Ammonia (Unionized)	TMDL Required
309	Santa Rita Creek (Monterey County)	Low Dissolved Oxygen	TMDL Required
309	Santa Rita Creek (Monterey County)	Nitrate	TMDL Required

HU*	WATER BODY NAME	POLLUTANT NAME	LIST STATUS
309	Tembladero Slough	Chlorophyll-a	TMDL Required
309	Tembladero Slough	Nitrate	TMDL Required
309	Tembladero Slough	Nutrients	TMDL Required
	Total		**47**

Figure 3-1. Final 2010 303(d) listed nutrient and nutrient-related impairments in TMDL project area.



It should be noted that while water column pH impairments shown in Table 3-5 could possibly result from biostimulatory conditions, staff are not addressing the aforementioned pH 303(d) listings in this TMDL. The reasons are as follows:

1) The California Nutrient Numeric Endpoints (NNE) approach recommends that a pH of 9.0 (for COLD) or a pH of 9.5 (for WARM) represent the pH numeric endpoints which are indicative of a presumptive photosynthesis-driven pH impairment[62]. These numeric endpoints are well over the upper Basin Plan standard of 8.5. Only 0.02% of pH

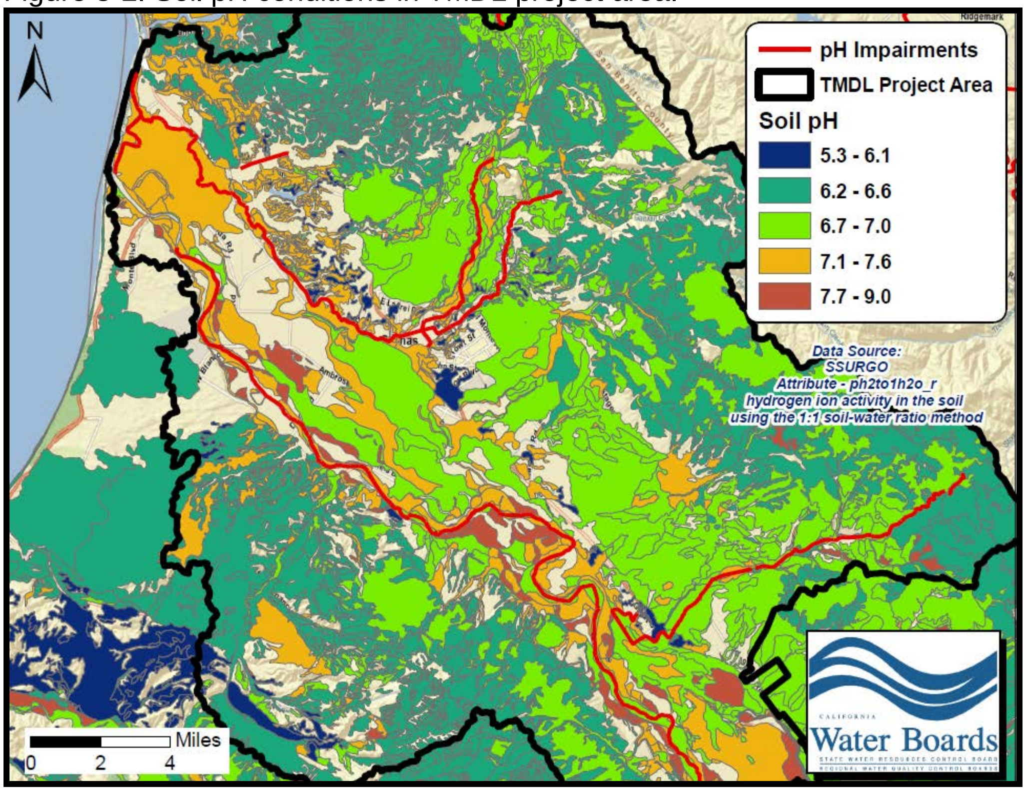
[62] See Table 3-2 in TetraTech (2006): Technical Approach to Develop Nutrient Numeric Endpoints for California (July 2006, prepared for USEPA Region IX, Contract No. 68-C-02-108-To-111).

samples in the TMDL project area exceed 9.5 pH (sample size = 1,149). Further, only 2.2% of samples exceed 9.0 pH. As such, based on California NNE guidance the current pH-based impairments in the project area cannot credibly be attributed to biostimulatory impairments.

2) In some areas of the lower Salinas Valley, ambient soil conditions are quite alkaline (see Figure 3-2). Locally, some soils range up to 9.0 pH units. Staff hypothesizes that some waterbody pH listings could potentially be related to local alkaline soil conditions, which are unrelated to water column photosynthesis and biostimulation

Therefore, at this time staff recommends that TMDL project area pH listing be addressed through a separate TMDL process or a future water quality standards action.

Figure 3-2. Soil pH conditions in TMDL project area.



3.7 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 lower Salinas Valley 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. These including 1) filtering the data to extract only grab samples and field measurements (thereby excluding field blanks and duplicates); and 2) setting grab sample data reported as censored data (i.e., measurements of constituents that are reported as less than the detection limit) equal to the method detection limit (MDL); for samples where an MDL was not reported, staff set the censored data equal to the median MDL that were reported for that constituent.

3.7.1 Preface: Nitrate Reporting Convention

Nitrate values are commonly reported as either nitrate (NO_3) or as nitrate-nitrogen (NO_3-N). The maximum contaminant level (MCL) in drinking water as nitrate (NO_3) is 45 mg/l, whereas this MCL when reported as NO_3-N is 10 mg/l. These concentration-based values are exactly equivalent to each other, the only difference being whether or not the molecular weight of the oxygen component of the nitrate molecule is included in the reporting.

For water quality data used in this TMDL project report nitrate is reported as N (i.e., NO3-N, or sometimes alternatively “Nitrate as N").

3.7.2 Water Quality Data Sources and Monitoring Sites

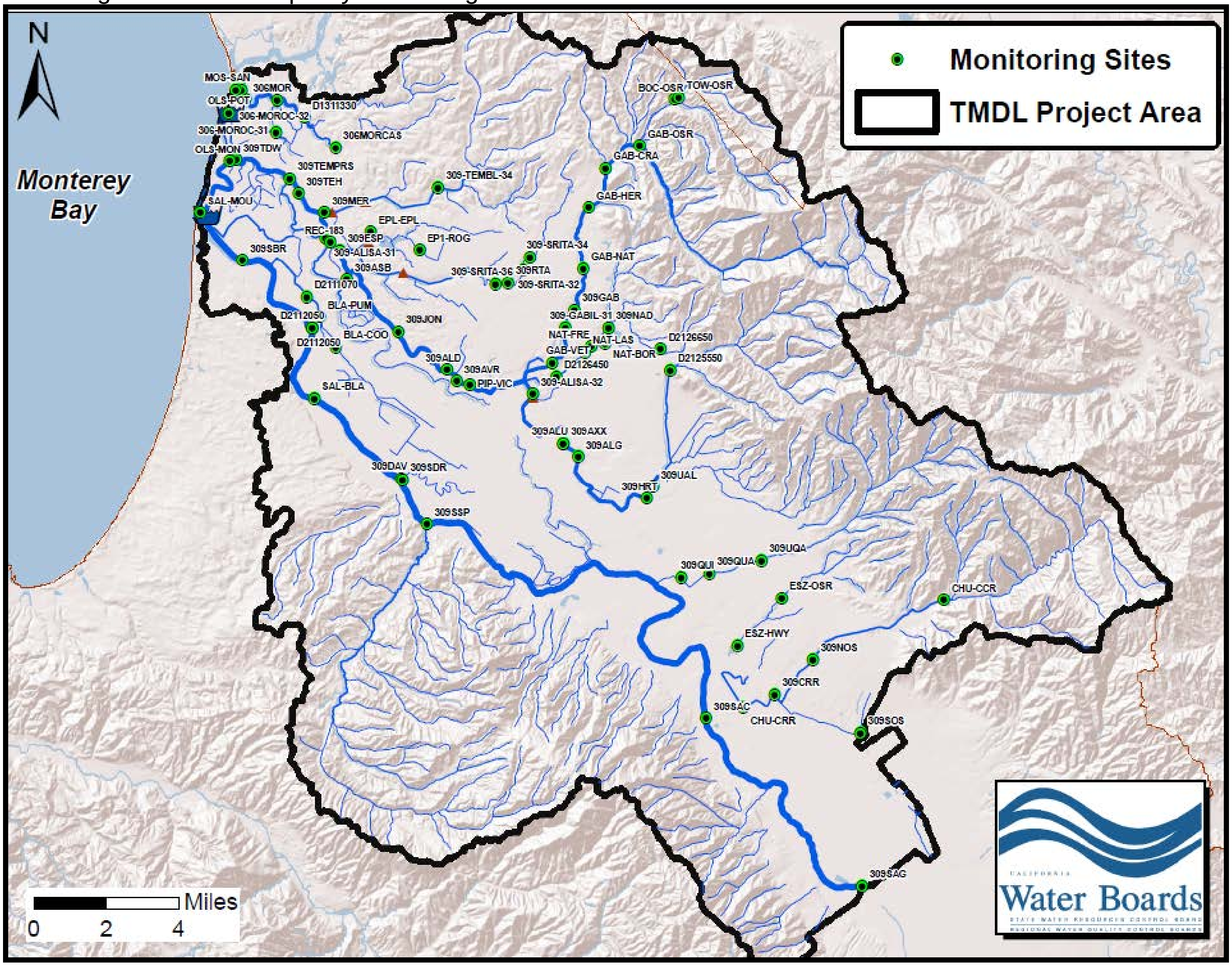
The water quality data used for this TMDL project included data from several sources, as outlined below:

1 Central Coast Ambient Monitoring Program (CCAMP). CCAMP is the Central Coast Water Board’s regional scaled water quality monitoring and assessment program.
2 Cooperative Monitoring Program (Central Coast Water Quality Preservation, Inc.)[63]
3 Central Coast Watershed Studies (CCoWS) Team (affiliated with the Watershed Institute at California State University-Monterey Bay)
4 Elkhorn Slough National Field Reserve (ESNERR)
5 Snap Shot Day monitoring program (Monterey Bay National Marine Sanctuary Citizen Watershed Monitoring Network)
6 U.S. Environmental Protection Agency, Storage and Retrieval Data Warehouse (STORET) – legacy data center.[64]
7 City of Salinas NPDES Stormwater Program Annual Reports.

Appendix A contains a tabulation of monitoring sites for the TMDL project area. Figure 3-3 illustrates the water quality monitoring sites in the TMDL project area.

[63] Cooperative Monitoring Program (CMP) is managed by Central Coast Water Quality Preservation, Inc. on behalf of irrigated agriculture throughout the Central Coast region.
[64] Online linkage: http://www.epa.gov/storet/

Figure 3-3. Water quality monitoring locations.



3.7.3 Water Quality Spatial and Temporal Trends

Figure 3-4 through Figure 3-12 illustrate a spatial representations[65] and statistical distributions of nitrate (as N), orthophosphate (as P), chlorophyll-a, and unionized ammonia (as N) throughout the Salinas River and Reclamation Canal basin. Figure 3-13 through Figure 3-16 illutrate time series plots of nitrate and/or orthophosphate at various spatial scales. Figure 3-17 and Figure 3-18 illustrate real-time data from moored chemical sensors maintained by the Monterey Bay Aquarium Institute in the Old Salinas River and Elkhorn Slough. A stakeholder who reviewed this TMDL project report noted that to the naked eye, some of the time series

[65] The spatial datasets illustrating estimated nitrogen and phosphorus land inputs of fertilizer and mansure were created and used by the U.S. Geological Survey (USGS) 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*

appear to show less change in recent years than in earlier one. However, staff did not perform statistical analyses to verify this observation.

As indicated by the spatial distributions shown in the figures, the TMDL project area of the lower Salinas River valley has elevated nutrient and algal biomass indicators (i.e., chlorophyll-a) relative to other areas within the Salinas River basin. Also, as shown in Figure 3-4 and Figure 3-5, the lower Salinas River valley has a higher intensity of nitrogen and phosphorus inputs from human activities (fertilizer and manure) relative to the rest of the Salinas River basin more broadly.

Figure 3-6 uses the data illustrated in Figure 3-4 and Figure 3-5 and presents linear correlations for paired datasets of nutrients in surface waters (i.e., median nutrient concentrations at individual monitoring sites) and nitrogen and phosphorus inputs from fertilizer/manure for the corresponding NHD catchment which spatially intersects that monitoring site. The Pearson's correlation coefficient[66] in Figure 3-6(A), R=0.6057 (note that R=1 is a perfect linear correlation), suggests reasonably good correlation between nitrate in surface waters and nitrogen fertilizer/manure catchment inputs, while the Pearson's correlation coefficient in Figure 3-6(B) (R= 0.2705) suggests a relatively poor correlation between orthophosphate in surface waters and phosphorus fertilizer/manure inputs. This suggests there are other significant compounding factors related to phosphorus concentrations in surface water, some examples could be flow variation, seasonality, sediment delivery, and natural inputs variation. Also, another confounding factor is that the correlations are for the paired sets of monitoring sites and the NHD catchment that spatially intersects the monitoring site, and does not account for inputs resulting from NHD catchments upstream of the monitoring site.

[66] As calculated in Microsoft Excel 2010

Figure 3-4. (A) Surface water NO3 as N (median concentration values – mg/L); and (B) estimated total nitrogen inputs (kg/hectare - year 2002) from fertilizer and manure, Salinas River-Reclamation Canal basin.

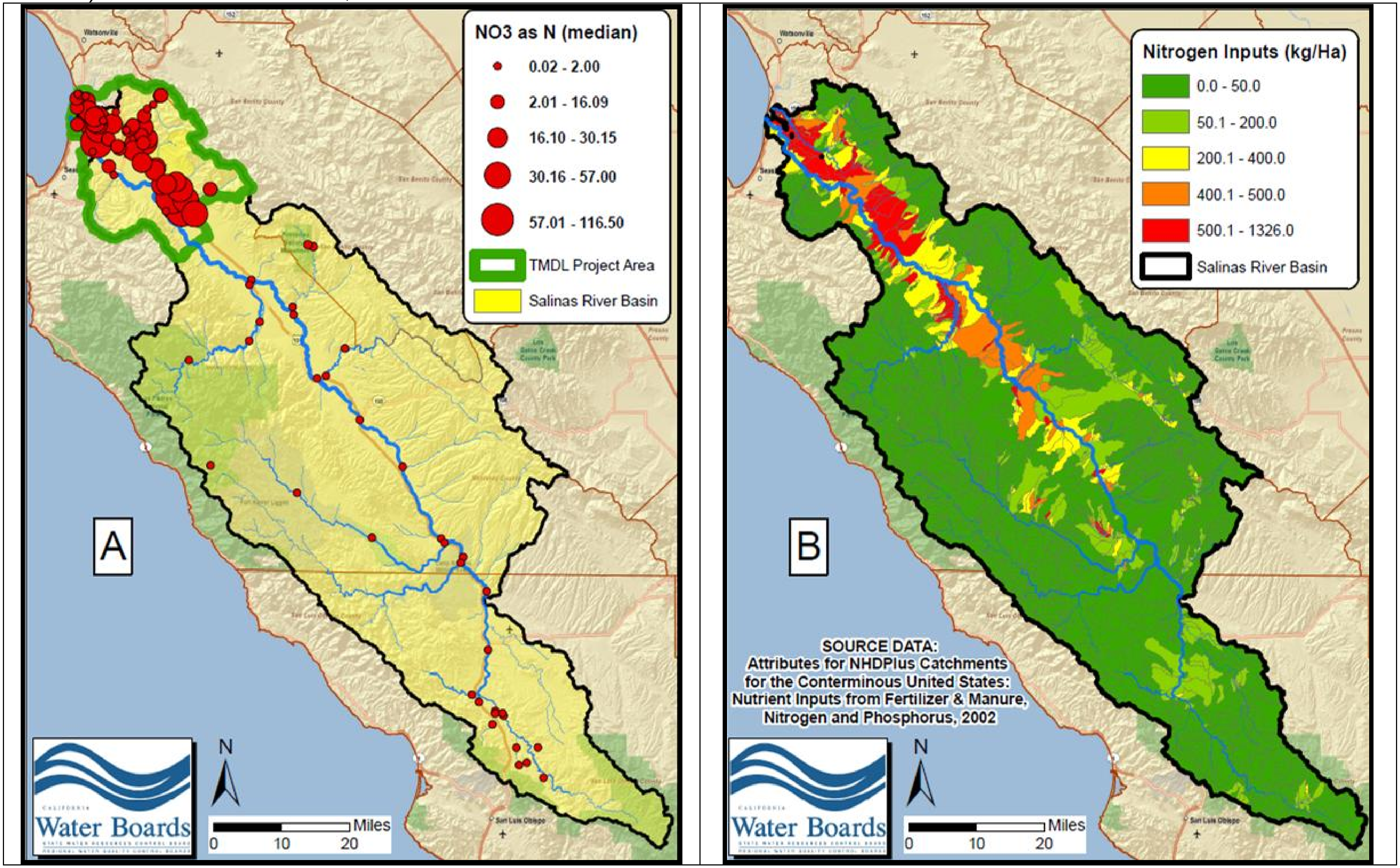


Figure 3-5. (A) Surface water orthophosphate as P (median concentration values – mg/L); and (B) estimated total phosphorus inputs (kg/hectare - year 2002) from fertilizer and manure, Salinas River-Reclamation Canal basin.

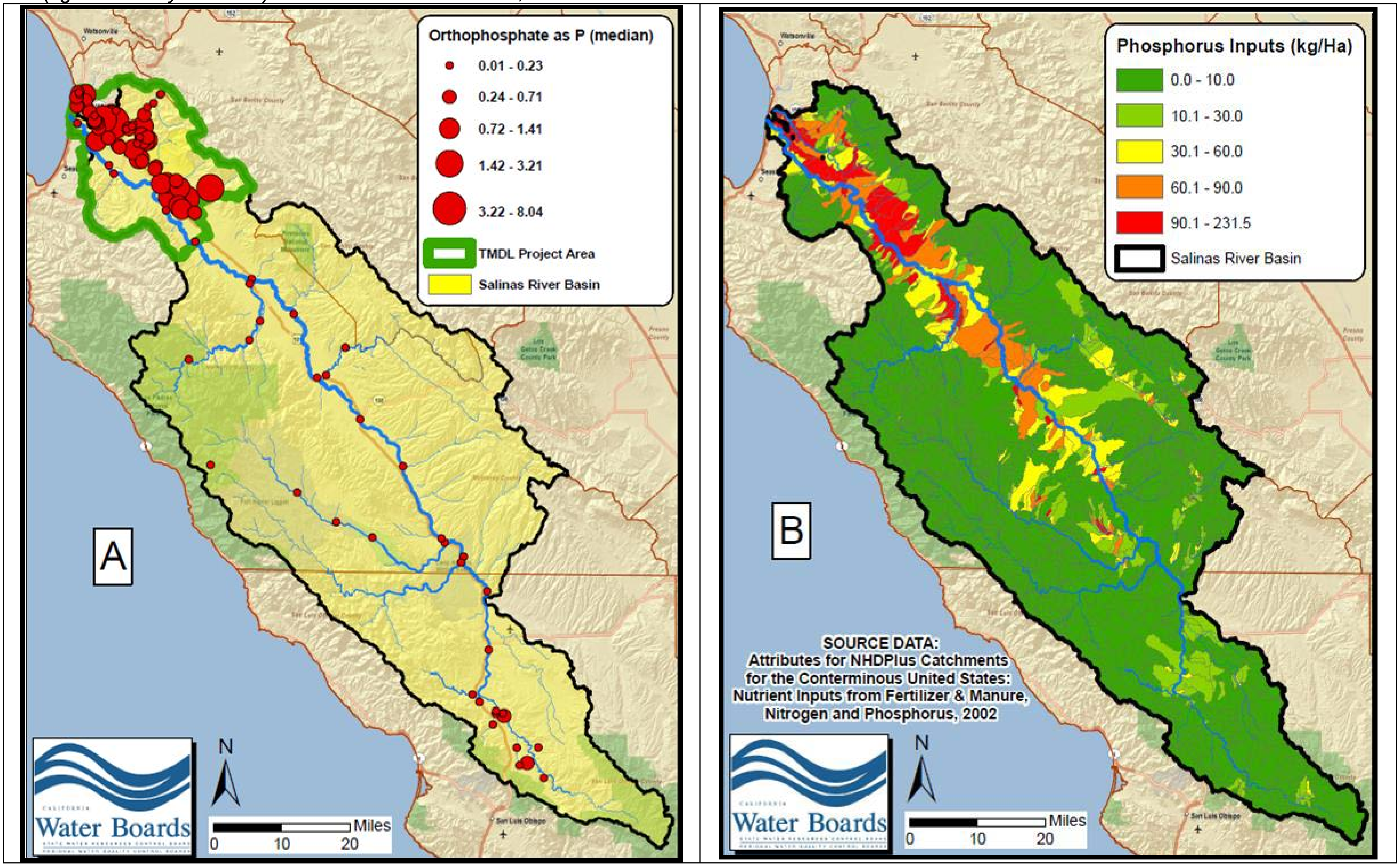


Figure 3-6. Linear correlation of paired data previously shown in Figure 3-4 and Figure 3-5: (A) Monitoring site surface water nitrate as N (median concentration values – mg/L) versus estimated total nitrogen inputs (kg/hectare - year 2002) from fertilizer and manure in NHD catchment which geographically overlays the corresponding monitoring site; and (B) Monitoring site surface water orthophosphate as P (median concentration values – mg/L) versus estimated total phosphorus inputs (kg/hectare - year 2002) from fertilizer and manure in NHD catchment which geographically overlays the corresponding monitoring site;

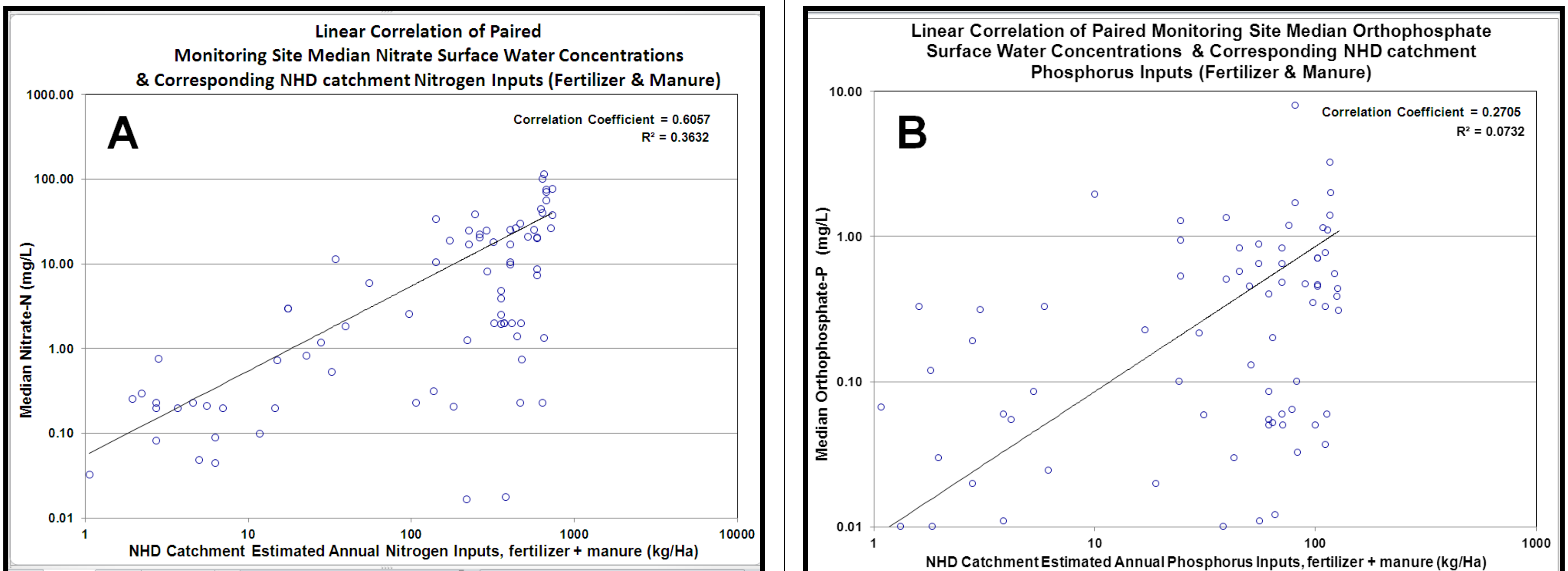


Figure 3-7. (A) Surface water chlorophyll-a (mean concentration values – mg/L); and (B) surface water unionized ammonia (NH3 as N – median concentration values mg/L), Salinas River-Reclamation Canal basin.

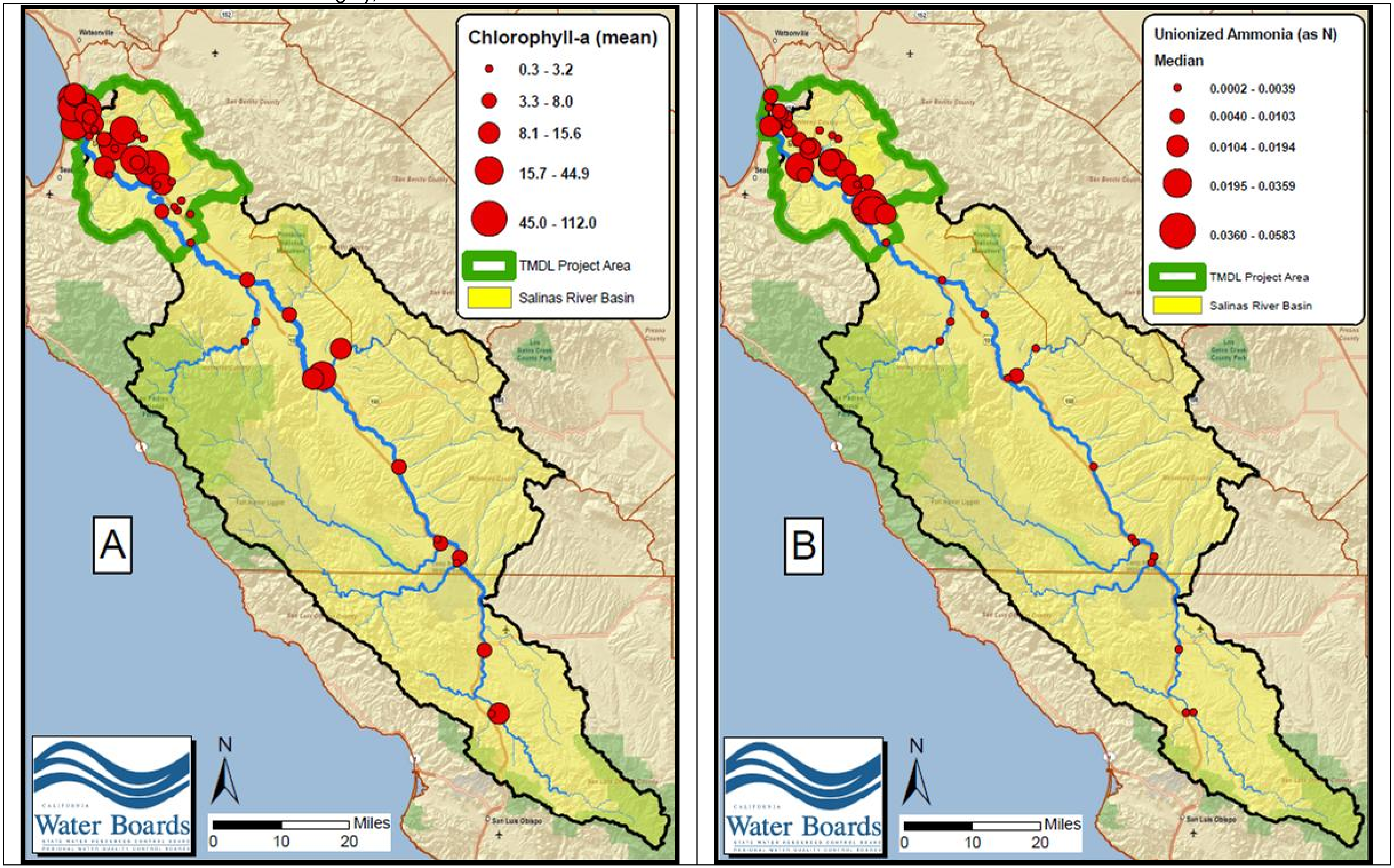


Figure 3-8. Surface water NO3 – N concentrations (median value), TMDL project area.

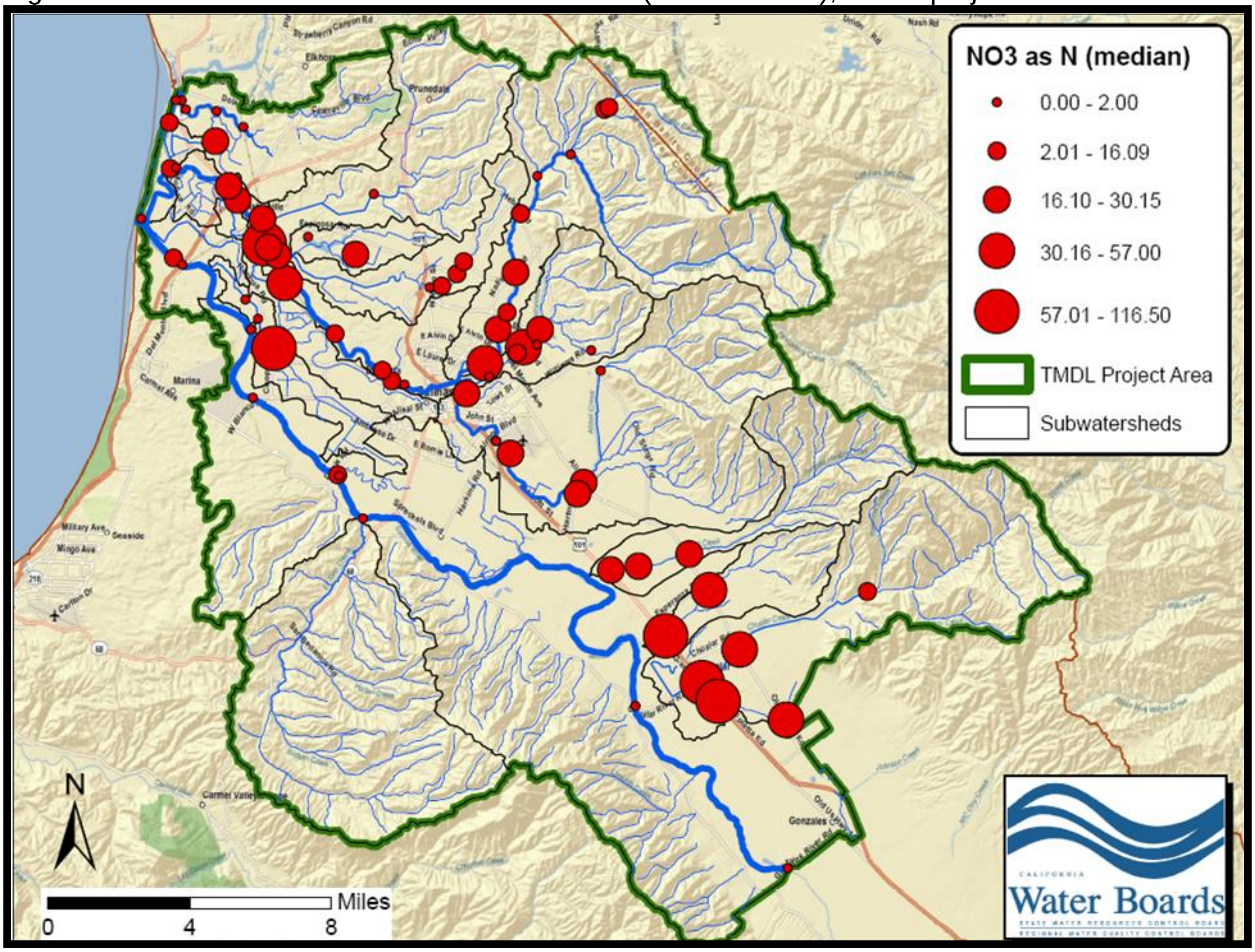


Figure 3-9. Box and whiskers plot, NO3 as N water quality data, Reclamation Canal-Tembladero Slough drainage and tributaries.

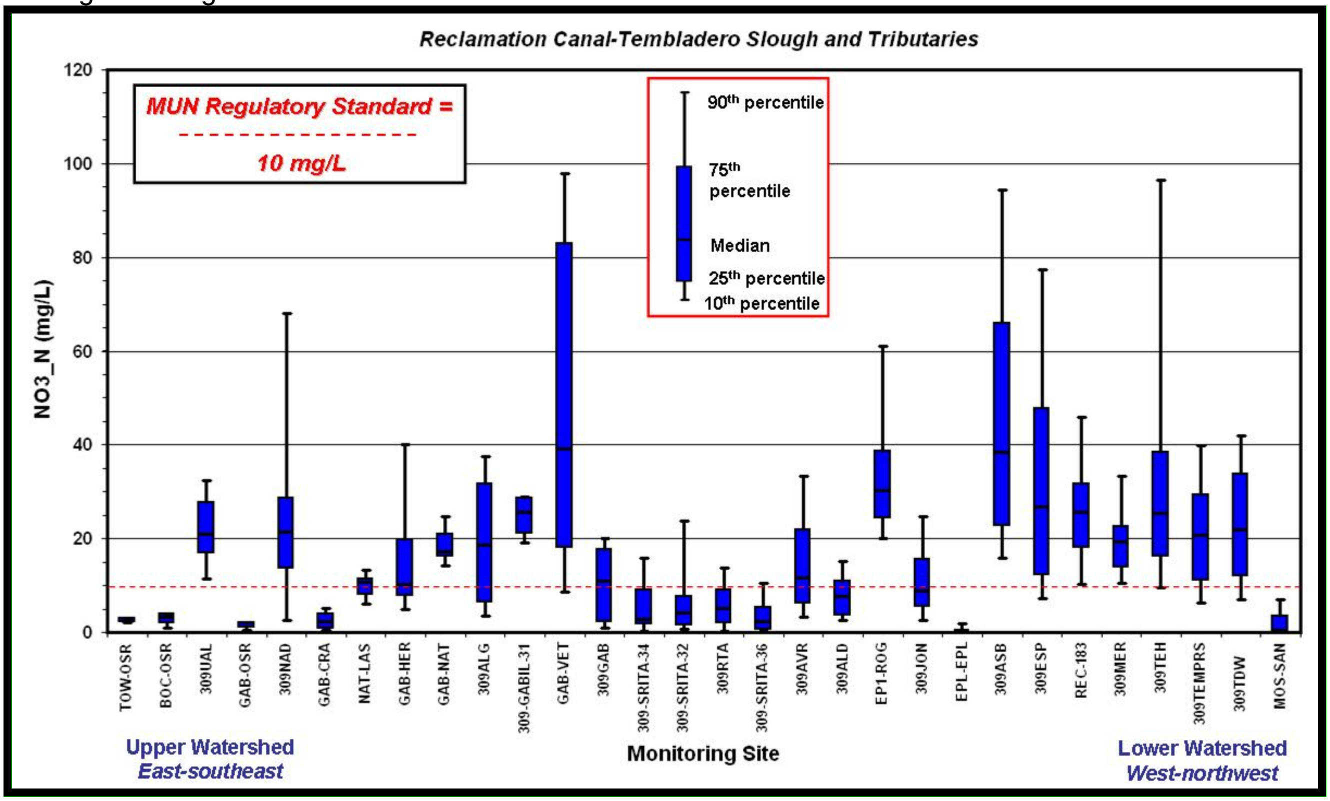


Figure 3-10. Box and whiskers plot, NO3 as N water quality data, lower Salinas River drainage and tributaries.

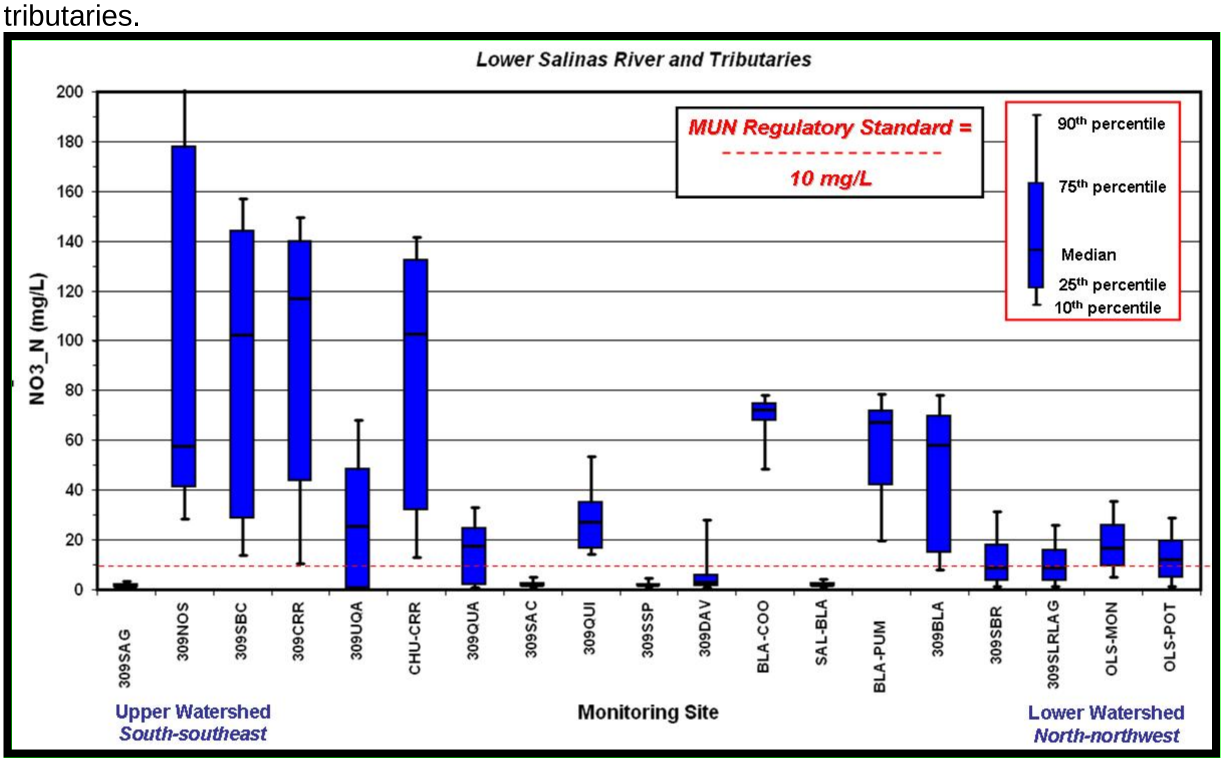


Figure 3-11. Box and whiskers plot, chlorophyll-a, Reclamation Canal-Tembladero Slough drainage and tributaries.

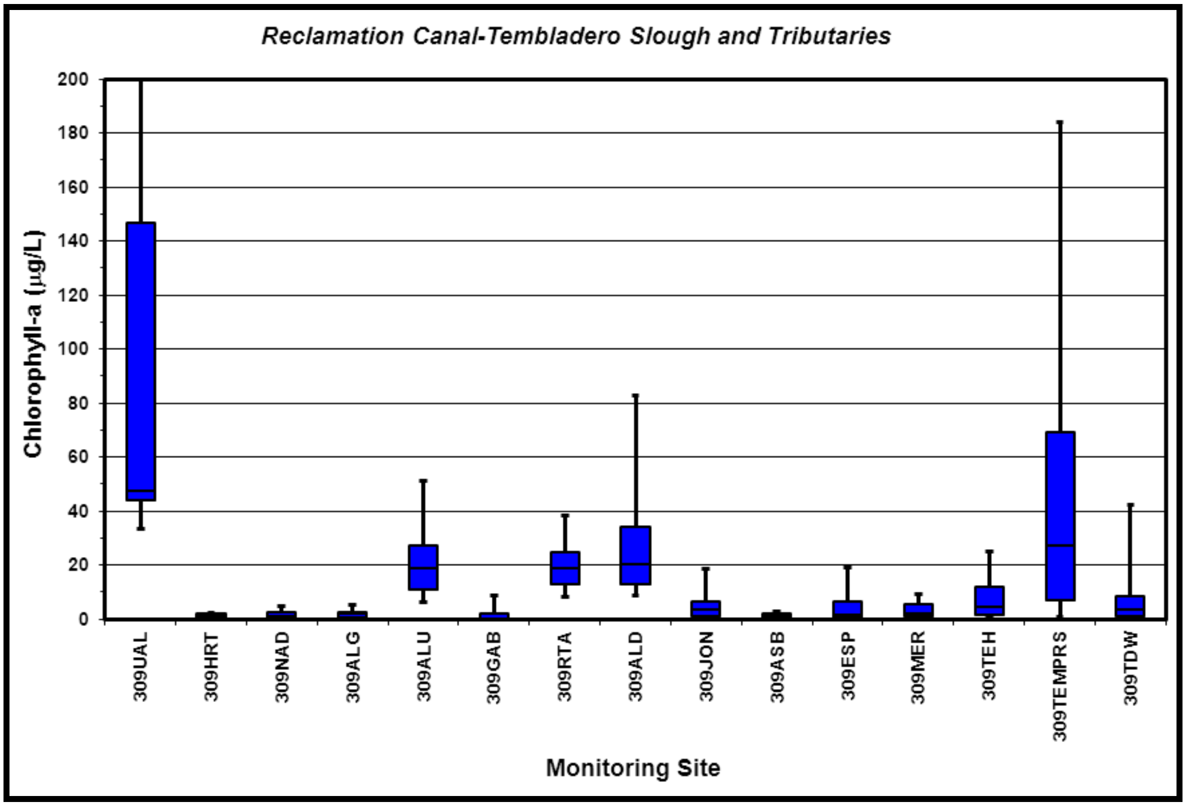


Figure 3-12. Box and whiskers plot, chlorophyll-a, lower Salinas River drainage and tributaries.

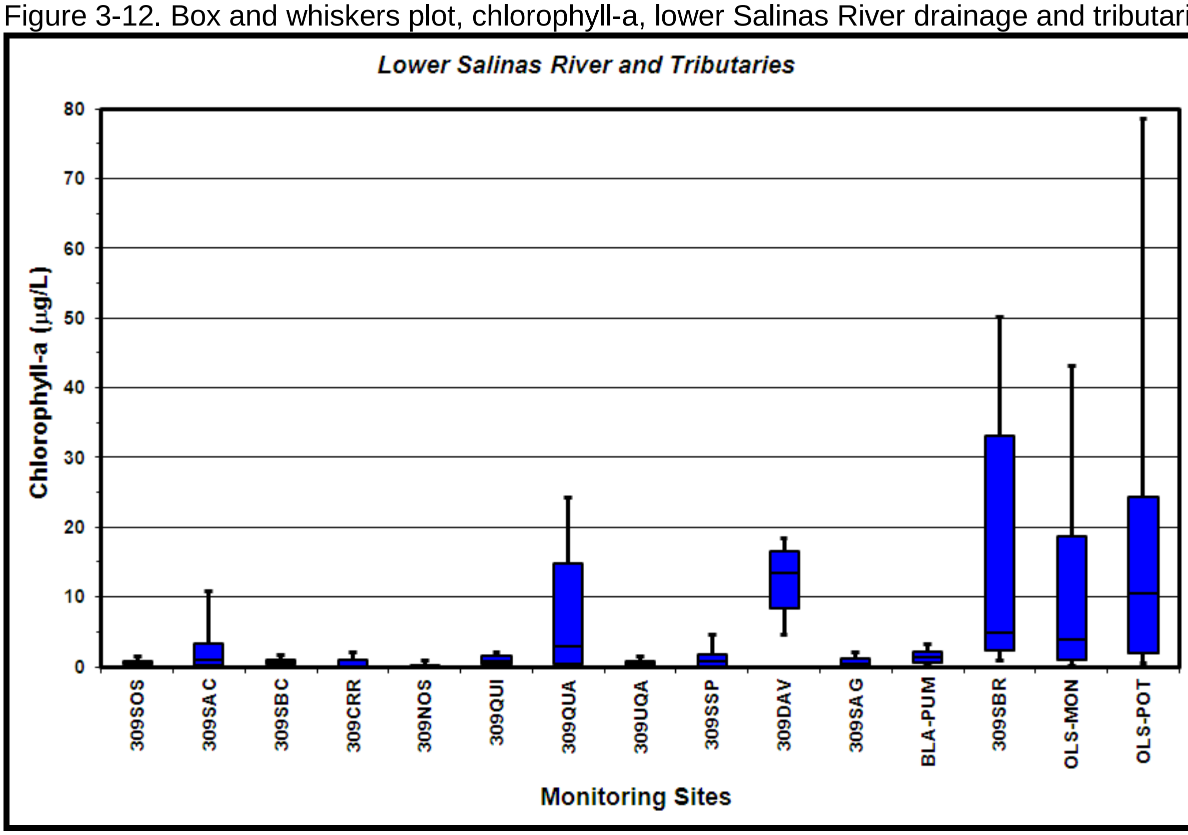
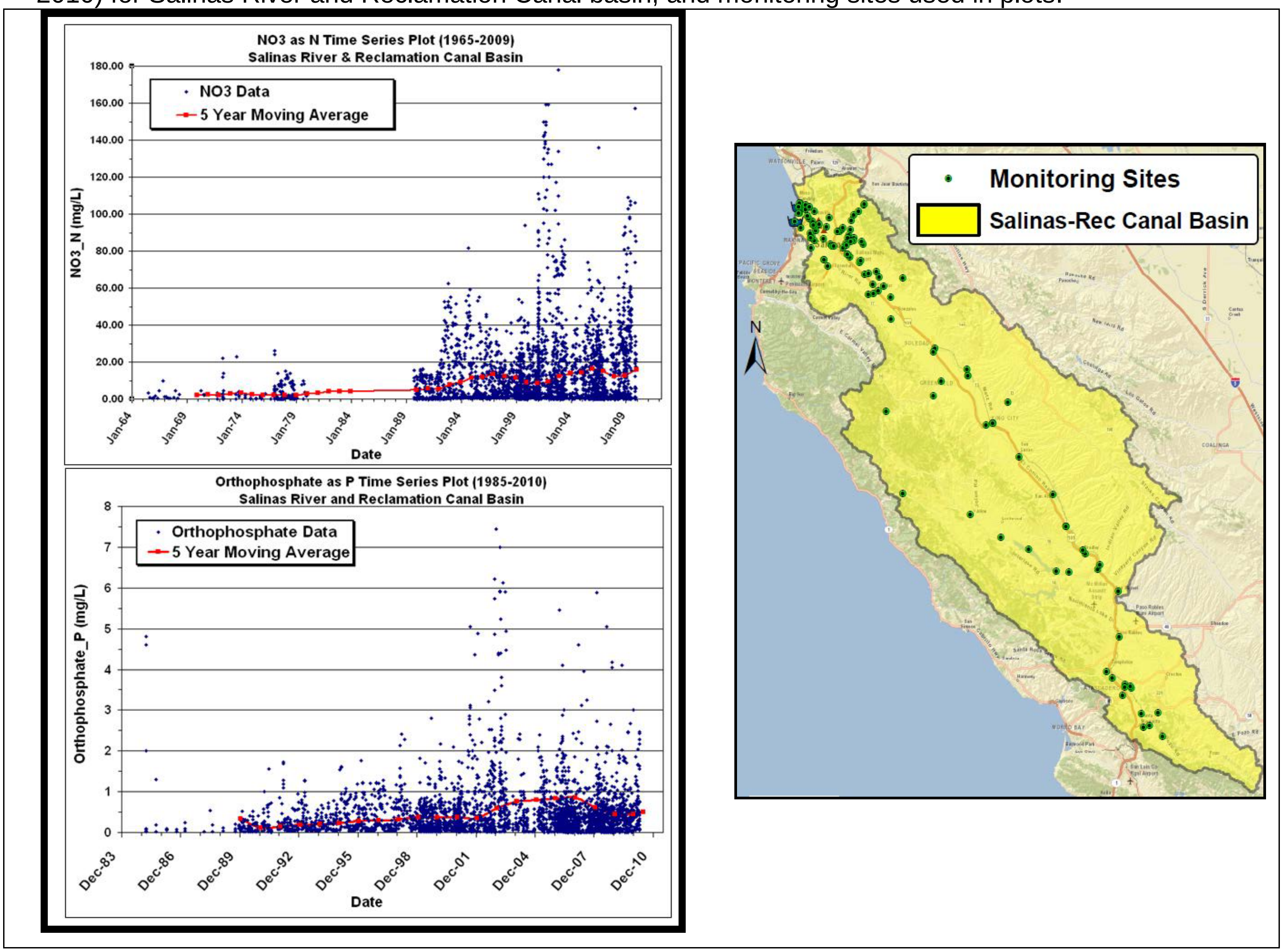


Figure 3-13 presents nitrate and orthophosphate time series plots, with five-year moving average overlays. This figure illustrates that the magnitude of nitrate and orthophosphate concentrations in surface waters in the Salinas River-Reclamation Canal basin have significantly increased over the 30 to 40 years, particularly in the lower Salinas River and Reclamation Canal-Tembladero Slough drainages. Note that moving averages are used to illustrate data trend by smoothing out year to year fluctuations and outliers; for example in Figure 3-13 the moving average illustrates the central tendency of the data over time increments consisting of rolling five-year intervals. Staff also performed a Kendall's tau nonparametric correlation test using R[67] on both the time series datasets shown in Figure 3-13. Kendall's tau is a statistical measure of the monotonic association between two variables. The correlation test indicates that both NO3 and ortho-P have a positive (increasing) trend over time (tau = 0.xxx and 0.yyy, respectively) and these correlations are both statistically significant (p-value < 2.2 e-16). This means there is a positive data trend pattern of increasing NO3 and ortho-P over time and there is a very low probability that it could be due to random chance[68] .

Figure 3-13. Water quality time series plot NO3 as N (1965-2010), and orthophosphate as P (1985-2010) for Salinas River and Reclamation Canal basin, and monitoring sites used in plots.



[67] 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/.

[68] Staff considered whether the trends indicated by the moving averages in the time series scatter plots could potentially be unacceptably biased by spatial and temporal changes in monitoring locations and frequencies. However, discretere stream reaches and monitoring sites from key locations in the lower Salinas Valley also show increating trends .

Figure 3-14. Time series (1965-2010), NO3 as N – lower Salinas River, Spreckels to Highway 1.

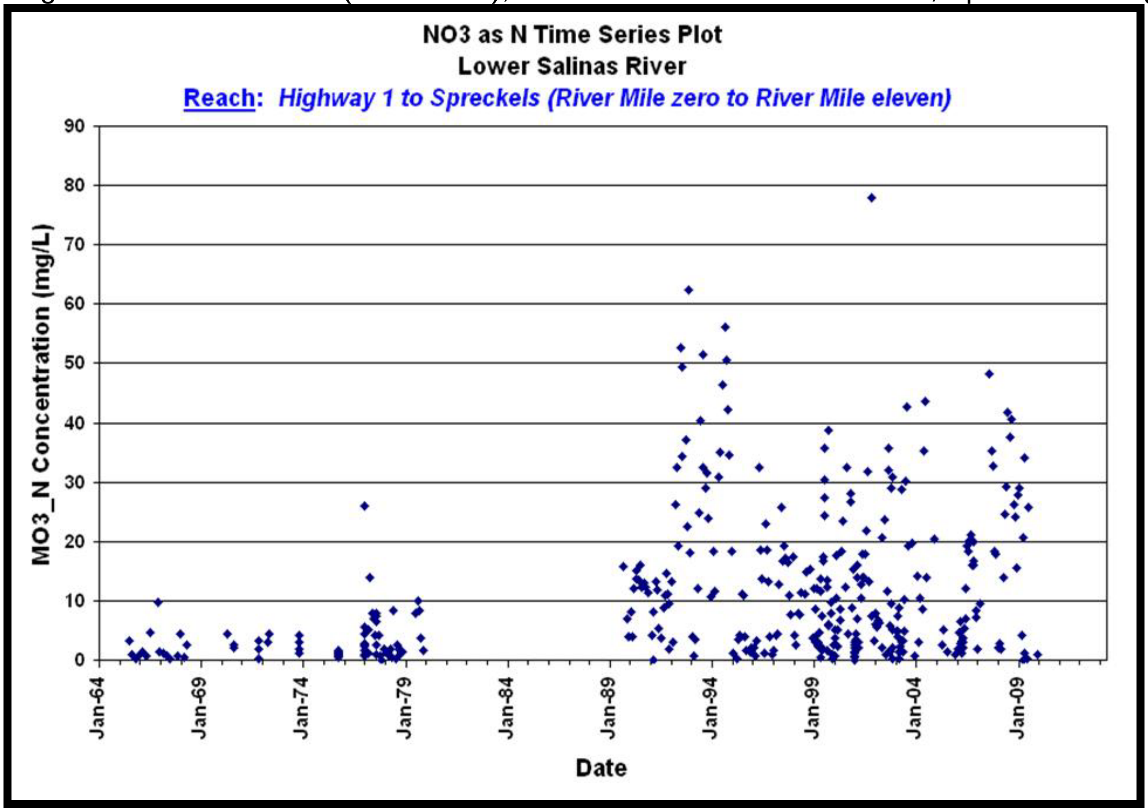


Figure 3-15. Time series (1972-2010), NO3 as N – lower Tembladero Slough.

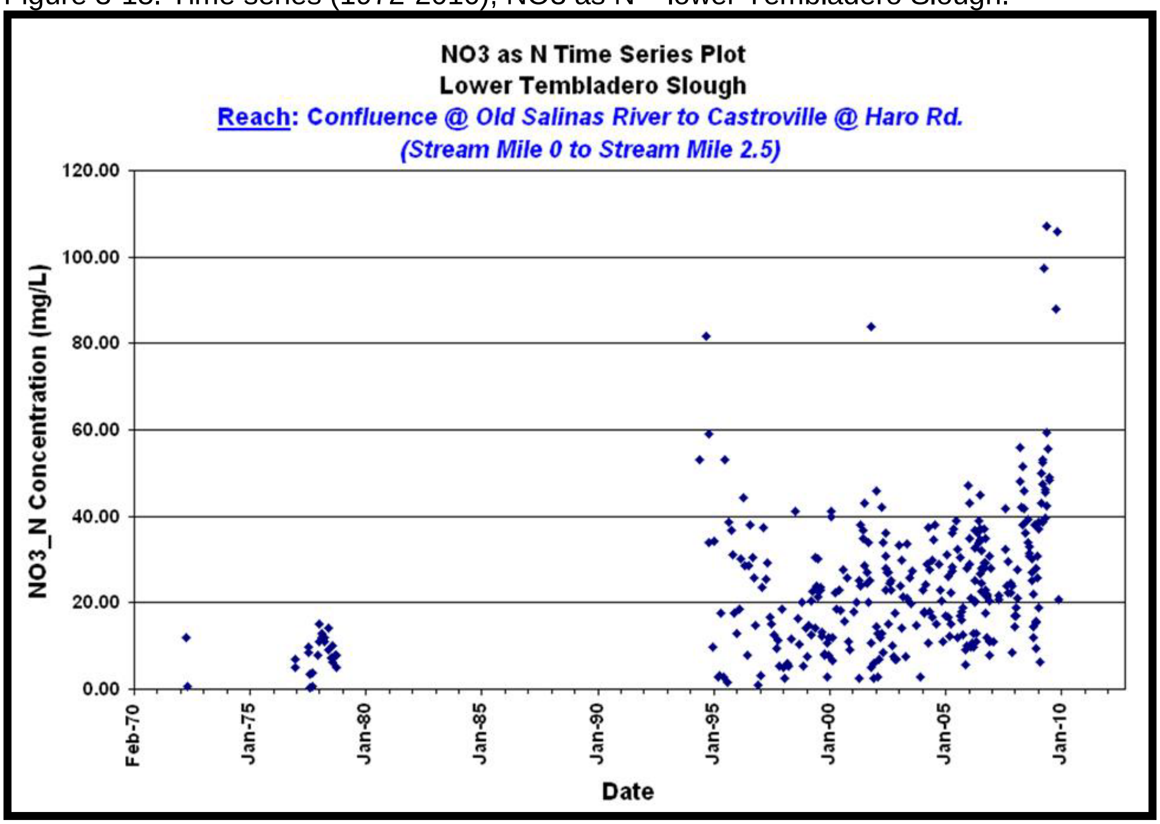


Figure 3-16. Time series (1972-2010), NO3 as N – Old Salinas River.

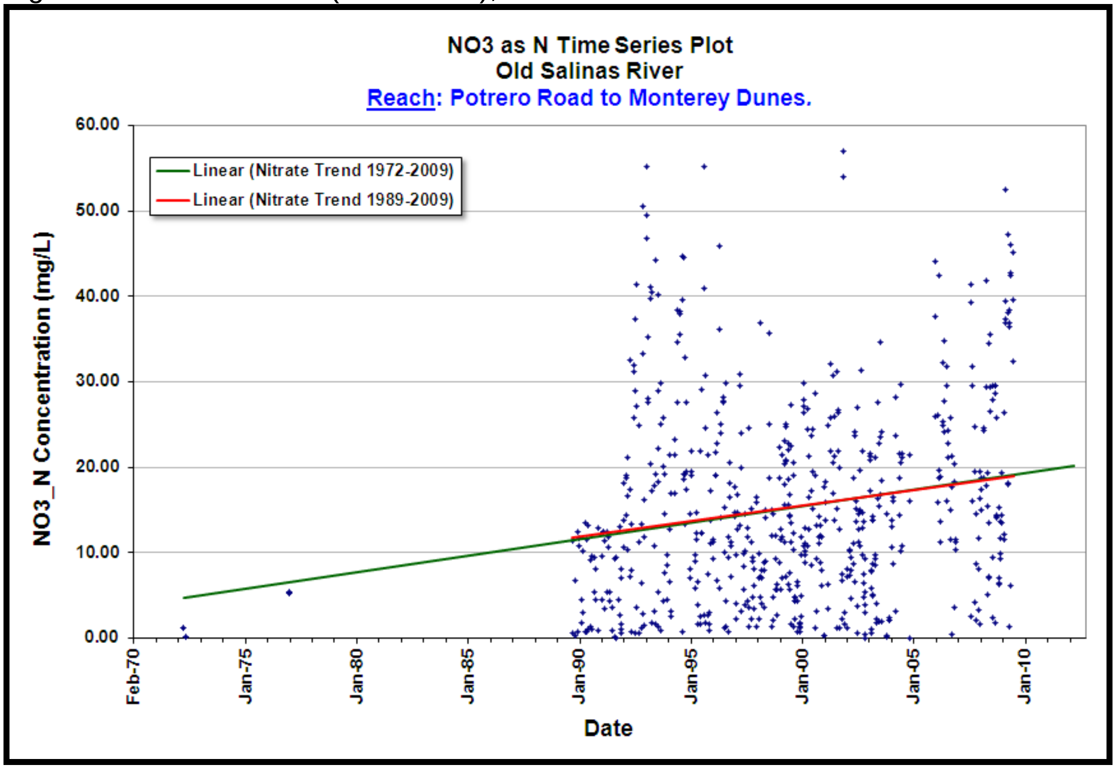


Figure 3-17. Time series (2004-2012), MBARI Moored Sensor, NO3 as N – Old Salinas River.

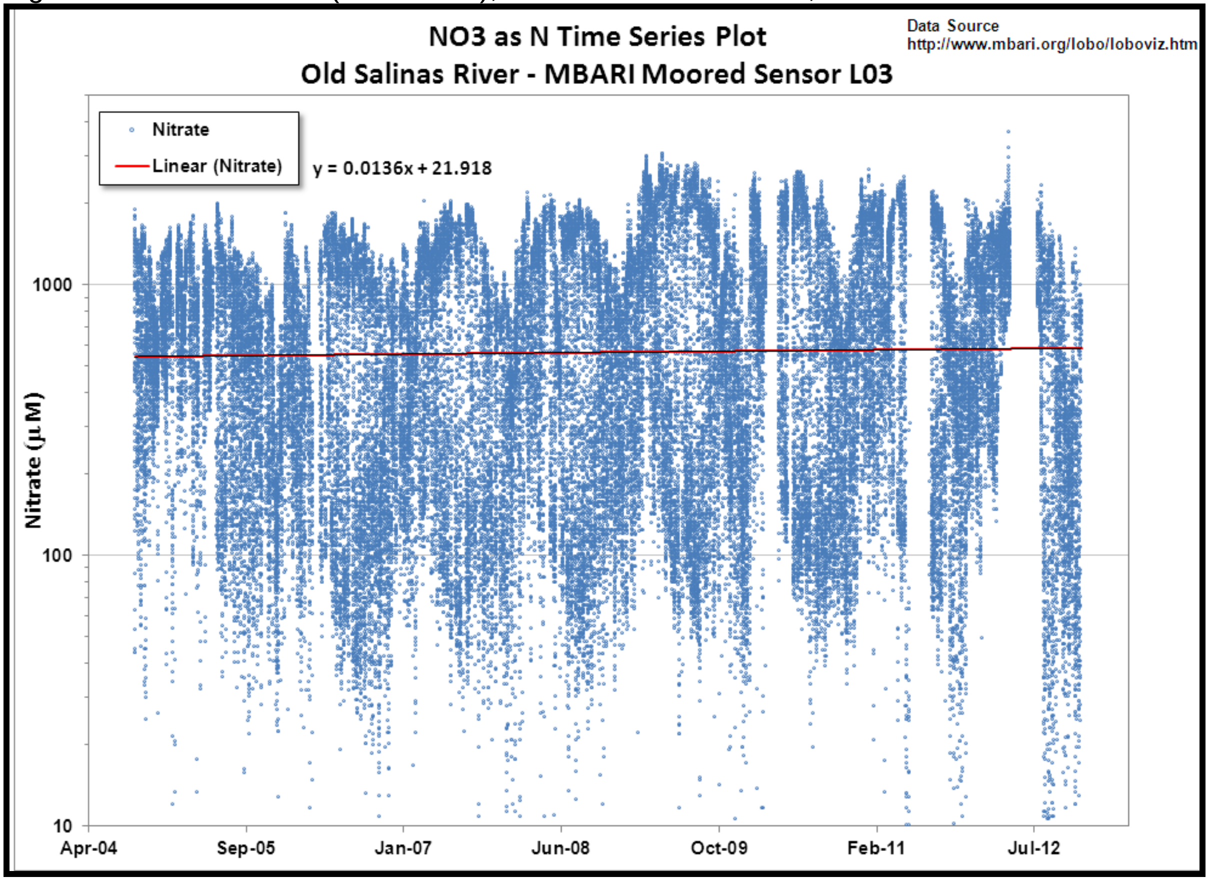
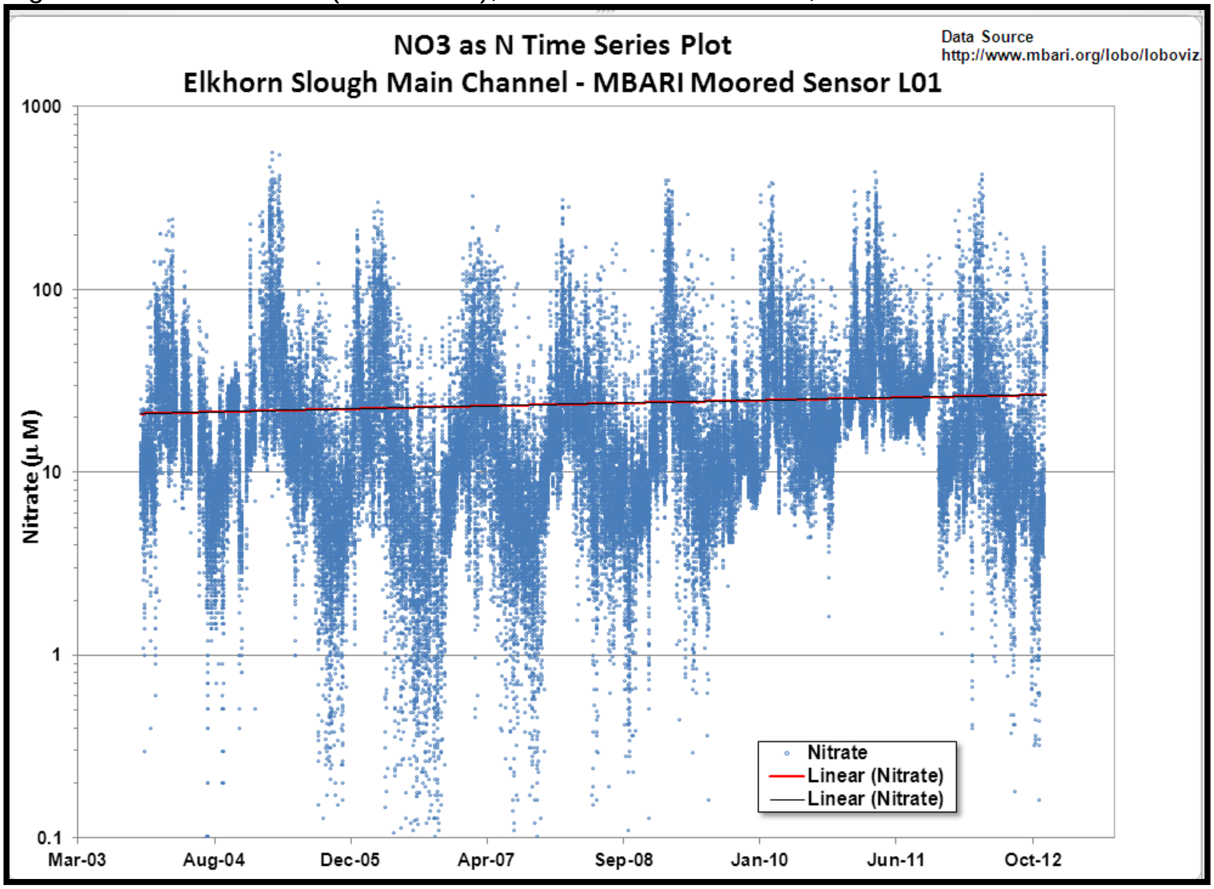


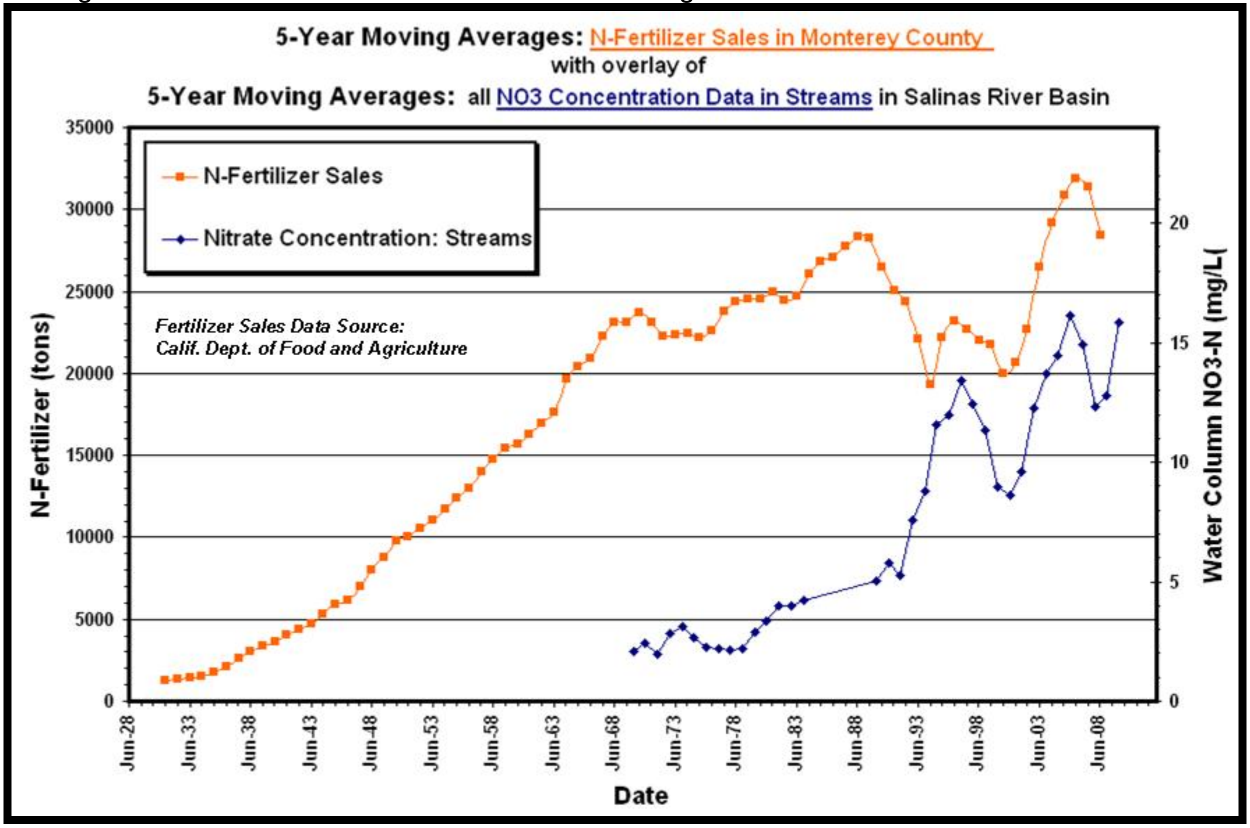
Figure 3-18. Time series (2004-2012), MBARI Moored Sensor, NO3 as N – Old Salinas River.



As illustrated in Figure 3-19, increasing sales and use of N-fertilizer[69] in Monterey County appear qualitatively to trend and comport with increasing nitrate concentrations in streams of the Salinas River-Reclamation Canal basin, suggesting an anthropogenic component to increasing nitrate concentrations in streams. However, a Kendall's tau correlation test on the dataset from Figure 3-19 indicates a p-value = 0.1121. Practically speaking, this means the association between fertilizer sales and water column nitrate is not statistically significant and there is an unacceptably high probability that the two dataset variables are not strongly associated. Undoubtedly, there are many other confounding factors besides the magnitude of fertilizer sales that impacts average water column nitrate concentration including, but not limited to, substantial interannual variability in runoff and precipitation and water and irrigation management. It should also be noted that use of manure as a soil amendment was more prevalent in the historic past, and these nutrient inputs are not captured by historic fertilizer sales reporting.

[69] Fertilizer tonnage reports are available by contacting the California Department of Food and Agriculture

Figure 3-19. 5-year moving averages of Monterey County N-fertilizer sales and 5-year moving averages of all nitrate concentrations from monitoring sites of the Salinas River-Rec. Canal basin.



3.7.4 Water Quality Seasonal Trends

Seasonal trends in nutrient water quality data are presented in Figure 3-21 through Figure 3-26. Also illustrated in these figures is information on upstream land use information that drains to the monitoring sites. These land use attributes are based on the National Land Cover Dataset (2001), and are available as catchment and reach-scale attributes with the NHDplus hydrography dataset. The nexus between land use and seasonal nutrient variation are summarized in Table 3-6.

Monitoring sites with drainage from agricultural areas typically show a strong pattern of seasonality, with substantially higher nitrate concentrations in the dry season. An example of this can be seen in Figure 3-21. In contrast, CCAMP monitoring sites from lightly-disturbed areas or areas with relatively limited anthropomorphic influence do not show strong or systematic seasonal trends in nutrient concentrations (see Figure 3-26). Areas with substantial urban influence show some seasonal variability, but not to the extent shown in the agricultural areas. It is noteworthy that orthophosphate data from municipal stormwater outfalls appears to track the seasonality observed for orthophosphate in receiving waters: higher orthophosphate concentrations in summer, lower in winter (see Figure 3-24).

Table 3-6. Nutrient seasonal variation.

Upstream Land Use Draining to Monitoring Site(s)	Geographic and Visual Reference	Nitrate Concentration Seasonality	Orthophosphate Concentration Seasonality	Observations
Substantial cropland input	Salinas River @ Blanco Drain (see Figure 3-21)	Strong Seasonal Trend Dry Season – Higher Wet Season - Lower	Strong Seasonal Trend Dry Season – Lower Wet Season - Higher	High summertime NO3 concentrations likely do to ag return flows, tailwater discharges
Substantial cropland input, with some urban input	Old Salinas River (see Figure 3-22)	Strong seasonal trend Dry Season – Higher Wet Season - Lower	Subdued seasonal trend; dry season marginally lower	
Mixed cropland and urban input	Tembladero Slough (see Figure 3-23	Subdued seasonal trend; dry season marginally higher	Subdued seasonal trend; dry season marginally lower.	
Substantial urban input	Reclamation Canal d/s of Salinas (see Figure 3-24)	Variable but typically higher in dry season	Dry Season – Higher Wet Season - Lower	Storm outfall concentrations of orthophosphate consistent with seasonality of orthophosphate observed in receiving water (see Figure 3-24)
Substantial rangeland input	Upper Gabilan Creek, Towne Creek, Big Oak Creek, upper Chualar Creek (see Figure 3-25)	Generally no dry season flows	Generally no dry season flows	Nitrate in wet season flows typically meet nitrate water quality objectives.
Reference sites: variable, generally no substantial cropland or urban inputs	Reference sites from lightly-disturbed areas of the middle and upper Salinas River basin (see Figure 3-26)	Subdued and variable seasonal trends, concentrations typically somewhat lower in summer.	No systematic seasonal variability.	At scale of data (tenths of a mg per L) systematic and strong seasonal variability is not expressed.

Seasonal trends in chlorophyll a concentrations are presented in Figure 3-27. It is important to recognize that biostimulation and excessive algal growth in the dry season months is episodic and variable; for example see Figure 3-20.

Figure 3-20. Two photos of Salinas River at Davis Road, July 2006 and July 2008, respectively.

Figure 3-27 shows that chlorophyll *a* concentrations do not typically show a strong and systematic seasonal component; however episodic elevated chlorophyll *a* spikes exceeding the 303(d) listing criteria of 40 μg/L are more consistently associated with the dry season. Also worth noting, the vertical scale on this graph is logarithmic.

Figure 3-21. Monthly nitrate and orthophosphate data, and land use upstream of monitoring site 309SRB, Salinas River.

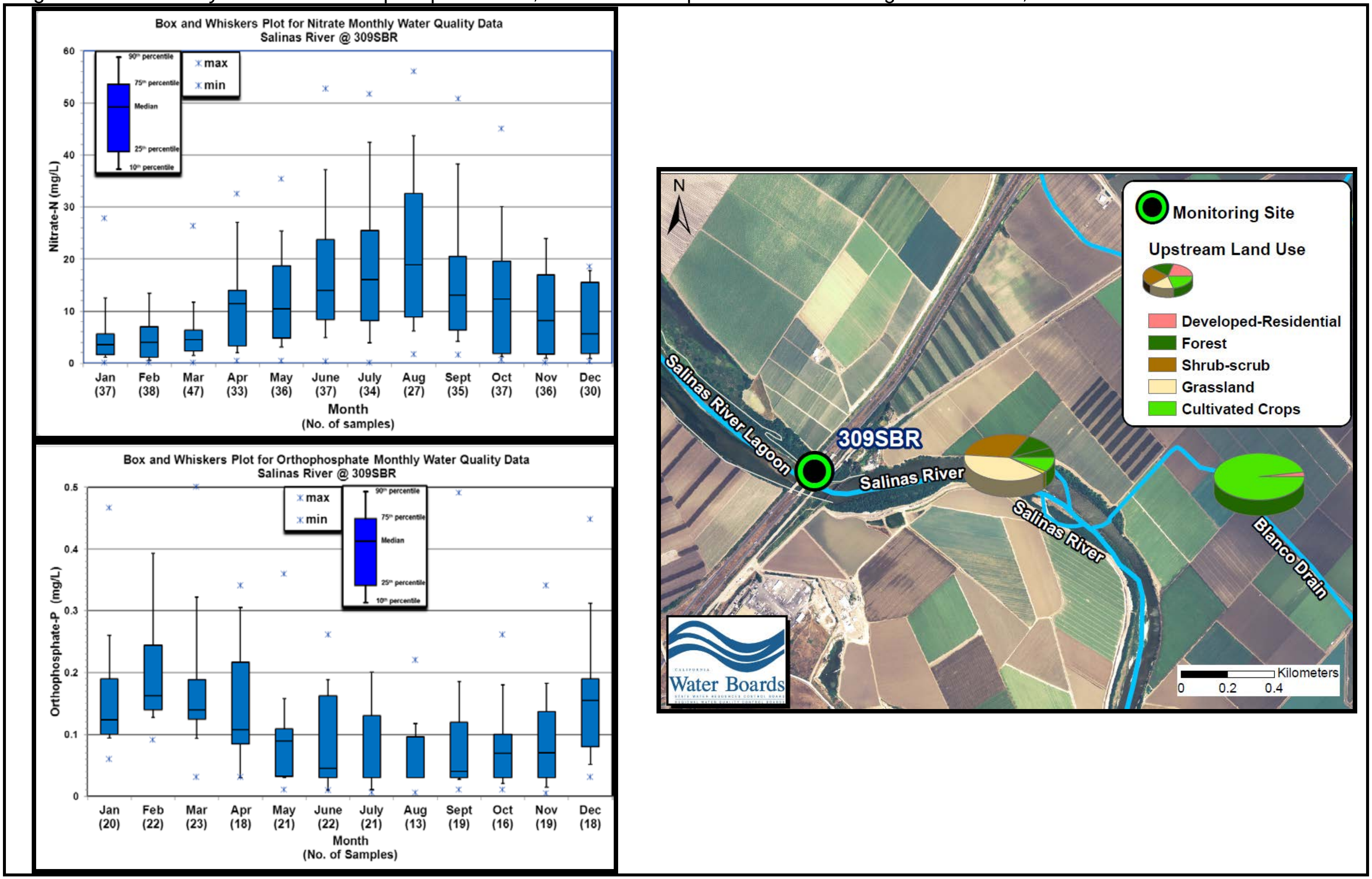


Figure 3-22. Monthly nitrate and orthophosphate data, and land use upstream of monitoring sites OLS-POT & OLS-MON, Old Salinas River.

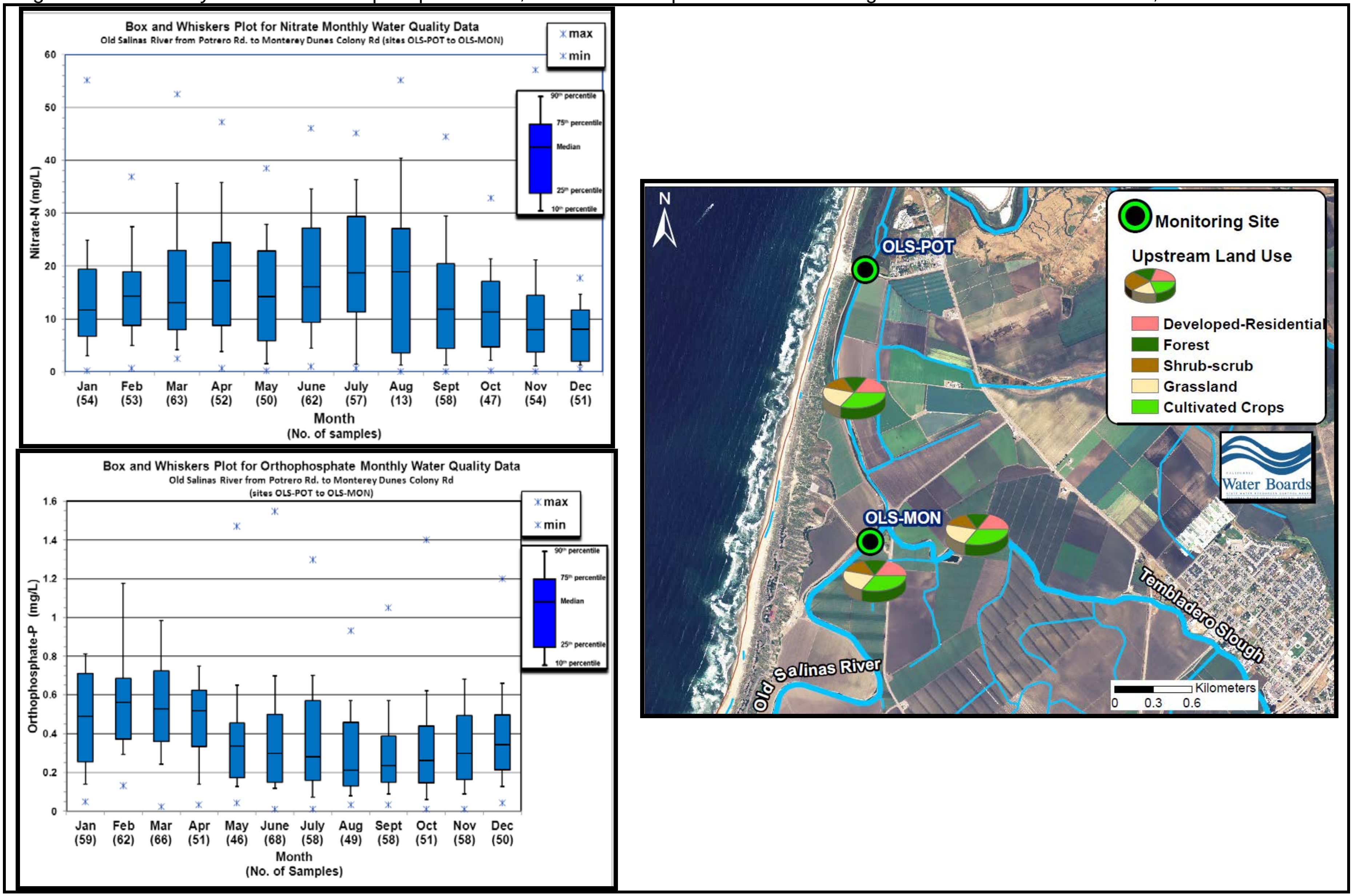
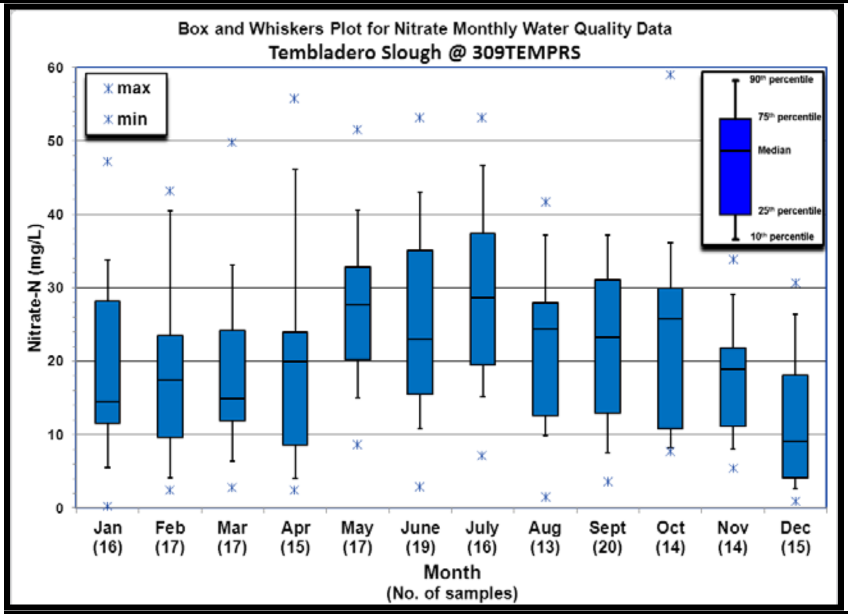
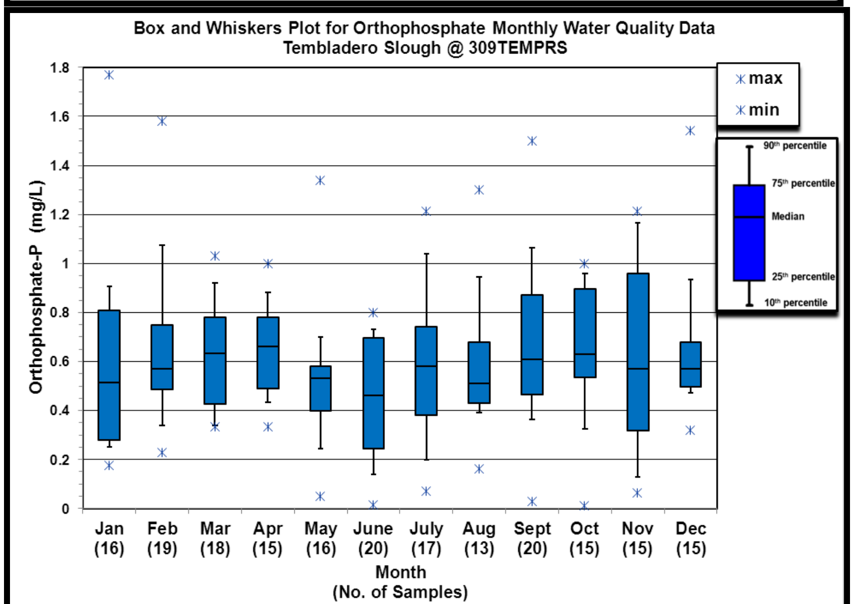


Figure 3-23. Monthly nitrate and orthophosphate data, and land use upstream of monitoring site 309TEMPRS, Tembladero Slough.





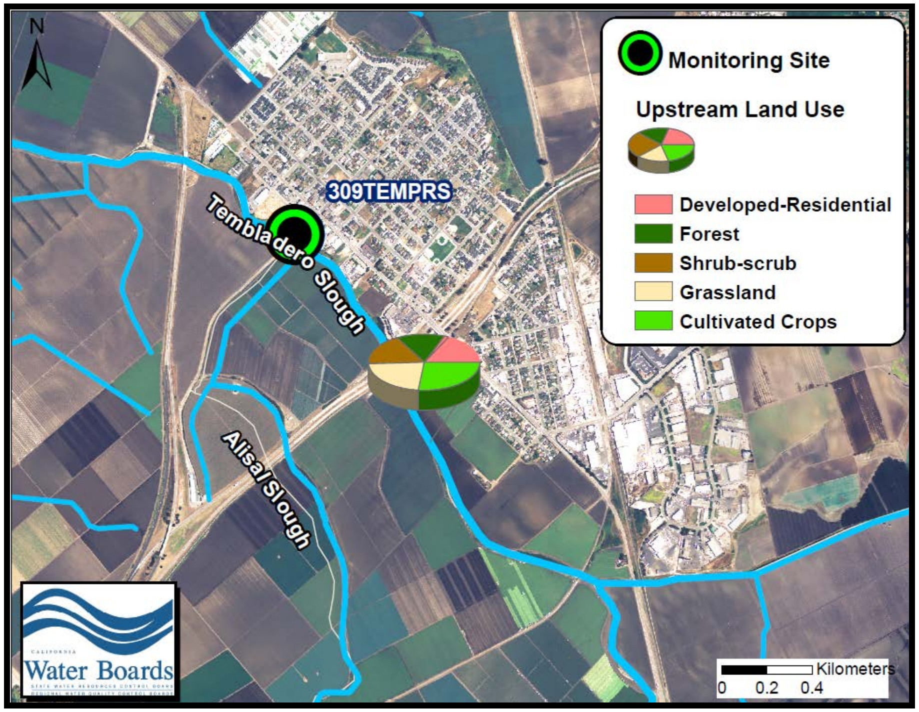


Figure 3-24. Monthly nitrate and orthophosphate data, and land use upstream of monitoring sites 309ALD, 309AVR, 309ALU, Reclamation Canal

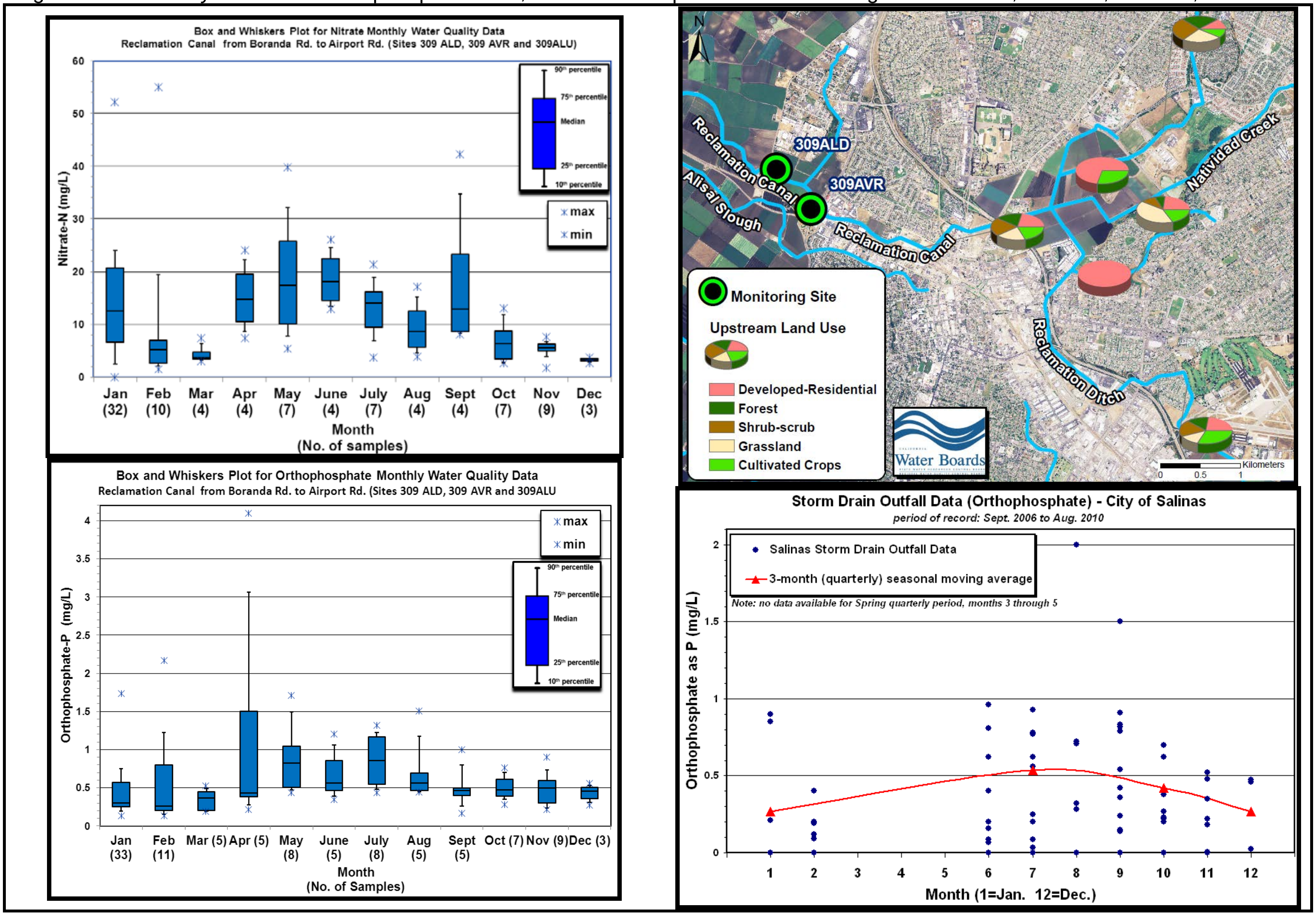


Figure 3-25. Monthly nitrate and orthophosphate data, and land use upper reaches of Gabilan, Towne, and Chualar creeks.

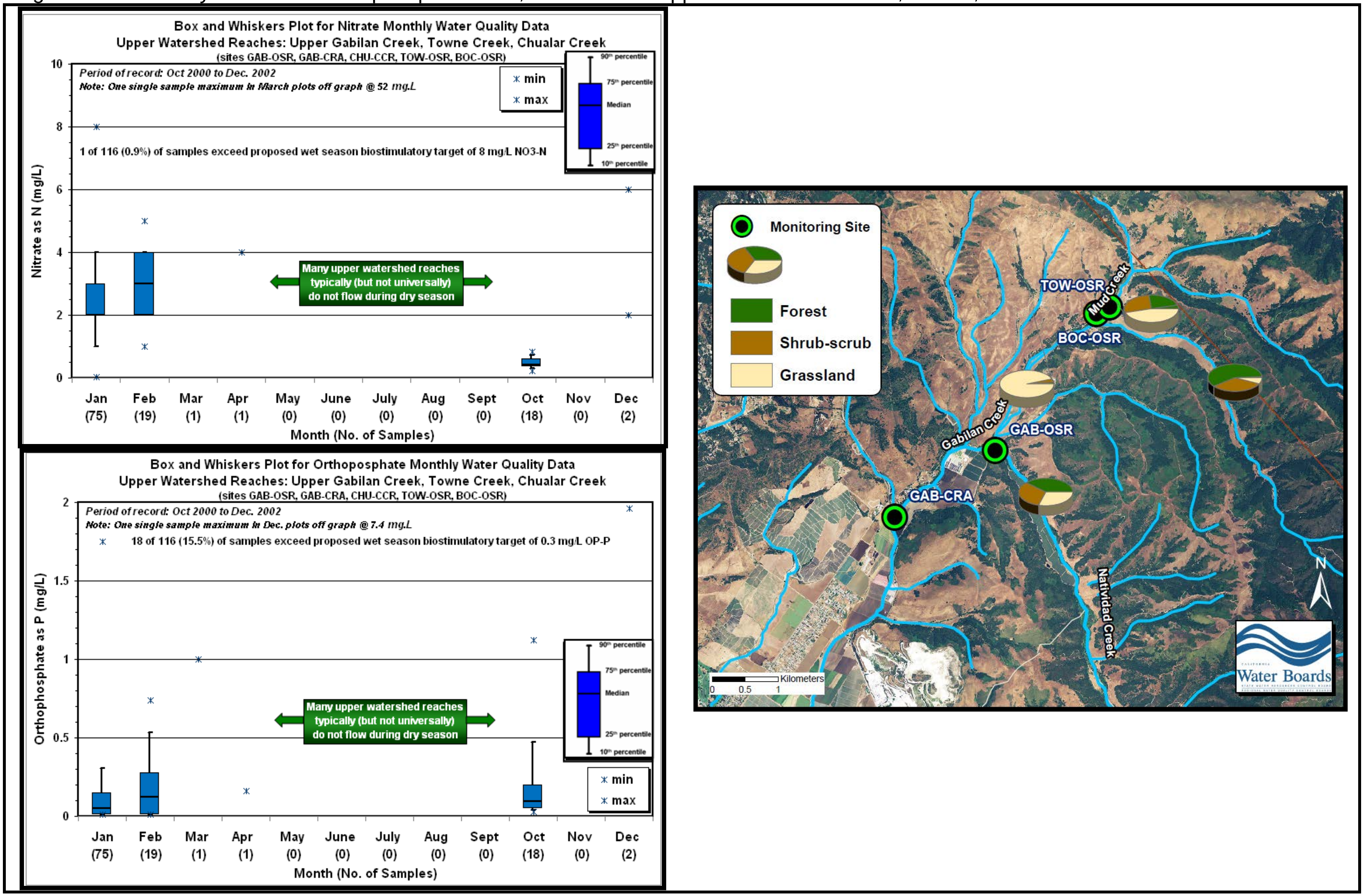


Figure 3-26. Monthly nitrate and orthophosphate data, reference sites: lightly-disturbed reaches of middle and upper Salinas River basin.

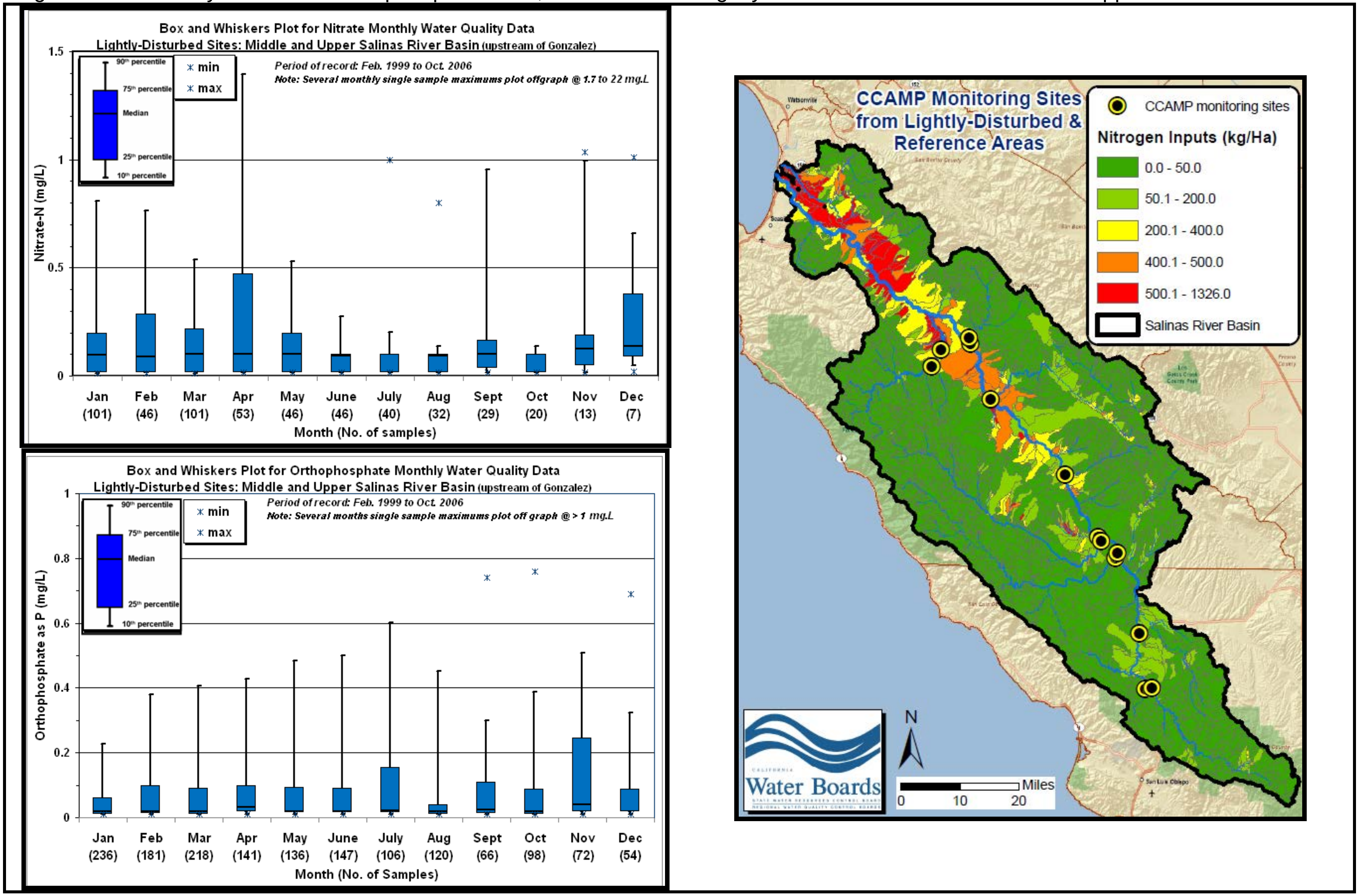
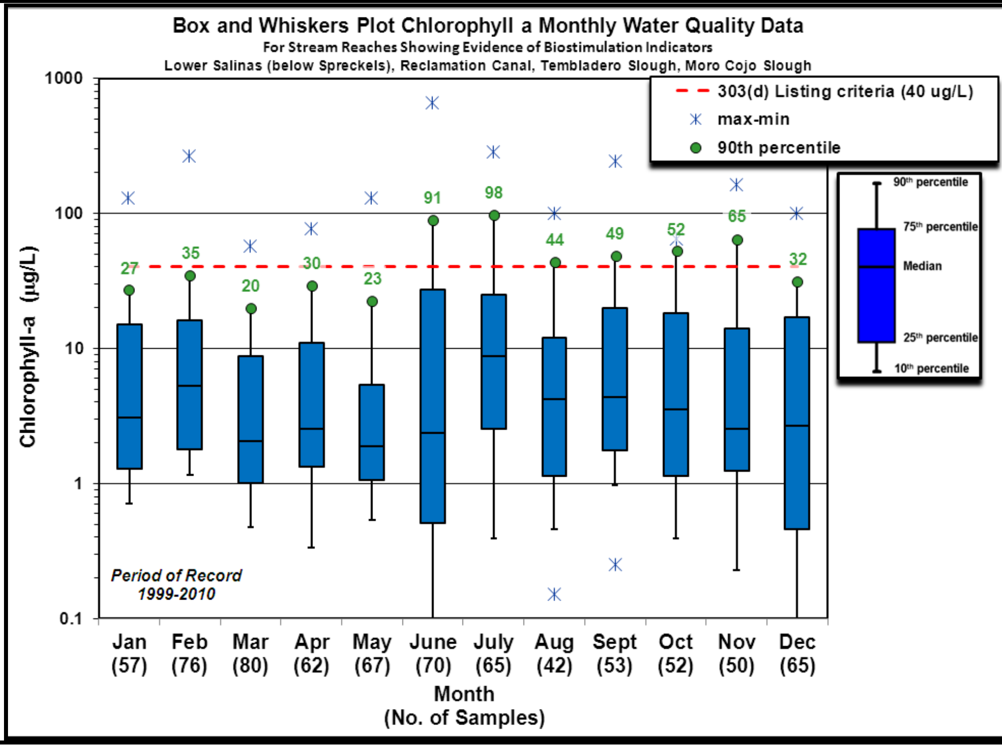
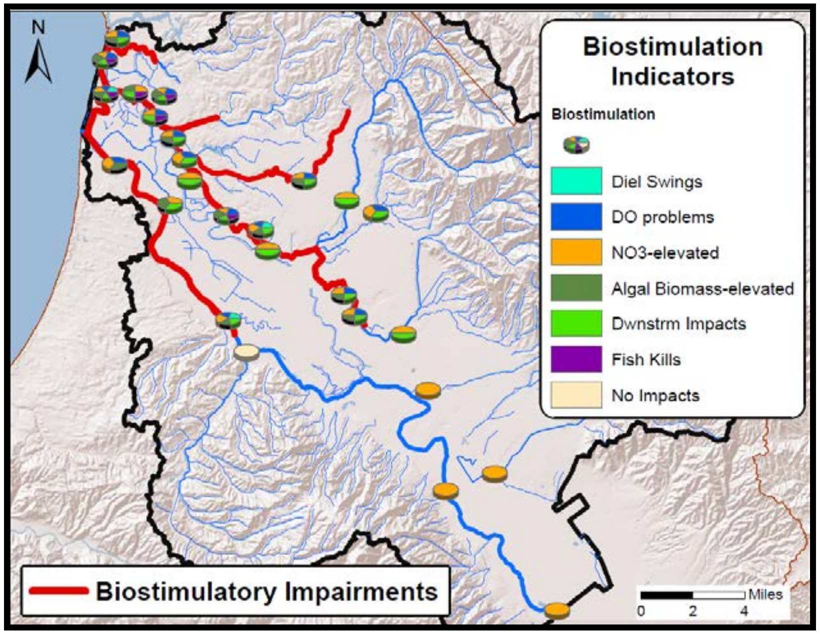


Figure 3-27. Box and whiskers plot of monthly chlorophyll *a* data from stream reaches which show evidence of biostimulation.





3.7.5 Water Quality Flow-based Trends (Mass Loads)

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 project area 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. A flow duration curve is transformed into a load duration curve by multiplying the flow by the water quality objective and a conversion factor. Flow duration record summaries developed for this project report are presented in Appendix B. The methodology for constructing load duration curves for this project report is based on the methodologies previously presented in the Central Coast Water Board's Fecal Coliform TMDL for the Lower Salinas River Watershed (2010)

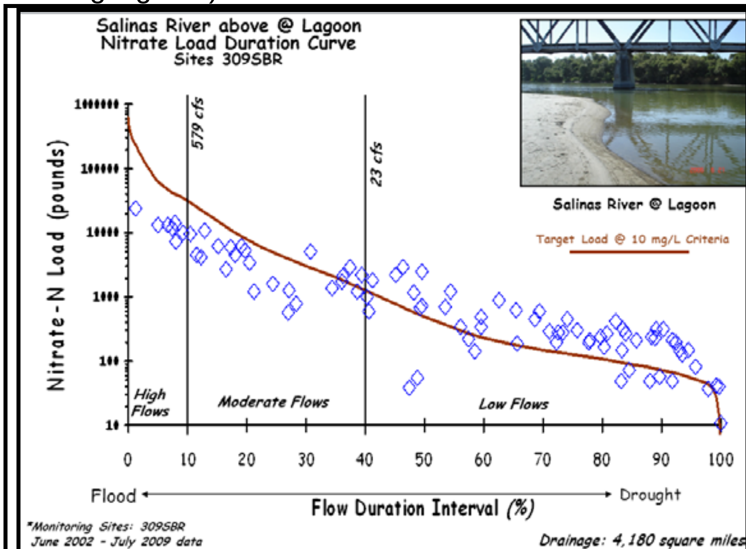
Load duration curve for representative project areas stream reaches are presented in Figure 3-28 through Figure 3-31. The target loads shown in these load duration curves are based on regulatory standards or published water quality guidelines, but do not necessarily represent the TMDLs themselves. Rather, the target loads in this context are for informational purposes, providing a uniform reference to assess pollutant loads as a function of flow. These load duration curves generally show flow-based trends illustrating that excursions of nutrients and chlorophyll a above the water quality criteria are relatively frequent across the low and moderate flow regimes. In contrast, there are few excursions above the water quality criteria in the high flow regime, with the exception of high levels orthophosphate in Tembladero Slough and the Reclamation Canal over all flow conditions, including high flows. In general, the load duration curves suggests that runoff events and precipitation events are not major drivers to nitrate water quality criteria exceedances and that elevated algal biomass, represented by chlorophyll a, are generally associated with low flow conditions. Summary observations of flow-based trends are presented in Table 3-7.

Table 3-7. Summary of flow-based trends in pollutant loads.

		Critical Flow Conditions *(The Flow Regime Exhibiting Highest Magnitude (%) of average Observed Daily Loads Exceeding the Reference Target Loads)*			
Drainage Basin	**Stream Reach**	**Nitrate** [A]	**Orthophosphate** [B]	**Chlorophyll** ***a*** [C]	**Unionized Ammonia** [D]
Lower Salinas River Watershed	Salinas River above Lagoon	**Low Flow Conditions** Strong flow-based trend	**Low Flow Conditions** Strong flow-based trend	**Low Flow Conditions** Strong flow-based trend	**No impairment**
Reclamation Canal Watershed	Tembladero Slough @ Castroville	**Low Flow Conditions** But all flow conditions are exceeding reference target loads	**High Flow Conditions** But all flow conditions are exceeding reference target loads	**Low and Moderate Flow Conditions** Exceedances are rare in high flow regime	**No impairment**
	Reclamation Canal downstream of Salinas @ San Jon Rd.	**Low and Moderate Flow Conditions** Strong flow-based trend	**Moderate Flow Conditions** But all flow conditions are exceeding reference target loads	**Moderate Flow Conditions** Exceedances also occur regularly in low flow regime	**Low Flow Conditions** Exceedances of target load during low flows are episodic and inconsistent

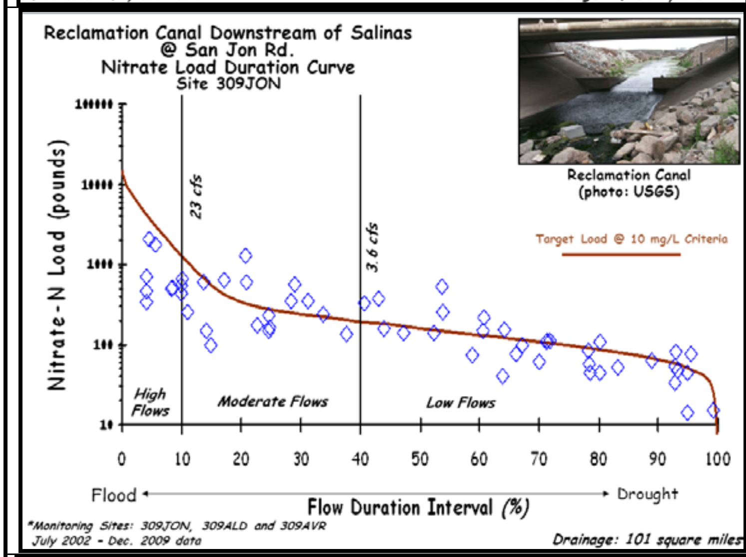
[A] Reference target load based on Basin Plan MUN standard for nitrate-N (10 mg/L)
[B] Reference target load based on State of Nevada phosphate criteria for Class B streams (0.3 mg/L as P)
[C] Reference target based on Central Coast reference condition for chlorophyll *a*, published by Worcester et al. (2010): 15 mcg/L
[D] Reference target load based on Basin Plan objective for unionized ammonia-N (0.025 mg/L)

Figure 3-28. Representative nitrate load duration curves for TMDL project area (with critical conditions highlighted).



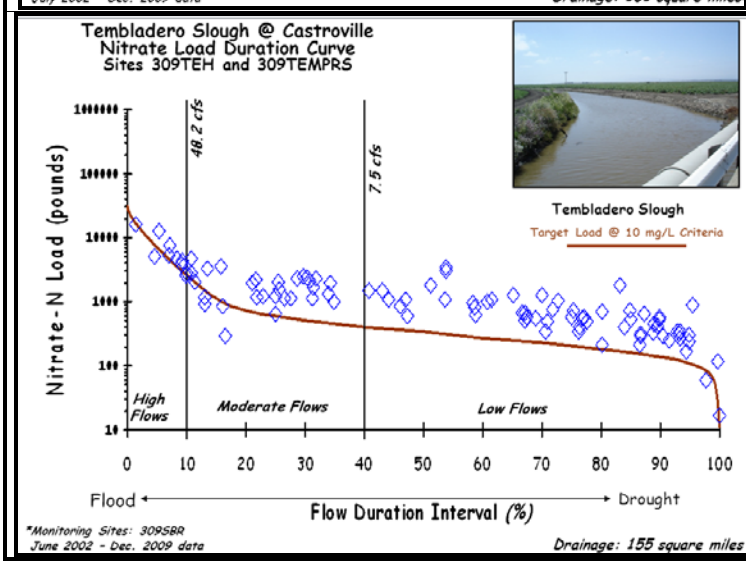
Salinas River Above Lagoon

Flow Regime	No. of Samples in Flow Regime	No. Exceeding 10 mg/L	% Exceeding 19 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	7	0	0%	13457	69,735	Mean observed load is 81% lower than mean target load.
Moderate	23	4	17%	3723	9,044	Mean observed load is 59% lower than mean target load.
Low	61	46	75%	437.8	240	Mean observed load is 45% higher than mean target load.
Estimate Average Annual Loads						
mean observed daily load (pounds)						2,270
mean annual observed load (pounds) – average daily load x 365						**828,387**
mean annual target load (pounds) at 10 mg/L criteria						**2,850,988**



Reclamation Canal downstream of Salinas @ San Jon Rd.

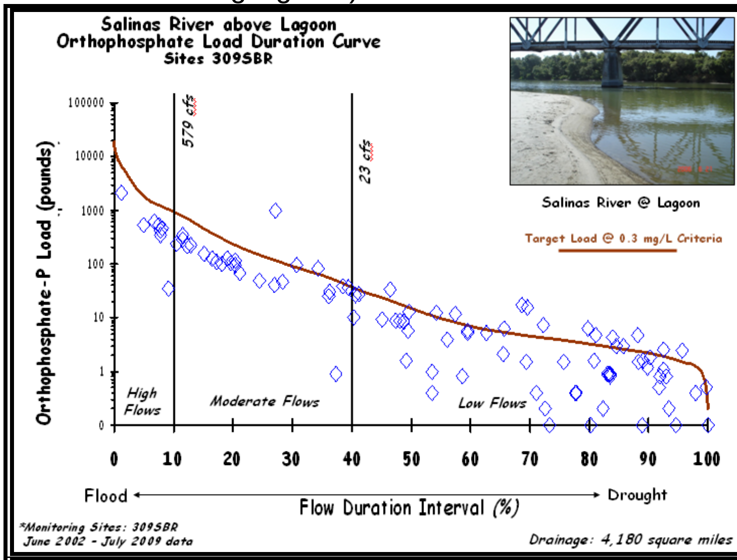
Flow Regime	No. of Samples in Flow Regime	No. Exceeding 10 mg/L	% Exceeding 19 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	9	0	0%	823	2,282	Mean observed load is 64% lower than mean target load.
Moderate	17	4	24%	392	357	Mean observed load is 8% higher than mean target load.
Low	33	13	39%	120	83	Mean observed load is 31% higher than mean target load.
Estimate Average Annual Loads						
mean observed daily load (pounds)						306
mean annual observed load (pounds) – average daily load x 365						**111,512**
mean annual target load (pounds) at 10 mg/L criteria						**181,553**



Tembladero Slough at Castroville

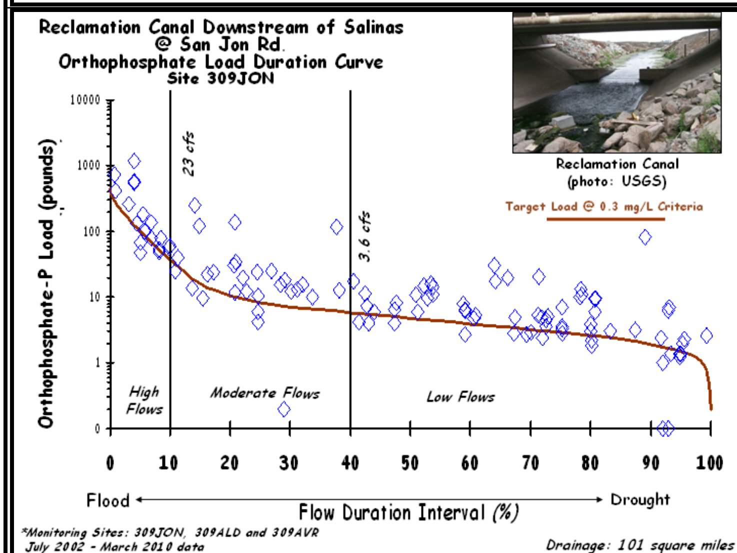
Flow Regime	No. of Samples in Flow Regime	No. Exceeding 10 mg/L	% Exceeding 19 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	10	7	70%	6,502	5,558	Mean observed load is 15% higher than mean target load.
Moderate	29	24	83%	1,812	882	Mean observed load is 51% higher than mean target load.
Low	62	61	98%	723	204	Mean observed load is 72% higher than mean target load.
Estimate Average Annual Loads						
mean observed daily load (pounds)						1,608
mean annual observed load (pounds) – average daily load x 365						**586,794**
mean annual target load (pounds) at 10 mg/L criteria						**339,094**

Figure 3-29. Representative orthophosphate load duration curves for TMDL project area (with critical conditions highlighted).



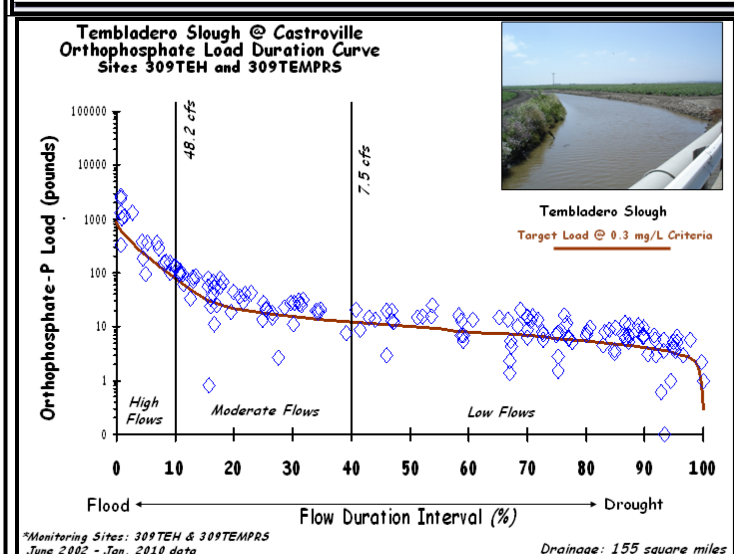
Salinas River Above Lagoon

Flow Regime	No. of Samples in Flow Regime	No. Exceeding 0.3 mg/L	% Exceeding 0.3 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	8	0	0%	632	1,979	Mean observed load is 68% lower than mean target load.
Moderate	25	3	12%	149	289	Mean observed load is 48% lower than mean target load.
Low	65	16	25%	4.6	7	Mean observed load is 34% lower than mean target load.
Estimated Average Annual Loads						
mean observed daily load (pounds)						93
mean annual observed load (pounds) – average daily load x 365						**33,803**
mean annual target load (pounds) at 0.3 mg/L criteria						**87,535**



Reclamation Canal downstream of Salinas @ San Jon Rd.

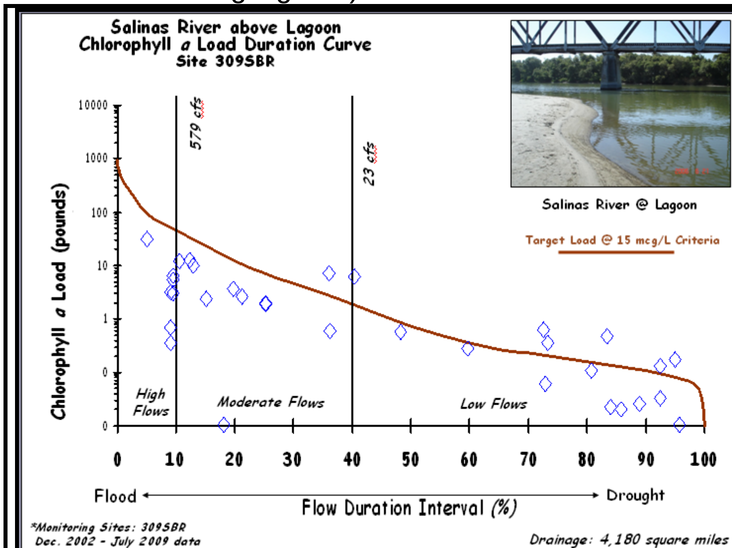
Flow Regime	No. of Samples in Flow Regime	No. Exceeding 0.3 mg/L	% Exceeding 0.3 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	19	14	74%	252	107	Mean observed load is 57% higher than mean target load.
Moderate	29	23	79%	38	12	Mean observed load is 67% higher than mean target load.
Low	67	49	73%	7.8	3	Mean observed load is 59% higher than mean target load.
Estimated Average Annual Loads						
mean observed daily load (pounds)						56
mean annual observed load (pounds) – average daily load x 365						**20,309**
mean annual target load (pounds) at 0.3 mg/L criteria						**8,295**



Tembladero Slough at Castroville

Flow Regime	No. of Samples in Flow Regime	No. Exceeding 0.3 mg/L	% Exceeding 0.3 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	**20**	**17**	**85%**	**702**	**430**	**Mean observed load is 39% higher than mean target load.**
Moderate	49	37	76%	40	28	Mean observed load is 30.2% higher than mean target load.
Low	92	70	76%	8.5	6.0	Mean observed load is 30% higher than mean target load.
Estimated Average Annual Loads						
mean observed daily load (pounds)						104
mean annual observed load (pounds) – average daily load x 365						**38,054**
mean annual target load (pounds) at 0.3 mg/L criteria						**18,632**

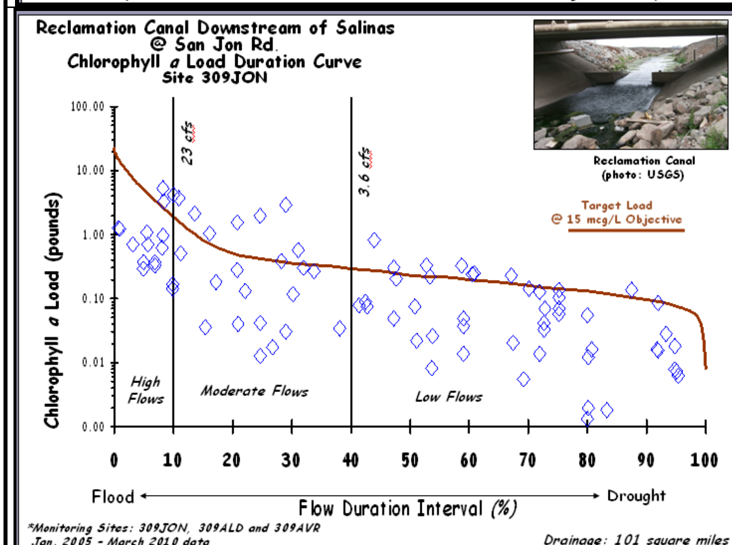
Figure 3-30. Representative chlorophyll *a* load duration curves for TMDL project area (with critical conditions highlighted).



Salinas River above Lagoon

Flow Regime	No. of Samples in Flow Regime	No. Exceeding 15 mcg/L	% Exceeding 15 mcg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	7	0	0%	7.3	57.5	Mean observed load is 87% lower than mean target load.
Moderate	12	1	8%	4.7	16.2	Mean observed load is 71% lower than mean target load.
Low	18	7	39%	0.5	0.3	Mean observed load is 46% higher than mean target load.

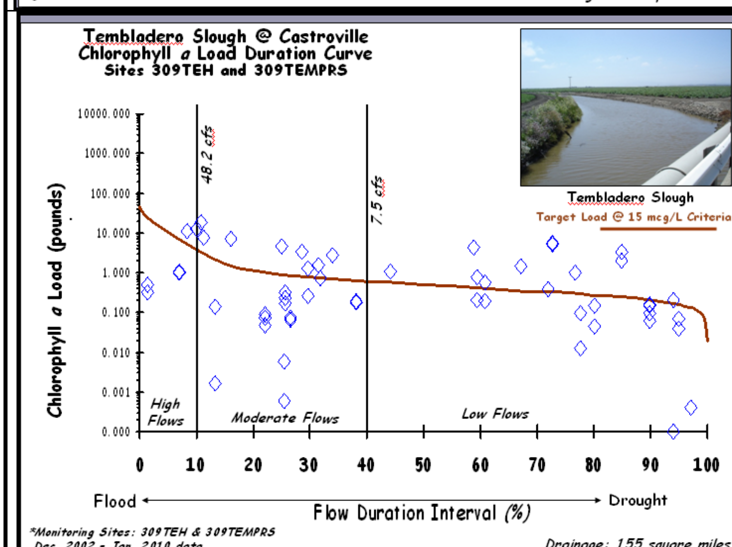
Estimated Average Annual Loads	
mean observed daily load (pounds)	3.2
mean annual observed load (pounds) – average daily load x 365	**1,154**
mean annual target load (pounds) at 15 mcg/L criteria	**5,935**



Reclamation Canal downstream of Salinas @ San Jon Rd.

Flow Regime	No. of Samples in Flow Regime	No. Exceeding 0.3 mg/L	% Exceeding 0.3 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	15	2	13%	1.12	5.15	Mean observed load is 78% lower than mean target load.
Moderate	23	9	39%	0.89	0.64	Mean observed load is 29% higher than mean target load.
Low	48	8	17%	0.10	0.17	Mean observed load is 42% lower than mean target load.

Estimated Average Annual Loads	
mean observed daily load (pounds)	0.49
mean annual observed load (pounds) – average daily load x 365	**178**
mean annual target load (pounds) at 15 mcg/L criteria	**424**

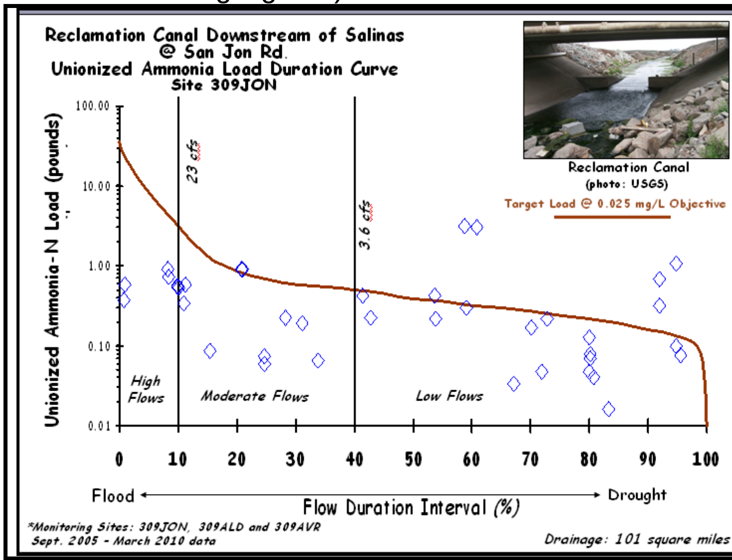


Tembladero Slough at Castroville

Flow Regime	No. of Samples in Flow Regime	No. Exceeding 15 mcg/L	% Exceeding 15 mcg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	6	2	33%	4	12	Mean observed load is 63% lower than mean target load.
Moderate	25	9	36%	2.0	1.2	Mean observed load is 40% higher than mean target load.
Low	30	15	50%	0.9	0.3	Mean observed load is 71% higher than mean target load.

Estimated Average Annual Loads	
mean observed daily load (pounds)	1.7
mean annual observed load (pounds) – average daily load x 365	**623**
mean annual target load (pounds) at 15 mcg/L criteria	**660**

Figure 3-31. Representative unionized ammonia load duration curve for TMDL project area (with critical condition highlighted).



Reclamation Canal downstream of Salinas @ San Jon Rd.

Flow Regime	No. of Samples in Flow Regime	No. Exceeding 0.025 mg/L	% Exceeding 0.025 mg/L	Mean Observed Daily Load (pounds)	Mean Target Daily Load (pounds)	Percent Difference
High	6	0	0%	0.61	10.52	Mean observed load is 94% lower than mean target load.
Moderate	12	2	17%	0.33	1.27	Mean observed load is 74% lower than mean target load.
Low	22	6	27%	0.50	0.26	Mean observed load is 48% higher than mean target load.
Estimated Average Annual Loads						
mean observed daily load (pounds)						0.47
mean annual observed load (pounds) – average daily load x 365						**170**
mean annual target load (pounds) at 0.025 mcg/L criteria						**767**

3.7.1 Water Quality Concentration – Flow Trends

Load duration curves presented in Section 3.7.5 are a convenient way of looking at pollutant mass-based loads as a function of flow. Staff also assessed variation in average water column nitrate concentrations as a function of flow. Daily flow records used in this assessment for representative monitoring sites come from the USGS gage 11152650, or are estimated from flow records available from upstream USGS stream gages. The summary trend assessment is presented in Table 3-8. Scatter plots of estimated flows versus nitrate concentrations are illustrated in Figure 3-32. A graphical bar chart summary of the data from Table 3-8 is presented in Figure 3-33.

Table 3-8. Trend assessment of paired flow-concentration events for representative monitoring sites.

Site-Waterbody	No. of Paired Flow-Concentration Data Events	Flow Exceedance[A] Percentile Range	Flow Range (cfs)	Flow Regime	Ave. Nitrate-N Concentration (mg/L) in Flow Range
309ALD-Reclamation Canal	59	90% to 100%	0 to 1.2	Very Low	9.1
		50% to 90%	1.3 to 2.9	Moderate-Low	10.5
		20% to 50%	3.0 to 6.3	Moderate	13.9
		0.1% to 20%	> 6.3	High	4.2
309TEH-Tembladero Slough	101	90% to 100%	0 to 2.5	Very Low	27.6
		50% to 90%	2.5 to 6.3	Moderate-Low	36.3
		20% to 50%	6.3 to 13.6	Moderate	30.1
		0.1% to 20%	>13.6	High	12.8
309SBR-Salinas River above lagoon	91	90% to 100%	0 to 1.3	Very Low	18.1
		50% to 90%	1.3 to 9.2	Moderate-Low	21.4
		20% to 50%	9.2 to 146.7	Moderate	12.6
		0.1% to 20%	>146.7	High	3.4

[A] Flow exceedance percentile is a measure of the probability that a certain flow will be exceeded; e.g., the 90th percentile flow is exceeded 90 percent of the time over the period of record.

Yellow cells = flow regime with highest average nitrate concentration

Figure 3-32. Time series combinations charts, and scatter plots for estimated flow versus observed nitrate concentrations at three representative monitoring sites.

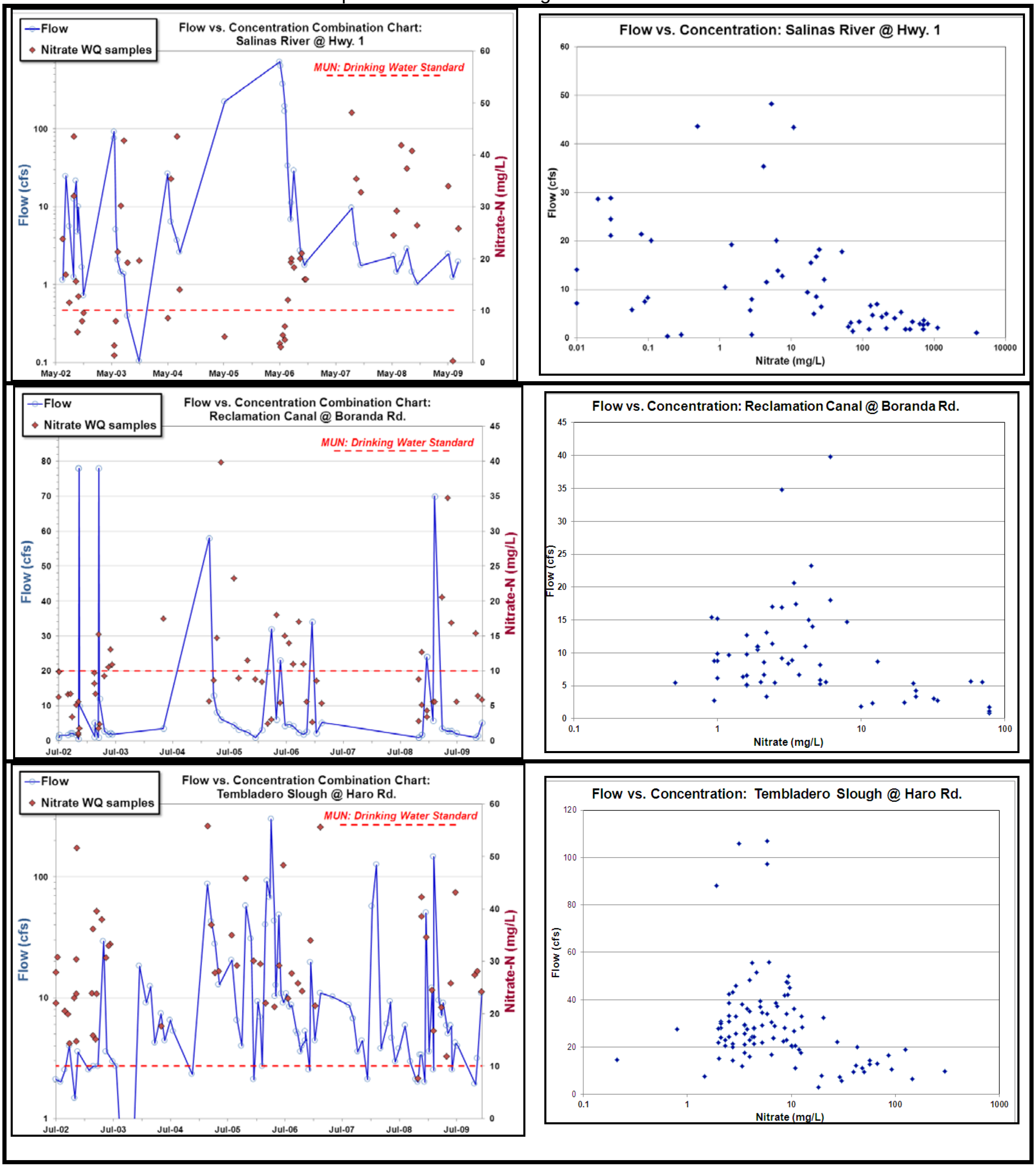
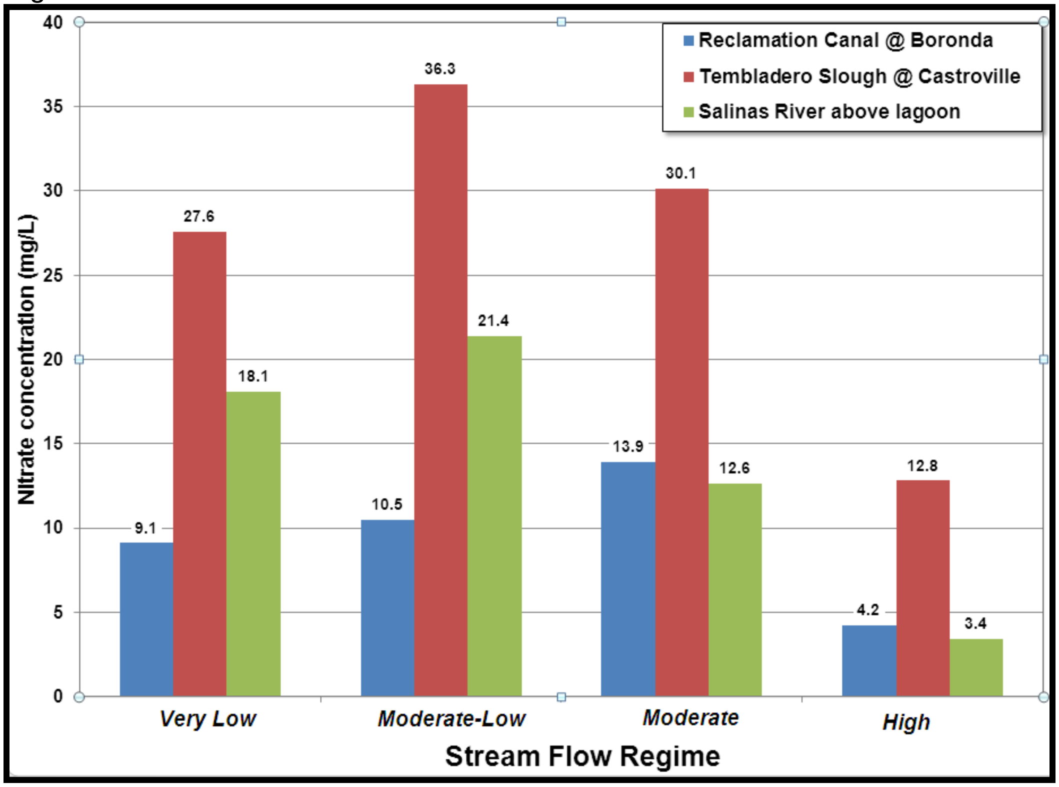


Figure 3-33. Average nitrate concentrations observed in various stream flow exceedance percentile regimes.



These data indicate that the highest nitrate concentrations, on average, for these monitoring locations are found in the moderately-low to moderate flow regimes (50th to 90th percentile flow exceedance probability). As expected from information previously presented in Section 3.7.5, high flows (0 to 20th percentile flow exceedance probability) provide diluting capacity which typically results in lower nitrate concentrations.

Also, the very low flow regime (90th to 100th percentile flow exceedance probability) exhibit nitrate concentrations that are (on average) marginally lower than concentrations found in the moderate to moderately-low flow regimes. Staff hypothesizes that the very low flow regime may represent conditions when there is less tailwater and return flows discharging to these stream reaches, and thus natural groundwater seepage and baseflow begins to make up a larger fraction of the stream flow. Since shallow groundwater nitrate concentrations would generally be expected to be lower on average than in tailwater and leachate, groundwater seepage may have a marginal diluting effect on the stream at the 90th to 100th flow exceedance percentile-very low flow regime. An alternative hypothesis is that these lower nitrate concentrations in the very low flow regime may be a result of denitrification or algae uptake.

3.7.2 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 (SWRCB, 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 the late-night 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.

Figure 3-34 illustrated diel data from a reference site showing no impacts from biostimulation. The diel variation in DO and pH is very subdued with DO concentrations only ranging over a magnitude of about 1 mg/L. In contrast, Figure 3-35 illustrates wide swings in DO and pH for monitoring site 309DAV during the diel period of August 30-31, 2006. The nature of the DO and pH swings is consistent with excessive algal biomass aquatic plants in these stream reaches.

Figure 3-34. Diel data reference site: Salinas River at King City.

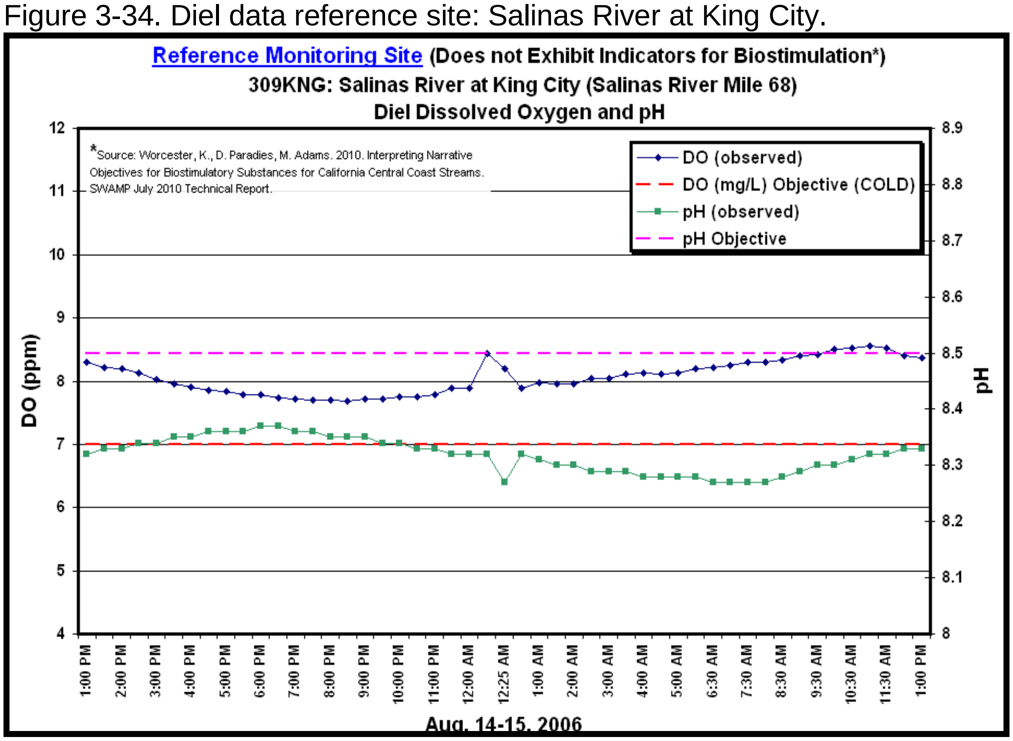
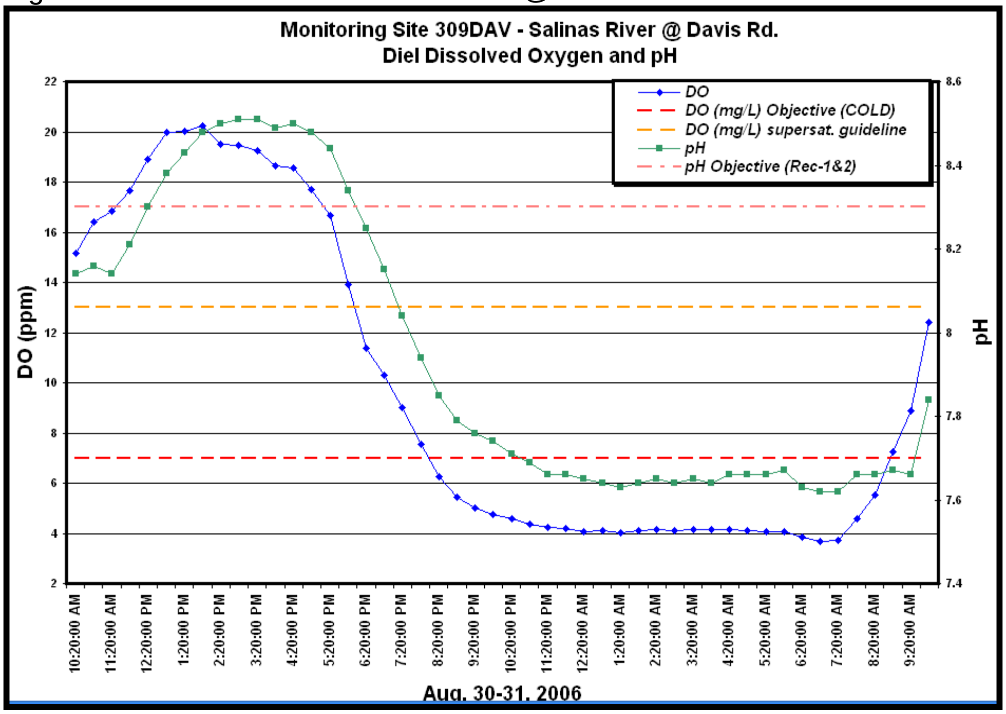


Figure 3-35. Diel Data for Salinas River @ Davis Road.



It is important to note however, the limited diel data available for the project area do not always indicate wide swings in DO and pH. As such, there are evidently temporal and spatial variations in DO and pH swings in the project area. Appendix C contains the remainder of the diel data for the project area.

3.7.3 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[70]. Due to biostimulation of surface waters in the TMDL project area, 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^{o} C range and pH in the 6 to 9 range, with most blooms occurring in late summer and early fall (WHO, 2003). Scientists conductin research at Pinto Lake (located north of the TMDL project area, in Santa Cruz county) report that microcystins are significantly correlated to chlorphyll 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 1.3. 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[71] (OEHHA, 2012).

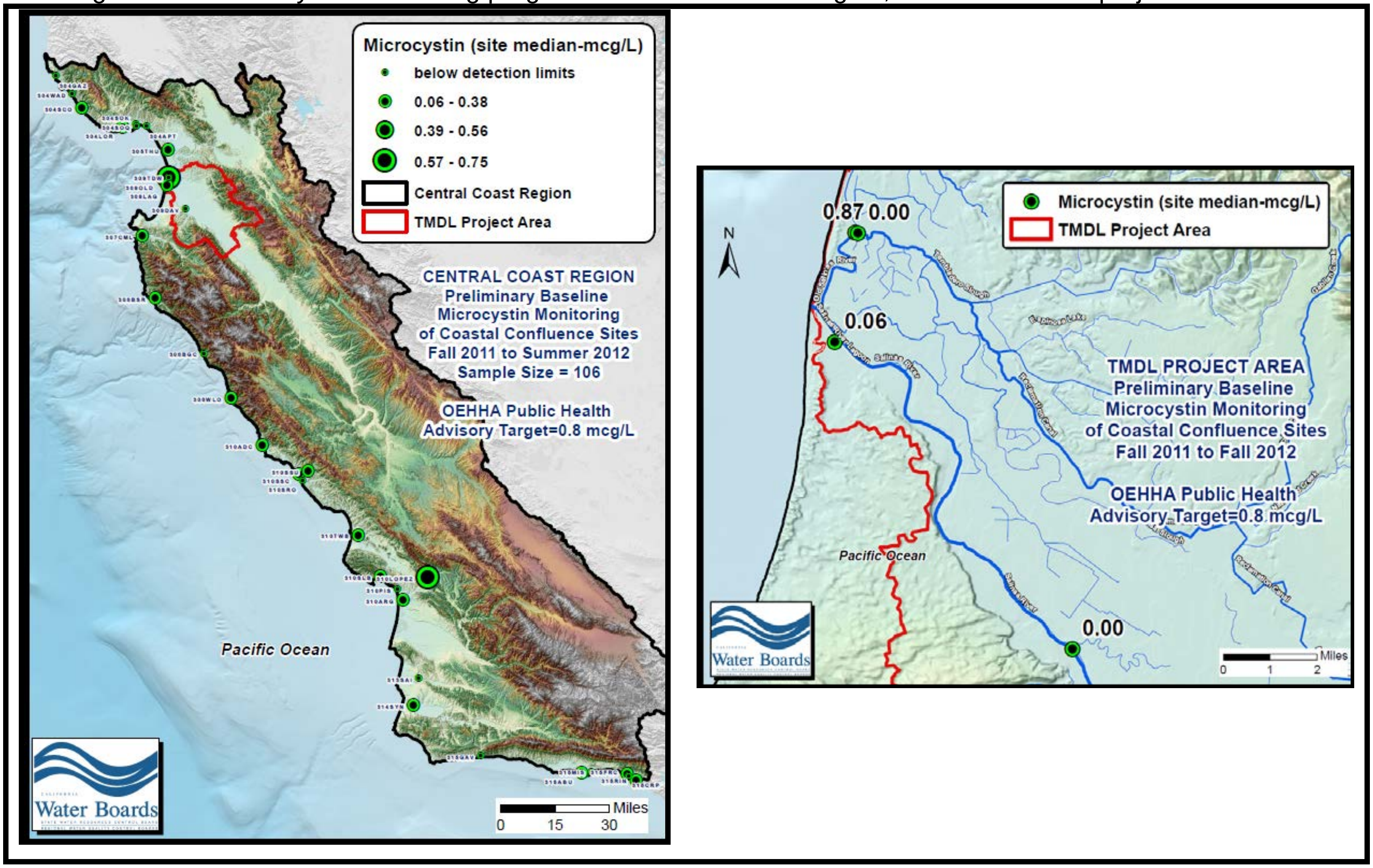
The Water Board contracted with the University of California-Santa Cruz to initiate a microcystin sampling program in 2011. The goal of the contract was to begin collection of regional baseline data at coastal confluence sites. Figure 3-36 illustrates the location of microcystin monitoring sites that were

[70] U.S. Environmental Protection Agency. Drinking Water Treatability Database. Online linkage: http://iaspub.epa.gov/tdb/pages/contaminant/contaminantOverview.do?contaminantId=-1336577584

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

sampled in Sept-July 2012 in the central coast region, and at higher map resolution in the TMDL project area.

Figure 3-36. Microcystin monitoring program sites central coast region, and in the TMDL project area.



Initial results available to staff (consisting of 106 samples) are incorporated into this project 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. Also, 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 3-9.

Table 3-9. Central Coast microcystin summary statistics (μg/L) from UC Santa Cruz dataset.

No. of Samples	Temporal Representation	Min	25th percentile	Median	Arithmetic Mean	75th percentile	Max
108	Sept. 2011-Oct. 2012	N.D.	N.D.	N.D.	0.12	0.11	1.92

N.D. = below detection limits

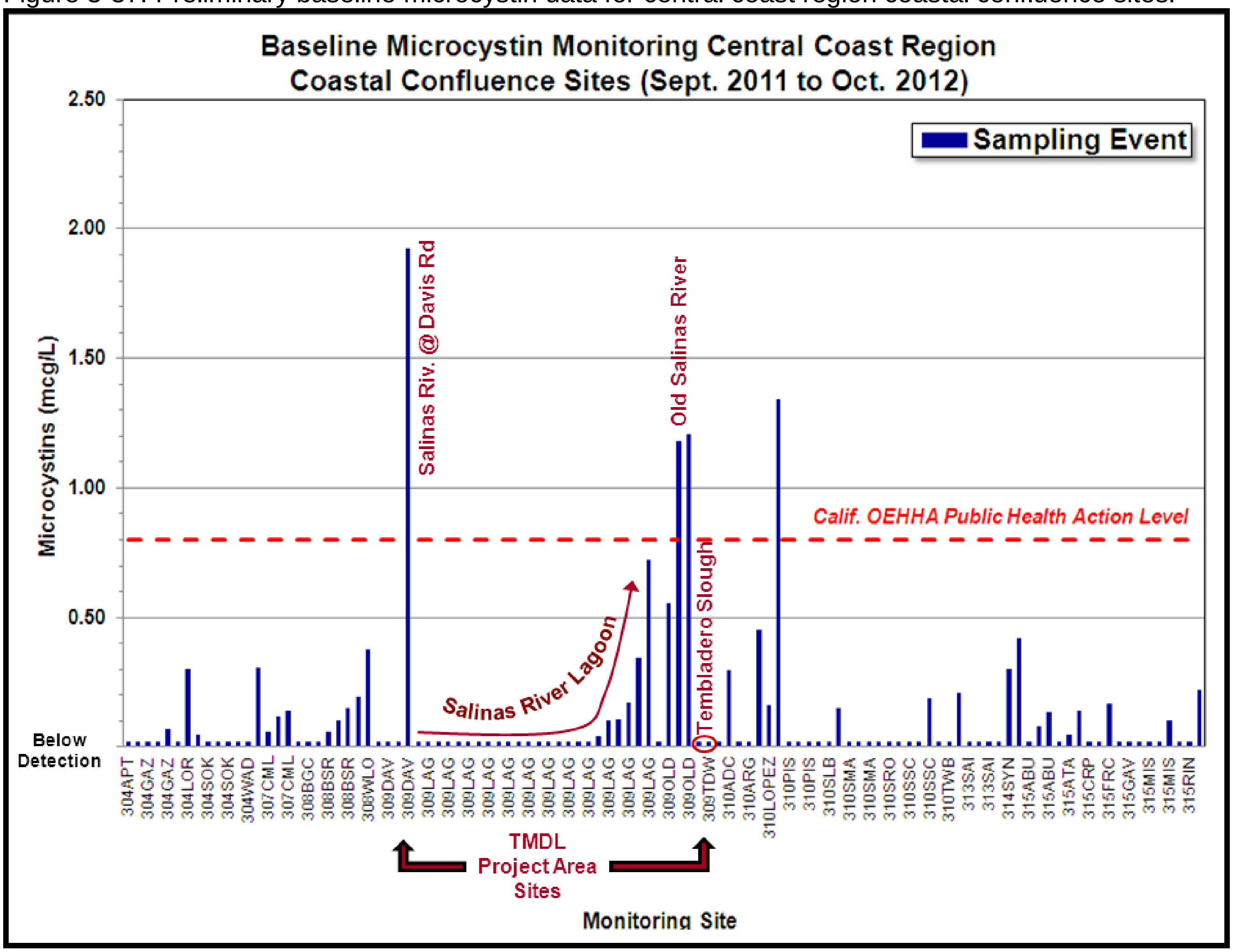
Noteworthy is the fact that the Old Salinas River at Monterey Dunes and the Salinas River at Davis Road had the highest concentrations of microcystins found in the entire central coast region at monitored coastal confluence stream sites[72] (see Figure 3-37). Two out of four samples from the Old Salinas River (OSR) exceeded the California OEHAA recommended public health action-level (0.8

[72] One lake site was sampled in the Central Coast region (Lopez Lake in San Luis Obispo county – site 310 LOPEZ) also had elevated microcystin concentrations.

μg/L) for recreational uses[73]; the average for three samples from the OSR is 1.18 μg/L One out fo four samples from the Salinas River at Davis Road exceeded the California OEHAA recommended public health action-level (0.8 μg/L) for recreational uses; the Salinas River exceedance is the highest concentration (1.92 mg/L) observed at monitored coastal confluence streams in the central coast region.

On average, samples collected from the Salinas River Lagoon had elevated microcystin levels in comparison to regional ambient conditions for coastal confluence sites; however there were no excedances of the OEHAA public health action level in the lagoon. In contrast, microcystins in Tembladero Slough were not detected in either of the two samples collected from monitoring site 309TDW. It should be noted that the scientists collecting this data reported that microcystin data collected statewide in 2011 were unusually low (personal communication, Dr. Raphael Kudela, Univ. of California-Santa Cruz, Oct. 4, 2011), so the potential for higher observed concentrations of microcystins in TMDL project area waterbodies is possible in future sampling events. Summary statistics for microcystins in TMDL project area monitoring sites are presented in Section 3.7.6.2, Table 3-20.

Figure 3-37. Preliminary baseline microcystin data for central coast region coastal confluence sites.



[73] The microcystin data is reported as naograms per gram of resin. These results can be converted to a water column-equivalent concentration by dividing the reported results by ten (personal communication, Dr. Raphael Kudela, Professor of Ocean Sciences, University of California-Santa Cruz, April 24, 2012)

Collectively, limited available data indicate that cyanotoxins (microcystins) resulting from biostimulation and algal blooms in the TMDL project area can locally be present and are locally elevated above ambient conditions (i.e., Old Salinas River, Lower Salinas River, Salinas River Lagoon). However, at this time the spatially and temporally-limited microcystin data available to staff only indicate impairments of water quality objectives and beneficial uses for the Old Salinas River on the basis of the listing criteria and methodologies identified in the California 303(d) Listing Policy.

3.7.4 MS4 Storm Drain Outfall Data

Impaired waterbodies listed for impairment pursuant to CWA Section 303(d) are listed on the basis of receiving waters. However, storm drain outfall data are useful to provide insight to urban runoff and concentrations of effluent discharging to receiving waters. Storm drain data are available from both CCAMP and the City of Salinas, and are tabulated in Table 3-11 through Table 3-12. Locations of storm drain outfalls and spatial distribution of average pollutant concentrations in effluent is presented in
Figure 3-38. Photo documentation of outfalls is presented in Figure 3-39. The water quality dataset suggests that nitrate and unionzed ammonia excedances of water quality numeric criteria in effluent are localized, but not pervasive to all the monitored storm drains. In contrast, orthophosphate in effluent routinely exceeds numeric criteria in all the monitored outfalls.

It should be noted that the City of Salinas' stormwater outfall on the Salinas River (site ID 309SDR) is conveyed from a pump stations through a pipe approximately one mile in length and passes beneath agricultural lands. City staff have reportedly detected groundwater intrusion into the pipe at several locations through video inspection of the pipe. It is likely that groundwater entering the pipe as it passes through agricultural land is contaminated with nutrients associated with agriculture[74]. The stormwater pump stations, discharge pipe, and outfall on the Salinas River are part of the City's MS4 because they are owned and operated by the City, who is responsible for discharges from its MS4 to receiving waters (refer to footnote 74).

[74] See: Fact Sheet/Rationale Technical Report for Order No. R3-2012-0005 NPDES Permit No. CA0049981, Waste Discharge Requirements for City of Salinas Municipal Storm Water Discharges.

Table 3-10. Storm drain outfall summary statistics for nitrate as N (units = mg/L).

Receiving Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 8 mg/L	% Exceeding 8 mg/L	No. Exceeding 6.4 mg/L	% Exceeding 6.4 mg/L	No. Exceeding 1.4 mg/L	% Exceeding 1.4 mg/L
Reclamation Canal	309AXX	18	1/3/2000	2/14/2007	0.61	10.10	12.48	27.00	12	67%	13	72%	-	-
Salinas River	309SDR	24	2/1/1999	2/14/2007	0.56	41.24	34.71	63.00	19	79%	-	-	21	88%
Reclamation Canal northeast	309U07	7	11/26/2006	1/19/2010	0.27	0.53	1.45	4.90	0	0%	0	0%	-	-
Salinas River	309U19	7	11/26/2006	1/19/2010	0.25	0.45	0.84	2.90	0	0%	-	-	1	14%
Reclamation Canal northeast	309U32	7	11/26/2006	1/19/2010	0.51	2.40	2.40	4.90	0	0%	0	0%	-	-
Reclamation Canal southwest	309U52	7	11/26/2006	40197.00	0.28	0.71	0.65	1.00	0	0%	0	0%	-	-

The exceedance frequencies in this table are based on seasonal biostimulatory numeric targets for nitrate-N (see Section 4.3).

Table 3-11. Storm drain outfall summary statistics for orthophosphate as P (units = mg/L).

Receiving Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.3 mg/L	% Exceeding 0.3 mg/L	No. Exceeding 0.13 mg/L	% Exceeding 0.13 mg/L	No. Exceeding 0.07 mg/L	% Exceeding 0.07 mg/L
Reclamation Canal	309AXX	18	1/3/2000	2/14/2007	0.15	0.30	0.49	1.56	7	39%	18	100%	-	-
Salinas River	309SDR	24	2/1/1999	2/14/2007	0.11	0.41	0.39	0.63	22	92%	-	-	24	100%
Reclamation Canal northeast	309U07	21	9/26/2006	1/19/2010	0.09	0.36	0.44	1.50	12	57%	19	90%	-	-
Salinas River	309U19	24	26/9/2006	28/7/2010	0.12	0.67	0.67	2.00	20	83%	-	-	24	100%
Reclamation Canal northeast	309U32	23	9/26/2006	0.900	0.02	0.20	0.28	0.28	8	35%	15	65%	-	-
Reclamation Canal southwest	309U52	8	9/26/2006	1/19/2010	0.11	0.24	0.29	0.83	2	25%	5	63%	-	-

The exceedance frequencies in this table are based on seasonal biostimulatoyr numeric targets for orthophosphate-P (see Section 4.3).

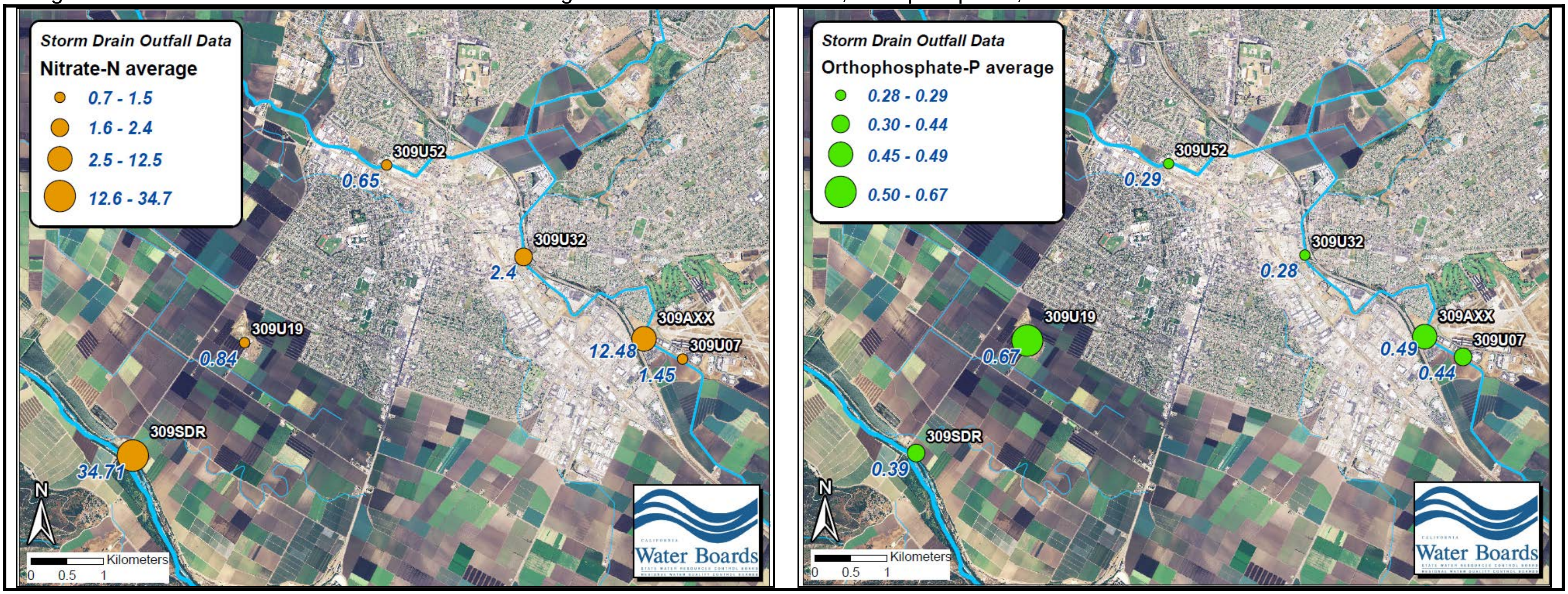
Table 3-12. Storm drain outfall summary statistics for unionzed ammonia as N (units = mg/L).

Receiving Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.025 mg/L	% Exceeding 0.025 mg/L
Reclamation Canal	309AXX	14	1/24/2006	2/14/2007	0.0042	0.0135	0.0255	0.1082	3	21%
Salinas River	309SDR	12	2/27/2006	2/14/2007	0.0001	0.0004	0.0006	0.0022	0	0%
Reclamation Canal northeast	309U07	16	9/26/2006	1/19/2010	0.0001	0.0035	0.0074	0.0400	1	6%
Salinas River	309U19	11	12/10/2007	6/22/2010	0.0001	0.0032	0.0096	0.0744	1	9%

Receiving Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.025 mg/L	% Exceeding 0.025 mg/L
Reclamation Canal northeast	309U32	13	5/12/2007	7/28/2010	0.0005	0.0120	0.0147	0.0500	2	15%
Reclamation Canal southwest	309U52	5	12/10/2007	10/13/2009	0.0010	0.0020	0.0028	0.0070	0	0%

The exceedance frequencies in this table are compared to the Basin Plan water quality objective for unionized ammonia = 0.025 mg/L

Figure 3-38. Storm drain outfall locations and average concentrations of nitrate, orthophosphate, and unionized ammonia.



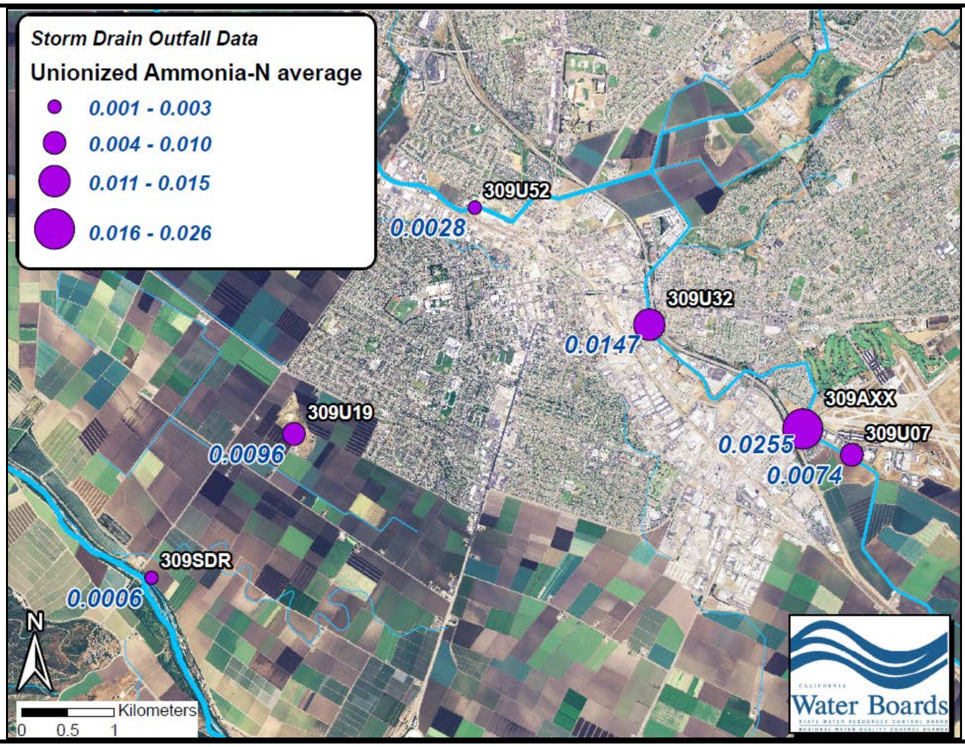
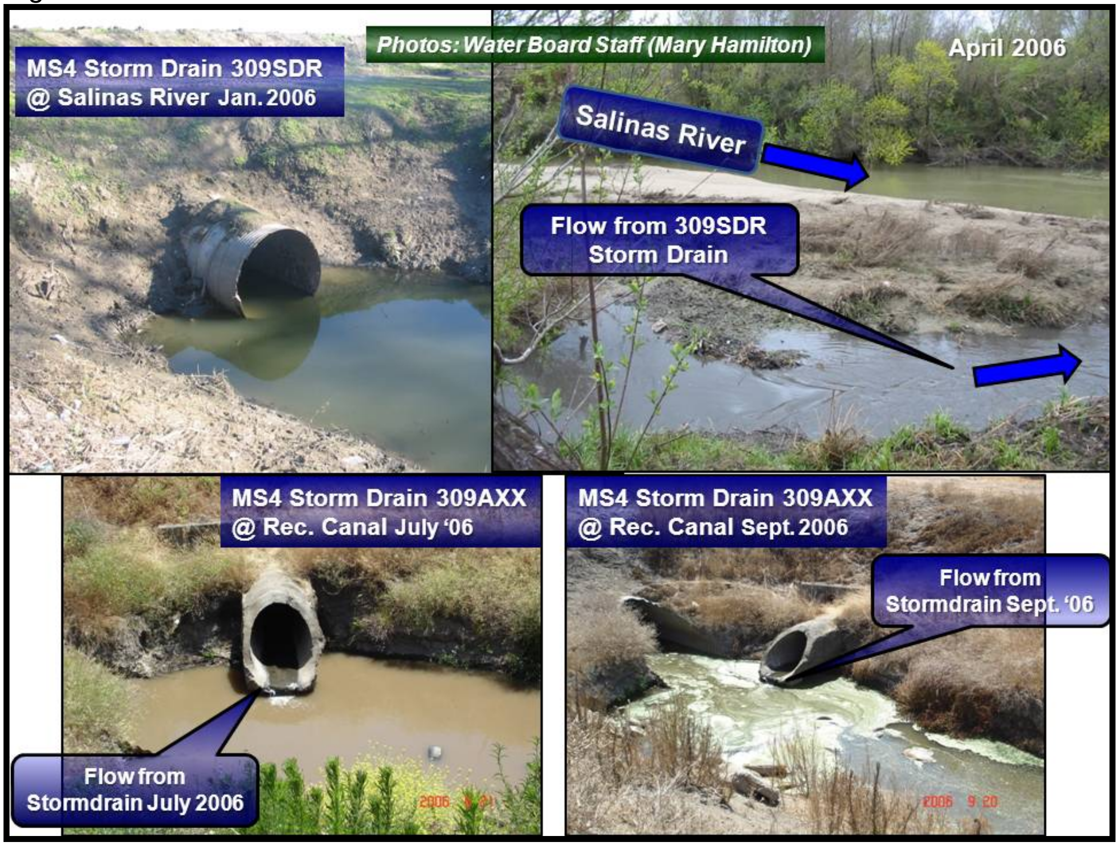

Storm Drain Outfall Data
Unionized Ammonia-N average
0.001 - 0.003
0.004 - 0.010
0.011 - 0.015
0.016 - 0.026
309U52
0.0028
309U32
0.0147
309AXX
309U07
0.0255
0.0074
309U19
0.0096
309SDR
0.0006
N
Kilometers
0 0.5 1
Water Boards

Figure 3-39. Photo documentation of MS4 storm drain outfalls.



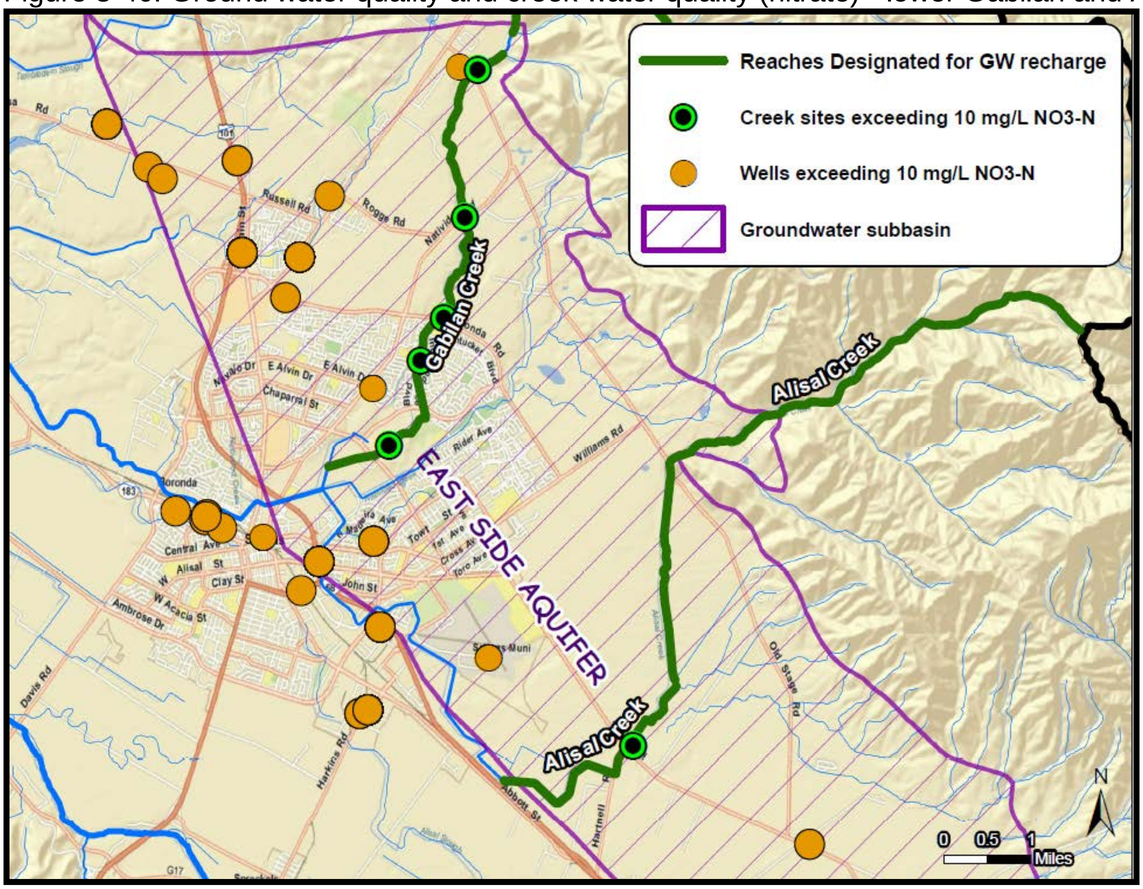
3.7.5 Data Assessment of Potential for GWR Impairments

The groundwater recharge (GWR) beneficial use is recognition 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. Most surface waters and ground waters of the central coast region are both designated with the MUN beneficial use. The MUN nitrate water quality objective (10 mg/L) therefore applies to *both* the creek water, and to the underlying groundwater. This numeric water quality objective and the MUN designation of underlying groundwater is relevant to the extent that portions project area streams recharge the underlying groundwater resource. 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 (SWRCB, 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 project area include: 1) Salinas River upstream of USGS gage at Spreckels; 2) Moro Cojo Slough; 3) Gabilan Creek; and 4) Alisal Creek. Surface waters of the Moro Cojo Slough, and the Salinas River upstream of Spreckels are not currently impaired on the basis of the MUN nitrate objective of 10 mg/L nitrate-N (refer to Table 3-13); therefore these stream reaches are supporting GWR with respect to nitrate, and thus supporting MUN of the underlying groundwater resources.

However, Gabilan Creek and Alisal Creek are designated for groundwater recharge (GWR) beneficial uses and both the creek waters and local groundwater frequently exceed the drinking water MUN objective of 10 mg/L nitrate-N (see Figure 3-40). These two creeks overlie the East Side groundwater subbasin. MWRCA (2006) reports that the East Side aquifer is typically recharged by streams (which include Gabilan Creek and Alisal Creek) draining the Gabilan Range during wet years; therefore stream infiltration can locally be an is an important hydrologic process pertaining to the supply and maintenance of local groundwater resources.

Figure 3-40. Ground water quality and creek water quality (nitrate) - lower Gabilan and Alisal creeks.

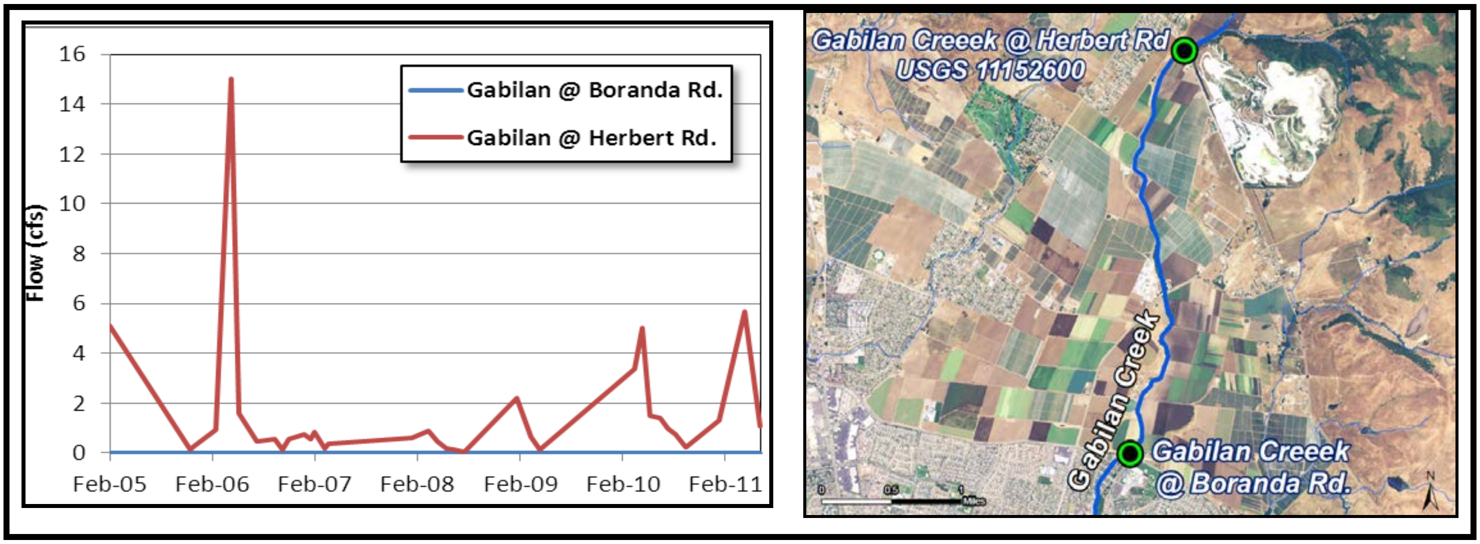


Stream infiltration[75] and groundwater recharge is unequivocally demonstrated by observations of flow loss in lower Gabilan Creek between Herbert Road and Boranda Road (located 3.2 creek miles downstream from Herbert Road) – see Figure 3-41. During sampling events when there is zero flow at the Boranda Road monitoring site, and when there is measurable flow on the same day at the upstream USGS gage near Herbert Road, average flow loss between the sites is about 1.6 cfs, and flow loses of up to 4 to 5 cfs are observed over the period of record. One daily observation in 2006 indicated a flow loss of 15 cfs between the two locations. According to eWRIMS[76] data, there are no point of diversion water rights on Gabilan Creek between Herbert Road and Boranda Road; therefore the flow differences between the two creek locations are presumed to be the net amount of surface water that percolates to the aquifer. These data show that locally, lower Gabilan Creek is a losing stream. Assuming the aforementioned average flow-loss of 1.6 cfs is representative of a long-term average, this represents 1,158 acre-feet of recharge on average annually within this three-mile reach

[75] Stream infiltration is the volume of water that percolates through a streambed into the aquifer.
[76] eWRIMS = Electronic Water Rights Information Management System (State Water Resources Control Board)

of Gabilan Creek During wet years, the magnitude of the aforementioned flow losses could conceivably result in several thousand acre-feet annually of recharge locally to groundwater just within this 3-mile reach of creek[77]. It should be reiterated, as previously noted, that groundwater recharge from Gabilan Creek and other streams overlying the Eastside Aquifer is locally important only during wet years due to the intermittent flow regimes of these streams.

Figure 3-41. Gabilan Creek stream flow loss between Herbert Rd. & Boranda Rd. on days with zero flow at Boranda Rd.



Further, as shown in Figure 3-42, SSURGO soil attributes data indicate that the lower the lower reaches of Gabilan and Alisal Creek are comprised primarily of course-grained material such as gravelly loams, sand and sandy loams. Therefore, the creek beds represent a high-permeability, and efficient conduit for groundwater recharge. Permeability is a measure of a soil or rock's ability to transmit fluid. Note that in sandy soils, water can be transmitted as rates as high as one to ten meters (3.3 feet to 33 feet) per day (refer to Figure 3-42). Locally, well logs[78] and groundwater elevation data in the vicinity of lower Gabilan and Alisal creeks suggest relatively little vertical separation between the creek beds and the water table (typically a few feet to a few tens of feet).

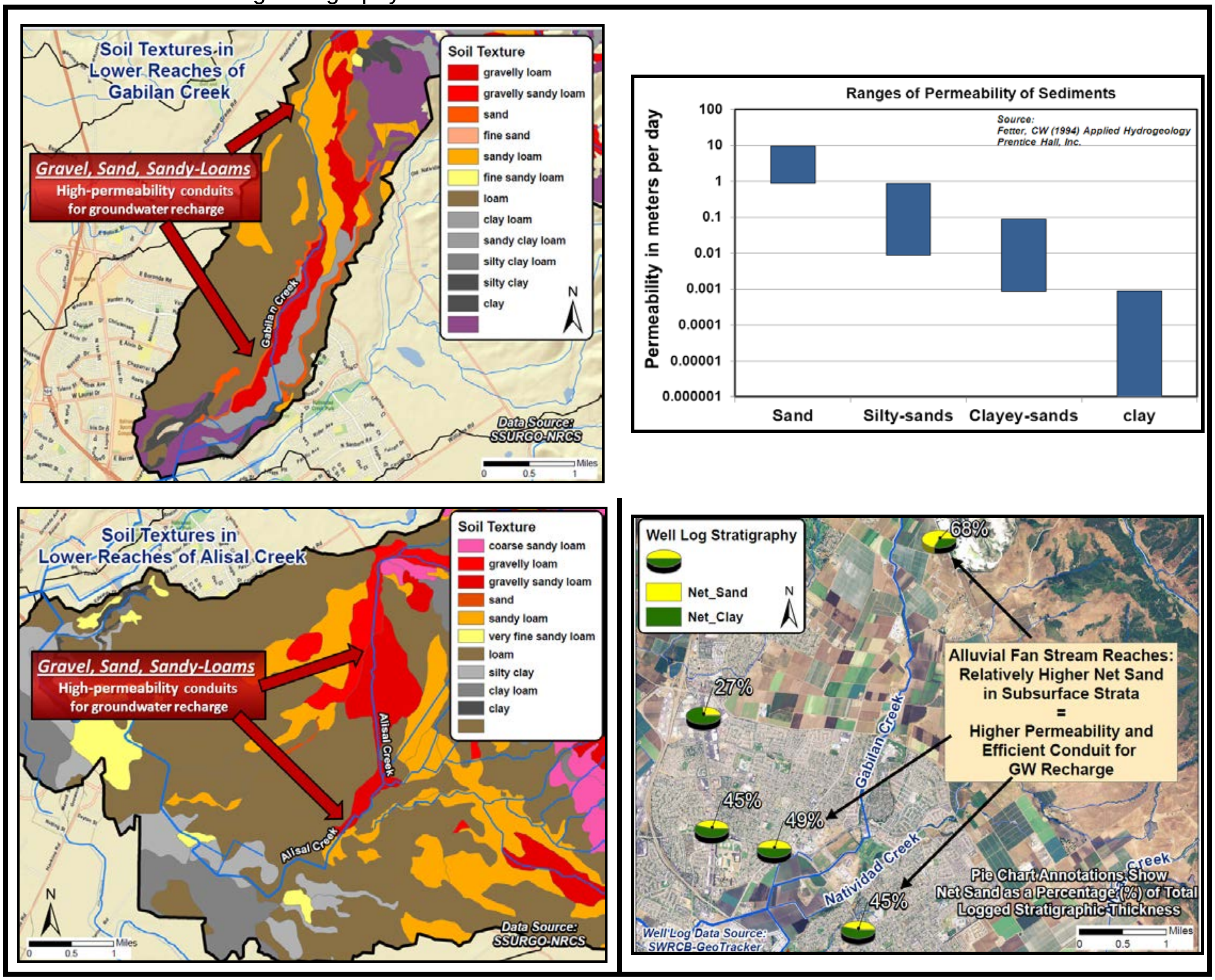
Additionally, available environmental well log stratigraphy within the alluvial fan areas of these creek reaches also generally indicate relatively high proportions of net sand relative to net clay in the shallow subsurface (<100 feet below ground surface), thus indicating favorable hydrogeologic conditions for percolation of surface waters to the saturated zone beneath (see Figure 3-42). To the extent low-permeability subsurface clay layers are present, these are characterized as discontinuous lenses and paleosols formed by the decomposition of alluvial gravels (MCWRA, 2006) and therefore do not constitute systematic and laterally-continuous hydraulic barriers to surface water infiltration on these alluvial fan stream reaches. Further underscoring that alluvial fan clay and paleosol horizons generally do not constitute laterally-continuous barriers to vertical hydraulic connectivity, researchers have reported that breaks in the subsurface lateral continuity of paleosols in alluvial fan depositional systems occur where channels incised through the paleosols resulting from the aggradation of new depositional sequences (Weissmann et al., 2002).

[77] One cubic foot per second = 724 acre-feet per year, or 2 acre-feet per day.

[78] Well logs and ground water depths are available at State Water Resourced Control Board's GAMA-Geotracker Regulator website. Due to confidentiality provisions in the California Water Code pertaining to well completion reports, staff cannot show or publish well logs evaluated for this project report.

Also noteworthy is the fact that CEC and Moss Landing Marine Laboratories (1994) report that sections of the nitrate-polluted lower Gabilan Creek and Natividad Creek may be one of the best aquifer recharge areas in the lower Salinas Valley. This reporting constitutes an independent, and additional line of evidence highlighting the importance of the groundwater recharge beneficial use in these reaches.

Figure 3-42. Lower Gabilan and Alisal creeks: soil textures, with graph of typical permeability ranges, and shallow well log stratigraphy.



Based on all of the aforementioned information, the designated groundwater recharge (GWR) beneficial uses of Gabilan Creek and Alisal Creek are not being supported for the following reasons:

- *Both the creek 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 creek are currently exceeding the drinking water standard, these groundwaters have no further assimalitive capacity to absorb nitrate polluted creek water percolating 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). While denitrification is reportedly 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 creeks in the project area.

3.7.6 Summary Water Quality Statistics

3.7.6.1 Data Representing Current Water Quality Conditions

In several previous sections of this project report, staff presented various permutations of both recent vintage and older data to provide historical context and trend patterns regarding water quality issues in the TMDL project area. However, in terms of assessing current water quality impairments and regulatory compliance with water quality objectives Staff used only data representing the most recent ten years of water quality monitoring (beginning in 1999). This is consistent with the California 303(d) listing policy which provides that unless the data are deemed not valid, all data and information should be used. The State Water Resources Control Board Listing Policy (SWRCB, 2004) provides that all data, regardless of age, can be used in 303(d) list assessments; there are no data age requirements in the Listing Policy. However, it is incumbent on the Water Boards to use their judgment to assess the appropriateness of the data. The important aspect of data is its relevance to describing plausible current conditions of the water quality segments. As such, staff excluded older data which generally have poor documentation records, and are of older vintage which presumably do not plausibly represent recent or current watershed conditions.

An additional line of evidence that supports the use of the most recent ten years of monitoring data was developed using the National Land Cover Database (NLCD) 1992/2001 Retrofit Land Cover Change product[79]. During TMDL development, the most recent NLCD dataset available to staff was the 2001-vintage NLCD Land Use/Land Cover raster, including the 1992/2001 Retrofit Land Cover Change product. Figure 3-43 and Figure 3-44 illustrate land cover change in the TMDL project area from 1992-2001. These figures show that 4.2% of land in the TMDL project area was converted to another type of land use sometime between the years 1992-2001. 4.2% does not represent a substantial or radical magnitude of change at the project area scale.

It is recognized that land use changes at the local scale can be more dramatic and result in wide variability in local conditions. However, the water quality dataset staff used collectively represented a large geographic scale (e.g., basin and watershed-scale); therefore as a practical matter it is appropriate to compare basin-scale water quality data to basin-scale land use changes. Since only

[79] The NLCD 1992/2001 retrofit land cover change product is available from the Multi-Resolution Land Characteristics Consortium (MRLC), and is a dataset that allows users to conduct change analysis between the 1992 NLCD dataset and the 2001 NLCD dataset. Online linkage: http://www.mrlc.gov/nlcdrlc.php

4.2% of land area was converted to another land use between 1992 and 2001, it is therefore presumed that land use change from 1999 to 2010 is not substantially or radically different from the magnitude of land use change observed from the 1992-2001. Therefore, using the most recent ten years of monitoring data (1999-2010) is appropriate to assess compliance with water quality standards because at the project area-scale, land use/land cover likely has not substantially and radically changed more than a few percent during the past decade.

Figure 3-43. Map of estimated land cover changes, 1992-2001.

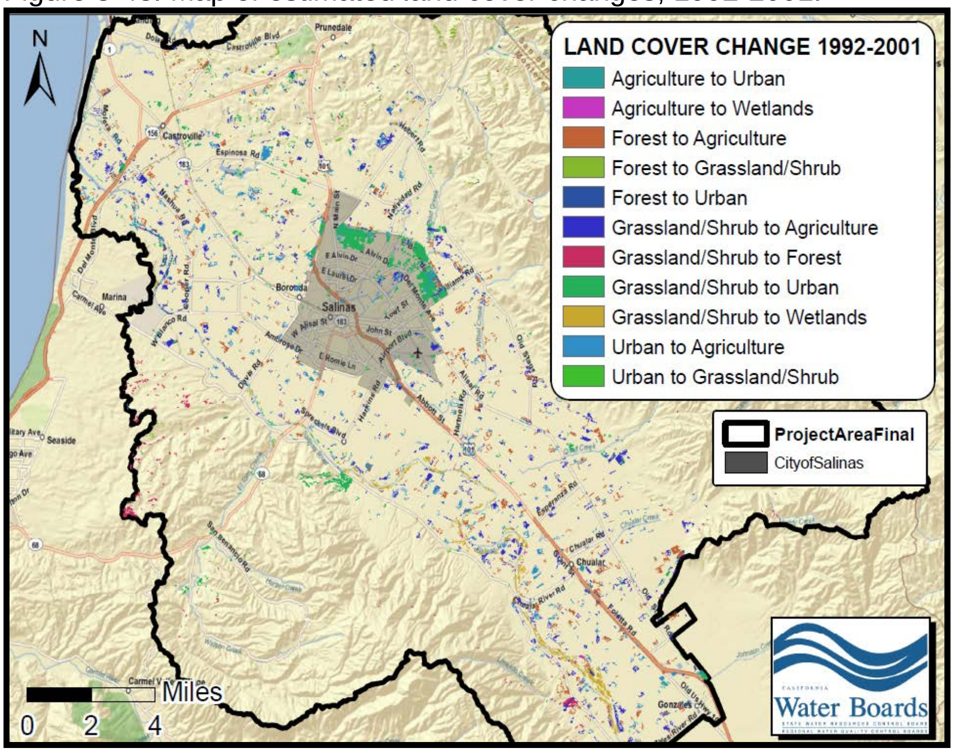
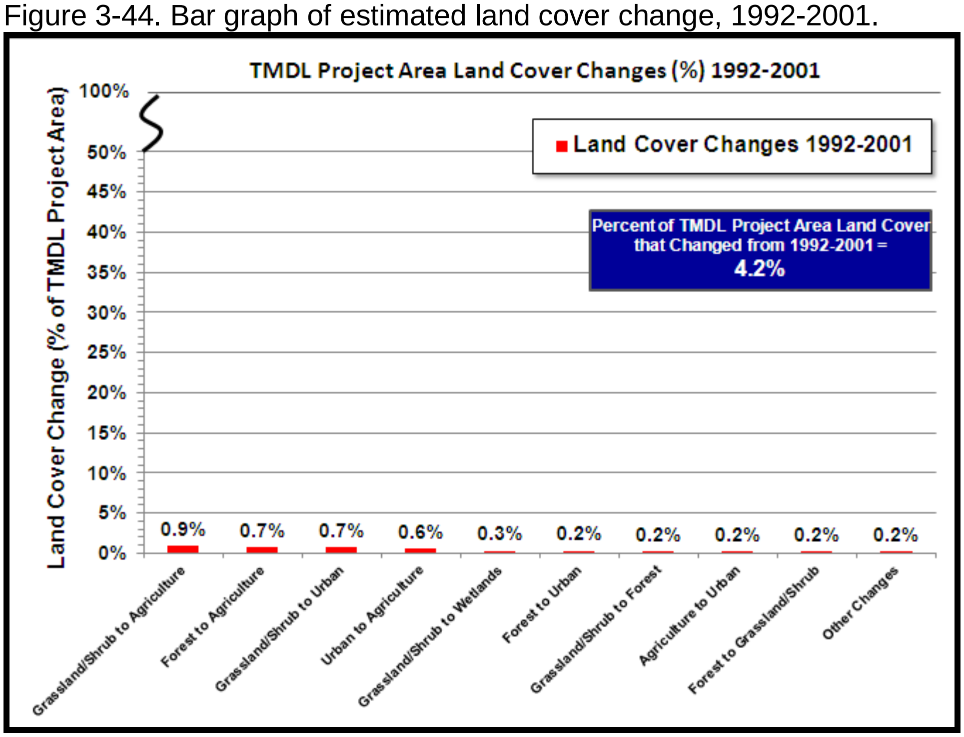


Figure 3-44. Bar graph of estimated land cover change, 1992-2001.



3.7.6.2 Statistical Summary of 1999-2010 Monitoring Data

Table 3-13 through Table 3-20 present summary statistics for the last ten years of water quality data for the TMDL project area. As noted above, these water quality data represent the suite of samples that are used in this TMDL to assess water quality status and impairment, consistent with the California 303(d) Listing Policy and the Water Quality Control Plan for the Central Coast Region.

Table 3-13. TMDL project area summary statistics for nitrate as N (units = mg/L) and exceedances of drinking water standard.

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 10 mg/L (MUN Standard)	% Exceeding 10 mg/L
Alisal Creek	All Sites (309HRT & 309UAL)	8	7/28/1999	12/17/2008	6.1	20.30	21.17	35.73	7	88%
Alisal Slough	**All Sites**	23	5/17/2003	12/9/2009	11.9	34.80	44.88	109	23	100%
	309-ALISA-32	5	5/17/2003	5/6/2006	11.9	27.30	35.58	78.3	5	100%
	309ASB	18	2/22/2005	12/9/2009	12.9	38.20	47.47	109	18	100%
Blanco Drain	**All sites**	55	11/12/2001	12/9/2009	0.0	67.80	61.76	157	52	95%
	BLA-COO	20	11/12/2001	6/9/2003	38.4	71.80	71.38	133	20	100%
	BLA-PUM	35	7/8/2002	12/9/2009	0.0	62.60	56.27	157	32	91%
Chualar Creek	**All sites**	42	3/14/2001	3/24/2009	1.9	96.50	90.50	328	36	86%
	309CRR	12	3/14/2001	3/24/2009	8.5	116.50	93.96	150	10	83%
	309NOS	5	3/17/2002	12/17/2002	20.0	57.00	124.80	328	5	100%
	CHU-CCR	3	3/14/2001	12/17/2002	2.0	6.00	20.10	52.3	1	33%
	CHU-CRR	22	3/14/2001	12/17/2002	1.9	102.50	90.42	250	20	91%
Chualar Creek (south branch)	**All sites**	15	3/14/2001	11/19/2008	8.0	95.00	84.07	185	14	93%
	309SBC	13	3/14/2001	11/19/2008	8.0	102.00	90.82	185	12	92%
	309SOS	2	10/29/2008	11/19/2008	31.1	40.25	40.25	49.4	2	100%
Esperanza Creek	All Sites (ESZ-HWY & ESZ-OSR)	3	8/22/2001	5/23/2002	42.2	45.10	65.43	109	3	100%
Espinosa Slough[A]	309ESP	22	2/22/2005	12/9/2009	1.4	26.55	33.52	103	17	77%
Gabilan Creek	**All sites**	134	2/1/1999	1/8/2007	0.02	3.00	11.81	111	41	31%
	309GAB	20	2/1/1999	1/8/2007	0.6	10.67	10.49	24	11	55%
	309-GABIL-31	4	5/17/2003	5/6/2006	17.9	25.35	24.40	29	4	100%
	GAB-CRA	39	10/11/2000	4/24/2002	0.0	2.00	2.48	8	0	0%
	GAB-NAT	5	1/25/2001	2/19/2001	13.0	17.00	18.80	27	5	100%
	GAB-HER	16	10/29/2000	4/24/2002	1.4	10.00	16.21	49	7	44%
	GAB-OSR	33	10/11/2000	2/19/2001	0.3	2.0	1.48	3	0	0%
	GAB-VET	17	1/11/2001	5/23/2002	3.0	39.00	45.69	111	14	82%
Lower Reclamation Canal[A]	**All sites**	173	2/1/1999	12/9/2009	0.02	9.90	14.91	90	83	48%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 10 mg/L (MUN Standard)	% Exceeding 10 mg/L
	309ALD	29	2/1/1999	12/9/2009	1.4	7.42	7.86	18	8	28%
	309AVR	36	10/26/2000	12/17/2008	0.0	11.50	16.03	55	20	56%
	PIP-VIC	1	1/8/2001	1/8/2001	3			3	0	0%
	309JON	83	10/11/2000	12/9/2009	0.645104	8.70	13.28	64	34	41%
	REC-183	24	36899	37438	7.0	25.50	27.90	90	21	88%
Merrit Ditch	306MER	28	5/17/2003	12/9/2009	7.9	19.00	20.98	60.8	25	89%
Moro Cojo Slough[A]	All Sites	368	2/2/1999	12/9/2009	0.0	0.72	2.08	56.402	12	3%
	306MOR	141	2/2/1999	12/9/2009	0.0	0.45	1.56	56.402	2	1%
	306MORMLN	215	02/02/99	07/07/09	0.0	0.90	2.13	14.168	8	4%
	306-MOROC-31	6	5/17/2003	5/3/2008	0.9	7.90	13.85	37	2	33%
	306-MOROC-32	6	05/17/03	05/03/08	0.1	0.16	0.36	1.48	0	0%
Moss Landing	MOS-SAN	15	11/12/2001	6/9/2003	0.02	0.20	3.43	32	1	7%
Natividad Creek	**All sites**	28	5/17/2003	12/8/2009	0.01	21.30	27.44	90.8	22	79%
	309NAD	20	5/17/2003	12/8/2009	0.01	21.30	27.44	90.8	17	85%
	NAT-FRE & NAT-LAS	8	8/1/2002	5/3/2008	3.18	10.90	12.84	34.3	5	63%
Old Salinas River	**All sites**	345	2/2/1999	7/7/2009	0.02	14.39	16.10	57	233	68%
	OLS-MON	113	2/2/1999	7/7/2009	0.23	16.50	18.68	57	84	74%
	OLS-POT	232	2/2/1999	7/7/2009	0.02	13.74	14.84	54	149	64%
Quail Creek	**All sites**	43	2/1/1999	12/8/2009	0.01	22.02	25.05	93.70	31	72%
	309QUA	21	2/1/1999	10/30/2008	0.6	17.00	19.12	93.7	12	57%
	309QUI	17	4/14/2005	12/8/2009	0.01	26.80	30.62	81.7	16	94%
	309UQA	5	11/9/1999	12/18/2008	0.02	25.10	31.00	81	3	60%
Salinas River	**All sites**	311	2/1/1999	12/8/2009	0.002	4.00	9.13	78	92	30%
	309DAV	51	2/1/1999	6/9/2003	0.3	3.00	9.32	78	12	24%
	309SAC	56	2/1/1999	12/8/2009	0.1	1.35	1.95	6.4	0	0%
	309SAG	27	1/11/2001	12/8/2009	0.2	2.00	2.28	6	0	0%
	309SBR	163	2/2/1999	7/7/2009	0.1	9.54	13.29	67	80	49%
	309SSP	14	1/10/2001	12/8/2009	0.002	1.38	1.85	7	0	0%
Santa Rita Creek	**All sites**	98	1/8/2004	5/3/2008	0.02	3.01	12.16	440	19	19%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 10 mg/L (MUN Standard)	% Exceeding 10 mg/L
	309RTA	31	2/1/1999	5/3/2008	0.02	4.90	7.93	64	6	19%
	309-SRITA-32	29	1/8/2004	5/3/2008	0.02	3.91	11.34	136	6	21%
	309-SRITA-34	20	8/26/2005	5/3/2008	0.02	6.07	11.60	440	5	25%
	309-SRITA-36	18	8/26/2005	12/9/2006	0.02	1.99	4.35	24.2	2	11%
Storm Drain @ Reclamation Canal	309AXX	18	1/3/2000	2/14/2007	0.6	10.10	12.48	27	9	50%
Storm Drain @ Salinas River	309SDR	24	2/1/1999	2/14/2007	0.6	41.24	34.71	63	17	71%
Tembladero Slough[A]	**All sites**	255	2/2/1999	12/9/2009	0.2	23.73	25.90	107	224	88%
	309TDW	102	4/26/2001	7/7/2009	5.0	25.51	27.20	84	93	91%
	309TEH	22	7/1/2002	12/9/2009	5.7	25.15	37.03	107	19	86%
	309-TEMBL-34	1		5/7/2005				2	0	0%
	309TEMPRS	130	2/2/1999	7/7/2009	0.2	22.85	23.19	55.79	112	86%
Towne Creek	TOW-OSR	21	1/8/2001	2/19/2001	2.0	3.00	2.76	4	0	0%
Towne Creek tributary (Big Oak Creek)	BOC-OSR	20	1/7/2001	2/18/2001	1.0	3.00	2.70	5	0	0%
Upper Reclamation Canal[A]	**All sites**	48	2/1/1999	12/8/2009	0.02	13.00	16.48	85.4	28	58%
	309ALG	18	2/22/2005	12/8/2009	0.02	18.35	21.90	85.4	12	67%
	309ALU	30	2/1/1999	12/8/2009	2.19	11.76	13.23	42.24	16	53%

[A] *These stream reaches are not designated for MUN in Table 2-1 of the Basin Plan.*

Table 3-14. TMDL project area summary statistics for nitrate as N (units = mg/L) and exceedances of agricultural supply water quality criterion.

Waterbody[A]	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 30 mg/L[B]	% Exceeding 30 mg/L	No. Exceeding 100 mg/L[C]	% Exceeding 100 mg/L
Alisal Creek sites	All Sites (309HRT & 309UAL)	8	7/28/1999	12/17/2008	6.1	20.3	21.2	35.7	1	12.5%	0	0%
Gabilan Creek	**All sites**	134	2/1/1999	1/8/2007	0.0	3.0	11.8	111.0	12	9.0%	2	1.5%
	309GAB	20	2/1/1999	1/8/2007	0.6	10.7	10.5	24.0	0	0%	0	0%
	309-GABIL-31	4	5/17/2003	5/6/2006	17.9	25.4	24.4	29.0	0	0%	0	0%
	GAB-CRA	39	10/11/2000	4/24/2002	0.0	2.0	2.5	8.0	0	0%	0	0%

Waterbody[A]	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 30 mg/L[B]	% Exceeding 30 mg/L	No. Exceeding 100 mg/L[C]	% Exceeding 100 mg/L
	GAB-NAT	5	1/25/2001	2/19/2001	13.0	17.0	18.8	27.0	0	0%	0	0%
	GAB-HER	16	10/29/2000	4/24/2002	1.4	10.0	16.2	49.0	3	18.8%	0	0%
	GAB-OSR	33	10/11/2000	2/19/2001	0.3	10.0	16.2	3.0	0	0%	0	0%
	GAB-VET	17	1/11/2001	5/23/2002	3.0	39.0	45.7	111.0	9	52.9%	2	11.8%
Salinas River	**All sites**	311	2/1/1999	12/8/2009	0.0	4.0	9.1	78.0	22	7.1%	0	0%
	309DAV	51	2/1/1999	6/9/2003	0.3	3.0	9.3	78.0	5	9.8%	0	0%
	309SAC	56	2/1/1999	12/8/2009	0.1	1.3	1.9	6.4	0	0%	0	0%
	309SAG	27	1/11/2001	12/8/2009	0.2	2.0	2.3	6.0	0	0%	0	0%
	309SBR	163	2/2/1999	7/7/2009	0.1	9.5	13.3	67.0	17	10.4%	0	0%
	309SSP	14	1/10/2001	12/8/2009	0.0	1.4	1.9	7.0	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-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-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 3-15. TMDL project area summary statistics for unionized ammonia as N (units = mg/L).

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.025 mg/L (toxicity standard)	% Exceeding 0.025 mg/L
Alisal Creek	309HRT	4	8/27/2008	12/17/2008	0.0011	0.015881	0.024125	0.063645	2	50%
Alisal Slough	309ASB	23	8/30/2005	3/31/2010	0.0004	0.008505	0.014223	0.063596	5	22%
Blanco Drain	BLA-PUM	21	12/12/2006	3/31/2010	0.0004	0.003278	0.016438	0.257112	1	5%
Chualar Creek	309CRR	6	5/30/2007	1/19/2010	0.0025	0.058266	0.118892	0.344601	3	50%
Chualar Creek (south branch)	**All Sites**	8	11/19/2008	0.1977977	0.0050	0.021716	0.042593	0.197798	3	38%
	309SBC	4	11/19/2008	0.1977977	0.0050	0.026568	0.063974	0.197798	2	50%
	309SOS	4	11/19/2008	0.0396374	0.0064	0.019426	0.021211	0.039637	1	25%
Espinosa Slough	309ESP	20	1/30/2007	3/31/2010	0.0003	0.003937	0.00582	0.01936	0	0%
Gabilan Creek	309GAB	10	6/28/2005	2/23/2010	0.0001	0.002137	0.002825	0.007636	0	0%
Lower Reclamation Canal	**All Sites**	41	11/30/1999	3/31/2010	0.0002	0.008138	0.029091	0.236739	8	20%
	309ALD	14	11/30/1999	2/14/2007	0.0022	0.004727	0.039463	0.236739	3	21%
	309AVR	5	8/27/2008	12/17/2008	0.0043	0.014496	0.020239	0.053834	1	20%
	309JON	22	11/29/2005	3/31/2010	0.0002	0.010267	0.024503	0.206688	4	18%
Merrit Ditch	309MER	22	2/22/2005	3/31/2010	0.0003	0.006174	0.016597	0.083755	4	18%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.025 mg/L (toxicity standard)	% Exceeding 0.025 mg/L
Moro Cojo Slough	306MOR	33	1/23/2006	3/31/2010	0.0002	0.009776	0.020256	0.216779	7	21%
Natividad Creek	309NAD	18	2/22/2005	3/30/2010	0.0002	0.00238	0.030332	0.203237	3	17%
Quail Creek	**All Sites**	41	0.0004717	3/30/2010	0.0005	0.0072	0.065	1.347	7	17%
	309QUA	16	0.0006653	10/30/2008	0.0007	0.0030	0.010	0.040	2	13%
	309QUI	20	0.0004717	3/30/2010	0.0005	0.0138	0.124	1.347	5	25%
	309UQA	5	0.0026392	12/18/2008	0.0026	0.0044	0.006	0.011	0	0%
Salinas River	**All Sites**	66	11/30/1999	3/31/2010	0.0003	0.001906	0.008883	0.132491	4	6%
	309DAV	1		11/30/1999				0.000714	0	0%
	309SAC	27	11/30/1999	3/30/2010	0.0003	0.001963	0.006598	0.037624	2	7%
	309SAG	14	1/30/2007	3/30/2010	0.0004	0.005173	0.007136	0.023145	0	0%
	309SBR	15	4/26/2001	1/8/2007	0.0004	0.001807	0.007249	0.055484	1	7%
	309SSP	9	7/27/2005	3/31/2010	0.0003	0.006524	0.022084	0.132491	1	11%
Santa Rita Creek	309RTA	13	1/24/2006	2/14/2007	0.0004	0.029657	0.027575	0.278294	2	15%
Storm Drain @ Reclamation Canal	309AXX	14	1/24/2006	2/14/2007	0.0042	0.013508	0.025529	0.108201	3	21%
Storm Drain @ Salinas River	309SDR	12	2/27/2006	2/14/2007	0.0001	0.000383	0.000561	0.002177	0	0%
Tembladero Slough	**All Sites**	88	4/26/2001	3/31/2010	0.0001	0.000987	0.003509	0.04354	1	1%
	309TDW	54	4/26/2001	12/12/2006	0.0001	0.00049	0.000714	0.003531	0	0%
	309TEH	21	1/30/2007	3/31/2010	0.0003	0.005782	0.008735	0.04354	1	5%
	309TEMPRS	13	1/23/2006	2/14/2007	0.0017	0.005026	0.006677	0.018128	0	0%
Upper Reclamation Canal	**All Sites**	35	11/30/1999	3/30/2010	0.0003	0.019472	0.084416	0.867962	15	43%
	309ALG	20	1/30/2007	3/30/2010	0.0003	0.023716	0.071083	0.548243	9	45%
	309ALU	15	11/30/1999	2/14/2007	0.0031	0.014921	0.102194	0.867962	6	40%

Table 3-16. TMDL project area summary statistics for orthophosphate as P (units = mg/L).

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.3 mg/L[A]	% Exceeding 0.3 mg/L
Alisal Creek	All Sites (309UAL, 309HRT)	22	7/28/1999	12/17/2008	0.30	0.71	0.75	1.39	22	100%
Alisal Slough	309ASB	72	1/26/2005	3/31/2010	0.01	0.44	0.46	1.02	56	78%
Blanco Drain	All Sites	100	11/12/2001	3/31/2010	0.01	0.46	0.80	4.40	83	83%
	BLA-COO	20	11/12/2001	6/9/2003	0.29	1.41	1.45	4.40	19	95%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.3 mg/L[A]	% Exceeding 0.3 mg/L
	BLA-PUM	80	7/8/2002	3/31/2010	0.01	0.42	0.64	3.60	64	80%
Chualar Creek	All Sites	71	3/14/2001	1/19/2010	0.01	1.32	2.82	25.80	68	96%
	309CRR	38	3/14/2001	1/19/2010	0.01	1.12	1.43	5.05	36	95%
	309NOS	9	3/17/2002	4/17/2008	0.67	3.21	7.43	25.80	9	100%
	CHU-CCR	3	3/14/2001	12/17/2002	1.00	1.96	3.47	7.44	3	100%
	CHU-CRR	21	3/14/2001	12/17/2002	0.05	1.81	3.29	19.40	20	95%
Chualar Creek (south branch)	All Sites	33	3/14/2001	11/19/2008	0.05	0.66	1.06	3.06	27	82%
	309SBC	21	3/14/2001	11/19/2008	0.28	0.78	1.30	3.06	20	95%
	309SOS	10	1/25/2008	11/19/2008	0.05	0.33	0.37	0.74	7	70%
Esperanza Creek	All Sites	3	8/22/2001	5/23/2002	1.14	1.57	1.70	2.40	3	100%
Espinosa Slough	309ESP	69	1/26/2005	3/31/2010	0.01	0.39	0.44	1.86	45	65%
Gabilan Creek	All Sites	147	2/1/1999	2/23/2010	0.01	0.17	0.38	2.30	56	38%
	309GAB	32	2/1/1999	2/23/2010	0.01	0.65	0.79	2.30	24	75%
	309-GABIL-31	4	5/17/2003	5/6/2006	0.01	0.06	0.07	0.14	0	0%
	GAB-CRA	39	10/11/2000	4/24/2002	0.01	0.20	0.34	1.75	14	36%
	GAB-HER	16	10/29/2000	4/24/2002	0.06	0.52	0.58	1.38	12	75%
	GAB-NAT	5	1/25/2001	2/19/2001	0.59	0.83	0.77	0.86	5	100%
	GAB-OSR	33	10/11/2000	2/19/2001	0.01	0.05	0.07	0.23	0	0%
	GAB-VET	17	1/11/2001	5/23/2002	0.01	0.03	0.14	0.94	1	6%
Lower Reclamation Canal	All Sites	229	2/1/1999	3/31/2010	0.01	0.41	0.62	12.90	157	69%
	309ALD	29	2/1/1999	2/14/2007	0.18	0.46	0.56	4.10	20	69%
	309AVR	45	10/26/2000	12/17/2008	0.13	0.33	0.41	1.16	24	53%
	309JON	130	10/11/2000	3/31/2010	0.01	0.45	0.76	12.90	97	75%
	PIP-VIC	1		1/8/2001				0.38	1	100%
	REC-183	24	1/8/2001	7/1/2002	0.01	0.35	0.36	0.70	15	63%
Merrit Ditch	309MER	74	5/17/2003	3/31/2010	0.01	0.22	0.29	1.67	27	36%
Moro Cojo Slough	All Sites	468	2/2/1999	3/31/2010	0.01	0.16	0.39	4.40	158	34%
	306MOR	208	2/2/1999	3/31/2010	0.01	0.18	0.43	4.40	81	39%
	306MORCAS	4	02/07/06	05/02/06	0.21	0.29	0.29	0.36	2	50%
	306MORMLN	246	02/02/99	07/07/09	0.03	0.15	0.33	4.36	67	27%
	306-MOROC-31	5	5/17/2003	5/7/2007	0.05	0.91	0.89	1.49	4	80%
	306-MOROC-	5	5/17/2003	5/7/2007	0.05	0.93	0.69	1.10	4	80%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.3 mg/L[A]	% Exceeding 0.3 mg/L
	32									
Moss Landing Harbor @ Sanholdt Rd.	MOS-SAN	15	11/12/2001	6/9/2003	0.13	0.53	0.80	2.50	12	80%
Natividad Creek	All Sites	75	8/1/2002	3/30/2010	0.01	0.49	0.63	3.96	58	77%
	309NAD-NAT-BOR	67	8/1/2002	3/30/2010	0.01	0.47	0.63	3.96	52	78%
	NAT-FRE-NAT-LAS	8	8/1/2002	5/3/2008	0.05	0.62	0.61	1.13	6	75%
Old Salinas River	All Sites	384	2/2/1999	7/7/2009	0.01	0.37	0.41	2.40	235	61%
	OLS-MON	124	2/2/1999	7/7/2009	0.01	0.37	0.38	1.30	74	60%
	OLS-POT	260	2/2/1999	7/7/2009	0.01	0.37	0.43	2.40	161	62%
Quail Creek	All Sites	113	2/1/1999	3/30/2010	0.01	1.19	1.52	14.00	103	91%
	309QUA	29	2/1/1999	10/30/2008	0.14	1.35	2.02	14.00	26	90%
	309QUI	70	1/27/2005	3/30/2010	0.01	1.19	1.51	5.05	68	97%
	309UQA	14	11/9/1999	12/18/2008	0.04	0.51	0.55	1.73	9	64%
Salinas River	All Sites	420	2/1/1999	3/31/2010	0.004	0.09	0.15	2.60	39	9%
	309DAV	50	2/1/1999	6/9/2003	0.01	0.10	0.28	2.60	10	20%
	309SAC	94	2/1/1999	3/30/2010	0.01	0.06	0.08	0.46	2	2%
	309SAG	63	1/11/2001	3/30/2010	0.01	0.07	0.09	0.31	1	2%
	309SBR	164	2/2/1999	7/7/2009	0.00	0.12	0.18	2.42	24	15%
	309SSP	49	1/10/2001	3/31/2010	0.01	0.09	0.12	1.35	2	4%
Santa Rita Creek	All Sites	36	5/1/2004	5/3/2008	0.01	0.25	0.37	1.53	19	53%
	309RTA	19	5/1/2004	2/14/2007	0.01	0.40	0.57	1.53	5	26%
	309-SRITA-32	7	5/6/2006	5/3/2008	0.01	0.05	0.14	0.60	6	86%
	309-SRITA-34	6	5/6/2006	5/3/2008	0.01	0.06	0.13	0.57	5	83%
	309-SRITA-36	4	9/16/2006	12/9/2006	0.01	0.09	0.17	0.50	3	75%
Storm Drain @ Reclamation Canal	309AXX	18	1/3/2000	2/14/2007	0.15	0.30	0.49	1.56	7	39%
Storm Drain @ Salinas River	309SDR	24	0.11	0.627	0.11	0.41	0.39	0.63	16	67%
Tembladero Slough	All Sites	341	2/2/1999	3/31/2010	0.01	0.49	0.49	1.34	248	73%
	309TDW	129	4/26/2001	7/7/2009	0.01	0.50	0.48	1.07	79	61%
	309TEH	75	7/1/2002	3/31/2010	0.01	0.45	0.46	1.28	56	75%
	309-TEMBL-34	1		5/7/2005				0.01	0	0%
	309TEMPRS	136	02/02/99	07/07/09	0.01	0.51	0.52	1.34	113	83%
Towne Creek	TOW-OSR	21	1/8/2001	2/19/2001	0.01	0.01	0.04	0.21	0	0%
Towne Creek tributary (Big Oak Creek)	BOC-OSR	20	1/7/2001	2/18/2001	0.01	0.06	0.12	0.37	1	5%
Upper Reclamation Canal	All Sites	104	2/1/1999	3/30/2010	0.01	0.68	0.83	5.46	92	88%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 0.3 mg/L[A]	% Exceeding 0.3 mg/L
	309ALG	74	2/22/2005	3/30/2010	0.01	0.65	0.79	5.46	64	86%
	309ALU	30	2/1/1999	2/14/2007	0.29	0.87	0.93	2.16	28	93%

[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 3-17. TMDL project area summary statistics for dissolved oxygen (units = mg/L).

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Mean	Max	No. Under 5 mg/L objective	% Under 5 mg/L objective	No. Under 7 mg/L objective	% Under 7 mg/L objective
Alisal Creek	All Sites (309HRT & 309UAL)	16	7/28/1999	12/17/2008	5.73	8.8	11.53	0	0%	2	13%
Alisal Slough	All Sites (309ASB & 309Alisa-32)	66	5/17/2003	3/31/2010	5.03	9.6	15.19	0	0%	6	9%
Blanco Drain	BLA-PUM	61	1/26/2005	3/31/2010	4.48	8.7	13.06	2	3%	12	20%
Chualar Creek	All Sites	28	2/17/2005	1/19/2010	3.99	8.1	11.79	1	4%	6	21%
	309CRR	24	2/17/2005	1/19/2010	3.99	8.1	11.79	1	4%	6	25%
	309NOS	4	1/25/2008	4/17/2008	8.94	10.3	11.38	0	0%	0	0%
Chualar Creek (south branch)	All Sites	21	1/25/2008	11/19/2008	5.84	9.0	12.206	0	0%	3	14%
	309SBC	11	1/25/2008	11/19/2008	5.84	8.7	12.206	0	0%	2	18%
	309SOS	10	1/25/2008	11/19/2008	6.8	9.3	11.56	0	0%	1	10%
Espinosa Slough	309ESP	61	1/26/2005	3/31/2010	4.7	10.7	21.85	1	2%	9	15%
Gabilan Creek	All Sites	35	2/1/1999	2/23/2010	4.94	8.4	12.23	1	3%	7	20%
	309GAB	31	2/1/1999	2/23/2010	4.94	8.4	12.23	1	3%	7	23%
	309-GABIL-31	4	5/17/2003	5/6/2006	8	8.2	8.83	0	0%	0	0%
Lower Reclamation Canal	All Sites	103	2/1/1999	3/31/2010	1.2	9.4	19.58	10	10%	22	21%
	309ALD	27	2/1/1999	2/14/2007	1.2	8.1	18.25	5	19%	9	33%
	309AVR	15	5/17/2003	12/17/2008	5.89	11.1	19.58	0	0%	1	7%
	309JON	61	1/26/2005	3/31/2010	2.67	9.6	18.36	5	8%	12	20%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Mean	Max	No. Under 5 mg/L objective	% Under 5 mg/L objective	No. Under 7 mg/L objective	% Under 7 mg/L objective
Merrit Ditch	309MER	67	5/17/2003	3/31/2010	3.91	9.5	19.54	4	6%	13	19%
Moro Cojo Slough	All Sites	188	3/1/1999	3/31/2010	0.3	7.1	22.12	61	32%	98	52%
	306MOR	114	3/1/1999	3/31/2010	0.49	6.8	22.12	45	39%	66	58%
	306MORCAS	12	02/07/06	05/05/06	0.38	1.3	2.55	12	100%	12	100%
	306MORMLN	51	03/01/99	10/10/06	0.30	8.1	14.67	4	8%	19	37%
	306-MOROC-31	5	5/17/2003	5/3/2008	9.4	12.1	15	0	0%	0	0%
	306-MOROC-32	6	5/17/2003	5/3/2008	5	10.4	15.5	0	0%	1	17%
Natividad Creek	All Sites	64	5/17/2003	3/30/2010	1.39	7.4	11.28	6	9%	23	36%
	309NAD	58	5/17/2003	3/30/2010	1.39	7.6	11.28	4	7%	18	31%
	NAT-LAS	6	5/17/2003	5/3/2008	3	4.9	7	2	33%	5	83%
Old Salinas River	All Sites	107	3/1/1999	3/31/2010	1.83	8.6	19.79	17	16%	29	27%
	OLS-MON	58	3/29/1999	3/31/2010	1.83	8.3	19.79	10	17%	19	33%
	OLS-POT	49	03/01/99	10/10/06	3.61	8.9	14.31	7	14%	10	20%
Quail Creek	All Sites	106	2/1/1999	3/30/2010	2.17	8.5	14.52	5	5%	26	25%
	309QUA	30	2/1/1999	10/30/2008	5.36	8.9	11.57	0	0%	6	20%
	309QUI	63	1/27/2005	3/30/2010	3.2	8.5	14.52	4	6%	16	25%
	309UQA	13	11/9/1999	12/18/2008	2.17	7.9	11.06	1	8%	4	31%
Salinas River	All Sites	237	2/1/1999	3/31/2010	4.34	9.8	19.21	3	1%	24	10%
	309DAV	15	2/1/1999	5/15/2000	8.32	10.9	13.1	0	0%	0	0%
	309SAC	75	2/1/1999	3/30/2010	5.22	9.9	13.73	0	0%	3	4%
	309SAG	42	5/17/2003	3/30/2010	5.41	8.9	14.35	0	0%	6	14%
	309SBR	64	3/1/1999	2/14/2007	5.66	10.2	19.21	0	0%	7	11%
	309SSP	41	1/27/2005	3/31/2010	4.34	9.6	19.12	3	7%	8	20%
Santa Rita Creek	All Sites	88	1/8/2004	5/3/2008	2.54	8.3	16.66	8	9%	24	27%
	309RTA	30	5/1/2004	2/14/2007	3.21	7.8	11.9	5	17%	9	30%
	309-SRITA-32	24	1/8/2004	5/3/2008	5.67	8.3	11.16	0	0%	5	21%
	309-	17	8/26/2005	5/3/2008	2.54	7.5	11.16	3	18%	7	41%

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Mean	Max	No. Under 5 mg/L objective	% Under 5 mg/L objective	No. Under 7 mg/L objective	% Under 7 mg/L objective
	SRITA-34										
	309-SRITA-36	17	8/26/2005	12/9/2006	5.8	10.0	16.66	0	0%	3	18%
Tembladero Slough	All Sites	142	03/01/99	03/31/10	2.73	8.9	20.03	6	4%	37	26%
	309TDW	20	11/06/02	05/03/08	6.01	10.0	12.53	0	0%	1	5%
	309TEH	61	1/26/2005	3/31/2010	2.73	9.0	17.38	3	5%	16	26%
	309-TEMBL-34	1	5/7/2005	5/7/2005				0	0%	0	0%
	309TEMPRS	60	3/1/1999	5/3/2008	3.684116	8.5	20.03	3	5%	20	33%
Upper Reclamation Canal	All Sites	91	2/1/1999	3/30/2010	1.34	8.6	17.54	13	14%	27	30%
	309ALG	61	1/27/2005	3/30/2010	1.34	9.4	17.54	5	8%	14	23%
	309ALU	30	2/1/1999	2/14/2007	3.16	7.1	11.87	8	27%	13	43%

Table 3-18. TMDL project area summary statistics for dissolved oxygen saturation (units = %).

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median Saturation (%)	Max
Alisal Creek	All Sites (309HRT & 309UAL)	16	7/28/1999	12/17/2008	63.2	88	113.2
Alisal Slough	309ASB	61	1/26/2005	3/31/2010	50	101	154.7
Blanco Drain	BLA-PUM	61	1/26/2005	3/31/2010	47.1	85	149.6
Chualar Creek	All Sites	28	2/17/2005	1/19/2010	40.4	87	106.3
	309CRR	24	2/17/2005	1/19/2010	40.4	86	106.3
	309NOS	4	1/25/2008	4/17/2008	97.2	100	105
Chualar Creek (south branch)	All Sites	21	1/25/2008	11/19/2008	61.9	96	110.5
	309SBC	11	1/25/2008	11/19/2008	61.9	90	103.7
	309SOS	10	1/25/2008	11/19/2008	81.1	100	110.5
Espinosa Slough	309ESP	61	1/26/2005	3/31/2010	46.6	98	258.7
Gabilan Creek	309GAB	31	2/1/1999	2/23/2010	53.6	89	125
Lower Reclamation Canal	All Sites	100	2/1/1999	3/31/2010	11.6	88	227.7
	309ALD	27	2/1/1999	2/14/2007	11.6	80	219.5
	309AVR	12	1/26/2008	12/17/2008	60.3	104	214.4

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median Saturation (%)	Max
	309JON	61	1/26/2005	3/31/2010	27.4	92	227.7
Merrit Ditch	309MER	61	1/26/2005	3/31/2010	39.5	88	203
Natividad Creek	309NAD	52	1/27/2005	3/30/2010	13.9	81	136.3
Old Salinas River	All Sites	107	3/1/1999	3/31/2010	22.1	85	217.5
	OLS-MON	58	3/29/1999	3/31/2010	22.1	85	217.5
	OLS-POT	49	03/01/99	10/10/06	38.8	87	158.8
Quail Creek	All Sites	106	2/1/1999	3/30/2010	106	89	167.9
	309QUA	30	2/1/1999	10/30/2008	54.3	91	109.6
	309QUI	63	1/27/2005	3/30/2010	31	88	167.9
	309UQA	13	11/9/1999	12/18/2008	22.5	93	103.1
Salinas River	All Sites	225	2/1/1999	3/31/2010	45.6	99	200
	309DAV	15	2/1/1999	5/15/2000	82.5	111	141.6
	309SAC	71	2/1/1999	3/30/2010	53.1	101	120.4
	309SAG	38	1/25/2006	3/30/2010	57.3	96	119.2
	309SBR	60	3/1/1999	2/14/2007	56	97	200
	309SSP	41	1/27/2005	3/31/2010	45.6	91	184.7
Santa Rita Creek	309RTA	14	1/24/2006	2/14/2007	28.8	78	119
Tembladero Slough	All Sites	130	03/01/99	03/31/10	25.4	84	218.4
	309TDW	15	11/06/02	10/10/06	67.4	105	129.3
	309TEH	60	1/26/2005	3/31/2010	25.4	82	202
	309TEMPRS	55	3/1/1999	2/14/2007	42	80	218.4
Upper Reclamation Canal	All Sites	91	2/1/1999	3/30/2010	13.1	86	197.8
	309ALG	61	1/27/2005	3/30/2010	13.1	98	197.8
	309ALU	30	2/1/1999	2/14/2007	33.2	71	125.7

Table 3-19. TMDL project area summary statistics for chlorophyll a (units = μg/L).

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 40 μg/L
Alisal Creek	**All Sites** (30HRT & 309UAL)	17	7/28/1999	12/17/2008	0.21	1.30	1.32	2.54	5
	309HRT	11	1/25/2008	12/17/2008	0.21	1.30	1.32	1.32	0
	309UAL	6	7/28/1999	2/10/2000	24.00	47.50	112.00	112.00	5
Alisal Slough	309ASB	60	1/26/2005	3/31/2010	0.01	1.38	2.09	35.00	0
Blanco Drain	BLA-PUM	60	1/26/2005	3/31/2010	0.01	1.31	1.88	28.00	0

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 40 µg/L
Chualar Creek	**All Sites**	27	2/23/2005	1/19/2010	0.07	1.17	1.75	6.63	0
	309CRR	23	2/23/2005	1/19/2010	0.07	1.34	1.92	6.63	0
	309NOS	4	1/25/2008	4/17/2008	0.11	0.82	0.77	1.32	0
Chualar Creek (south branch)	All sites	21	1/25/2008	11/19/2008	0.19	0.74	0.91	3.46	0
	309SBC	11	1/25/2008	11/19/2008	0.19	0.71	0.84	2.22	0
	309SOS	10	1/25/2008	11/19/2008	0.20	0.78	0.99	3.46	0
Espinosa Slough	309ESP	60	1/26/2005	3/31/2010	0.01	1.76	9.64	132.83	3
Gabilan Creek	309GAB	31	2/1/1999	2/23/2010	0.72	2.69	7.52	50.00	1
Lower Reclamation Canal	**All sites**	101	2/1/1999	3/31/2010	0.08	4.89	15.05	150.00	8
	309ALD	29	2/1/1999	2/14/2007	4.10	20.20	34.43	150.00	6
	309AVR	12	1/26/2008	12/17/2008	0.15	1.54	2.90	10.81	0
	309JON	60	1/26/2005	3/31/2010	0.08	3.49	8.12	120.00	2
Merrit Ditch	309MER	60	1/26/2005	3/31/2010	0.01	2.05	5.07	36.14	0
Natividad Creek	309NAD	51	1/27/2005	3/30/2010	0.01	1.35	2.74	31.65	0
Old Salinas River	**All Sites**	132	03/29/99	03/31/10	0.01	6.58	25.88	330.22	22
	OLS-MON	64	03/29/99	03/31/10	0.01	4.70	21.61	330.22	8
	OLS-POT	68	03/29/99	07/07/09	0.01	10.52	29.89	257.39	14
Quail Creek	**All Sites**	102	2/1/1999	3/30/2010	0.01	93.00	4.38	93.00	3
	309QUA	29	2/1/1999	10/30/2008	0.01	5.70	12.43	93.00	3
	309QUI	61	1/27/2005	3/30/2010	0.03	1.05	1.25	4.03	0
	309UQA	12	1/25/2008	12/18/2008	0.06	0.36	0.85	4.91	0
Salinas River	**All Sites**	211	2/1/1999	3/31/2010	0.01	1.98	9.58	280.00	11
	309DAV	14	2/1/1999	5/15/2000	3.50	13.50	14.71	52.00	1
	309SAC	68	3/1/1999	3/30/2010	0.01	1.35	5.51	60.00	2
	309SAG	38	1/25/2006	3/30/2010	0.01	0.75	1.13	8.37	0
	309SBR	51	03/29/99	7/7/2009	0.01	4.90	25.08	280.00	8
	309SSP	40	1/27/2005	3/31/2010	0.01	1.43	2.97	23.00	0
Tembladero Slough	**All Sites**	133	03/29/99	03/31/10	0.01	7.00	33.97	660.00	26
	309TDW	24	12/03/02	07/07/09	0.01	3.45	25.05	235.93	3
	309TEH	60	01/26/05	3/31/2010	0.18	4.72	9.96	67.61	3
	309TEMPRS	49	03/29/99	07/07/09	0.01	27.11	67.73	660.00	20
Upper Reclamation Canal	**All Sites**	90	2/1/1999	3/30/2010	0.01	3.03	12.02	140.00	6

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Median	Mean	Max	No. Exceeding 40 µg/L
	309ALG	60	1/27/2005	3/30/2010	0.01	1.91	5.75	140.00	1
	309ALU	30.00	2/1/1999	2/14/2007	2.10	18.90	24.56	110.00	5

Table 3-20. TMDL project area summary statistics for microcystins (units = µg/L).

Waterbody	Site ID	No. of Samples	Temporal Representation		Min	Mean	Max	No. Exceeding 0.8 µg/L [A]	% Exceeding 0.8 µg/L
Salinas River	309DAV	4	9/14/2011	10/16/2012	N.D.	0.48	N.D.	1	33%
Salinas River Lagoon	309LAG	24	1/4/2012	7/12/2012	N.D.	0.06	0.72	0	0%
Old Salinas River	OLD-MON	4	9/14/2011	10/16/2012	N.D.	0.74	1.18	2	50%
Tembladero Slough	309TDW	2	9/14/2011	10/13/2011	N.D.	-	N.D.	0	0%

[A] 0.8 µg/L is a California Office of Environmental Health Hazard Assessment has public health action level for microcystins.

Microcystin data is reported as nanograms per gram of resin. These results can be converted to a water column-equivalent concentration, as reported here, by dividing the reported resin results by ten (personal communication, Dr. Raphael Kudela, Professor of Ocean Sciences, University of California-Santa Cruz, April 24, 2012)

3.8 Photo Documentation of Biostimulation

Water Board staff, researchers, and other public entities periodically photo-document evidence of biostimulation and excessive algal growth at water quality monitoring sites in the TMDL project area. Photographic documentation of biostimulatory effects on surface waters of the project area is shown in Figure 3-46; 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. While an overall goal of nutrient TMDLs is to significantly reduce the amount of biomass in the system, some level of biomass is necessary to provide habitat to fish and other aquatic organisms.

Figure 3-45. Location of photo monitoring sites.

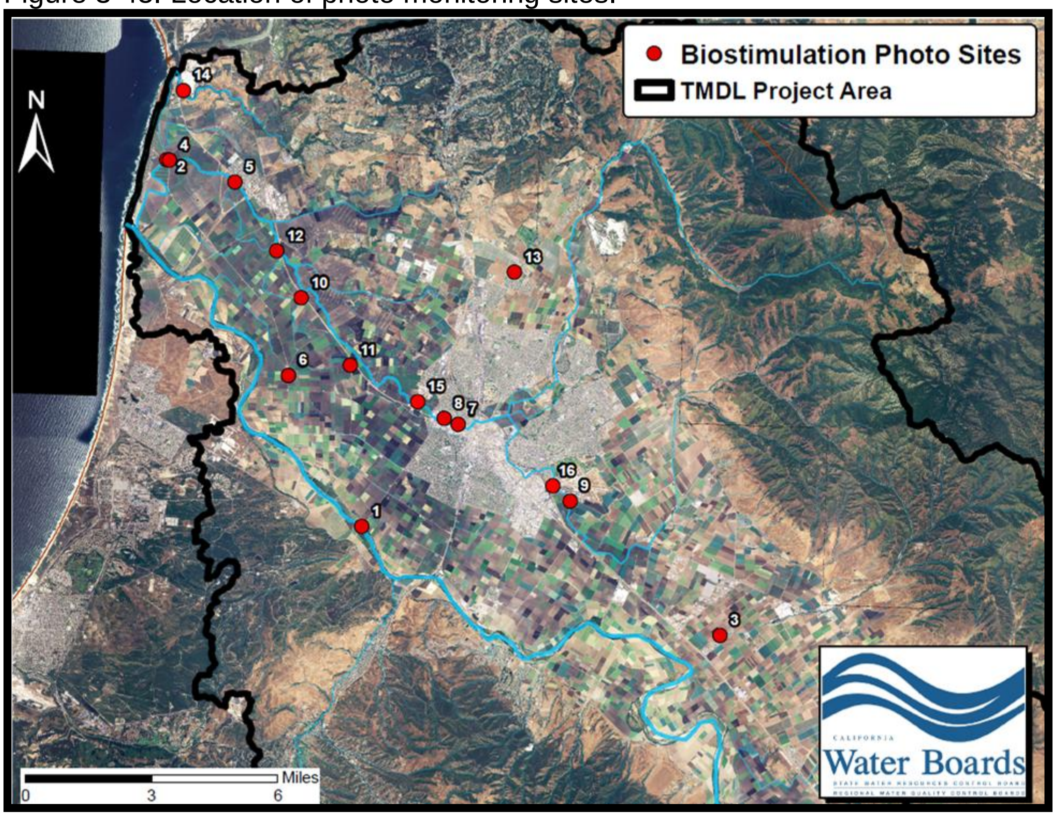


Figure 3-46. Photo documentation of biostimulation.

Photo documentation

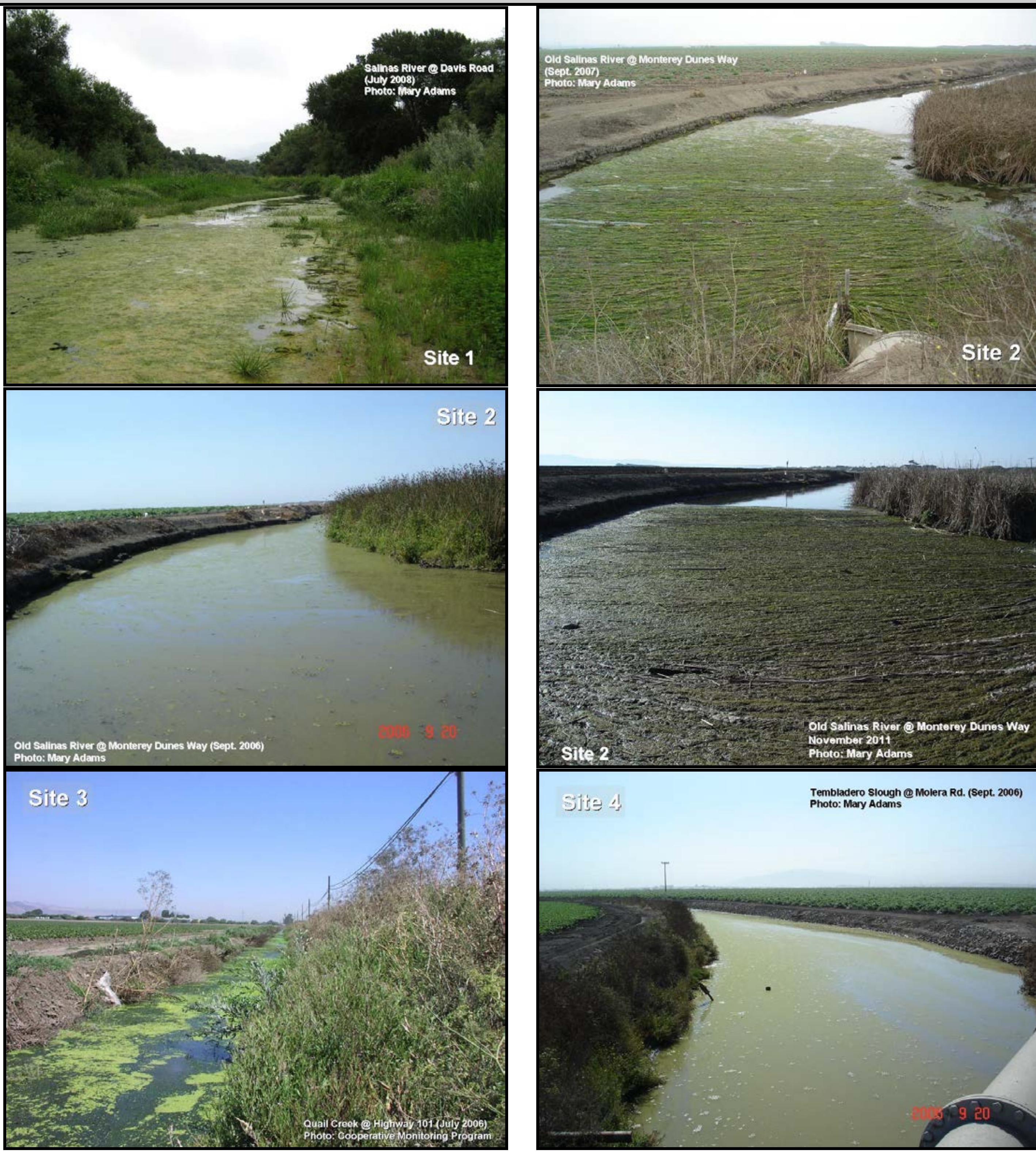


Photo documentation

Tembladero Slough @ Preston Rd. (Sept. 2006)
Photo: Mary Hamilton

Blanco Drain @ Cooper Rd (2002)
Photo: Don Kozlowski - CCoWS

Reclamation Canal @ Rico St. (July 2004)
Photo: Joel Casagrande

Reclamation Canal @ Victor St. (July 2004)
Photo: Joel Casagrande

Reclamation Canal @ La Guardia St.. (July 2006)
Photo: Cooperative Monitoring Program

Alisal Slough @ Hwy. 183 (Sept. 2008)
Photo: Peter Meertens

Photo documentation

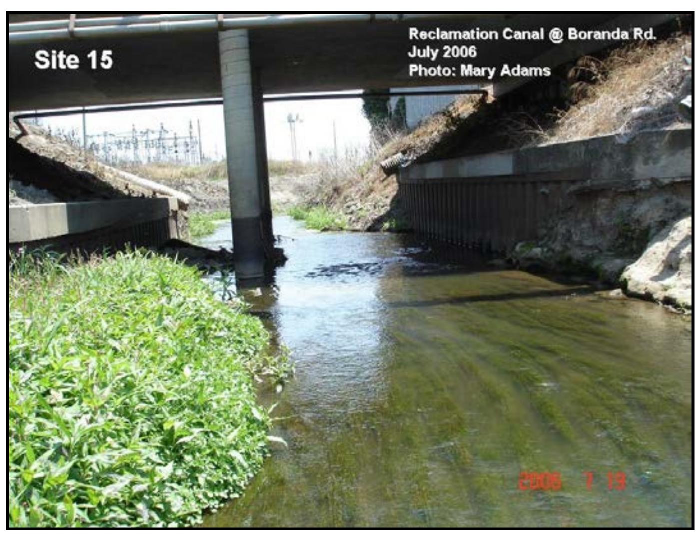


Photo documentation

3.9 Factors Limiting the Risk of Biostimulation

3.9.1 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. Table 3-21 presents published nitrogen:phosphorus ratios (TN:TP) for limiting algal response.

Table 3-21. Published Nutrient Limiting Thresholds (N:P ratio)*

N Limiting Threshold	Transition - N & P Co-limiting	P Limiting Threshold	Source[A]
<10:1	10:1 – 20:1	>20:1	Schanz and Juon (1983)
		> 20:1	Petersen et al. (1993)
		> 20:1	Stockner and Shortreed (1978)
		> 20:1	Pringle (1987)
<10:1			Grimm and Fisher (1986)
<12.6:1			Dodds et al. (1998)
		>17:1	Borchardt (1996)
<12:1			Lohman (1988)
<16:1		>16:1	Tetratech (2004)[B]

A-Sources as reported by Missouri Dept. of Natural Resources in *Total Maximum Daily Load (TMDL) for James River (2001)*
B- Progress Report – Development of Nutrient Criteria in California: 2003-2004 (TetraTech, 2004)

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 is important to recognize however, that because nutrients occur in such high water column concentrations in the TMDL project area, it is likely that nutrients do not limit algal productivity (personal communications Brent Hughes, Elkhorn Slough National Estuarine Research Reserve, 9 Aug. 2011; Dr. Ken Johnson, 8 Sept. 2011, and Dr. Jane Caffrey, University of West Florida, 12Sept.2011). Researchers have indicated that nutrients in this system have in fact saturated the productivity potential in downstream receiving waters, such as Elkhorn Slough. Therefore, information provided in this section may indicate which nutrient could ultimately become limiting if loading of both nitrogen and phosphorus were progressively reduced at approximately equivalent rates.

In principle, the ratio of nitrogen to phosphorus in the water column is considered a line of evidence of which nutrient is, or could potentially, limit algal growth in a waterbody (U.S. EPA 2000). Figure 3-47 indicates that streams in the Salinas River-Reclamation Canal basin tend for the most part to be nitrogen-limited. This observation is consistent with findings reported by TetraTech (2004). TetraTech (2004) found that streams in subecoregion 6 are more often limited by nitrogen than by phosphorus (refer back to Figure 2-9 for location of subecoregion 6). TetraTech reported that this may explain why there is a strong correlation between water quality impairment and nitrate levels in streams in subecoregion 6. It should be noted however, that TetraTech also reported that a substantial proportion of lakes in subecoregions 6 appear to be limited by phosphorus.

Figure 3-48 and Figure 3-49 illustrate TN:TP ratios for monitoring sites specific to the TMDL project area. Generally, project area streams appear to be well below the P-limiting conditions of TN:TP=20, indicating N-limitation or co-limitation. However, the two coastal confluence sites located in the most downstream positions of the project area appear to be P limited (Salinas River above the lagoon, and Tembladero Slough at Preston Rd.)

Figure 3-47. Hydrologic Unit 309 (Salinas River and Reclamation Canal Basin) TN:TP scatter plot.

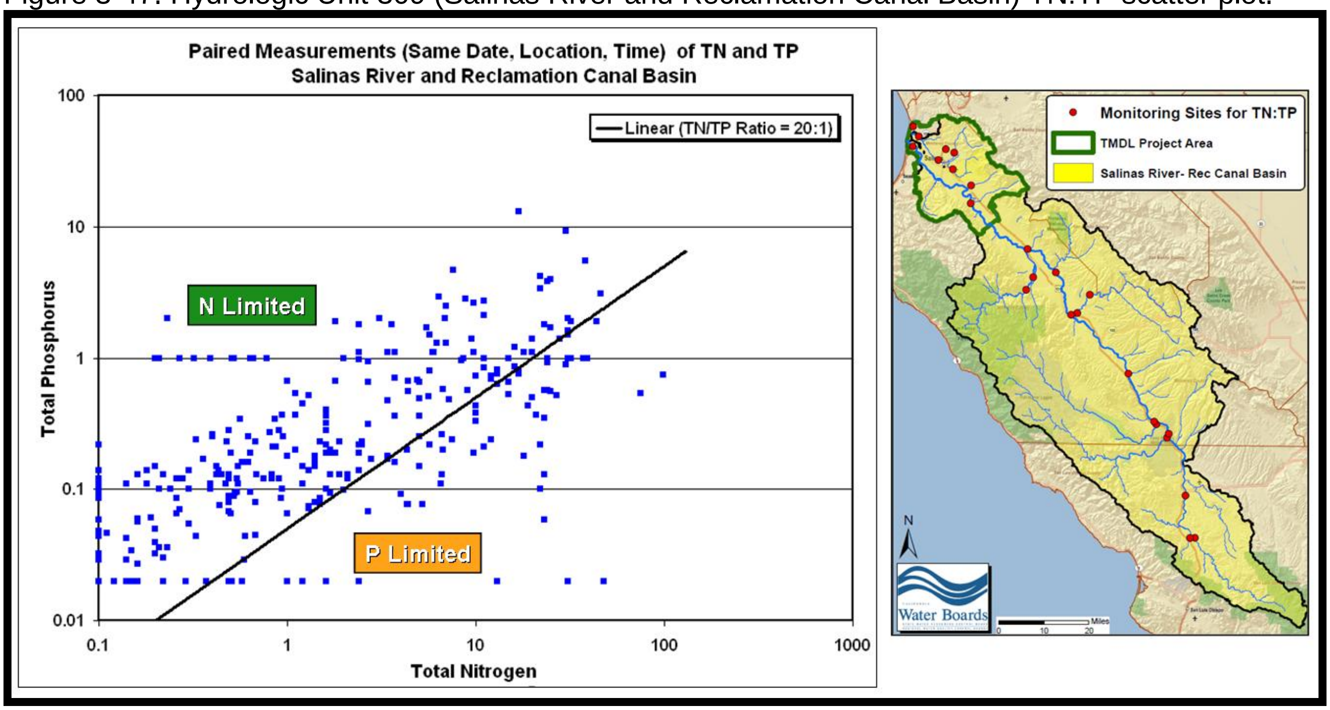


Figure 3-48. Water column TN:TP ratios (geomean of individual monitoring site samples).

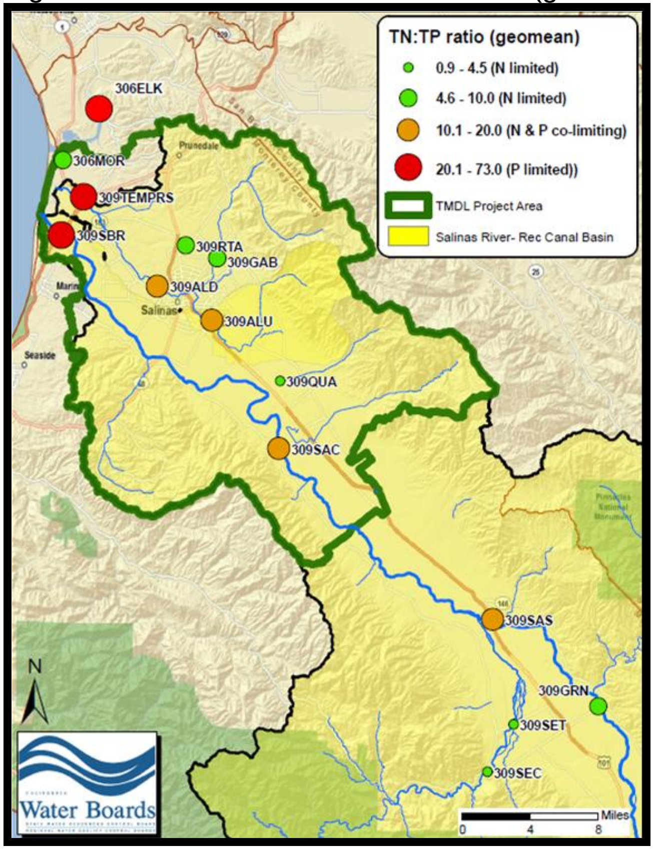


Figure 3-49. Box and whiskers plot of TN:TP ratios in TMDL project area (total water quality samples, n=103).

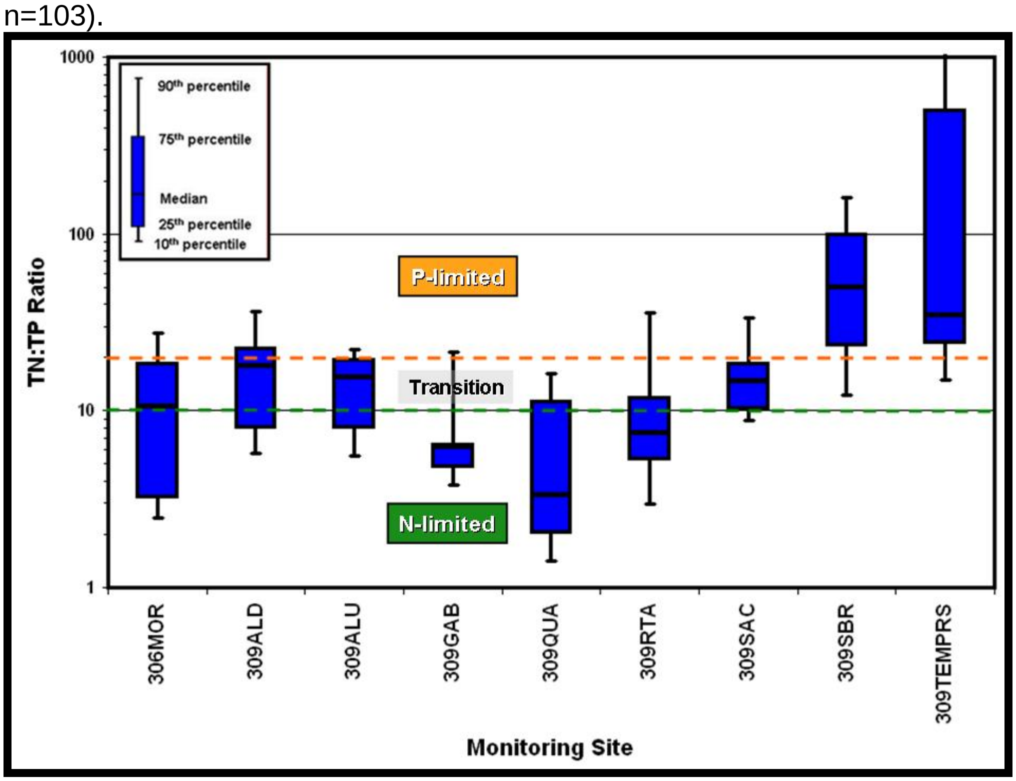


Table 3-22. Nutrient limitation determination for sites in TMDL project area.

Monitoring Station	Period of Record	Number of Samples	TN:TP (geomean of samples)	Potential Limiting Nutrient
306MOR – Moro Cojo Slough @ Hwy 1	Jan. 2006-Feb. 2007	14	7.98	N
309ALD-Reclamation Canal @ Boranda Rd.	Jan. 2006-Feb. 2007	14	16.01	Transition range N & P co-limiting
309ALU- Reclamation Canal @ Airport Rd.	Jan. 2006-Feb. 2007	15	16	Transition range N & P co-limiting
309GAB- Gabilan Creek @ Independence Rd. and Boranda Rd.	Jan. 2006-Jan. 2007	7	7.11	N
309QUA- Quail Creek @ Potter Rd.	Jan. 2006-Feb. 2007	14	4.24	N
309RTA- Santa Rita Creek @ Santa Rita park	Jan. 2006-Feb. 2007	14	8.94	N
309SAC- Salinas River @ Chualar	Jan. 2006-Feb. 2007	11	13.53	Transition range N & P co-limiting
309SBR- Salinas River @ Hwy 1	Jan. 2006-Feb. 2007	13	43.47	P
309TEMPRS- Tembladero Slough @ Preston	Jan. 2006-Feb. 2007	14	72.99	P

Note: It is important to recognize that because nutrients occur in such high water column concentrations in the TMDL project area, it is likely that nutrients do not limit algal productivity. Information in this table may indicate which nutrient could ultimately become limiting if loading of both nitrogen and phosphorus were progressively reduced at approximately equivalent rates.

3.9.2 Sunlight Availability (Turbidity and 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 have indicated that nutrients have in fact saturated the productivity potential in downstream receiving waters, such as Elkhorn Slough (personal communication, Brent Hughes, Elkhorn Slough National Estuarine Research Reserve, Aug. 9, 2011). Indeed, researchers have indicated that when nutrients are as high as they are in this system, 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[80], estuarine researcher (University of West Florida), personal communication to Water Board staff, Sept. 12, 2011*

Further, during a presentation to Water Board staff in February 2012, scientists[81] 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

[80] 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.
[81] Dr. Scott Rollins (Spokane Falls Community College) and Dr. Marc Los Huertos (Calif. State University at Monterey Bay)

4.3). 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 4.3).

3.9.3 Stream Flow and 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 3.7.5) illustrates that water column nitrate and algal biomass (as represented by chlorophyll *a*) are typically more problematic during low-flow conditions in the TMDL project area, 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 than for summer 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 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[82]. 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 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[83] have similarly incorporated seasonal targets for nutrients for the same reasons. Seasonal biostimulatory nutrient targets are developed and presented in Section 4.3.

3.10 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)[84] to assess TMDL project area waterbodies which are exhibiting a range of indicators of biostimulation. These ranges of

[82] State of Connecticut Dept. of Environmental Protection. 2005. A Total Maximum Daily Load Analysis for Linsley Pond in North Branford and Branford, Connecticut

[84] 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.

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 2.1). 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 project area surface waters. Appendix C contains the all of the data and information used to assess biostimulatory impairments. Consistent with USEPA guidance, staff asserted biostimulatory impairment only where a waterbody exhibits a range of biostimulatory water quality indicators. Table 3-23 summarizes the range of biostimulatory indicators needed to assert biostimulatory impairment. The range of indicators in Table 3-23 constitute multiple lines of evidence, in a weight-of-evidence approach, to assert biostimulatory impairments.

Table 3-23. 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; reports of fish kills likely due to low dissolved oxygen; and/or evidence of downstream nutrient impacts to a waterbody that does show multiple indicators of biostimulation problems (see Section 3.11– 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).

Table 3-24 presents the numeric criteria and screening values used to assess the potential indicators of biostimulation (refer back to Table 3-23). Table 3-25 presents the biostimulatory assessment matrix for TMDL project area waterbodies. As previously noted, Appendix C contains all the data and information used to assess biostimulatory impairments.

Table 3-24. Water quality objectives and screening criteria used as indicators of biostimulation.

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 they can provide additional weight of evidence)**		
Constituent – Parameter	**Source of Screening Criteria**	**Screening Criteria/Method**
Wide diel swings in DO - pH	Wide diel swings widely reported in scientific literature as indicating potential biostimulation	Observational – compare diel swings to reference sites (reference sites show diel DO variation of less than 1 mg/L).
Early morning DO crashes (pre-dawn sampling program)	Early morning DO crashes widely reported in scientific literature as indicating potential biostimulation	Early morning DO crashes, depressed below Basin Plan numeric objectives, based on data from pre-dawn sampling program.
Low dissolved oxygen and/or oxygen super saturation	Basin Plan Objectives and California Surface Water Ambient Monitoring Program Technical Report[A]	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 SWRCB Listing Policy (2004)[c]
Chlorophyll *a*	California Surface Water Ambient Monitoring Program Technical Report[A]	Exceeding 15 mg/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[A]	NO3-N exceeding 1/mg/L (central coast reference condition) = evidence of nutrient enrichment (Assessed using geomean of all samples at monitoring site > 1mg/L).
Evidence of phosphorus enrichment relative to reference conditions	USEPA 25th percentile reference approach for rivers and streams (USEPA, 2000a)	Orthophosphate-P exceeding 25th percentile of inland streams for hydrologic unit 309 (Salinas Watershed) = 0.074 mg/L (assessed using geomean of all samples at monitoring site > 0.074mg/L).
Percent Floating Algal Cover	California Surface Water Ambient Monitoring Program Technical Report[A]	One or more observances of 50% cover or greater = 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.
Downstream Impacts	USEPA Scientific Advisory Board (2010) stressed the importance of recognizing downstream impacts[B]	Observational: assess whether stream reach showing 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).

[A] 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.
[B] U.S. EPA Science Advisory Board Review of “Empirical Approaches for Nutrient Criteria Derivation”. U.S Environmental Protection Agency. April 27, 2010.
[C] State Water Resources Control Board (SWRCB). 2004. Water Quality Control Policy for Developing California’s Clean Water Act Section 303(d) List.

Table 3-25. Biostimulation assessment matrix.

Stream Reach	DO Problems			Nutrient Enrichment	Elevated Algal Biomass		Other indicators of Biostimulatory problems			Biostimulatory Impairment in Stream Reach?
	Wide Diel DO Swings	Pre-dawn DO crashes	Low DO and/or DO supersaturation	NO3-N exceeding reference conditions; or orthophosphate-P exceeding reference conditions	Chlorophyll a exceeding reference conditions	Excess floating algal cover (≥50% cover)	Downstream nutrient impacts to waterbody exhibiting biostimulation	Reported fish kills likely or possibly linked to DO problems	Photo documentation of excessive algal biomass	
Old Salinas River @ Potrero Rd.	No data	No data	Yes	Yes	Yes	No data	Yes (Elkhorn Slough)	Yes	No	Yes
Old Salinas River @ Monterey Dunes	Yes	Yes	Yes	Yes	Yes	Yes	Yes (Elkhorn Slough)	Yes	Yes	Yes
Salinas River @ Hwy. 1	No data	No data	Yes	Yes	Yes	No	Yes (Elkhorn Slough)	No	No	Yes
Salinas River @ Davis Rd.	Yes	Yes	Yes	Yes	No	Yes	Yes (Elkhorn Slough)	No	Yes	Yes
Salinas River @ Spreckels	No data	No data	No	No	No	No	No	No	No	No - based on DO and algal biomass problems not being expressed
Salinas River @ Chualar	No data	No data	No	Yes	No	No	No (no biostim observed at Salinas Riv. @ Spreckels)	No	No	No - based on DO and algal biomass problems not being expressed
Salinas River @ Gonzalez	No data	No data	No	Yes	No	No	No (no biostim observed at Salinas Riv. @ Spreckels)	No	No	No - based on DO and algal biomass problems not being expressed
Tembladero Slough @ Molera	No	No	No	Yes	Yes	No data	Yes	Yes	Yes	No – based on DO problems not being expressed; however, downstream nutrient impacts to Elkhorn Slough are present
Tembladero Slough @ Preston Rd	No	No	Yes	Yes	Yes	No data	Yes (Elkhorn Slough)	Yes	Yes	Yes

Stream Reach	DO Problems			Nutrient Enrichment	Elevated Algal Biomass		Other indicators of Biostimulatory problems			Biostimulatory Impairment in Stream Reach?
	Wide Diel DO Swings	Pre-dawn DO crashes	Low DO and/or DO supersaturation	NO3-N exceeding reference conditions; or orthophosphate-P exceeding reference conditions	Chlorophyll a exceeding reference conditions	Excess floating algal cover (≥50% cover)	Downstream nutrient impacts to waterbody exhibiting biostimulation	Reported fish kills likely or possibly linked to DO problems	Photo documentation of excessive algal biomass	
Tembladero Slough @ Haro Rd	No data	No data	Yes	Yes	No	No	Yes (Elkhorn Slough)	Yes	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Elkhorn Slough are present
Merritt Ditch upstream of Hwy 183	No data	No data	Yes	Yes	No	Yes	Yes (Tembladero Slough and Elkhorn Slough)	No	No	Yes
Lower Reclamation Canal San Jon Rd. to Victor Rd.	Yes	Yes	Yes	Yes	Yes	Yes	Yes (Tembladero Slough and Elkhorn Slough)	Yes	Yes	Yes
Upper Reclamation Canal Airport Rd. to La Guardia	No data	Yes	Yes	Yes	Yes	Yes	Yes (Tembladero Slough and Elkhorn Slough)	No	Yes	Yes
Quail Creek Hwy 101 to Potter Rd.	No data	No	No	Yes	No	Yes	No (biostimulation not present in Salinas Riv. above Sprekels)	No	Yes	No- based on DO problems not being expressed
Chualar Creek River Road to Old Stage Rd. and unnamed tributary	No data	No data	No	Yes	No	No	No (biostimulation not present in Salinas Riv. above Sprekels)	No	No	No- based on DO and algal biomass problems not being expressed
Esperanza Creek Old Stage Rd. to Hwy. 101	No data	No data	No data	Yes	No data	No data	No	No	No	No- based on lack of evidence of DO or algal biomass problems
Blanco Drain @ pump	No data	No data	No	Yes	No	Yes	Yes (Salinas River below Spreckels)	No	Yes	No – based on DO problems not being expressed; however, downstream nutrient impacts to Salinas River below

Stream Reach	DO Problems			Nutrient Enrichment	Elevated Algal Biomass		Other indicators of Biostimulatory problems			Biostimulatory Impairment in Stream Reach?
	Wide Diel DO Swings	Pre-dawn DO crashes	Low DO and/or DO supersaturation	NO3-N exceeding reference conditions; or orthophosphate-P exceeding reference conditions	Chlorophyll a exceeding reference conditions	Excess floating algal cover (≥50% cover)	Downstream nutrient impacts to waterbody exhibiting biostimulation	Reported fish kills likely or possibly linked to DO problems	Photo documentation of excessive algal biomass	
										Spreckels are present
Espinosa Slough @ site 309ESP	No data	No data	Yes	Yes	No	No	Yes (lower Reclamation Canal)	No	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present
AlisalSlough @ White Barn	No data	No data	No	Yes	No	No	Yes (lower Reclamation Canal-Tembladero Slough)	No	No	No – based on DO and algal biomass problems not being expressed; however, downstream nutrient impacts to the Tembladero Slough are present
Santa Rita Creek @ Santa Rita park	No data	No data	Yes	Yes	Yes	No	Yes (lower Reclamation Canal)	No	Yes	Yes
Gabilan Creek @ Boronda Rd.	No data	No data	Yes	Yes	No	No	Yes (lower Reclamation Canal)	No	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present
Natividad Creek - Las Casitas to Boronda Rd.	No data	No data	Yes (median DO saturation below Basin Plan objective)	Yes	No	No	Yes (lower Reclamation Canal)	No	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present

Stream Reach	DO Problems			Nutrient Enrichment	Elevated Algal Biomass		Other indicators of Biostimulatory problems			Biostimulatory Impairment in Stream Reach?
	Wide Diel DO Swings	Pre-dawn DO crashes	Low DO and/or DO supersaturation	NO3-N exceeding reference conditions; or orthophosphate-P exceeding reference conditions	Chlorophyll a exceeding reference conditions	Excess floating algal cover (≥50% cover)	Downstream nutrient impacts to waterbody exhibiting biostimulation	Reported fish kills likely or possibly linked to DO problems	Photo documentation of excessive algal biomass	
Alisal Creek - Hartnell and Boronda Rds.	No data	No data	No	Yes	Yes	No data	Yes (lower Reclamation Canal)	No	Yes	No – based on DO problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present
Moro Cojo Slough, sites 306MORMLN, 306MOR, 306-MOROC-32	No data	No data	Yes	Yes (orthophosphate exceeding reference conditions)	No	Yes	Yes (Elkhorn Slough)	No	Yes	Yes

3.11 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[85]. 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.

For example, Gabilan Creek does not appear to be currently exhibiting a range of biostimulation indicators, however Gabilan Creek has high nutrient concentrations and is discharging these nutrient loads to the Reclamation Canal – the Reclamation Canal does indeed show sustained indicators of biostimulation. Further, TMDL project area waterbodies ultimately drain into Moss Landing Harbor, Elkhorn Slough estuary, and ultimately Monterey Bay (refer back to Figure 1-2). Tidal forces in the estuary cause mixing and dispersion of the freshwater-inputs and nutrient loads originating from the Old Salinas River and Tembladero Slough (Jannasch et al., 2008).

As such, Elkhorn Slough estuary and Monterey Bay represent the coastal confluence receiving waters for TMDL project area streams. It is important to recognize that these downstream receiving waters are managed as sensitive ecological areas and accordingly have been designated as National and State Marine Protection Areas (see Figure 3-24). National Marine Protected Areas have legally established goals and conservation objectives. The Marine Protected Areas shown in Figure 3-24 are classified as Natural Heritage areas, and are thus established and managed wholly or in part to sustain, conserve, and restore the protected area's natural biodiversity, populations, habitats, and ecosystems6. The conservation focus and level of protection established for marine protected areas in the Elkhorn Slough area is summarized in Table 3-6.

Therefore, it is important to be cognizant that pollutant loads from TMDL project area streams are discharging into coastal confluence waterbodies that are formally recognized and managed as sensitive ecological receiving waters.

[85] 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."*

Figure 3-50. Elkhorn Slough - National Marine Protected Areas.

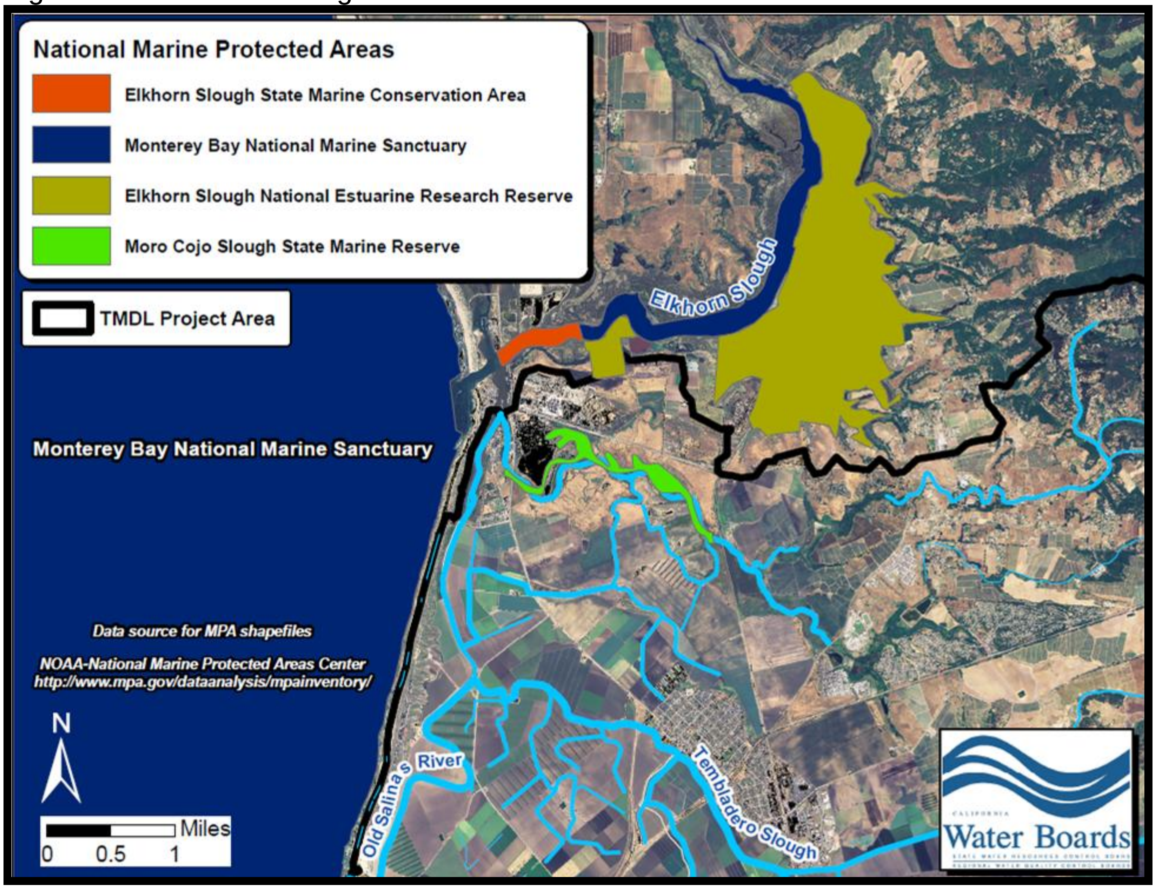


Table 3-26. Elkhorn Slough-area MPAs - conservation focus and level of protection established.

MPA Site Name	Primary Conservation Focus	Scale of Protection	Classifications and Definitions for U.S. Marine Protected Areas
Elkhorn Slough State Marine Reserve	Natural Heritage	Ecosystem	**Natural Heritage**: *MPAs or zones established and managed wholly or in part to sustain, conserve, restore, and understand the protected area's natural biodiversity, populations, communities, habitats, and ecosystems; the ecological and physical processes upon which they depend; and, the ecological services, human uses and values they provide to this and future generations.* **Ecosystem**: *MPAs or zones whose legal authorities and management measures are intended to protect all of the components and processes of the ecosystem within its boundaries.*
Moro Cojo Slough State Marine Reserve	Natural Heritage	Ecosystem	
Monterey Bay National Marine Sanctuary	Natural Heritage	Ecosystem	
Elkhorn Slough National Estuarine Research Reserve	Natural Heritage	Ecosystem	
Elkhorn Slough State Marine Conservation Area	Natural Heritage	Ecosystem	

Source: National Oceanic and Atmospheric Administration http://www.mpa.gov/

3.11.1 Surface water inflows to Elkhorn Slough

The magnitude and scope of freshwater surface water inflows to Elkhorn Slough estuary from the TMDL project area are important to consider in terms of assessing the overall nutrient loading risk to the slough from the project area.

Figure 3-25 illustrates the magnitude of freshwater surface inflows (on a mean annual acre-feet volumetric basis) into Elkhorn Slough estuary from its major freshwater tributaries. These inflows are estimated from the NHDplus hydrologic attribute dataset, which provides estimates of mean annual flow (mean annual cubic feet per second) for NHD flow lines. Mean annual flow in cubic feet per second can be converted to mean annual discharge in acre-feet using appropriate conversion factors. It is important to note that contributions to the overall water budget of Elkhorn Slough estuary via baseflow, precipitation, and tidal influx are not accounted for. However, the NHDplus estimated surface fresh water inflows appear to indicate that the largest fraction of freshwater surface inflows into Elkhorn Slough estuary and Moss Landing Harbor originate from Tembladero Slough and the Old Salinas River. This observation is consistent with reporting from the Monterey Bay Aquarium Research Institute (MBARI) – see Figure 3-26.

It should be noted that there are seasonal and spatial variability in surface water inflows to the Elkhorn Slough estuary and Moss Landing Harbor from the TMDL project area. For example estimated dry season inflows to Moss Landing Harbor are largely attributable to the Tembladero Slough drainage system (refer back to Section 2.5), while during the wet season, flows in the Old Salinas River channel originating from the Salinas River Lagoon is estimated to be the larger contributor of surface water inflows to Moss Landing Harbor .

Figure 3-51. Elkhorn Slough, estimated surface water inflows.

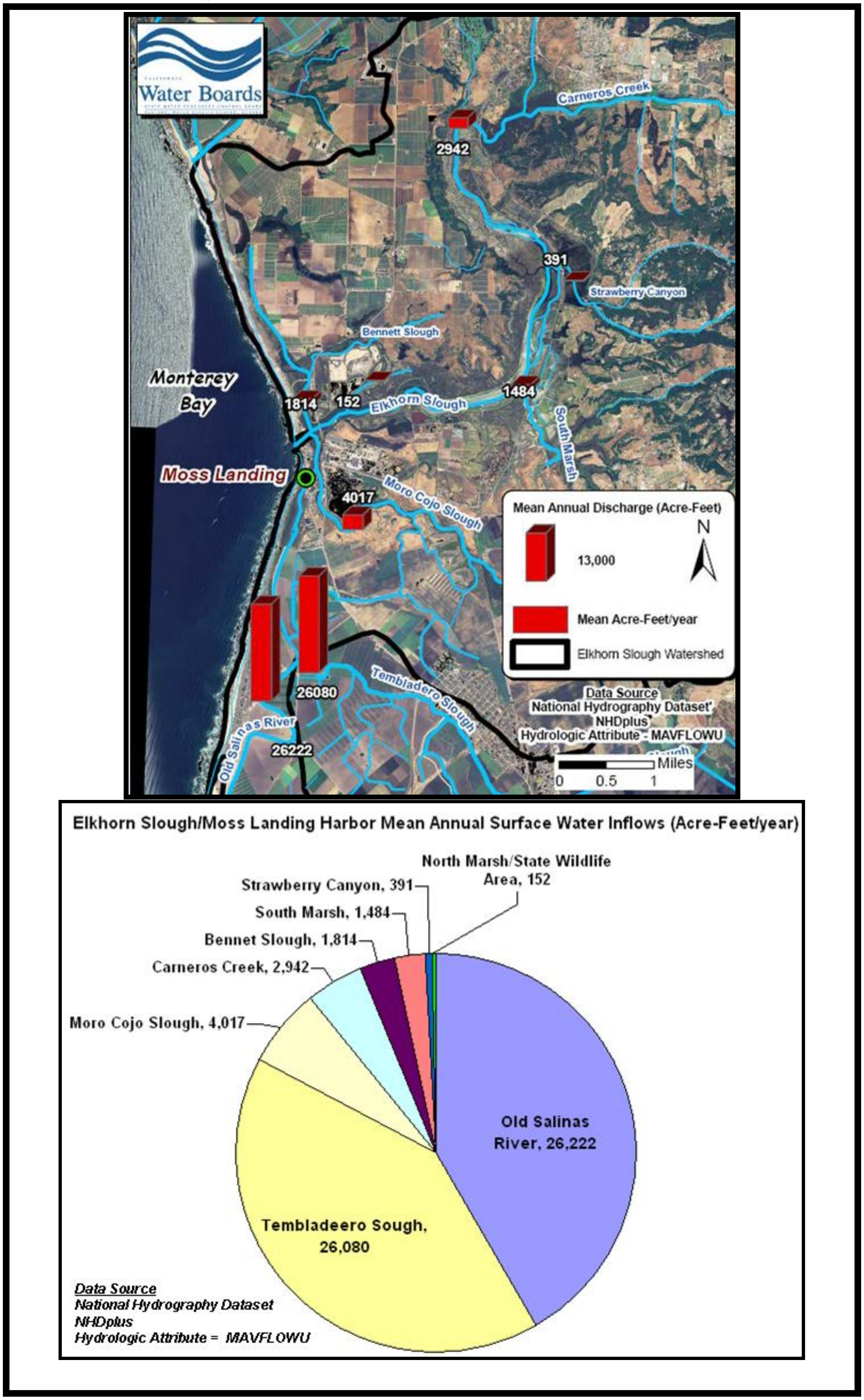
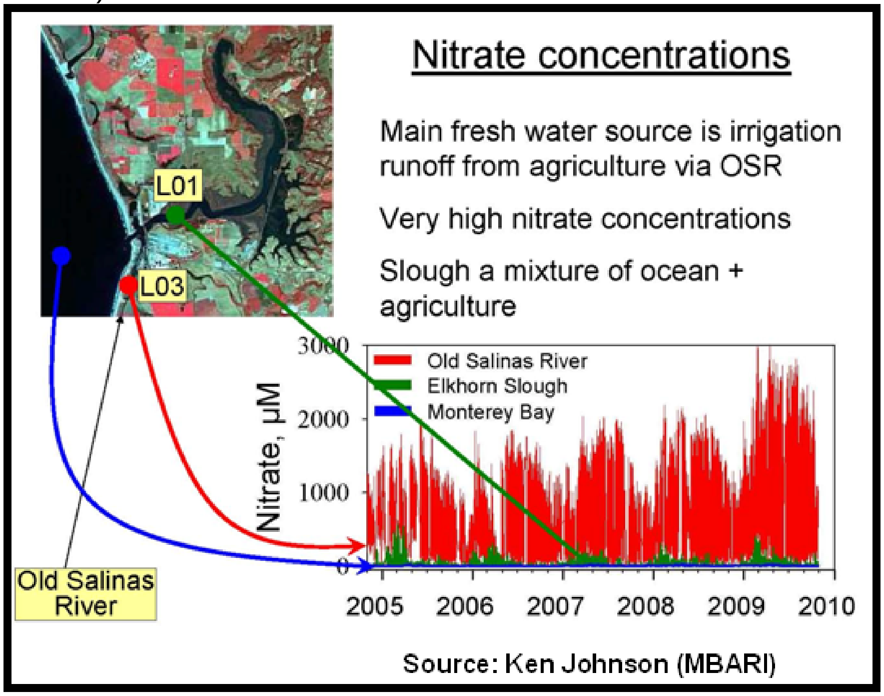


Figure 3-52. Freshwater nitrate inputs to Elkhorn Slough (data and figure from: Ken Johnson MBARI).



3.11.2 Biostimulatory Conditions in Elkhorn Slough

A significant body of scientific research and assessments of Elkhorn Slough have been conducted in recent years to evaluate the nature and scale of biostimulation and associated eutrophic effects in the waterbody.

Recent research has focused on refined spatial and temporal assessments of eutrophication in Elkhorn Slough, and the water quality impairments that have resulted from intense nutrient loading in the last few decades (Chapin et al, 2004; Schaadt, 2005; Caffrey et al., 2007; Guenni et al., 2008; Jannasch et. al., 2008; Johnson, 2008. Hughes, 2009; Hughes et al, 2010). Elkhorn Slough researchers over the past decade have observed high phytoplankton concentrations, abundant and persistent macroalgal mats, elevated unionized ammonia, and hypoxia events likely due to elevated dissolved nutrient concentrations. The body of research indicates that biostimulation is widespread in Elkhorn Slough.

The National Estuarine Eutrophication Assessment Update (NEEA, 2007) provided summary assessments for eutrophication issues in Elkhorn Slough. NEEA concluded in the 2007 assessment that Elkhorn Slough was exhibiting moderate eutrophic conditions with high primary symptoms (chlorophyll a and macroalgae), but more serious secondary symptoms (dissolved oxygen problems, nuisance/toxic blooms) still not being expressed. NEEA also concluded that nutrient-related symptoms in the estuary are likely to substantially worsen in the future. It should be noted that the 2007 NEEA assessment was not a comprehensive survey, reportedly focused on the main channel areas and did not asses dissolved oxygen impairments. However, as noted previously, more recent research has provided more refined spatial and temporal assessments indicating more widespread eutrophication problems in the slough.

The California Department of Fish and Game (DFG), in a letter to the Water Board dated May 21, 2009, stated:

> *"The poor water quality in Elkhorn Slough has produced highly eutrophic conditions that have the potential to harm local fauna. The negative consequences of eutrophication in estuarine environments causes much concern because it can increase primary productivity, leading to increases in benthic oxygen demand that can cause diel crashes in dissolved oxygen. This crash in dissolved oxygen has deleterious effects to species such as clams, sharks, rays, and bottom fish. Crashes in dissolved oxygen can also lead to trophic collapses because habitat of prey items becomes limited due to hypoxic conditions. Elkhorn Slough has a rich assemblage of marine mammals, fish, invertebrates, and shorebirds that are impacted by poor water quality."*
>
> *(California Department of Fish and Game, letter to Water Board dated May 21, 2009, from Jeffrey R. Single, Ph.D., Regional Manager-California Dept. of Fish and Game)*

As reported by Hughes et al., 2011 (in press), it should be noted that Elkhorn Slough is a complex estuarine system and not all locations have the same biostimulation signature (see Figure 3-53). The most important factor in differences in eutrophic conditions is reportedly due to residence time. Residence time is in large part related to tidal range in most areas. Parts of the slough exhibiting low to moderate eutrophic scores are in the main channel of Elkhorn Slough which are subject to unrestricted tidal exchange. Sites characterized by a restricted tidal range, and thus characterized by high residence times, tend to exhibit high-eutrophic to hyper-eutrophic expressions (Hughes et al, 2011, in press).

Figure 3-53. Eutrophic expressions in Elkhorn Slough (figure from Hughes et al., 2011).

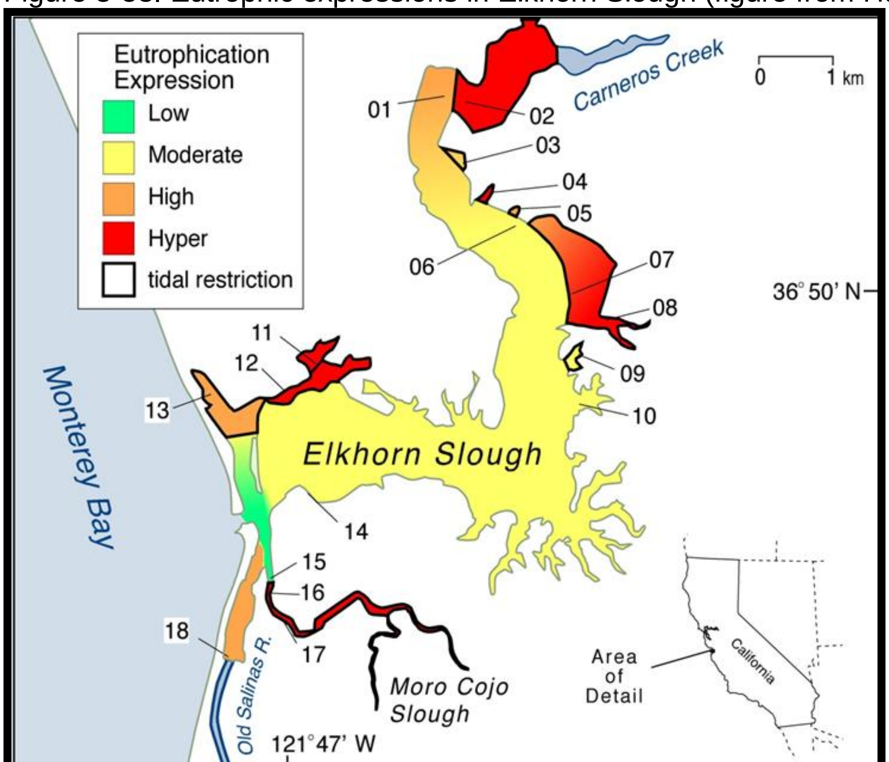
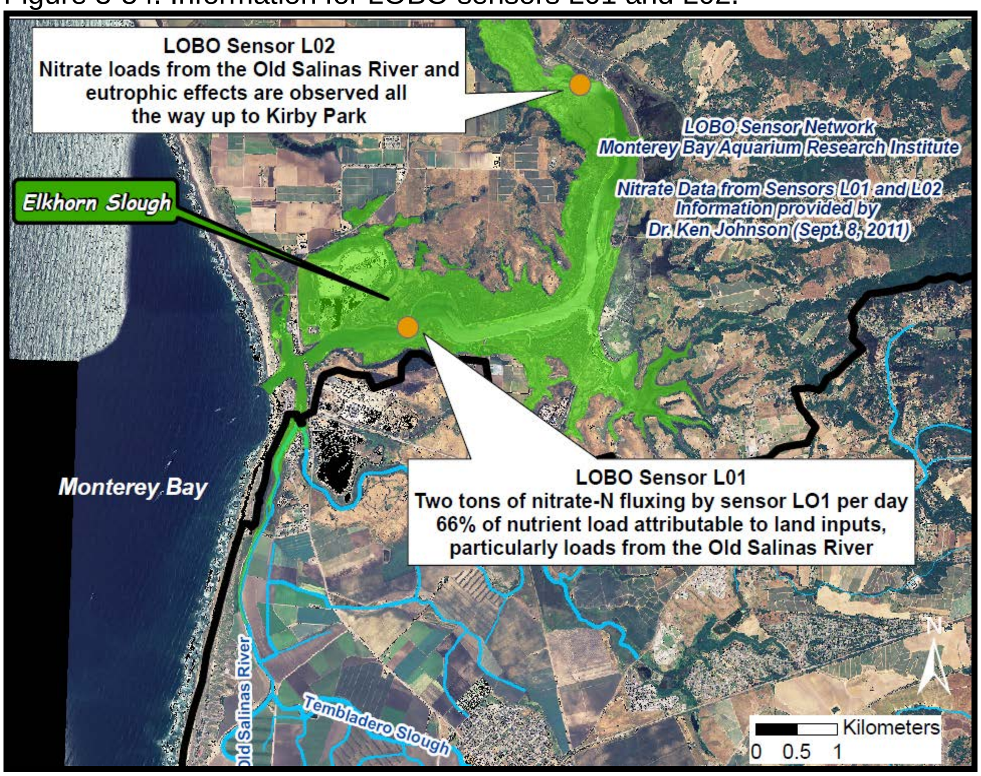


Figure from. Hughes, B, J. Haskins, K. Wasson, E. Watson. 2011 "Identifying factors that influence expression in a central California estuary" (in press, Marine Ecology Progress Series doi: 10.3354/meps09295).

In recent years, monitoring networks and sensor platforms in the Elkhorn Slough estuary providing real-time and continuous data of a range of water quality parameters have allowed researchers to identify biogeochemical and pollutant-loading processes that were previously unrecognized in years past. These data have reportedly established with a high degree of scientific certainty, that the Old Salinas River (and its tributary Tembladero Slough), which intersects the Elkhorn Slough estuary at Moss Landing Harbor, is the main source of nitrate transported into the slough (Jannasch et al, 2008), and that transport of nitrate into the slough is strongly influenced by tidal cycles (for example, see Figure 3-54). Dr. Ken Johnson, senior scientist at the Monterey Bay Aquarium Research Institute (MBARI)[86], reports substantial nitrate loads from the Old Salinas River are being pushed by tidal cycles up into the middle-upper reaches of the slough, as indicated by the LOBO[87] water column sensor at Kirby Park (personal communication, Dr. Ken Johnson, Sept. 11, 2011). Also noteworthy is that LOBO sensor L03 located at the Old Salinas River (OSR) estuary indicates decreasing nitrate water column concentrations coming from the OSR channel during the years 2010 and 2011. While definitive conclusions cannot be drawn about the nature of the recent apparent drop in nitrate loads in the OSR, Staff speculates that it may be partially attributable to operation of the Salinas River Diversion Facility (refer to Section 7.13.8).

Figure 3-54. Information for LOBO sensors L01 and L02.



Based on the aforementioned information, Staff finds that the body of scientific research, and the broad scientific consensus of estuarine researchers and scientists affiliated with the National Oceanic and Atmospheric Administration, Monterey Bay Aquarium Research Institute, California Department of Fish and Game, and the Elkhorn Slough National Estuarine Research Reserve is

[86] MBARI is a private, non-profit research center funded by the David and Lucile Packard Foundation. The institute is comprised of 220 scientists, engineers, and administrative staff. The mission of MBARI is to conduct world-class research and education in ocean sciences and technology.

[87] The LOBO (Land/Ocean Biogeochemical Observatory) network is part of the Monterey Bay Aquarium Research Institute's moored data network in Monterey Bay.

that 1) Elkhorn Slough is expressing moderate eutrophic conditions (locally hyper-eutrohphic) and these conditions are expected to worsen over time; 2) Elkhorn Slough has been subject to intensive and increasing nutrient loading (primarily from the lower Salinas valley); and 3) while eutrophication is indeed a function of many factors (including tidal range and residence time) nutrient loads are contributing to excessive primary production of algal biomass and hypoxic conditions in the slough which can and will lead to an overall loss in biodiversity.

In summary, consistent with TMDL technical guidance from USEPA, due to the scope and magnitude of surface water inflows into Moss Landing Harbor and Elkhorn Slough estuary from the TMDL project area, this project report will take into consideration biostimulatory effects in Elkhorn Slough estuary that are attributable in part to nutrient-rich surface water inflows from the project area,

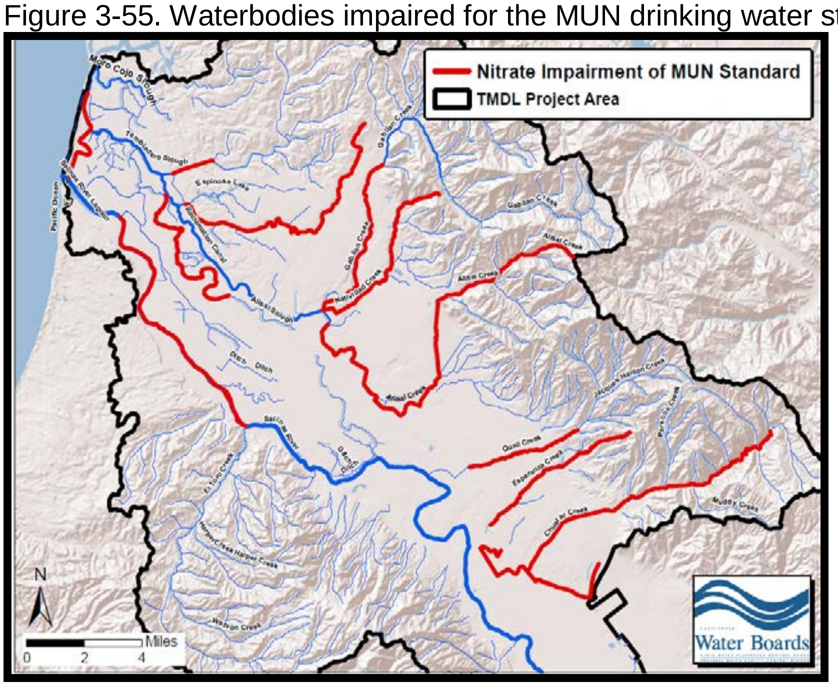
3.12 Summary of Nutrient-Related Impairments Addressed in this TMDL

The standards and water quality objectives that are being used to assess water quality conditions are contained in the Basin Plan for nitrate, un-ionized ammonia, and low dissolved oxygen and were previously presented in Table 3-2. Summary statistics of water quality parameters and exceedance frequencies as compared to numeric water quality objectives were previously presented in Section 3.7.6. Consequently, these exceedance frequencies are compared to the guidelines in the California Listing Policy (refer back to Section 3.5) 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 3.10.

3.12.1 Nitrate (Impairment of MUN)

Figure 3-55 illustrates the spatial distribution of MUN-designated stream reaches impaired for the nitrate as N drinking water standard (MUN).

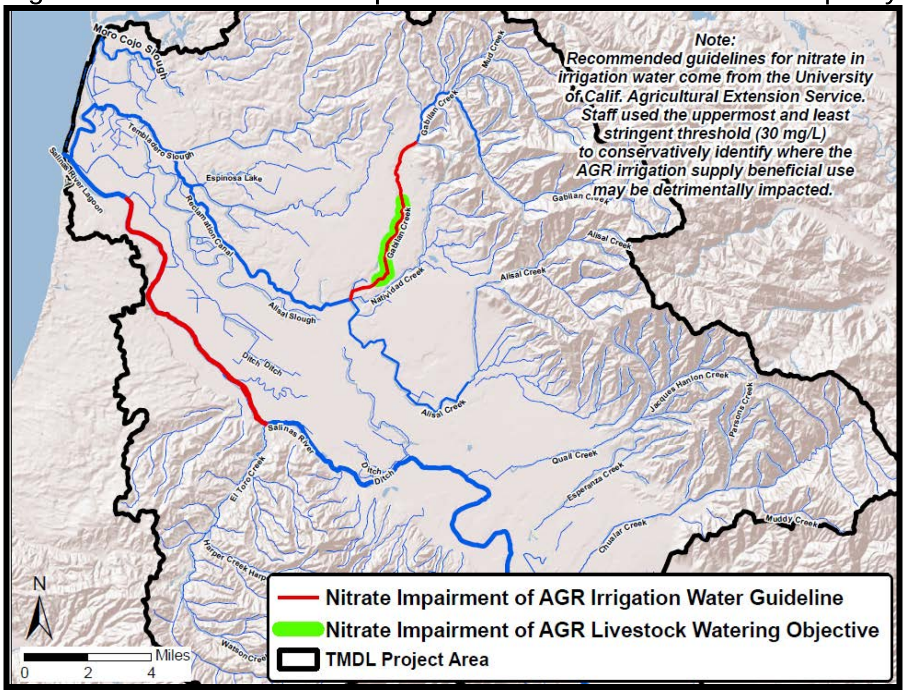
Figure 3-55. Waterbodies impaired for the MUN drinking water standard.



3.12.2 Nitrate (Impairment AGR Criteria)

Figure 3-56 illustrates the spatial distribution of AGR-designated stream reaches impaired for the nitrate as N agricultural supply (irrigation water and livestock watering) criterion (AGR).

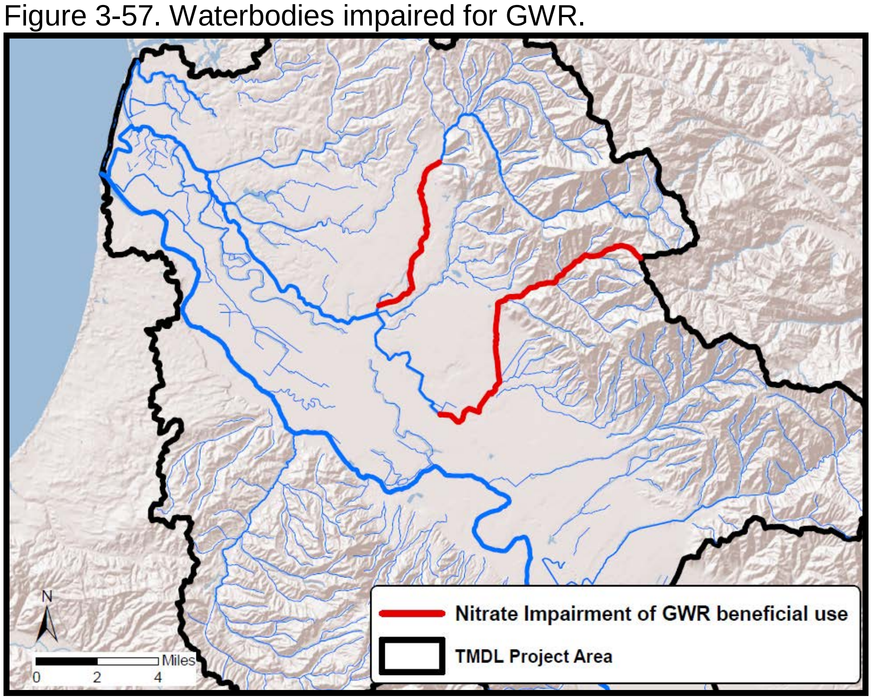
Figure 3-56. Waterbodies impaired on the basis of AGR water quality criterion.



3.12.1 Nitrate (Impairment of GWR)

Figure 3-57 illustrates the spatial distribution of impairments of the groundwater recharge beneficial uses for streams designated for GWR *(also refer back to Table 3-14)*.

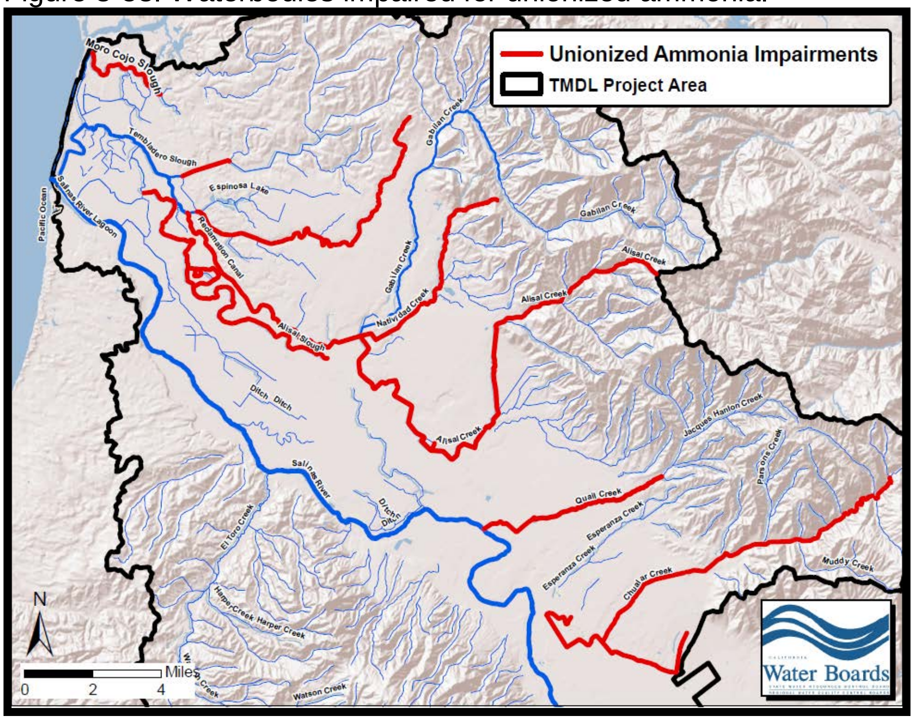
Figure 3-57. Waterbodies impaired for GWR.



3.12.2 Unionized Ammonia (Toxicity)

Figure 3-58 illustrates the spatial distribution of stream reaches impaired for unionized ammonia.

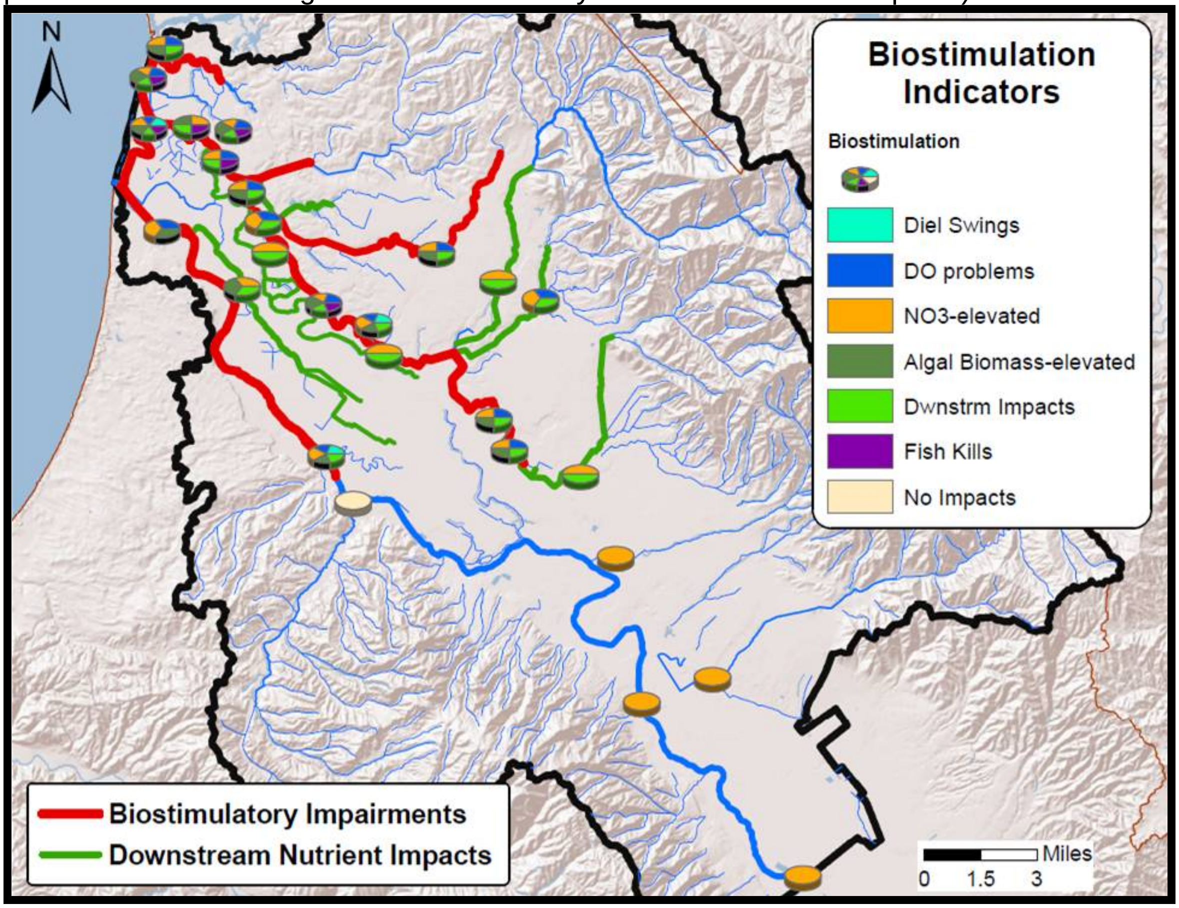
Figure 3-58. Waterbodies impaired for unionized ammonia.



3.12.3 Biostimulatory Impairments (nutrients, chlorophyll-a, microcystins & low DO)

Figure 3-59 illustrates the spatial distribution of biostimulatory impairments in the project area based on the range on biostimulation indicators previously presented in Section 3.10 and the biostimulation assessment matrix (refer back to Table 3-25).

Figure 3-59. Stream reaches exhibiting biostimulatory impairments: (elevated nutrients + DO problems + elevated algal biomass + microcystins + downstream impacts).



3.12.4 Tabular Summaries of All Identified Impairments

Table 3-27 presents a status summary of potential impairments of designated beneficial uses of surface waters in the TMDL project area. Table 3-28 presents all waterbody/pollutant combinations addressed in this TMDL. 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, Water Board policy 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 TMDL project area, as shown in Table 3-28.

Table 3-27. Status summary of project area surface water designated beneficial uses 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 (NO3-N)	Yes	Lower Salinas River (downstream of Spreckels), Old Salinas River, Merrit Ditch, Alisal Slough, Santa Rita Creek, Gabilan Creek, Natividad Creek, Alisal Creek, Quail Creek, Esperanza Creek, Chualar Creek (See Table 3-28 or refer to Figure 3-55)
AGR (irrigation water supply)	30 mg/L (NO3-N) *(for sensitive crops)*	Yes[C]	Salinas River *Downstream of Spreckels (Site 309SSP) to Lagoon* Gabilan Creek *Downstream of Crazy Horse Rd. to Veterans Park Bridge* *(refer back to Table 3-14 or refer to Figure 3-56)*
AGR (livestock watering)	100 mg/L (NO3-N)	Yes	Gabilan Creek *Downstream of Natividad Rd. to Veterans Park bridge* *(refer back to Table 3-14 or refer to Figure 3-56)*
GWR (groundwater recharge)	10 mg/L (NO3-N) in conjunction with situation specific lines of evidence [D]	Yes	Gabilan Creek *All reaches downstream of Crazy Horse Road* Alisal Creek *All Reaches*
Aquatic Habitat beneficial uses (WARM, COLD, SPWN)	Biostimulatory substances objective & Unionized ammonia objective (0.025 mg/L)	Yes[E]	Lower Salinas River, Blanco Drain, Moro Cojo Slough, Old Salinas River, Tembladero Slough, Merrit Ditch, Reclamation Canal, Espinosa Slough, Santa Rita, Gabilan Creek, Natividad Creek, Alisal Creek, Alisal Slough (See Table 3-28)
REC-1 (water contact recreation)	Basin Plan toxicity objective algal toxins 0.8 µg/L microcystins	Yes[F]	Old Salinas River *All Reaches* *Only Old Salinas River, Salinas River Lagoon, Tembladero Slough and Lower Salinas River have been assessed at this time*

[A] Refer to Table 3-2 and Table 3-24.
[B] Based on exceedance frequencies in California 303(d) Listing Policy - see Table 3-3
[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 3.7.5 and the California Listing Policy Section 3.11 (SWRCB, 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] Limited amounts of microcystin data are currently available for the lower Salinas River, Salinas River lagoon, Old Salinas River, and Tembladero Slough.

Table 3-28. Tabular summary of waterbody impairments addressed in this TMDL.

		Unionized Ammonia		Nitrate (Impairment of MUN Standard)		Impairment by Biostimulatory Substances[A, B]		303(d) List Information	
Water Body Name	Waterbody Identification (WBID)	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Currently Listed on 303(d) List?	Impairments and 303(d) Listing(s) **Addressed in this TMDL? (no. of impairments addressed)**
Lower Salinas River	CAR3091101020021007193102	No	-	Yes	Spreckels (downstream of mon. site 309SSP) to Salinas River Lagoon	Yes	Spreckels (downstream of mon. site 309SSP) to Salinas River Lagoon	Yes, for Nitrate (biostim)	Yes (1)
Old Salinas River	CAR3091101020080611145518	No	-	Yes	All reaches	Yes *(includes microcystin impairment of Old Salinas River)*	All reaches	Yes, for Nitrate (biostim) Yes, for Chlorophyll a Yes, for low dissolved oxygen No, for microcystins	Yes, nitrate, chlorphyll a, low dissolved oxygen Microcytin impairment herin is identified on the basis of the 303(d) listing policy, this impairment is anticipated to be added to the 303(d) list in the next listing cycle. (4)
Salinas River Lagoon (north)	CAE3091101019980828143232					Yes	All reaches	Yes, for Nitrate (biostim)	Yes (1)
Moro Cojo Slough	CAE3060001519981209132246	Yes	All reaches	No	-	Yes	All reaches	Yes, for low dissolved oxygen Yes, for unionized ammonia	Yes (2)
Tembladero Slough	CAR3091101019981209131830	No	-	No	-	Yes	All reaches	Yes, for Nitrate (biostim) Yes, for Nutrients Yes, for Chlorophyll a	Yes (3)
Merrit Ditch	CAR3091101020080604152147	Yes	All reaches	Yes	All reaches	Yes	All reaches	Yes, for Nitrate (biostim) Yes, for low dissolved oxygen Yes, for unionized ammonia	Yes (3)
Reclamation Canal	CAR3091101019980828112229	Yes	All reaches	No	-	Yes	All reaches	Yes, for Nitrate (biostim) Yes, for low dissolved oxygen Yes, for unionized ammonia	Yes (3)
Alisal Slough	CAR3091101020090311204028	Yes	All reaches	Yes	All reaches	Yes	All reaches	Yes, for Nitrate (biostim) Yes, for low dissolved oxygen No, for unionized ammonia	Yes (3)

		Unionized Ammonia		Nitrate (Impairment of MUN Standard)		Impairment by Biostimulatory Substances[A, B]		303(d) List Information	
Water Body Name	Waterbody Identification (WBID)	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Currently Listed on 303(d) List?	Impairments and 303(d) Listing(s) **Addressed in this TMDL? (no. of impairments addressed)**
Blanco Drain	CAR3091101019981209161509	No	-	No	-	Yes	All reaches	Yes, for Nitrate (biostim) Yes, for low dissolved oxygen	Yes (2)
Espinosa Slough	CAR3091101019981230135152	No	-	No	-	Yes	All reaches	Yes, for Nitrate Yes, for unionized ammonia	Yes (2)
Santa Rita Creek	CAR3091900020060731111350	Yes	All reaches	Yes	All reaches	Yes	All reaches	Yes, for Nitrate Yes, for low dissolved oxygen Yes, for unionized ammonia	Yes (3)
Gabilan Creek	CAR3091900019990304092345	No	-	Yes	Downstream of Crazy Horse Rd to confluence w/ Rec Canal	Yes	Downstream of Crazy Horse Rd to confluence w/ Rec Canal	Yes, for Nitrate Yes, for unionized ammonia Note that data in this report does not indicate unionized ammonia impairment.	Yes (2)
Natividad Creek	CAR3091101020050531125140	Yes	All reaches	Yes	All reaches	Yes	All reaches	Yes, for Nitrate (biostim) Yes, for low dissolved oxygen Yes, for unionized ammonia	Yes (3)
Alisal Creek	CAR3097009519990222130537	Yes	All reaches	Yes	All reaches	Yes	All reaches	Yes, for Nitrate (biostim) Yes, for Chlorophyll a No, for unionized ammonia	Yes (3)
Quail Creek	CAR3091900020011227140647	Yes	Downstream of Old Stage Rd. to confluence w/ Salinas River	Yes	All reaches	No	-	Yes, for Nitrate Yes, for low dissolved oxygen Yes, for unionized ammonia	Yes: Note that newer vintage data does not indicate DO impairment (3)
Esperanza Creek	CAR3091101020080604161515	No data	-	Yes	All reaches	No	-	Yes, for Nitrate	Yes (1)
Chualar Creek including Chualar Creek South Branch	CAR3091900020080604161337	Yes	All reaches	Yes	Downstream of Chualar Canyon Rd. crossing (site CHUCCR) to confluence w/ Salinas River	No	-	Yes, for Nitrate Yes, for unionized ammonia	Yes (2)

		Unionized Ammonia		Nitrate (Impairment of MUN Standard)		Impairment by Biostimulatory Substances[A, B]		303(d) List Information	
Water Body Name	Waterbody Identification (WBID)	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Impaired?	Impaired Reach	Currently Listed on 303(d) List?	Impairments and 303(d) Listing(s) **Addressed in this TMDL? (no. of impairments addressed)**
Total Water Body/Pollutant Combinations addressed in this TMDL								**41**	

[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 project report

3.13 Problem Statement

Discharges of nitrogen compounds and orthophosphate are occurring at levels in surface waters which are impairing a wide spectrum of beneficial uses and, therefore, constitute a serious water quality problem. The municipal and domestic drinking water supply (MUN, GWR) beneficial uses and the range of aquatic habitat beneficial uses are currently impaired; additionally, locally some waterbodies do not meet non-regulatory recommended guidelines for nitrate in agricultural supply water for sensitive crops indicating that potential or future designated agricultural supply beneficial uses may be detrimentally impacted (refer back to Basin Plan water quality objectives in Table 3-2). A total of 34 waterbody/pollutant combinations are impaired due to exceedances of water quality objectives. 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 TMDL project area.

As a result of these conditions, beneficial uses are not being protected. By developing TMDLs for the aforementioned pollutants, the water quality standards violations being addressed in this TMDL include:

- Violations of drinking water standard for nitrate
- Violations of the Basin Plan general toxicity objective for inland surface waters and estuaries (violations of un-ionized ammonia objective)
- Violations of the Basin Plan narrative general objective for biostimulatory substances in inland surface waters and estuaries (as expressed by excessive nutrients, chlorophyll a, algal biomass, and low dissolved oxygen)

The proposed TMDLs would protect and restore the municipal and domestic water supply beneficial use (MUN) and aquatic habitat beneficial uses currently being degraded by violations of the toxicity objective, and the biostimulatory substances objective including the following beneficial uses: wildlife habitat (WILD), cold fresh water habitat (COLD), warm fresh water habitat (WARM), migration of aquatic organisms (MIGR), spawning, reproduction, and/or early development (SPWN), preservation of biological habitats of special significance (BIOL), and rare, threatened, or endangered species (RARE). In addition, current or potential future beneficial uses of the agricultural water supply beneficial use (AGR) are not being supported. Nitrates can create problems not only for water supplies and aquatic habitat, but also potentially for nitrogen sensitive crops (grapes, avocado, citrus[88]) by detrimentally impacting crop yield or quality. Nitrogen in the irrigation water acts the same as fertilizer nitrogen and excesses will cause problems just as fertilizer excesses cause problems. Basin Plan water quality guidelines protective of nitrogen sensitive crops and the AGR beneficial use were previously identified in Table 3-2.

For waterbodies that are not expressing biostimulatory impairments, the most stringent relevant water quality objective for nitrate (and therefore the one that is protective of the full range of all nitrate-impaired designated beneficial uses) is the numeric Basin Plan objective for nitrate in

[88] Source: Natural Resources Conservation Service, U.S. Department of Agriculture. "Irrigation Water Quality" http://www.nm.nrcs.usda.gov/technical/fotg/section-1/irrigation-guide/irrigation-water-quality.pdf and Ayers and Scott (1994). Water Quality for Agriculture. In: United Nations Food and Agriculture Program. http://www.fao.org/DOCREP/003/T0234E/T0234E06.htm

municipal and domestic water supply. Reducing nitrate pollution and ultimately achieving the nitrate drinking water quality standard in these waterbodies will therefore restore and be protective of the full range of MUN, GWR and/or AGR designated beneficial uses of the surface waters which are being currently impaired by excess nitrate.

All waterbodies are required to attain the Basin Plan general toxicity objective for unionized ammonia in inland surface waters and estuaries.

For waterbodies that are expressing biostimulatory impairments, the most stringent relevant water quality objective for nitrate-nutrients (and therefore the one that is protective of the full range of all nutrient-impaired designated beneficial uses) is the Basin Plan narrative general objective for biostimulatory substances in inland surface waters and estuaries. These waterbodies must achieve concentration-based wasteload and load allocations for nitrate and orthophosphate as identified in Section 6.4. Reducing nutrient pollution and ultimately achieving the load allocations for nutrients in these waterbodies will therefore restore and be protective of the full range of Aquatic Habitat, MUN, GWR, and/or AGR designated beneficial uses of the surface waters which are being currently impaired by excess nutrients.

4 NUMERIC TARGETS

4.1 Target for Nitrate (MUN 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.*

4.2 Target for Unionized Ammonia

The Basin Plan contains numeric water quality objectives for un-ionized ammonia protective of the general toxicity objective 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.*

4.3 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 (SWRCB, 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 (SWRCB, 2011a). Therefore, in order to implement the Basin Plan's narrative objective for biostimulatory substances the Water Board is required 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." (SWRCB, 1999)*
>
> *-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[89,90]. 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).

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[89] 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.

[90] 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

Proposed numeric targets for biostimulatory substances are presented in Table 4-1. Appendix D contains all the data, assessments, and information used to derive numeric targets for biostimulatory substances. Staff followed 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 <u>when the stream physiography,</u> 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 (SWRCB, 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, 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 4.3.1 and Section 4.3.2. As noted previously, Appendix D 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:***
>
> ✓ <u>Using a combination of recognized approaches</u> (i.e., literature values, statistical approaches, predictive modeling approaches) result in criteria of greater scientific validity *(guidance source: USEPA, 2000a. Nutrient Criteria Guidance Manual*);
>
> ✓ <u>Classify and group streams</u> needing nutrient targets, based on similar characteristics *(guidance source: USEPA, 2000a. Nutrient Criteria Guidance Manual);*
>
> ✓ <u>Targets should not be lower</u> than expected concentrations found in background/natural conditions *(guidance source: California NNE Approach guidance – TetraTech, 2006).*

Staff provided TMDL project information and draft numeric targets for biostimulatory substances for review by public agencies and stakeholders during the Fall of 2011. In a letter from the

NOAA-National Marine Fisheries Service (NMFS) to Water Board staff dated Nov. 10, 2011, NMFS fisheries biologists indicated they supported the proposed biostimulatory numeric targets and the methodologies used to develop them. NMFS noted that targets could be adjusted in the future as new information is developed:

> *"NMFS reviewed the documents provided by the Central Coast Regional Water Quality Control Board (Water Board) during this scoping process and supports the preliminary target concentrations for biostimulatory substances as presented in the CEQA Scoping Meeting and Project Status Update report (Scoping Report, Water Board 2011). If these targets prove to be set incorrectly, they may be adjusted in the future as new information dictates."*
>
> *Steven A. Edmondson*
> *Southwest Regional Habitat Manager - Habitat Conservation Division*
> *National Oceanic and Atmospheric Administration – National Marine Fisheries Service*
> *Letter to Water Board Staff - Nov. 10, 2011*

In addition to using established and recognized methodologies in developing nutrient numeric water quality criteria, staff also submitted our technical analysis and approaches for independent scientific peer review by researchers with expertise in nutrient pollution and water quality issues. The following is a summary scientific peer review comment regarding the proposed nutrient targets received by Water Board staff:

> ***"On the whole, in my opinion the numeric targets strike a reasonable balance between being over- protective and under-protective.*** *Nutrient targets in surface waters (1.4-6.4 mg-N/L for nitrate; 0.07- 0.13 mg-P/L for orthophosphate) are around an order of magnitude above ambient background levels (e.g., ~0.15 mg-N/L for nitrate; ~0.07 mg-P/L for orthophosphate), but are around an order of magnitude below current typical levels in surface waters in Project Areas (~3-25 mg-N/L for nitrate; ~0.1-1 mg-P/L for orthophosphate).* ***This is a reasonable starting point****"**
>
> *- Dr. Marc Beutel, Associate Professor, Washington State University Department of Civil and Environmental Engineering - Scientific Peer Review: summary comment April 2012.*
>
> **emphasis added by Water Board staff*

Table 4-1. Numeric targets for biostimulatory substances (geomorphic classifications and soil properties data from NRCS-SSURGO – canopy cover from NLCD and field observation).

Waterbody Type	Geomorphology & Stream Characteristics	Project Area Stream Reaches	Allowable Nitrate-N (mg/L)	Allowable Orthophosphate-P (mg/L)	Methodology for Developing Numeric Target	Notes Pertaining to Development of Targets
Alluvial Valley River – flood plain	Alluvial valley river. Alluvial flood plain. Low ambient turbidity 13% average canopy cover; sandy substrate	Lower Salinas River – Spreckels to and including Salinas River Lagoon (north)	**1.4** **Dry Season Samples (May 1-Oct 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.07** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	Generally low ambient turbidity (5 NTU-25th percentile), sandy substrate, good sunlight penetration, low to moderate canopy cover indicates risk of biostimulation at relatively low concentrations of nutrients.
Lower Alluvial Valley streams and sloughs	Alluvial basin floor and alluvial floodplains; Moderate ambient turbidity; Muddy to earthen substrates and fine-grained soil conditions; almost no canopy cover	Tembladero Slough all reaches	**6.4** **Dry Season Samples (May 1-Oct 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.13** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	muddy and fine-grained substrates and local soil conditions result in relatively high ambient turbidity (30 NTU – 25th percentile) which precludes good sunlight penetration of water column; risk of biostimulation occurs at relatively higher nutrient concentrations.
		Blanco Drain all reaches				
		Merritt Ditch dwnstrm of Merritt Lake				
		Reclamation Canal downstream of Hartnell Rd. to confluence w/Tembladero Slough				
		Alisal Slough all reaches				
		Espinosa Slough from Espinosa lake to confluence with Reclamation Canal				
		Santa Rita Creek all reaches				
Upper alluvial Valley tributaries	Alluvial fans, alluvial plains and alluvial terraces, low to moderate ambient turbidity; generally silty or sandy substrates and soil conditions, canopy cover generally 20% or lower.	Gabilan Creek all reaches	**2.0** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.07** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	Relatively low ambient turbidity (<1 NTU-25th percentile), silty or sandy substrates and local soil conditions. Canopy cover generally 40% or less Sunlight penetration likely moderate. These stream reaches are currently not expressing a full range of biostimulatory indicators. They are however, discharging elevated nutrient loads to impaired downstream waterbodies. Nutrient targets protect against downstream impacts and against the risk of biostimulation in these stream reaches.
		Natividad Creek all reaches				
		Alisal Creek upstream of Hartnell Rd.				

Waterbody Type	Geomorphology & Stream Characteristics	Project Area Stream Reaches	Allowable Nitrate-N (mg/L)	Allowable Orthophosphate-P (mg/L)	Methodology for Developing Numeric Target	Notes Pertaining to Development of Targets
Old Salinas River	Coastal flood plain and tidal flats Moderately high ambient turbidity, minimal canopy cover.	Old Salinas River from slide gate infow @ Salinas River Lagoon to Old Salinas River at Potrero Rd.	**3.1** **Dry Season Samples (May 1-Oct. 31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.07** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	muddy and fine-grained substrates and local soil conditions result in relatively high ambient turbidity (30 NTU – 25th percentile) which precludes good sunlight penetration of water column; risk of biostimulation occurs at relatively higher nutrient concentrations.
			Allowable Total Nitrogen-N (mg/L)			
Moro Cojo Slough	Tidal Flats. Low ambient turbidity, minimal canopy cover	Moro Cojo Slough, all reaches	**1.7** **(TOTAL NITROGEN)** **Dry Season Samples (May 1-Oct. 31)** **8.0** **(TOTAL NITROGEN)** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.13** **Dry Season (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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	Generally low ambient turbidity (4 NTU), good sunlight penetration, low canopy cover indicates risk of biostimulation at low concentrations of nutrients. Note that **Nitrate-N is likely only a small fraction of total N** in the water column at site 306MOR, likely due to elevated biological uptake of NO3 in tidal flat-estuarine environment and sequestration of N in biomass and other phases

4.3.1 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 4-2 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 D)

Table 4-2. 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 TMDL project area – 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 working on developing nutrient criteria in the Pajaro River watershed, to the north of the TMDL project area, 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 (SWRCB, 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 project area monitoring programs do not collect or report total kjeldahl nitrogen (TKN) or total phosphorus (TP), and only report nitrate and nitrite, and orthophosphate. Particularly problematic is that, many of the major monitoring programs that are active in the TMDL project area have only been collection orthophosphate data and not total phosphorus data (e.g., Cooperative Monitoring Program, City of Salinas stormwater program, Elkhorn Slough National Estuary Research Reserve monitoring program etc.). 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. Of all forms of phosphorus water column data collected in the TMDL project area since 1999, only about 6% of those samples are for total phosphorus. Also, to the extent there is data for total phosphorus, most of the total phosphorus data was collected in years 2006-2007 which is inadequate for temporal representation. As such total nitrogen and total phosphorus values are generally not widely or consistently available.

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. Furthermore, nitrate typically comprises over 95% total water column nitrogen in agricultural inland surface streams of the lower Salinas Valley (see Figure 4-1). Presumably, nitrate comprises a lower ratio of total nitrogen in the water columns of coastal estuaries and lagoons in the central coast region because these are typically areas of relatively high primary productivity, and nitrogen cycling and biological uptake make become more pronounced than in Salinas valley agricultural inland streams. It 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. It is noteworthy that nitrate is likely only a small fraction of total N in the water column at site 306MOR (refer again to Figure 4-1), presumably due to elevated biological uptake of bio-available nitrate in tidal flat environment and sequestration of nitrogen in organic phases and biomass. Consequently, the 25th percentile target for nitrate in Moro Coho slough is significantly lower than for inland alluvial valley streams of the project area, and nitrate in Moro Cojo slough is generally relatively low, even though other indicators of biostimulation in Moro Cojo slough[91] are routinely observed.

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 the overwhelming fraction of total water column nitrogen in Salinas Valley inland streams;

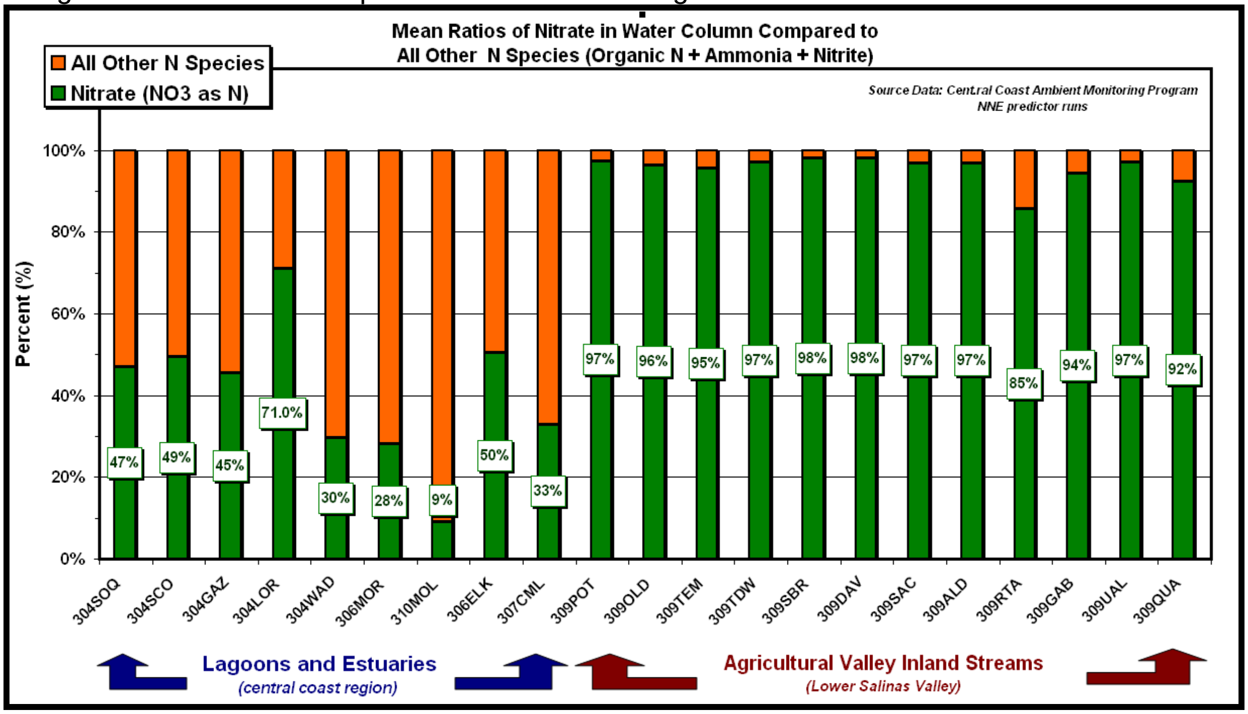
(2) because the limited amounts of available total nitrogen data are inadequate to represent spatial and temporal variation

(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.

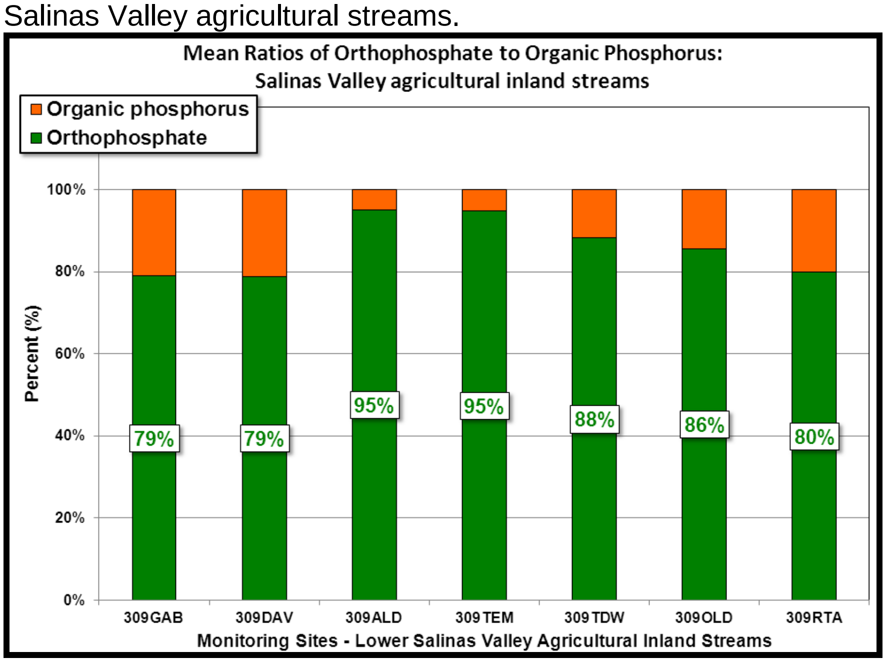
[91] Staff are proposing the total nitrogen be monitored in Moro Cojo Slough for use as a water quality indicator and as a load allocation.

Figure 4-1. Mean ratios of water column nitrate to other forms of nitrogen: Salinas Valley agricultural streams compared to central coast lagoons and estuaries.



Also, Figure 4-2 illustrates estimated mean ratios of orthophosphate and organic phosphorus for representative monitoring sites in the lower Salinas Valley and in estuaries/lagoons of the central coast region. While available data suggest that orthophosphate is generally the major component of water column total phosphate (as P), there is a substantial component of water column phosphate in forms other than orthophosphate.

Figure 4-2. Mean ratios of water column orthophosphate to organic phosphorus: lower Salinas Valley agricultural 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 project area waterbodies 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 3.10). 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 3-25).

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.

4.3.2 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 D 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 4.3.1 and Table 4-2).

It is noteworthy that the draft SWRCB Statewide Nutrient Policy (SWRCB, 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 SWRCB for statewide application.

4.4 Targets for Nutrient-Response Indicators (DO, Chlorophyll *a* and Microcystins)

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 techincal 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, but also include consideration of primary biological responses to nutrients*****. 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 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 wasteload 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[92]. Therefore, the current 303(d) listings for dissolved oxygen and chlorophyll that are associated with identified biostimulatory problems (refer to Section 3.12.4) 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 2.1), 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.

4.4.1 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.*

[92] 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.

- *For cold and spawning beneficial uses, dissolved oxygen concentrations shall not be reduced below 7.0 mg/L at any time.*
- *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 3.7.2) 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[93]. 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 supersatuartion 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.

4.4.2 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[94]. 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)[95]. 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.

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[93] Of 2,399 samples at these reference sites, only about 1% of the samples ever exceeded 13 mg/L DO.

[94] Oregon Adminstrative Rules (OAR). 2000. Nuisance Phytoplankton Growth. Water Quality Program Rules, 340-041-0150.

[95] North Carolina Administrative Code 15A NCAC 02B .0211(3)(a).

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.*

4.4.3 Microcystins

Microcystins are toxins produced by cyanobacteria (blue-green algae) and are associated with algal blooms and biostimulation in surface waterbodies[96]. 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[97] 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[98] 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 TMDL Project Area 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 TMDL project area.

5 SOURCE ANALYSIS

5.1 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 project report nutrient source loading estimates were accomplished using the US Environmental Protection Agency's STEPL model. STEPL (Spreadsheet Tool for Estimating Pollutant Load) allows the calculation of 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, phosphorus based on

[96] See: U.S. Environmental Protection Agency. Drinking Water Treatability Database.

[97] 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).

[98] Includes microcystins LA, LR, RR, and YR

various land uses and watershed characteristics. STEPL has been used previously in USEPA-approved TMDLs to estimate source loading[99].

For source assessment purposes, STEPL was used to estimate nutrient loads at the project area-scale. STEPL could also be used to allow for subwatershed-scale loading estimates. 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 details on the model can be found at: http://it.tetratech-ffx.com/stepl/.

STEPL input parameters used in this TMDL project are outlined in Table 5-1. STEPL spreadsheet results are presented in Appendix E. 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 5-1. STEPL input data.

Input Category	Input Data	Sources of Data
Mean Annual Rainfall	17.8 inches/year	PRISM precipitation dataset, including orographic effects See Section 2.7 & Figure 2-11. Note: for the Moro Cojo Slough subwatershed average annual precipitation was estimated as 16.3 inches based on Castroville rain gage – see Table 2-8.
Mean Rain Days/Year	47 days/year	Salinas city data at http://bestplaces.net/
Weather Station (for rain correction factors)	-	Santa Maria WSO Airport as provided in STEPL
Land Cover	See STEPL spreadsheets Appendix E	Farmland Mapping and Monitoring Program data - see Section 2.4 and Table 2-3
Urban Land Use Distributions (impervious surfaces categories)	STEPL default values	STEPL
Agricultural Animals	See STEPL spreadsheets Appendix E	Agricultural Census statistics, from Lower Salinas Watershed Fecal Coliform TMDL, Central Coast Water Board, 2010
Septic system discharge and failure rate data	See STEPL spreadsheets Appendix E	Septic System (OSDS) data as reported in Lower Salinas Watershed Fecal Coliform TMDL, Central Coast Water Board, 2010
Hydrologic Soil Group (HSG)	HSG "B"	"B" = the most common HSG based on soil distribution for TMDL project area – see Section 2.11 and Figure 2-31. Note: for the Moro Cojo Slough subwatershed, HSG C was used as an input value.
Soil N and P concentrations (%)	N = 0.10% P = 0.031%	• N (%) – estimated national median value from information in GWLF User's Manual, v. 2.0 (Cornell University, 1992 http://www.avgwlf.psu.edu/Downloads/GWLFManual.pdf). • P (%) – used STEPL default value
NRCS reference runoff curve numbers	STEPL default values	NRCS default curve numbers provided in STEPL

[99] 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.

Input Category	Input Data	Sources of Data
Nutrient concentration in runoff (mg/L)	<u>Agricultural Lands</u> N = 11.4 mg/L P = 0.64 mg/L <u>Urban Lands</u> N = 4.0 mg/L P = 0.53 mg/L <u>Grazing Lands (range)</u> N = 0.25 mg/L P = 0.27 mg/L <u>Forest</u> N = 0.2 mg/L 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 U.S. Dept. of Agriculture MANAGE database; see Figure 5-10 • Agricultural lands mean P runoff concentration data from Southern California Coastal Water Research Project, Technical Report 335 (Nov. 2000), Appendix C • Urban lands mean N runoff concentration. concentrations from average for western U.S. cities (San Diego, Phoenix, Denver, Boise) found in Shaver et al., 2007 • Urban lands mean P runoff concentration. concentrations from Southern California Coastal Water Research Project, Technical Report 335 (Nov. 2000), Appendix C • 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 categories) http://rangelandwatersheds.ucdavis.edu/Recent%20Outreach/tate%20oakdale%20mar%202012.pdf • Grazing lands mean P runoff concentration. from U.S. Dept. of Agriculture MANAGE database, average of values for no grazing-light grazing-moderate grazing land uses. • Forest mean N runoff concentration: used STEPL default values • Forest mean P runoff concentration: used STEPL default values
Nutrient concentration in shallow groundwater (mg/L)	<u>Valley floor (agricultural lands)</u> NO3-N = 10.3 P = 0.03 <u>Valley floor (urban lands)</u> NO3-N = 1.8 P = 0.03 <u>Uplands (forest and range)</u> NO3-N = 0.47 P = 0.03	• NO3-N (Ag Lands and Uplands)– mean values using USGS GWAVA model dataset (see Section 2.9 and • • • Figure 2-17) • NO3-N (Urban Lands) – mean value derived from USGS national dataset see 2.9 and Figure 2-18. • P – Mean value of project area data from USGS NURE dataset (see Figure 2-16)
Assumptions: manure was assumed to not be applied to cropland in the TMDL project area, and that chemical fertilizers are almost universally used for fertilization. This assumption is supported by reporting from local resource professionals and local stakeholders.		

5.2 Urban Runoff

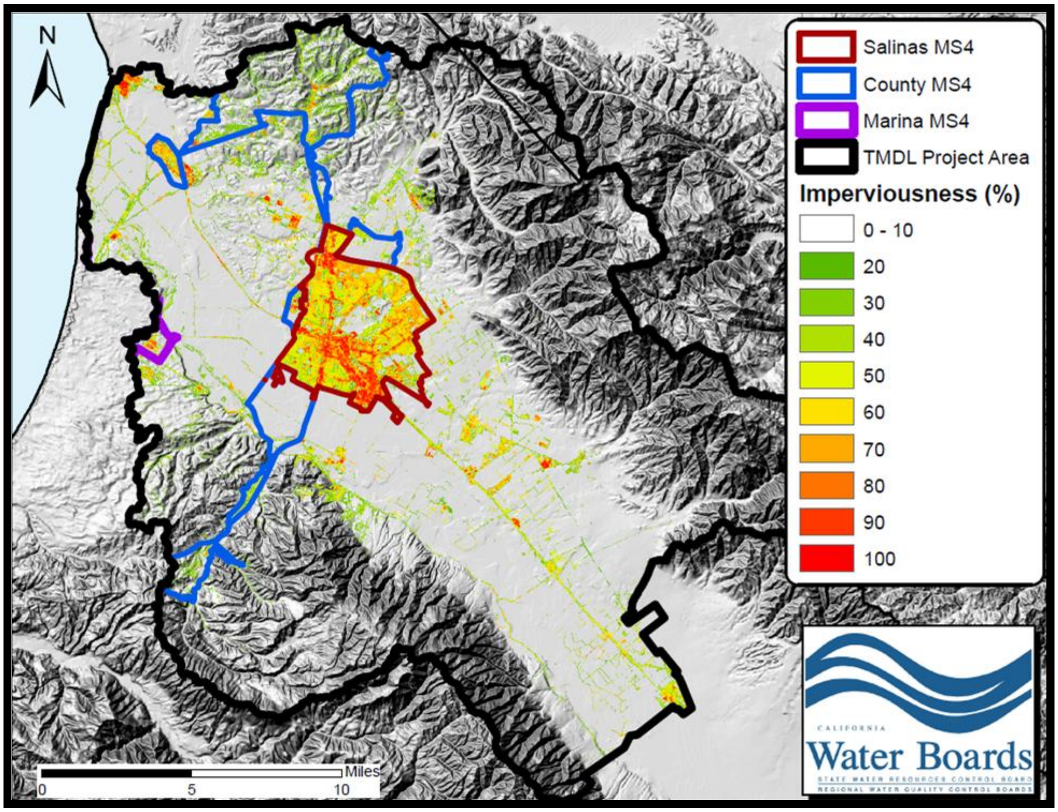
Urban runoff can be a contributor of nutrients to waterbodies. USEPA policy explicitly specifies NPDES-regulated urban stormwater discharges are point source discharges and, therefore, must be addressed by the WLA component of a TMDL.[100] The Water Board is the permitting authority for NPDES stormwater permits in the Central Coast region. Urban runoff can be a contributor of nutrients to waterbodies. Within residential areas, potential controllable nutrient sources can include lawn care fertilizers, grass clippings, organic debris from gardens and other greenwaste, trash, and pet waste (Tetratech, 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.

Impervious cover data are available from the National Land Cover Database (NLCD, 2001). NLCD provides per-pixel estimates of imperviousness (percent impervious cover) as derived from photographic imagery. Figure 5-1 illustrates the distribution and percent

[100] 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"*

imperviousness in the project area and the municipal separate storm sewer system (MS4) permit boundaries.

Figure 5-1. Project area impervious cover and approximate storm water MS4 permit boundaries.



There is a large plethora of nationwide and central coast regional data characterizing nitrate-nitrogen concentrations in urban runoff (see Figure 5-2). These data (438 total samples) illustrate that nitrate concentrations in urban runoff virtually never exceed the 10 mg/L MUN regulatory standard[101] and rarely exceed the proposed 8.0 mg/L (wet season) nitrate water quality targets proposed TMDL project area waterbodies. In fact, the central coast-specific urban runoff data (Santa Cruz and Monterey County) shown in Figure 5-2 infrequently exceed nitrate-N concentrations of 2 mg/L.

[101] 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.

Figure 5-2. Nitrate concentration in urban runoff: national, California, and central coast regional data.

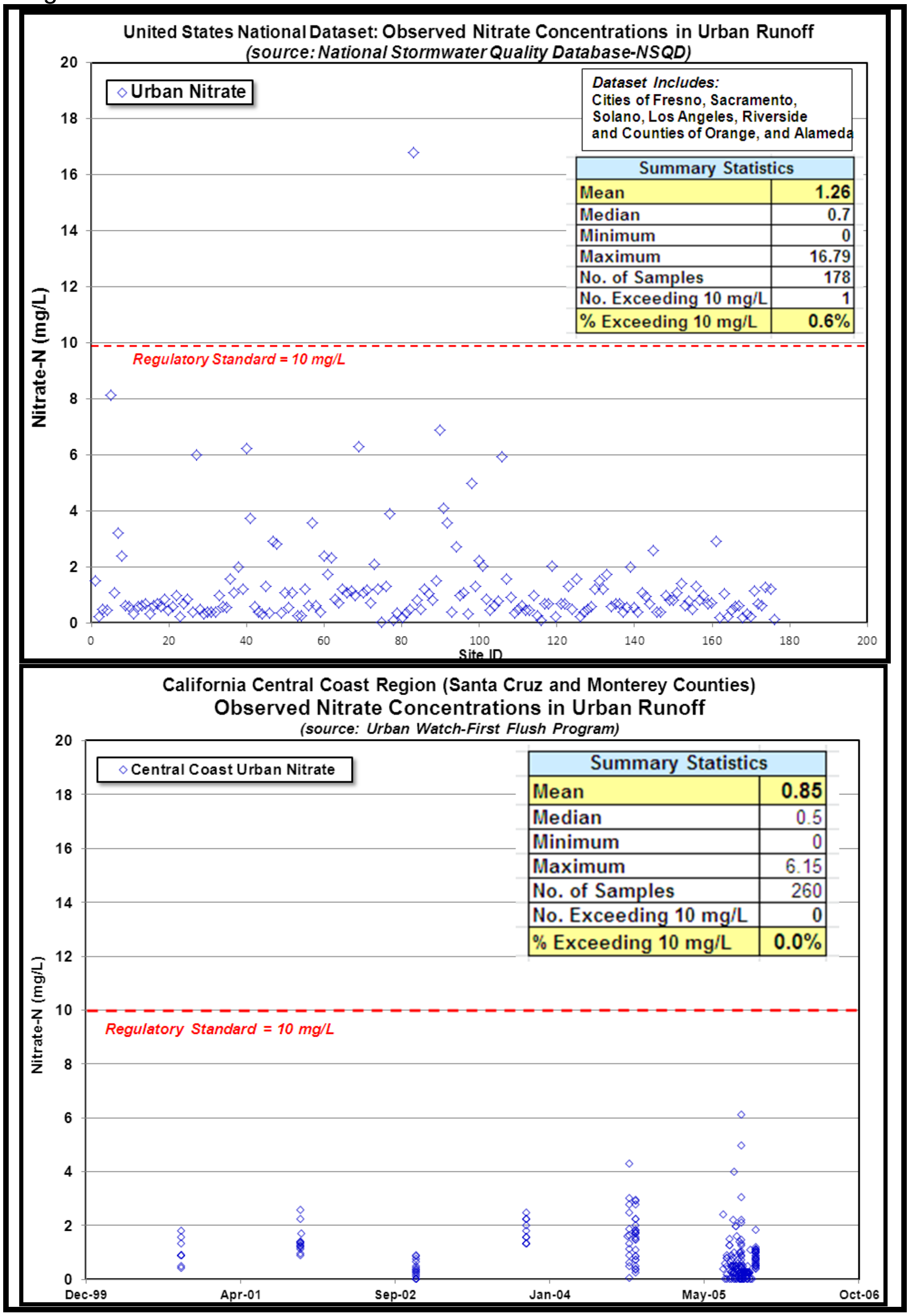
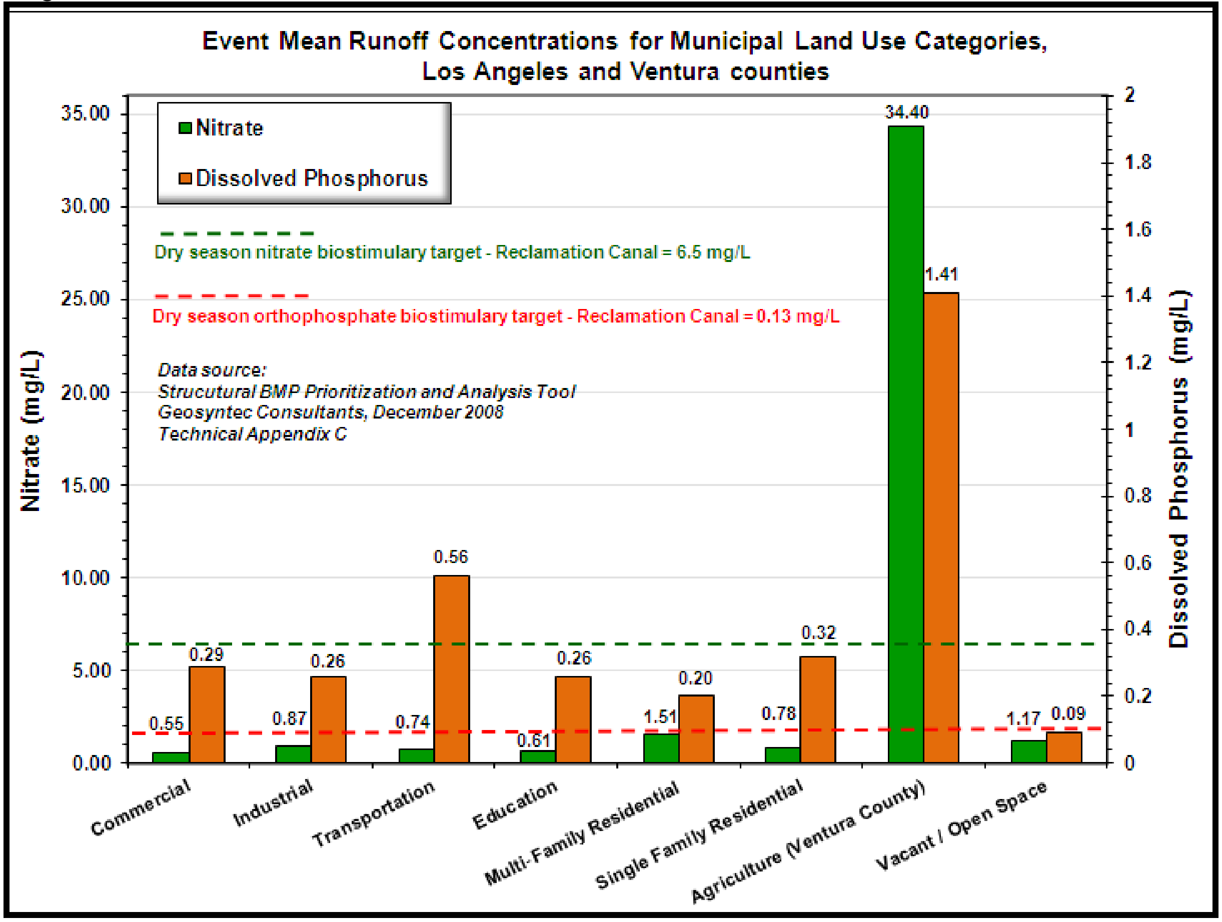


Figure 5-3. Runoff event mean concentration data for municipal land use categories, Los Angeles and Ventura counties.

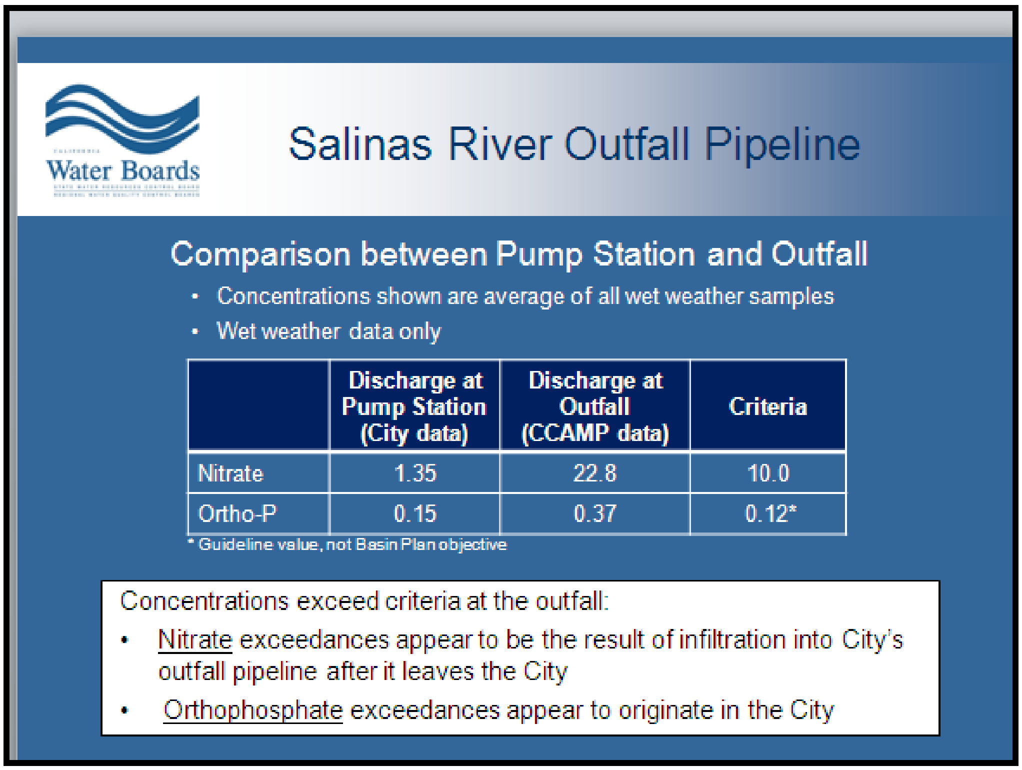


An additional line of evidence is available for urban runoff concentrations reported for Los Angeles and Ventura counties. Figure 5-3 illustrates statistical means for event mean concentration data for runoff water quality data from various municipal land use categories. For comparative purposes, this graph also has an overlay of the proposed dry season nitrate and orthophosphate water quality targets for the Reclamation Canal. On average, these municipal runoff data are well below all applicable nitrate water quality targets; however on average dissolved phosphate generally exceeds the proposed dry season orthophosphate target for the Reclamation Canal and are elevated well above USEPA ecoregional ambient criteria for phosphorus (refer back to Section 2.6). In particular, for this Los Angeles county dataset, transportation and single-family residential land use categories are typically the highest sources of phosphorus loads.

Collectively, all the aforementioned data indicate that nitrate concentrations in urban runoff are generally below applicable Basin Plan nitrate water quality criteria and proposed biostimulatory nitrate targets. However, while many of the currently monitored City of Salinas stormdrains, and other urban runoff data for the central coast region routinely have low levels of nitrate-N (<2 mg/L), two of the City's monitored outfalls routinely have high levels of nitrate (outfall 309SDR and 309AXX).

It should be noted that 309SDR is the City of Salinas'' stormwater outfall on the Salinas River and is conveyed from a pump station through a pipe passing beneath agricultural lands. City staff have reportedly detected groundwater intrusion into the pipe at several locations through video inspection of the pipe. Further, nitrate concentrations are reportedly substantially higher at the stormwater outfall on the Salinas River, than at the city's pump station (see Figure 5-4). Therefore, it is likely that nutrient-contaminated groundwater associated with agricultural operations enters the pipe as it passes under agricultural land. Regarding outfall 309AXX, it is unknown to staff whether or not high levels of nitrate in effluent in this outfall are associated with agricultural drainage entering this conveyance structure.

Figure 5-4. Comparison of data from Salinas pump station and city stormwater outfall at Salinas River.

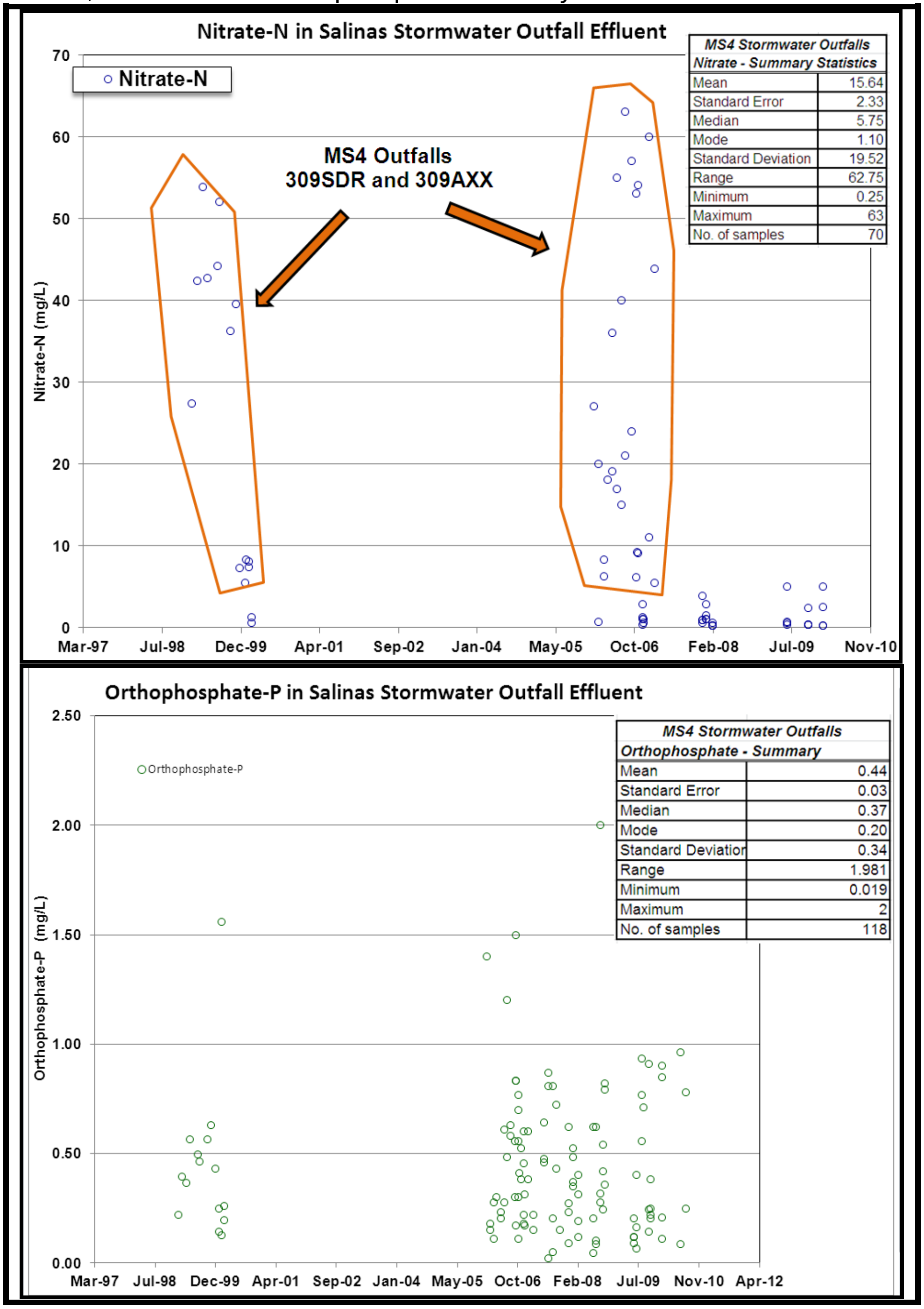


While high nitrate levels in MS4 effluent do not appear to be prevalent and may constitute localized problems at a few outfalls, in contrast orthophosphate in effluent from all City of Salinas stormwater outfalls are routinely high in orthophosphate, often exceed numeric water quality targets proposed in this TMDL, and are well above natural ambient background conditions found elsewhere in the Salinas River basin. Additionally, limited amounts of independent orthophosphate data from urban stormwater outfall drain monitoring associated with the CleanStreams monitoring program along Santa Rita Creek, also indicated generally high levels of orthophosphate in the outfalls[102], providing an additional line of evidence. Therefore, orthophosphate discharges associated with MS4 stormdrain outfalls appear to be more prevalent and problematic than nitrate in the TMDL

[102] CleanStreams collected eight orthophosphate samples in 2006 from urban stormwater outfalls along Santa Rita Creek, seven of these samples exceeded the proposed wet-season orthophosphate numeric target propsed for this TMDL (0.3 mg/L), and all eight samples exceed the proposed dry-season numeric target for Santa Rita Creek (0.13 mg/L).

project area. Note that this observation comports with runoff event mean concentration data from urban areas of Los Angeles and Ventura counties (refer back to Figure 5-3); i.e., dissolved phosphorus in these urban areas are typically at levels well above what would be expected in ambient, natural central coast reference conditions.

Figure 5-5, Nitrate-N and orthophosphate-P in City of Salinas MS4 outfall effluent.



Estimates for the average concentration of nitrogen in urban runoff used in this project report was derived from Shaver et al. (2007) taking a mean of nitrogen-N in runoff from the cities of San Diego, Phoenix, Boise, and Denver = 4.0 mg/L nitrogen-N. Average concentration of phosphorus-P in urban runoff used in this project report is taken from SCCWRP (2000) = 0.53 mg/L phosphate-P.

Using the parameter inputs identified in Section 5.1 the estimated annual nutrient load from urban runoff in the project area as calculated by STEPL is shown in Table 5-2.

Table 5-2. Urban Annual Estimated Load (lbs./year)

Source	N Load (lb/yr)	P Load (lb/yr)
Urban	**114,698**	**15,198**

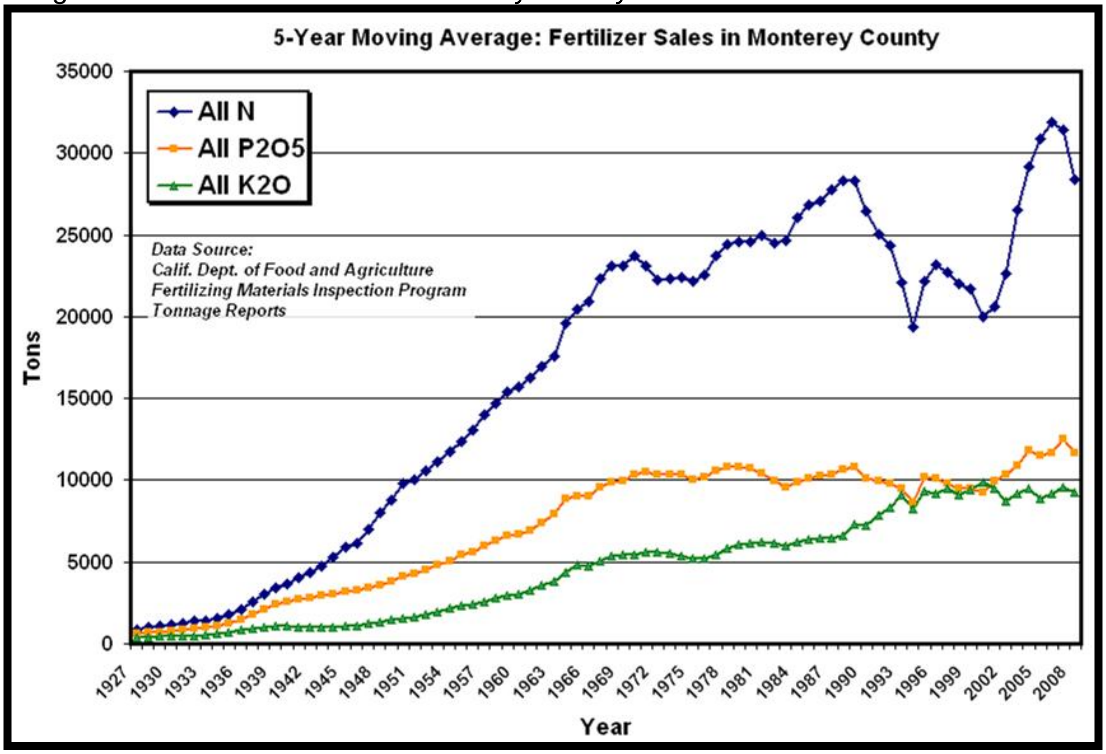
5.3 Cropland

Fertilizers or manure applied to cropland can constitute a significant source of nutrient loads to waterbodies. The primary concern with the application 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 (Tetratech, April 29, 2004).

Figure 5-6 illustrates temporal trends of fertilizer sales in Monterey County. It is important to recognize that fertilizer sales in a county does not necessarily mean those fertilizers were actually applied in that same county. Recorded sales in one county may actually be applied on crops in other, nearby counties. However, Krauter et al. (2002) reported fertilizer application estimates that were obtained from surveys, county farm advisors and crop specialists; these data indicated that in the Central Coast region, county fertilizer recorded sales correlated well with estimated in-county fertilizer applications (within 10 percent). Also, it is important to recognize that not all fertilizing material is sold to or applied to farm operations. The California Department of Food and Agriculture reports that for the annual period July 2007 to July 2008, non-farm entities purchased about 3% of fertilizing materials sold in Monterey County[103].

[103] California Department of Food and Agriculture Tonnage Report of Commercial Fertilizers and Agricultural Minerals, July 2007-July 2008.

Figure 5-6. Fertilizer sales in Monterey County



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 5-3 and Figure 5-7.

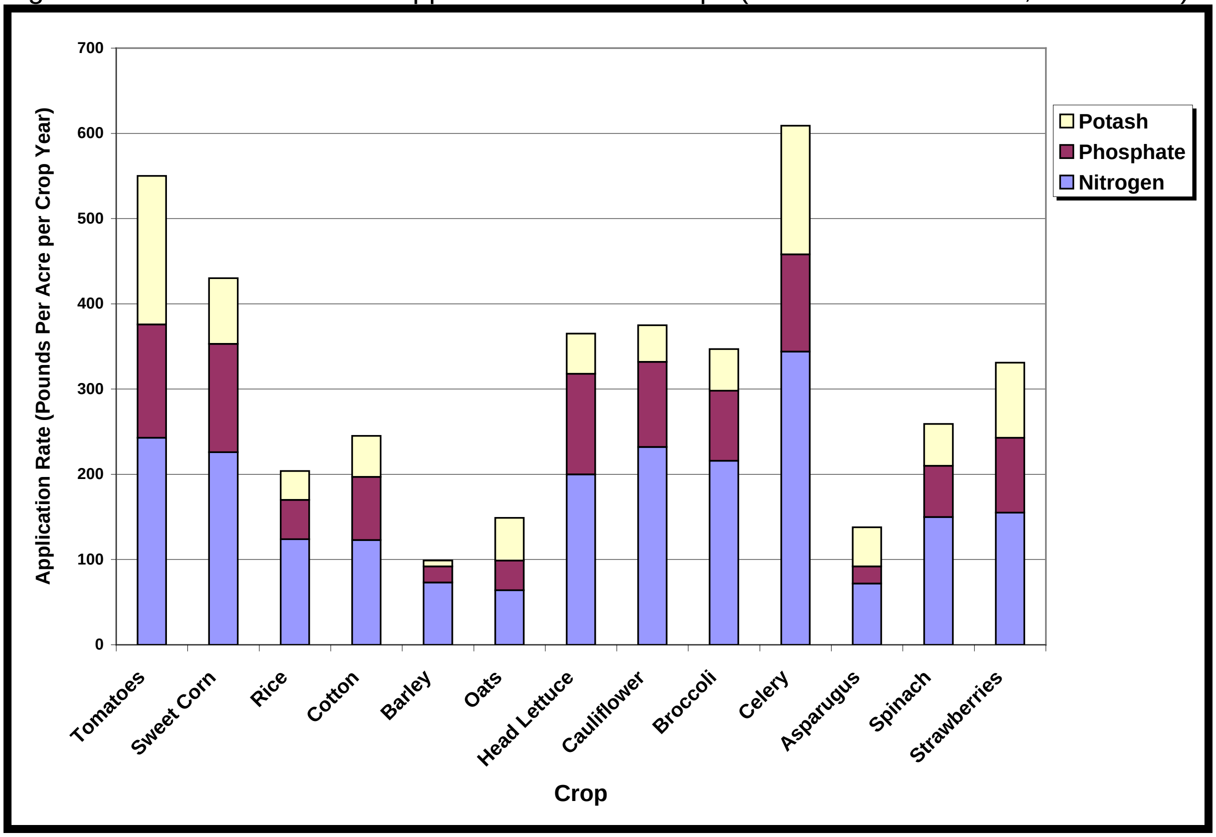
Table 5-3. Calif. Reported fertilizer application rates (National Agricultural Statistics Service).

Crop	Application Rate per Crop Year (pounds per acre) in California			Source
	Nitrogen	Phosphate	Potash	
Tomatoes	243	133	174	2007 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 5-7. California fertilizer application rates on crops (source: USDA-NASS, 2004-2008).



The estimated magnitude of nutrient loads from agricultural lands may 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 assess to the degree possible, local agricultural conditions in order to gage the level of risk of nutrient loading to surface water from these sources.

The California Department of Water Resources (DWR) has compiled digitized crop data for Monterey County, which can be used to create crop maps and crop pie charts in the Project Area, as shown in Figure 5-8 and Figure 5-9. The most recent version of DWR's Monterey County crop maps is 1997. Although the vintage of this data is not current, it can broadly be used to illustrate a credible representation of general crop types and cropping patterns in the Project Area. The DWR data indicates that the most common Project Area crop types are lettuce, broccoli, other cole crops, truck and berry crops, artichoke, strawberry, commercial nurseries and vineyard. This is consistent with more recent crop reporting (i.e., the 2008 Monterey County Agricultural Commissioner's Crop Report), which indicates that lettuce, broccoli, cole crops, and nursery products are among the major crops of the County.

Figure 5-8. Crop Cover and Distribution in Project Area (DWR, 1997).

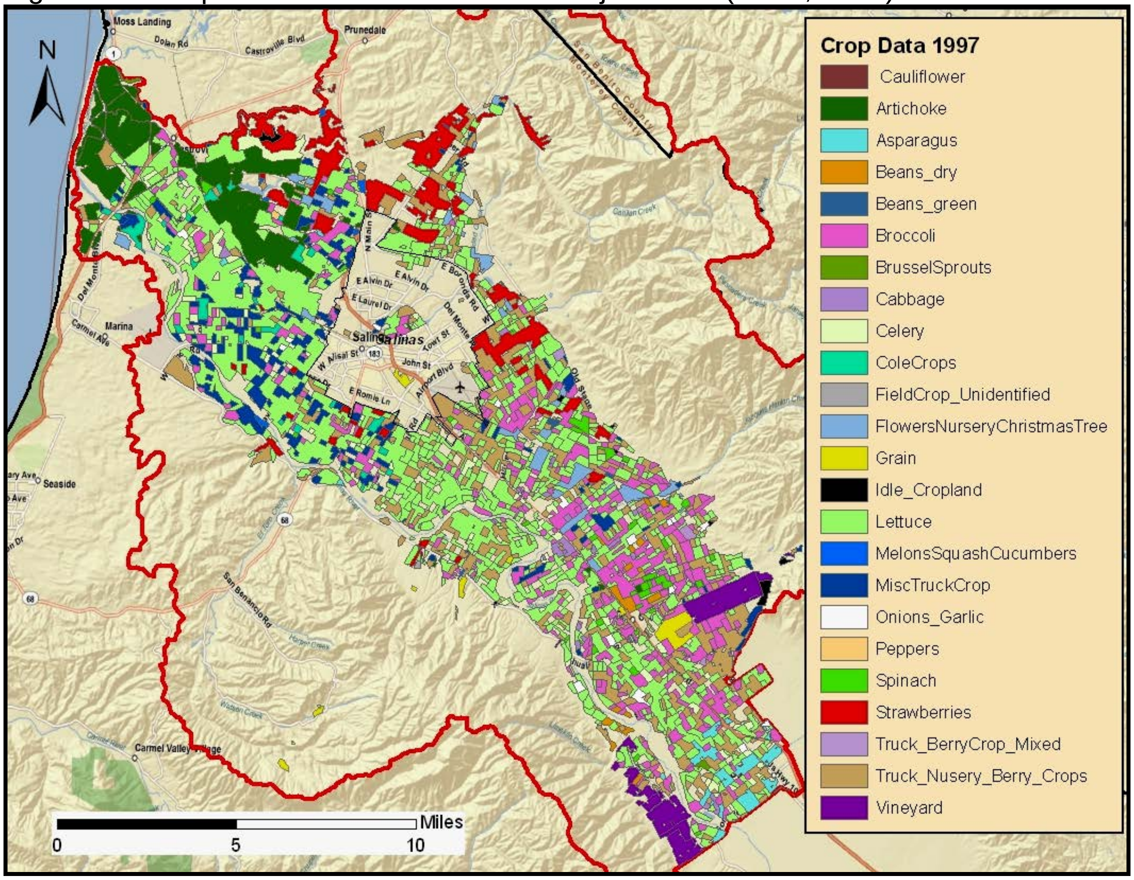
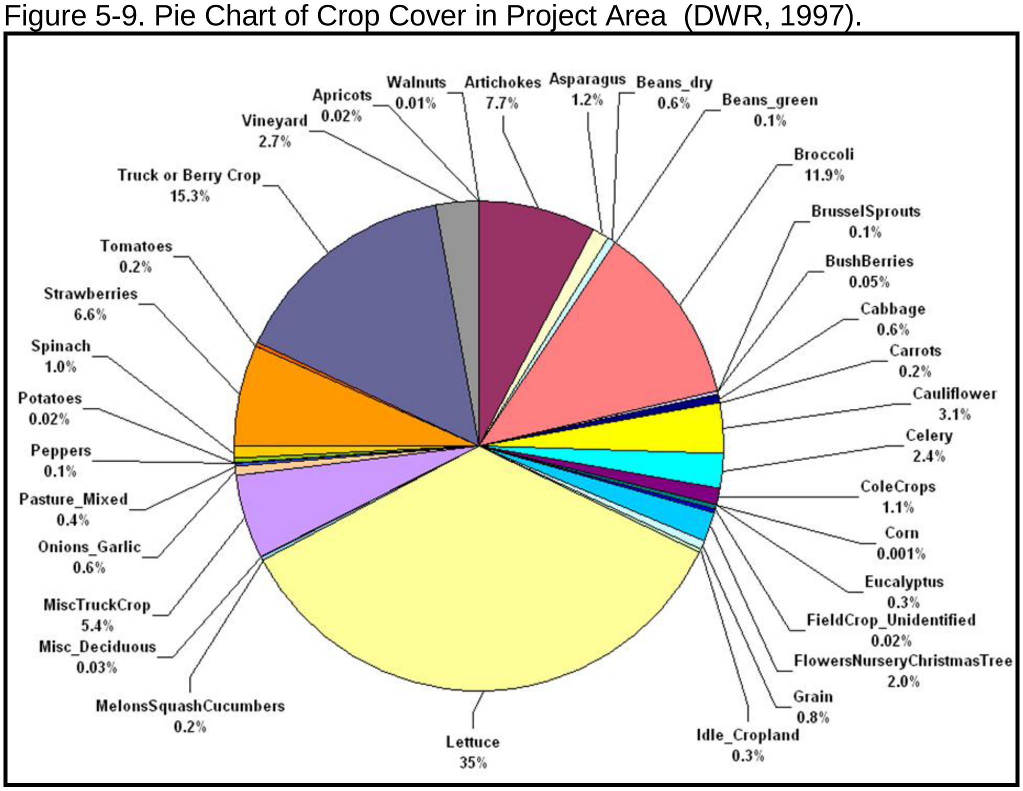


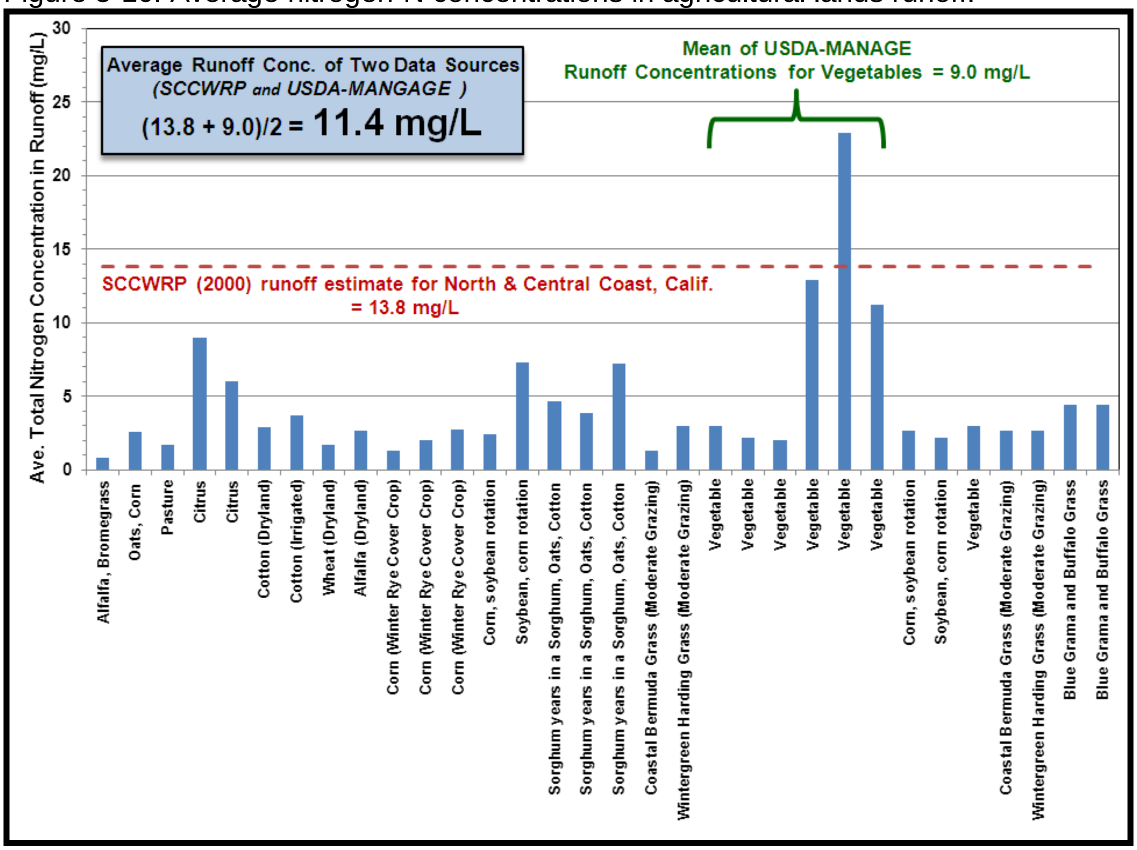
Figure 5-9. Pie Chart of Crop Cover in Project Area (DWR, 1997).



Therefore, based on California Department of Water Resources crop maps and recent-vintage Monterey County Agricultural Commissioner crop reports, cropland the lower Salinas valley is largely comprised of lettuce, broccoli, cole crops, nurseries, and berries. These types of crops (cole crops, row crops, berry crops) typically require the application of relatively larger amounts of fertilizer relative to other types of crops (e.g., grain and field crops), as previously shown in Figure 5-7.

Estimates for the average concentration of nitrogen in agricultural runoff used in this project report was derived using two data sources: SCCWRP (2000) and the U.S. Department of Agricultural-Agricultural Research Service's MANAGE database[104]. 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[105] is equivalent to 11.4 mg/L nitrogen-N, as illustrated in Figure 5-10. Average concentration of phosphorus-P in agricultural runoff used in this project report is taken from the aforementioned SCCWRP (2000) report = 0.64 mg/L phosphate-P.

Figure 5-10. Average nitrogen-N concentrations in agricultural lands runoff.



The estimated annual nutrient load from cropland in the project area as calculated by STEPL is shown in Table 5-4.

[104] 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

[105] Vegetable crops are the dominant type of crop cover in the TMDL project area.

Table 5-4. Cropland annual load (lbs./year).

Source	N Load (lb/yr)	P Load (lb/yr)
Cropland	**1,608,557**	**266,408**

5.4 Grazing Lands

Livestock and other domestic animals that spend significant periods of time in or near surface waters can contribute significant loads of nitrogen and phosphorus because they use only a portion of the nutrients fed to them and the remaining nutrients are excreted (Tetratech, 2004).

For example, in a normal finishing diet, a yearling cattle will retain only between 10 percent and 20 percent of the nitrogen and phosphorus it is fed. The rest of the nutrients are excreted as waste, and are thus available for runoff into nearby waterbodies or into the groundwater (Koelsch and Shapiro, 1997 as reported in Tetratech, 2004). Also, animal waste associated with confined animals (feedlots, dairies, etc.) can constitute a potential significant source of nutrient loads to surface waters. Unregulated or poorly managed confined animal facilities on a unit area basis (e.g., per acre) can typically be a higher pollutant loading risk than lightly grazed rangeland. It is important to recognize that many of these confined animal facilities will be located on the valley floor in the farmland land-use category. As such, nitrogen loading from domestic animal manure is also a component of the “cropland” load fraction in Section 5.3.

The estimated annual nutrient load from grazing lands in the project area as calculated by STEPL is shown in Table 5-5.

Table 5-5. Grazing lands annual load (lbs./year).

Source	N Load (lb/yr)	P Load (lb/yr)
Grazing Lands	**143,734**	**54,202**

5.5 Forest and Undeveloped Lands

The estimated annual nutrient load from forest-undeveloped land cover in the project area as calculated by STEPL is shown in Table 5-6.

In this TMDL project report, Staff endeavored to develop multiple lines of evidence which would indicate whether or not the proposed biostimulatory water quality targets would be achievable given background conditions. One such line of evidence is presented below in Figure 5-11. The U.S. Deparment of Agriculture has published observed nitrate concentrations in runoff from natural and lighltly-distubed grassland, woodland, and grain crop landscapes shown in Figure 5-11[106]; in addition estimated nitrate concentration in

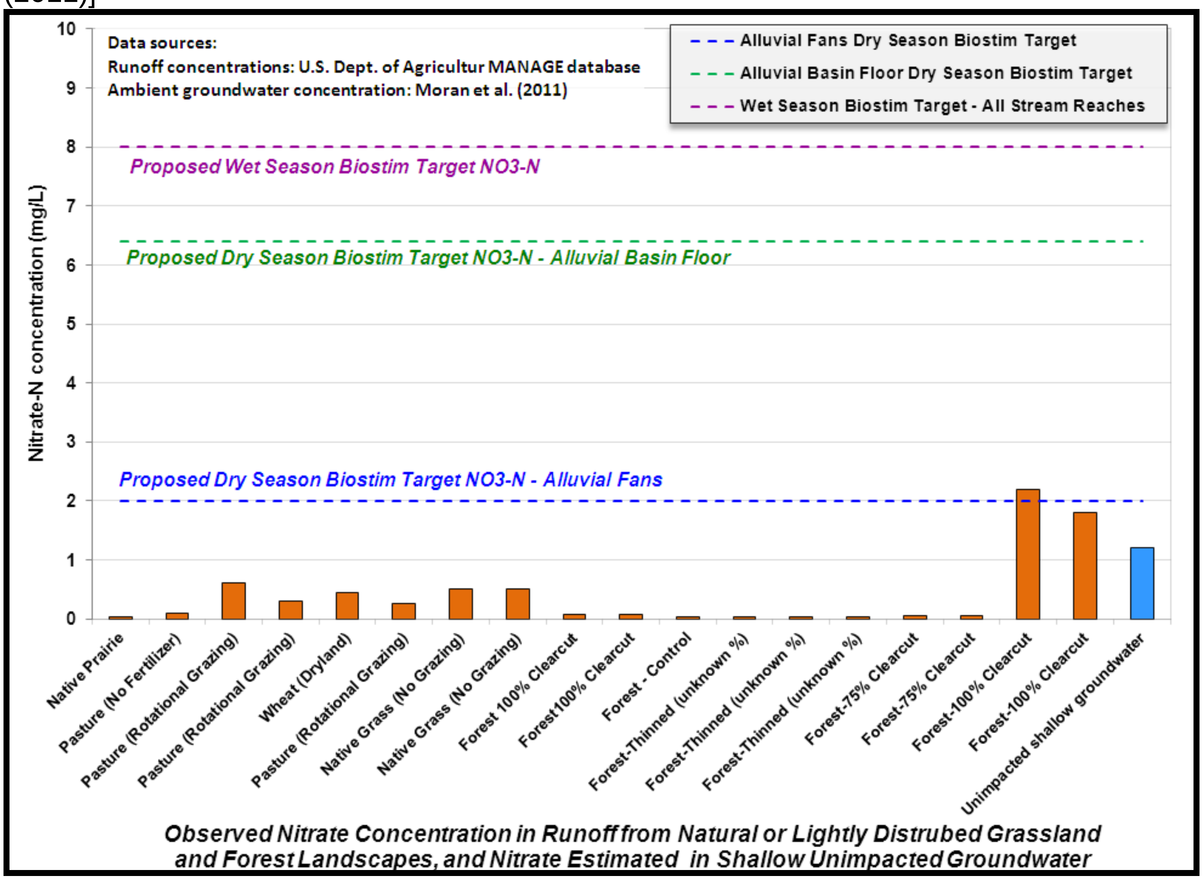
[106] Source: U.S. Department of Agriculture’s national MANAGE database. To estimate natural and lightly-disturbed background conditions staff used the native grasslands, ungrazed to lightly-grazed pasture, forest, and dryland grain farming land use categories, and excluded land management that included burned woodland, fertilized landscapes, and moderately to heavily grazed landscapes.

shallow groundwaters of the TMDL project area was previously presented in Section 2.9. Based on available evidence plausible estimates of background concentrations of nitrate in both runoff and in shallow groundwater are expected to be well below the proposed nitrate receiving water quality targets.

Table 5-6. Forest annual load (lbs./year).

Source	N Load (lb/yr)	P Load (lb/yr)
Forest	**14,205**	**5,561**

Figure 5-11. Nitrate concentrations in runoff from natural or lightly-disturbed grasslands, woodland, and grain crop landscapes in various ecoregions of the U.S., and nitrate concentration in unimpacted groundwater, compared to proposed nitrate biostimulatory targets [Sources: US Dept. of Agriculture MANAGE national database and Moran et al. (2011)]



5.6 Onsite Disposal Systems (OSDS)

State Water Resources Control Board recently estimated the number of existing OSDS found within 600 feet of 303(d) listed waterbodies in the project area (SWRCB, 2008). This estimate was 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 counts were based on an investigation using multiple sources: The main sources for the investigation are TOPO! (a U.S. Geological Survey [USGS] 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, staff estimated approximately 200 OSDS within a 600 foot buffer of Santa Rita Creek in the unincorporated community of Bolas Knolls north of the City of Salinas, as illustrated in Figure 5-12. Consequently, project area impaired water bodies with the number of OSDS within 600 feet of them, are tabulated in Table 5-7.

Figure 5-12. Bolsa Knolls housing units (OSDS) within 600 foot buffer of Santa Rita Creek.

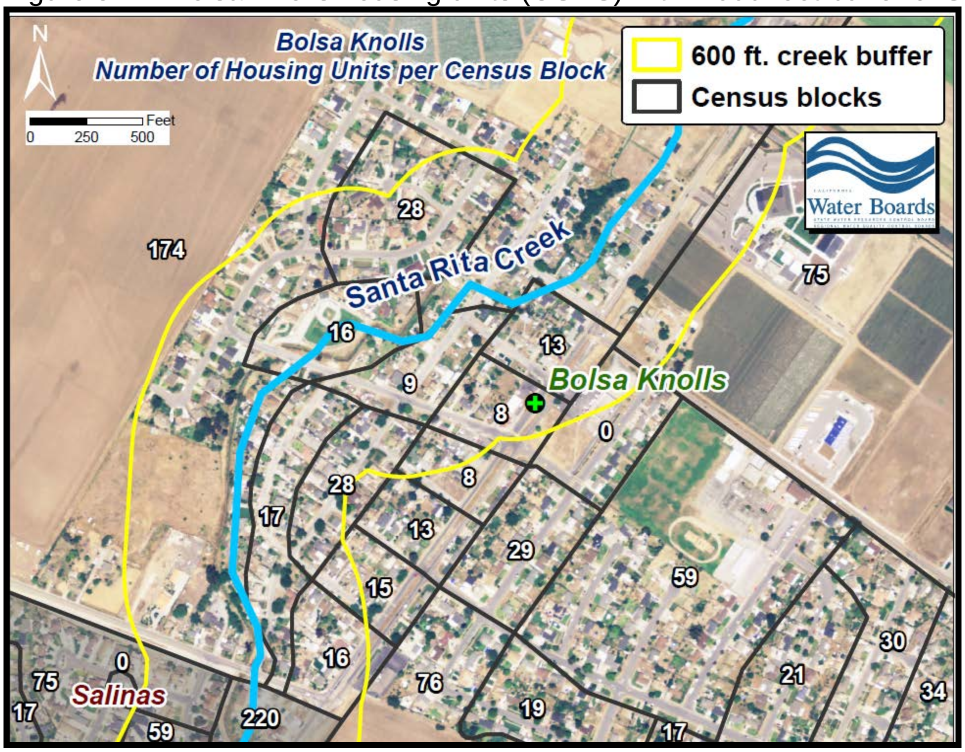


Table 5-7. Estimated locations and number of OSDS proximal to impaired waterbodies.

Impaired Water Body	Estimated OSDS within 600 Feet of Impaired Water Body	Drainage Basin
Alisal Creek	20	Reclamation Canal Basin
Espinosa Slough	20	Reclamation Canal Basin
Santa Rita Creek	200 estimated – see Figure 5-12	Reclamation Canal Basin
Gabilan Creek	0	Reclamation Canal Basin
Old Salinas River	20	Lower Salinas River Basin
Reclamation Ditch	0	Reclamation Canal Basin
Salinas Lagoon (North)	1	Lower Salinas River Basin
Tembladero Slough	2	Reclamation Canal Basin
	Total = 263	Total Reclamation Canal Basin = 242 Total Lower Salinas River Basin = 21

Consequently, the estimated annual nutrient load from OSDS (i.e., septic systems) to surface waters in the project area as calculated by STEPL is shown in Table 5-8. Because of the small and nominal magnitude of these loads, nutrient loading to surface waters from this source category is considered to be insignificant and negligible in the TMDL project area. It should be noted that OSDS impacts to underlying groundwater can locally be significant, but these potential OSDS groundwater impacts are outside the scope of the TMDL. In general, researchers have concluded that at the basin-scale and regional-scale of the Salinas Valley OSDS impacts to groundwater are relatively insignificant compared to agricultural fertilizer impacts (University of California-Davis, 2012).

Table 5-8. OSDS annual load (lbs./year).

Source	N Load (lb/yr)	P Load (lb/yr)
OSDS	**106**	**41**

5.7 Groundwater

Shallow groundwater provides the base flows to streams and can be an major source of surface water flows during the summer season. Therefore, dissolved nutrients in groundwater can be important nutrient sources during dry periods. Ground water contamination from nutrients can occur from various sources, including septic systems, fertilizer application, animal waste, waste-lagoon sludge, and soil mineralization (USEPA, 1999). In addition, groundwater has a natural, ambient background load of nitrogen and phosphorus. Note that controllable phosphorus leaching to groundwater is presumed to be negligible in this project 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 aquifer minerals in the subsurface.

The estimated annual nutrient load from groundwater to surface waters in the project area as calculated by STEPL is shown in Table 5-9.

Table 5-9. Groundwater annual load (lbs./year).

Source	N Load (lb/yr)	P Load (lb/yr)
Groundwater	**1,017,165**	**7,557**

The natural, ambient groundwater nitrate load may be approximated by using the estimated groundwater concentrations of nitrate in minimally-impacted, precipitation-derived groundwater of the lower Arroyo Seco River watershed of Monterey County (refer back to Section 2.9). Using the STEPL spreadsheet tool, and inputting the estimated background concentrations of nutrients in groundwater yields an ambient groundwater project area load of 191,095 lbs/year (see Section 5.10). This is a small fraction of the total groundwater load shown in Table 5-9, indicating that groundwater loads appear to be overwhelmingly due to human influences on groundwater in the project area, particularly agricultural sources (University of California-Davis, 2012).

5.8 Atmospheric Deposition

Input of nutrients in rainfall may be a significant source of loading. 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 watershed. Atmospheric deposition to project area surface waterbodies was estimated using estimates of the surface area of all surface waterbodies in the project area (estimated from NHDplus flowline data); wet deposition of inorganic nitrogen from USGS raster datasets available in NHDplus; and a literature values of dry atmospheric deposition of nitrate-N (Rast and Lee, 1983). Atmospheric deposition rates are illustrated in Figure 5-13.

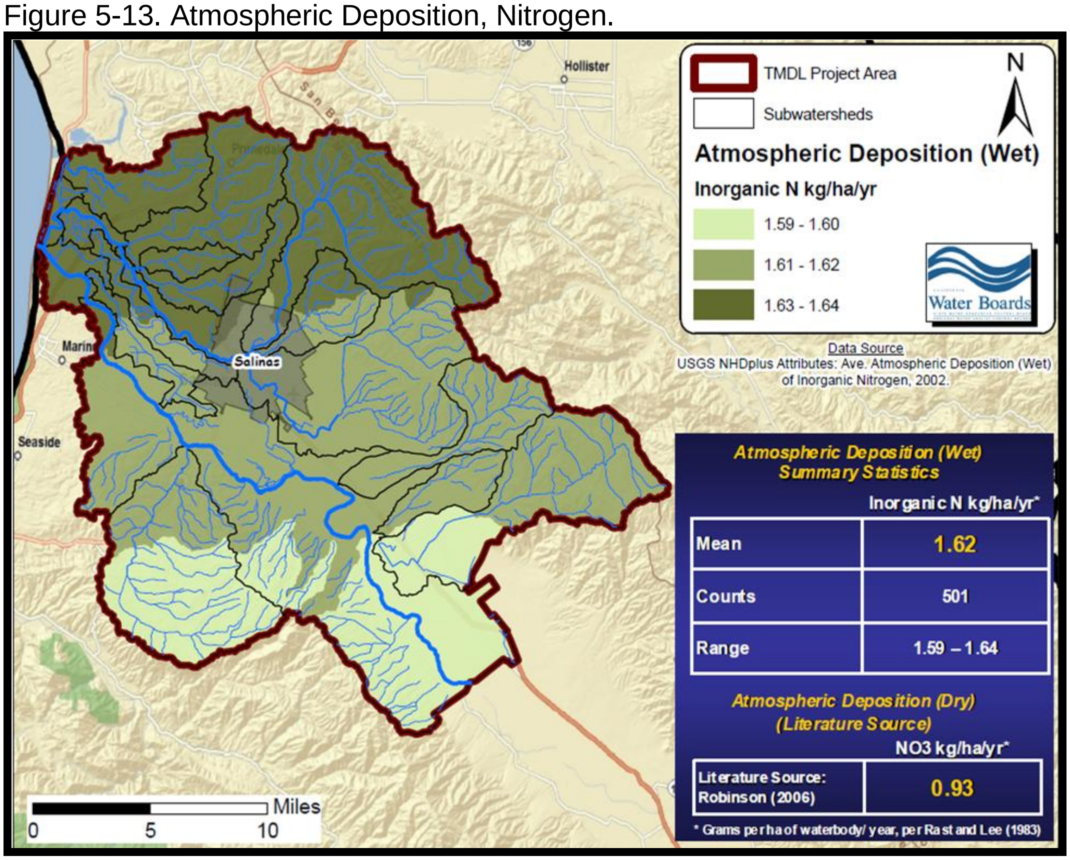
The length of all NHDplus surface water flowlines in the project area , is approximately 3.45 E+06 feet, and the average width of all streams in the project area is assumed to be approximately 5 feet. Accordingly, the total surface area of project area surface waterbodies is approximately 1.72 E+07 square feet, or 160 hectares. With an estimated combined dry and wet atmospheric deposition rate of 2.55 kg N/ha/yr (see Figure 5-13), the typical annual load from atmospheric deposition would be approximately 40 kg N/year, or 900 pounds N/year.

Atmospheric phosphorus can be found in organic and inorganic dust particles. The general atmospheric deposition rate for total phosphorus is 0.6 kg P/ha/yr (USEPA 1994, as reported in San Diego Regional Water Quality Control Board, 2006). Accordingly, using the stream surface areas presented above, the typical annual load of phosphorus would be approximately 96 kg/year, or 212 pounds/year (see Table 5-10).

Table 5-10. Atmospheric deposition annual load (lbs./year).

Source	N Load (lb/yr)	P Load (lb/yr)
Atmospheric deposition	900	212

Figure 5-13. Atmospheric Deposition, Nitrogen.

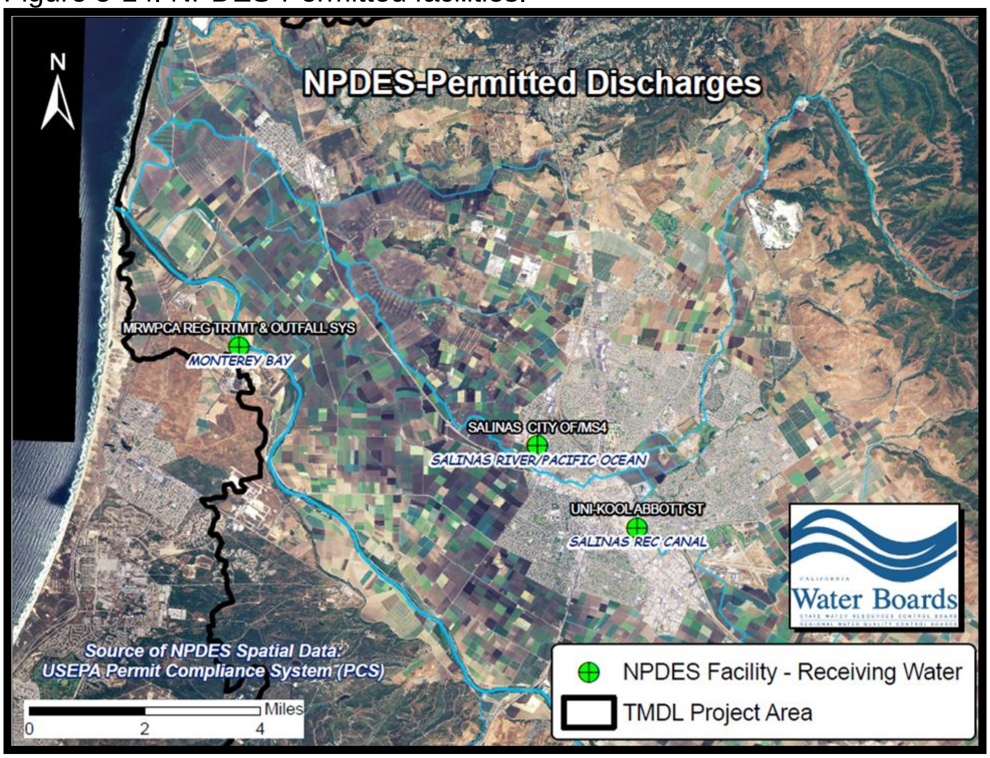


5.9 Other NPDES-Permitted Facilities

There are three NPDES-permitted facilities discharging to surface waters in the TMDL project area (see Figure 5-14) which are not associated with an urban MS4 stormwater permit.

The Monterey Regional Treatment and Outfall System (Permit CA0048551) discharges to Monterey Bay via an offshore pipeline, therefore there are no discharges to project area surface waters. The City of Salinas is an MS4 permitted stormwater entity (Permit CA0049981) that discharges runoff to the Salinas River, the Reclamation Canal and tributaries. It should be noted that the County of Monterey also is an MS-4 permitted entity in the project area. Note that load contributions from MS4 entities were estimated in Section 5.2. Finally, the Unikool-Abbot facility (Permit CA0005720) discharges to the Salinas Reclamation Canal. Water Board permitting staff has indicated to TMDL staff that there is currently no evidence available to the Water Board that the Unikool-Abbot facility is discharging nutrients in exceedance of proposed waste load allocations to a surface receiving waterbody.

Figure 5-14. NPDES-Permitted facilities.



5.10 Summary of Sources

It is worth reiterating that these are estimates for the TMDL project area. It is understood there will be substantial variation due to real-time conditions or due to local and site specific conditions. More information will be collected during TMDL implementation to assess controllable sources of nitrate pollution. It is important to recognize also that "annual" nitrate load estimates at the basin-scale do not adequately capture the variability, the magnitude, and the seasonal and flow-based nature of nutrient-related impairments locally. These types of variability were assessed and presented previously in Section 3.7.

Table 5-11 shows the summary of nutrient source categories and estimated annual nutrient loads. Also, the estimated relative magnitude of sources are also shown graphically in Figure 5-15. Overall, cropland and groundwater sources are estimated to be the dominant sources of nutrient loading in the TMDL project area. It is worth reiterating that these are estimates for the TMDL project area. It is understood there will be substantial variation due to real-time conditions or due to local and site specific conditions. More information will be collected during TMDL implementation to assess controllable sources of nitrate pollution. It is important to recognize also that "annual" nitrate load estimates at the basin-scale do not adequately capture the variability, the magnitude, and the seasonal and flow-based nature of nutrient-related impairments locally. These types of variability were assessed and presented previously in Section 3.7.

Table 5-11. Tabulation of estimated nutrient source loads in TMDL project area surface waters.

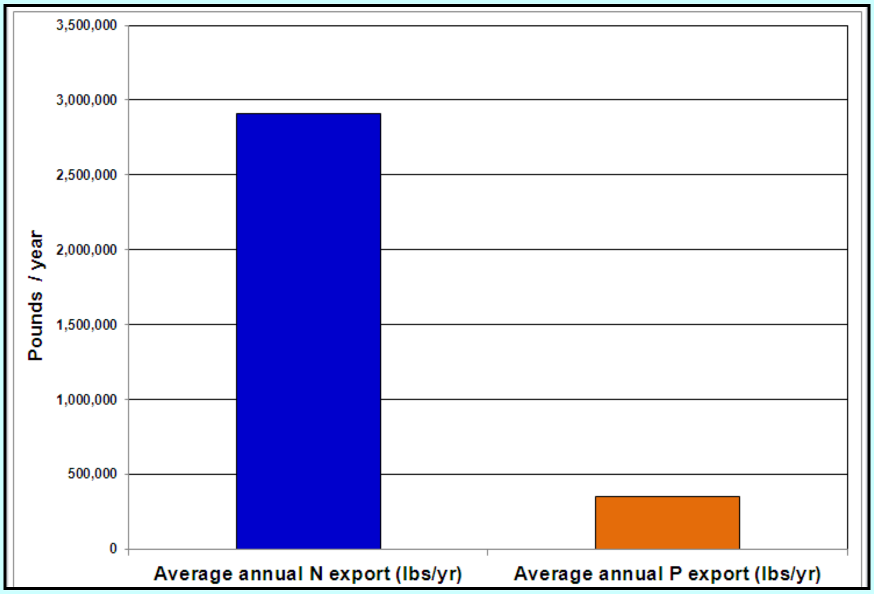
Sources	N Load (lb/yr)	P Load (lb/yr)	Bar Chart – Total N and P Annual Load
Urban	114,698	15,198	
Cropland	1,608,557	266,408	
Grazing Lands	143,734	54,202	
Forest	14,205	5,561	
Septic	106	41	
Groundwater	1,017,165	7,557	
Atmospheric Deposition	900	212	
Total	2,899,365	349,179	

Figure 5-15. Estimated average annual nutrient source loads to surface waters (% contribution).

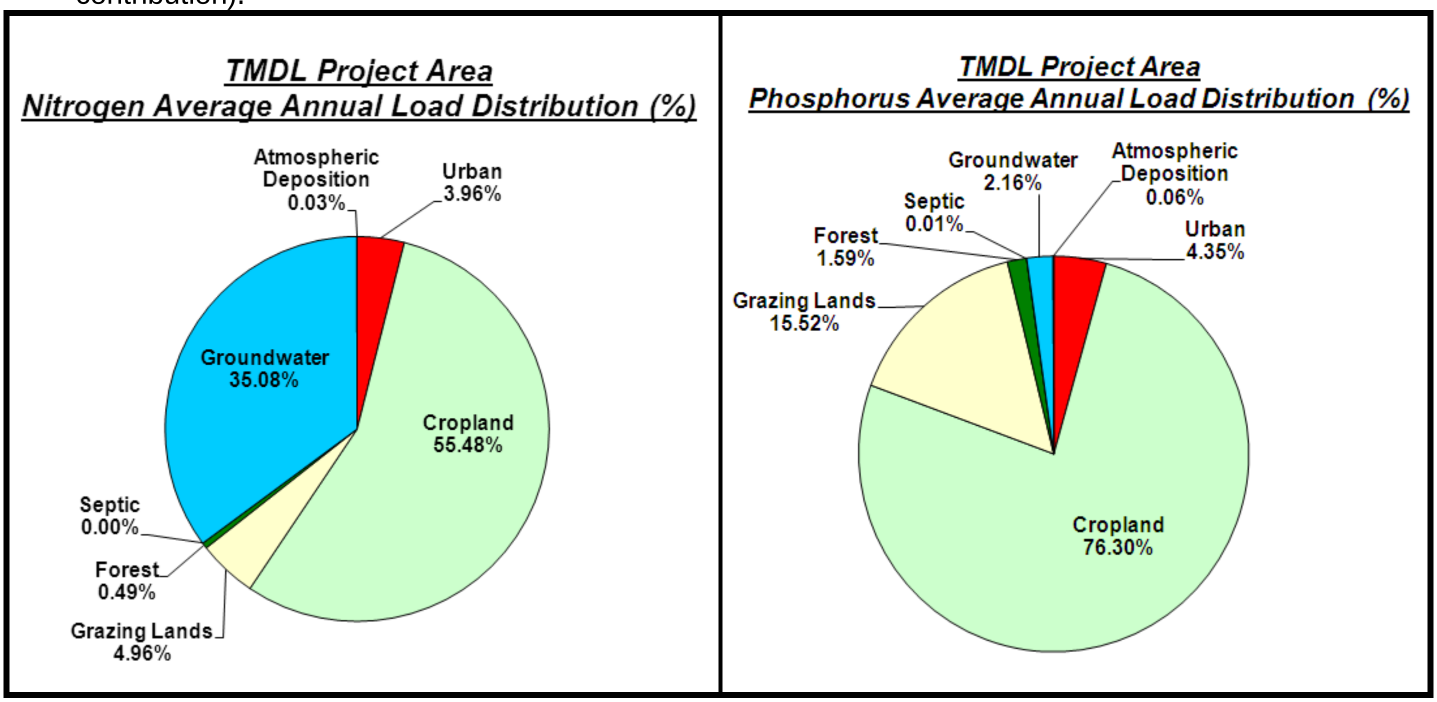
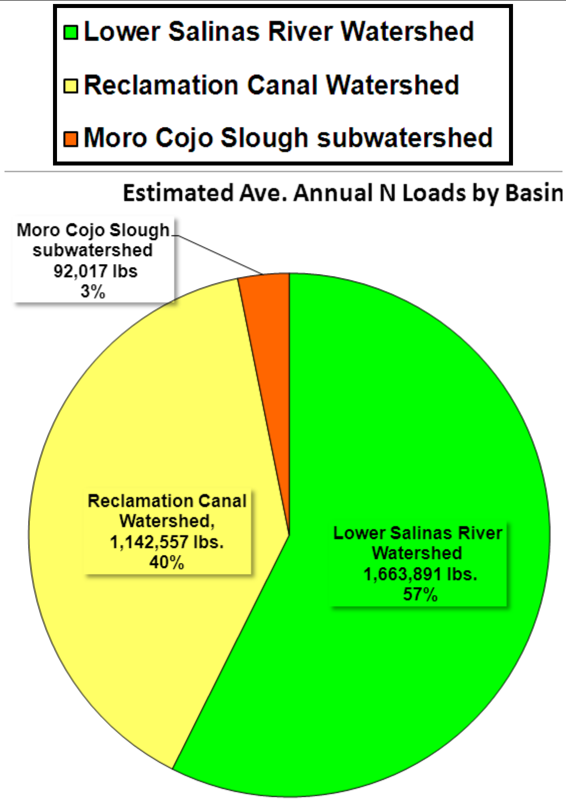
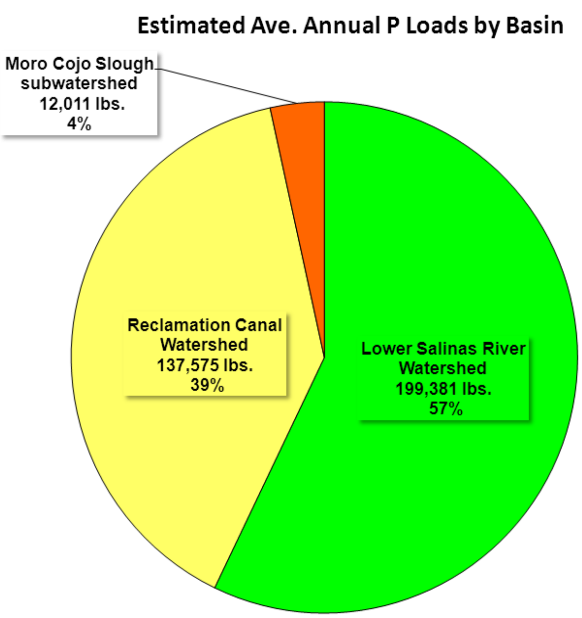
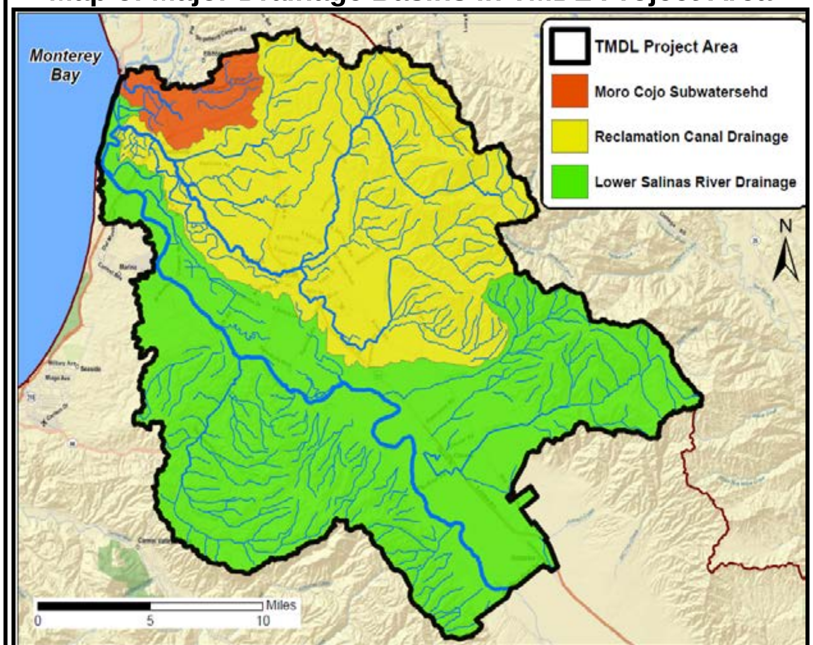


Figure 5-16. Estimated average annual nutrient source loads in major drainages of project area.





Map of Major Drainage Basins in TMDL Project Area



Estimated Nitrogen Yield by Drainage Basin

Drainage Basin	Acres	Nitrogen Yield (lbs/acre)
Lower Salinas River watershed	148,811	**11.2**
Reclamation Canal watershed	100,690	**11.4**
Moro Cojo Slough subwatershed	9,735	**9.5**

Estimated Phosphorus Yield by Drainage Basin

Drainage Basin	Acres	Phosphorus Yield (lbs/acre)
Lower Salinas River watershed	148,811	**1.3**
Reclamation Canal watershed	100,690	**1.4**
Moro Cojo Slough subwatershed	9,735	**1.2**

Table 5-12. Estimated average annual nutrient loads and yields by subwatershed.

	Land Cover (acres)				Predicted Nutrient Loads (lbs./yr)		Predicted Nutrient Yields (lbs./acre/yr)	
Subwatershed	**Urban**	**Cropland**	**Grazing Lands**	**Forest-Undev.**	**Predicted N Load**	**Predicted P Load**	**Predicted Annual N Yield**	**Predicted Annual P Yield**
Alisal Creek/Upper Rec Canal	3,796	10,135	12,724	3,000	**346,810**	**42,749**	**11.7**	**1.4**
Alisal Slough	705	3,884	0	32	**116,706**	**12,356**	**25.3**	**2.7**
Blanco Drain	64	4,374	0	1	**127,018**	**13,387**	**28.6**	**3.0**
Chualar Creek	123	7,737	13,511	4,051	**257,801**	**33,460**	**10.1**	**1.3**
El Toro Creek	1,333	26	15,566	10,137	**50,687**	**12,911**	**1.9**	**0.5**
Esperanza Creek	0	2,922	2,252	513	**89,993**	**10,523**	**15.8**	**1.9**
Espinosa Slough	37	2,158	0	460	**63,029**	**6,664**	**23.7**	**2.5**
Gabilan Creek	1,705	2,497	14,638	9,117	**121,671**	**19,960**	**4.4**	**0.7**
Merritt Lake	2,457	3,707	1,461	6,611	**129,985**	**14,821**	**9.1**	**1.0**
Moro Cojo Slough	1,478	3,185	487	4,585	**92,017**	**12,011**	**9.5**	**1.2**
Natividad Creek	1,002	1,476	4,494	364	**59,063**	**8,360**	**8.1**	**1.1**
Old Salinas River	44	1,058	37	353	**31,233**	**3,327**	**20.9**	**2.2**
Quail Creek	114	2,705	3,709	4,570	**90,496**	**11,405**	**8.2**	**1.0**
Reclamation Canal Lower	2,544	3,124	13	48	**105,795**	**11,366**	**18.5**	**2.0**
Sal River u/s of Spreckels	2,114	23,590	8,449	16,270	**725,960**	**81,129**	**14.4**	**1.6**
Sal River d/s of Spreckels	2,418	6,514	4,185	6,235	**216,848**	**25,190**	**11.2**	**1.3**
Salinas River Lagoon	34	2,485	508	810	**73,852**	**8,046**	**19.2**	**2.1**
Santa Rita Creek	1,143	4,769	281	154	**145,754**	**15,608**	**23.0**	**2.5**
Tembladero Slough	345	1,784	1	24	**53,847**	**5,734**	**25.0**	**2.7**

Regarding the previous Figure 5-15, it is important to recognize that each land use category has a certain, natural background level of nitrate contribution to creek waters that are unrelated to human activities. For example, although staff has estimated cropland as the overwhelming majority of the controllable nitrate load contribution to the surface waters (when also including the agricultural fertilizer impacts to shallow groundwater baseflow sources), staff estimates a relatively small fraction of the nitrate aggregate contribution is from natural, background conditions. In contrast, at the project area scale, estimated natural, non-controllable inputs of phosphorus constitute a relatively large fraction of total estimated phosphorus loads based on STEPL results. Note that controllable phosphorus leaching to groundwater was presumed to be negligible; 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 aquifer minerals in the subsurface. Therefore, phosphorus in groundwater is considered a natural, non-controllable source.

An estimate of natural, non-controllable nutrient inputs is made by setting the nutrient STEPL input parameters for each land use category to plausible background conditions (see Table 5-13). Background conditions for nutrient concentration in runoff are represented by inputting the values for the “forest” category previously shown in Table 5-1 for each land use category. Background nitrate-N concentrations for alluvial valley groundwater (urban and cropland categories) is 1.21 mg/L and for groundwater in upland ecoregions (grazing lands and forest) is 0.47 mg/L, as previously as shown in Table 5-1.

Table 5-13. STEPL input values for natural, background contributions.

Land Use	Nitrogen-N Concentration in Runoff (mg/L)	Nitrogen-N Concentration in shallow groundwater (mg/L)	Phosphorus-P Concentration in Runoff (mg/L)	Phosphorus-P Concentration in shallow groundwater (mg/L)
Urban	0.2	1.21	0.1	0.03
Cropland	0.2	1.21	0.1	0.03
Grazing Lands	0.2	0.47	0.1	0.03
Forest	0.2	0.47	0.1	0.03

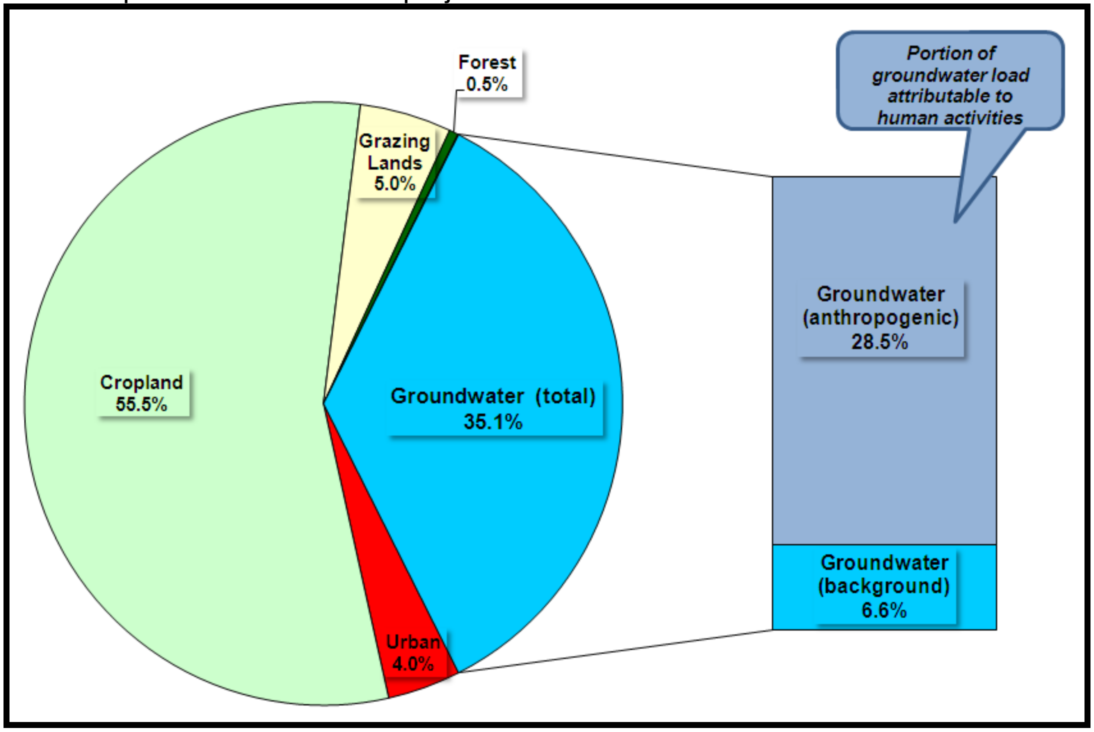
Table 5-14. Attribution of total loads, and non-controllable natural background loads by land use categories.

Source Category	**Estimated Total N Load (lb/yr)**	**Estimated Total P Load (lb/yr)**	**Estimated Background N Load (lb/yr)**	**Estimated Background P Load (lb/yr)**	**Percent of Total N Load attributable to natural background**	**Percent of Total P Load attributable to natural background**
Urban	114,698	15,198	5,735	2,867	5%	19%
Cropland	1,608,557	266,408	707,196	219,350	44%	82%
Grazing Lands	143,734	54,202	138,239	43,993	96%	81%
Forest	14,205	5,561	14,205	5,561	100%	100%
Septic	106	41	0	0	0%	0%
Groundwater	1,017,165	7,557	191,095	7,557	19%	100%
Atmospheric Deposition	900	212	900	212	100%	100%
Total	2,899,365	349,179	1,057,371	279,540	36%	80%

Note: these estimates are representative at the basin-scale of the entire TMDL project area. Depending on the level of human development and activities, locally at the subwatershed scale and reach scale, the relative contributions of anthropogenic nutrients and background nutrients will vary substantially.

Finally, since nitrate loads resulting from shallow groundwater baseflow inputs are a substantial and important source category, Figure 5-17 presents an illustration of the attribution of groundwater source loads to its natural background and anthropogenic components.

Figure 5-17. Attribution of groundwater nitrate source loads to anthropogenic and natural load components in the TMDL project area.



5.10.1 Comparison of Source Analysis with Previous Studies

Staff compared the source analysis conclusions presented herein with conclusions reached by other scientists in previous studies. Nutrient source analysis presented in this project report is consistent with conclusions from a previous study which analyzed nutrient sources for surface waters of the lower Salinas Valley. A team of scientists and researchers from the Watershed Institute at California State University-Monterey Bay concluded in 2003:

> *"The dominant source of high nutrient concentrations in southern Monterey Bay watersheds is irrigated agriculture. This is strongly suggested, albeit qualitatively, through overwhelming correlation between nutrient concentration data and land use."*
>
> *Source: "Nutrients in Surface Waters of Southern Monterey Bay Watersheds" (Anderson et al. 2003)*

Additionally, while grazing lands constitute a large and substantial proportion of land use in the TMDL project area, staff's analysis in this report indicates that project area grazing lands are a relatively insignificant source of nitrate and orthophosphate and that this source category is currently meeting its load allocation (refer to section 7.5). Staff's conclusions are supported by an independent line of research available from scientists at the Watershed Institute at California State University-Monterey Bay; these researchers concluded that data from southern Monterey Bay watersheds indicate that grazed lands are not significant nitrate or phosphate sources (Anderson et al., 2003).

Accordingly, Staff finds the source analysis developed in this project report is consistent with previous findings by researchers.

5.10.2 Supporting Evidence of Source Analysis from Geochemical Research

Overall, staff's source analysis indicates that cropland is the overwhelming source of controllable nutrient loading to surface waters of the project area. These results are consistent with findings from the Salinas Valley recently published by researchers from Lawrence Livermore National Laboratory (Moran et al. 2011). Lawrence Livermore National Laboratory (LLNL) found that geochemical and isotopic data indicates that irrigated agriculture is the largest source of nitrate to surface waters and groundwater in sampled areas of the Salinas Valley where nitrate concentrations are above a low background concentration. LLNL concluded that the nitrogen and oxygen isotopic composition of these nitrate samples typically fall within the range expected for inorganic fertilizers, and not within the expected range for animal waste. This study was limited in geographic scope, and should not be extrapolated to represent site specific conditions for all catchments and subwatersheds of the lower Salinas Valley However, this geochemical evidence provides an additional line of evidence supporting the mass balance-based source analysis developed in this TMDL project report.

5.10.3 Comparison of Predicted Loads to Observed Loads

As a preliminary validation of the STEPL annual load calculations, calibration to estimated annual loads from field water quality monitoring data may be evaluated.

Monitoring sites 309TDW (lower Tembladero Slough), OLS-MON (Old Salinas River), and 306MOR (lower Moro Cojo Slough) represent the downstream drainage outlets of the TMDL project area as it drains into Moss Landing Harbor and Elkhorn Slough estuary. Except for some wet winters, when the Salinas River lagoon is periodically breached to flow into Monterey Bay, the aforementioned sites represent the drainage outlet of the project area. Copious amounts of nitrogen as nitrate data are available for these sites. It is important to note that while nitrogen as nitrate is not directly comparable to total nitrogen (total N as calculated by STEPL), nonetheless nitrate is generally the largest fraction of nitrogen species in aquatic environments[107] and presents an opportunity for a screening assessment of the reasonableness of total N loads as estimated by STEPL. Table 5-15 illustrates the estimated mean annual loads (pounds/year) of nitrogen as nitrate at monitoring sites 309TDW, OLS_MON, and 306MOR. Mean annual loads were estimated by an 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. For this screening assessment, the mean annual flow at the monitoring sites were estimated from the NHDplus hydrologic attribute MAVFLOWU (see NHDplus documentation). As illustrated in Table 5-15 and using appropriate conversion factors the estimated mean annual nitrogen as nitrate load based on observed water quality data at project area watershed outlets is:

(1,327,554 + 1,651,779 + 17,375) = 2,996,708 pounds/year.

Note that this annual load estimate appears to qualitatively comport reasonably well with Elkhorn Slough loading estimates from NOAA's National Coastal Pollutant Discharge Inventory (NCPDI) survey. NCPDI used 1980's vintage data to estimate annual loads to Elkhorn Slough of 2,608,042 pounds per year

[107] Data used in this project report indicates that, on average, nitrogen as nitrate comprises over 95% of total water column nitrogen in inland surface streams of the lower Salinas Valley.

(http://ian.umces.edu/neea/siteinformation.php).

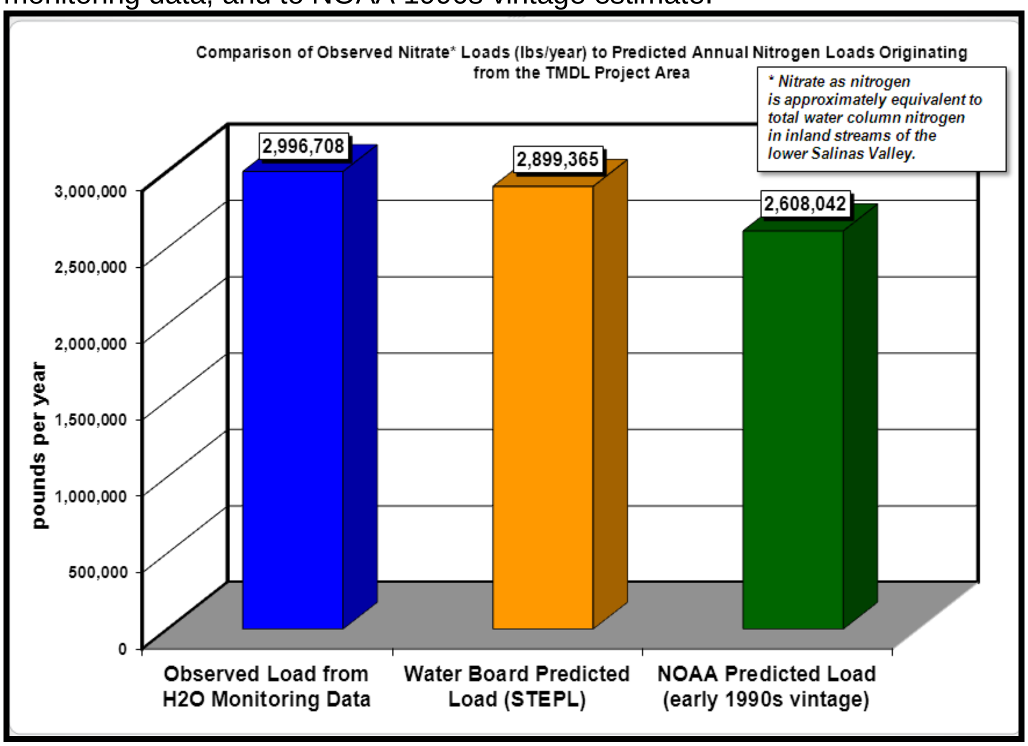
While the NCPDI estimate (2,608,042 pounds/year) is about 10% lower than the estimate staff calculated (2,899,365 pounds/year) it should be recognized that the NCPDI survey is based on older vintage data, and in fact nitrogen loading in Salinas River-Reclamation Canal basin and the TMDL project area itself have been increasing as indicated by time series plots (refer back to Figure 3-13, Figure 3-14, and Figure 3-15 and Figure 3-16).

Table 5-15. Estimated mean annual flows and mean nitrate-N concentrations at project area watershed outlets.

Waterbody	**Mean Annual Flow (cfs)** *source: NHDplus*	**Number of Samples**	**Mean NO3-N Concentration (mg/L)**
Tembladero Slough @ 309TDW	36	127	23.3
Old Salinas River @OLS-MON	36.2	202	18.6
Moro Cojo Slough @306MOR	5.5	247	1.6

A comparison of the estimated mean annual observed water column load to the estimated STEPL predicted annual load for nitrogen is shown in Figure 5-18, suggesting that the project area N loads calculated by STEPL appear to comport reasonably well with observed loads in water quality monitoring data at the project area downstream watershed outlets. Also, as shown in Figure 5-18, predicted STEPL estimated annual loads are reasonably consistent with a 1990s vintage loading estimate from NOAA's NCPDI survey for nitrogen loads to Elkhorn Slough[108]. These observations provide a measure of confidence that predicted annual loads using STEPL, in conjunction with input parameters consistent with physical conditions of the lower Salinas Valley (see Table 5-1), are plausible and credible.

Figure 5-18. Comparison of STEPL predicted nitrogen loads to nitrogen loads observed in monitoring data, and to NOAA 1990s vintage estimate.



[108] Most water column nitrogen in Elkhorn Slough is attributable to land contributions, since sea water influx associated with rising tides typically has very low nitrogen concentrations. Further, the freshwater drainage from land, and thus land-derived loads, to Elkhorn Slough is largely attributable to the lower Salinas Valley.

Similarly, estimated mean annual phosphate as P load fluxing out of the TMDL project area based on observed water quality data at project area watershed outlets is tabulated in Table 5-16.

Table 5-16. Estimated mean annual flows and mean phosphate-P concentrations at project area watershed outlets.

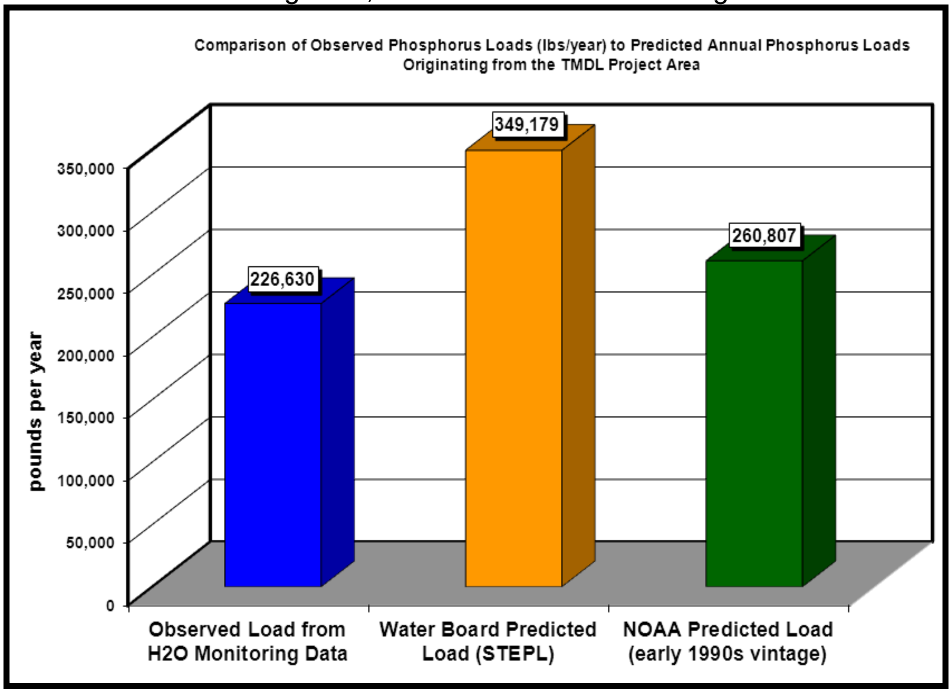
Waterbody	**Mean Annual Flow (cfs)** *source: NHDplus and USGS Spreckels Gage*	**Number of Samples**	**Mean total phosphate-P Concentration (mg/L)**	**Annual load pounds**
Tembladero Slough @ 309TDW	36	57	0.84	59,542
Old Salinas River @OLS-MON[A]	420	13	0.19	157,125
Moro Cojo Slough @306MOR	5.5	14	0.92	9,963
				Total = 226,630

[A] total phosphate data is not available for the Old Salinas River (OSR). Data from site 309SBR (Salinas River inflow to the lagoon) was assumed to be a plausible estimate of total phosphate concentrations in the OSR.

A comparison of the estimated mean annual observed water column load to the estimated STEPL predicted annual load for phosphorus is shown in Figure 5-19. The STEPL estimated load is well within the same order of magnitude as the observed water column loads at downstream outlets and with the older vintage NOAA prediction, suggesting that the STEPL estimates are reasonably plausible. However, the STEPL predicted annual phosphorus load is marginally higher than the NOAA predicted load and the observed water column load by 25% and 35%, respectively.

It should be recognized that STEPL estimates phosphorus delivered to surface waters, basin-wide, within the entire TMDL project area. Because phosphorus readily binds to sediment - and may thus be sequestered within the basin - the total basin-wide phosphorus load estimated by STEPL may not necessarily be observed in the water column at the downstream watershed outlets of the TMDL project area. 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. Also, the sample size for observed water column phosphorus amounted to less than 100 samples, perhaps introducing a bias by limited sample size and temporal distribution.

Figure 5-19. Comparison of STEPL predicted phosphorus loads to phosphorus loads observed in monitoring data, and to NOAA 1990s vintage estimate.



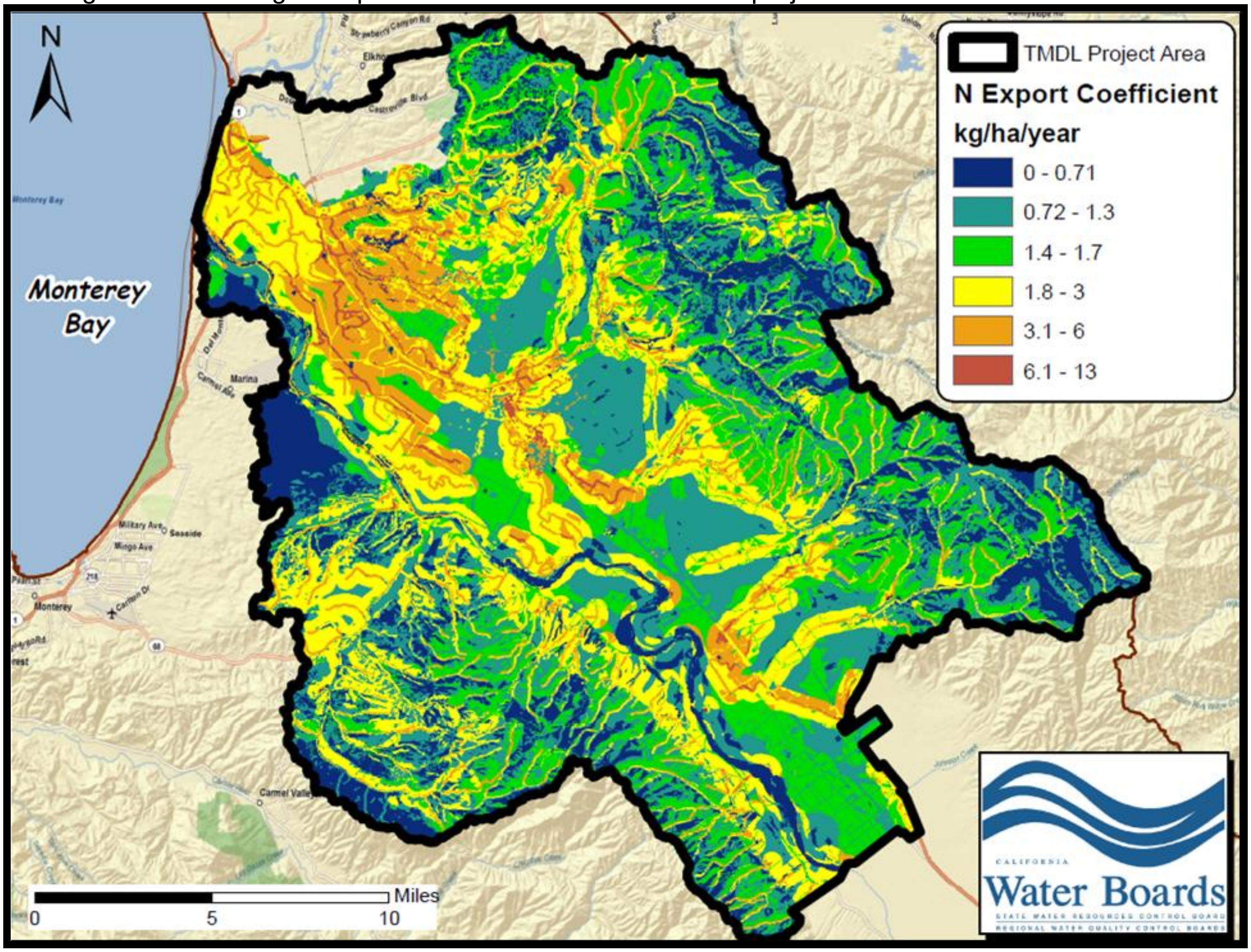
5.10.4 Export Coefficient Model

The Export Coefficient Model (ECM) (Reckhow et al., 1980) is a scoping model regularly used to compute lumped annual basin nitrogen loads based on summing nonpoint and point source estimated loads. Figure 5-20 illustrates the spatial distribution of nitrogen loading risk based on the ECM and peer-reviewed methodologies[109]. It is important to note that the information in this figure has no regulatory consequences; it is presented as an informational display illustrating a screening-level risk assessment. This particular ECM incorporates weighting factors applied to standard export coefficients based on the land use / hydrologic soil group/ and distance to stream combinations. Appendix F presents detailed information on the derivation of this scoping-level ECM. Loading risk is assessed based on peer-reviewed nitrogen loading coefficients, land cover (NLCD, 2001), hydrologic soil groups (NRCS-SSURGO), and distance to surface waterbody. The color gradation scale ranges from red (high risk) to blue (low risk). Consistent with Staff's source analysis, the ECM indicates that the magnitude and intensity of nitrogen loading is generally highest in agricultural valley floor reaches; in particular associated with the lower reaches of the project area; aka Tembladero Slough, the Reclamation Canal, and tributaries.

To summarize Section 5.10.1 through Section 5.10.4, multiple lines of evidence – including previous studies, geochemical data, and pollutant load estimates using various sources and methods – qualitatively appear to be consistent with staff's source analysis, and provide a weight-of-evidence approach which adds a measure of confidence to the source analysis staff developed.

[109] Reckhow, K. H., M. N. Beaulac, and J. R. Simpson, 1980. Modeling Phosphorous Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. EPA-440/5-80- 011

Figure 5-20. Nitrogen Export Coefficient Model for TMDL project area.



6 TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS

6.1 Introduction

The TMDL represents the loading capacity of a waterbody—the amount of a pollutant that the waterbody can assimilate and still support beneficial uses. The TMDL is the sum of allocations for nonpoint and point sources and any allocations for a margin of safety. TMDLs are often expressed as a mass load of the pollutant but can also be expressed as a unit of concentration (40 CFR 130.2(i)).

The TMDLs for nitrate, orthophosphate, and unionized ammonia for project areas waterbodies are set at a maximum concentrations (numeric targets) in receiving water as previously presented in Section 4. The TMDL allocations, which include background levels, are also equal to the numeric targets. Expressing the TMDL as a nitrate concentration equal to the water quality objectives and numeric targets provides a direct measure of the nitrogen compounds and orthophosphate levels in the watershed to compare with water quality objectives and provides a measurable target for sources to monitor and with which to comply. 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.

Load allocations for nitrogen compounds and orthophosphate are assigned to each source, including background. This allocation will require a reduction of existing loads by cropland landowners and operators, and MS4 stormwater entities.

Owners/operators of domestic animals and grazing animals are given an allocation, which is presumed to be equal to the existing load from this source category. At this time, this source category appears to be in compliance with their load allocation, consequently there are no additional requirements for owners/operators of domestic animals. It is important to note that lower Salinas River Watershed is in fact subject to the Domestic Animal Waste Discharge Prohibition (Water Quality Control Plan for the Central Coast Basin, Chapter 5. IV. Discharge Prohibitions), and are subject to compliance with an approved indicator bacteria TMDL load allocation. Implementation efforts by responsible parties to comply with this prohibition and indicator bacteria load allocation will, as a practical matter, also reduce the risk of nitrogen and phosphorus loading to surface waters from domestic animal waste.

6.2 Existing Loading and Loading Capacity

6.2.1 Estimates of Existing Loading

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. Average and seasonal flow estimates for project area stream reaches were previously presented in Section 2.5. Table 6-1 presents a tabulation of estimated mean annual existing nitrate loads, and percent reduction from the existing load to meet the loading capacity of the waterbody. Figure 6-1 illustrates the spatial extent of mean annual nitrate loads. Total flux of nitrate as N at the confluence of the Old Salinas River and Tembladero Slough into fluxing into the Old Salinas River Estuary is estimated at around three million pounds average, annually. This estimate is consistent with predicted load estimates previously presented in Section 5.10.1, and also comports reasonably well with a loading estimate provided by the National Oceanic and Atmospheric Administration (refer back to Section 5.10.1 and Figure 5-18).

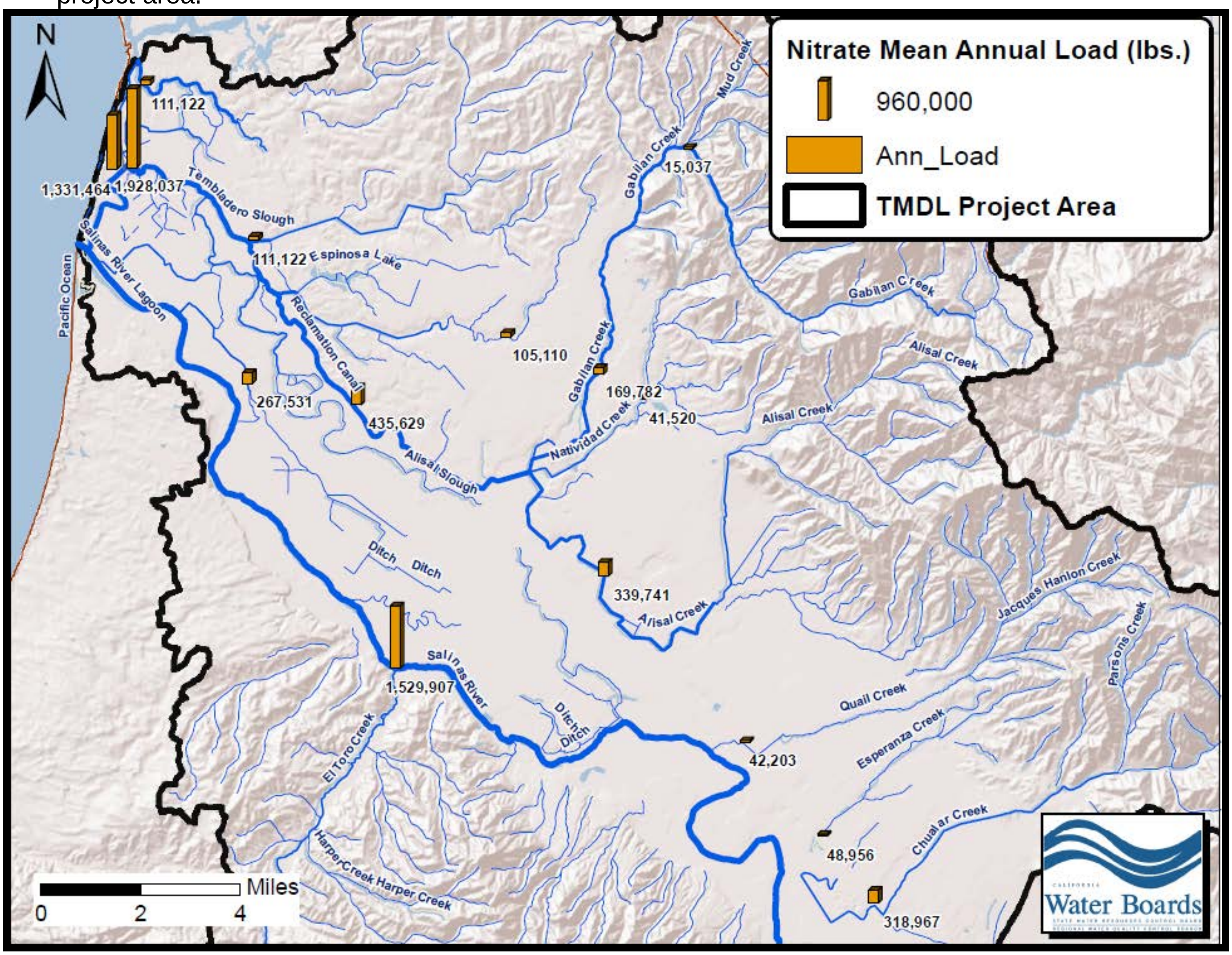
Table 6-1. Tabulation of estimated mean annual existing nitrate loads and percent reductions.

Waterbody-Site	Estimated Mean Annual Flow (cfs)	Mean Annual Conc. (mg/L)	Mean Annual Existing Load (lbs.)	Mean Annual Loading Capacity (lbs.)	% Reduction Goal[A]	NO3-N Numeric Target Used for Loading Capacity (mg/L)
Salinas River @ Spreckels-309 SSP	420	1.85	1,529,907	8,269,769	0%	MUN (10)
Salinas River @ Hwy 1 - 309SBR	350	13.29	9,158,769	5,513,179	40%	Wet Season Biostim (8.0)
Old Salinas Riv-OLS-MON	36.2	18.68	1,331,464	570,220	57%	Wet Season Biostim (8.0)
Tembladero Slough-309TDW	36	27.2	1,928,037	567,070	71%	Wet Season Biostim (8.0)
Moro Cojo Slough-306MOR	6	5.3	62,614	94,512	0%	Wet Season Biostim (8.0)
Chualar Creek-309CRR	1.79	90.5	318,967	35,245	89%	MUN (10)
Quail Creek-309QUI	0.7	30.62	42,203	13,783	67%	MUN (10)
Esperanza Creek-ESZ-HWY	0.38	65.43	48,956	7,482	85%	MUN (10)
Blanco Drain-BLA-PUM	5.75	61.76	699,229	90,574	87%	Wet Season Biostim (8.0)

Waterbody-Site	Estimated Mean Annual Flow (cfs)	Mean Annual Conc. (mg/L)	Mean Annual Existing Load (lbs.)	Mean Annual Loading Capacity (lbs.)	% Reduction Goal[A]	NO3-N Numeric Target Used for Loading Capacity (mg/L)
Lower Reclamation Canal-309JON	16.66	13.28	435,629	262,427	40%	Wet Season Biostim (8.0)
Upper Reclamation Canal-309ALG	10.47	16.48	339,741	164,923	51%	Wet Season Biostim (8.0)
Natividad Creek-309NAD	0.99	21.3	41,520	15,594	62%	Wet Season Biostim (8.0)
Gabilan Creek-309GAB	8.22	10.49	169,782	129,481	24%	Wet Season Biostim (8.0)
Alisal Creek – 309HRT & 309UAL	2.3	23.9	106,825	35,757	67%	Wet Season Biostim (8.0)
Alisal Slough – 309ASB	1.64	47.5	153,385	20,667	87%	Wet Season Biostim (8.0)
Santa Rita Creek-309SRTA-36	4.9	12.16	105,110	69,151	34%	Wet Season Biostim (8.0)
Merrit Ditch-309MER	3.7	20.98	111,122	58,282	48%	Wet Season Biostim (8.0)
Gabilan Creek-GAB-OSR	5.16	1.48	15.037	101,600	0%	MUN (10)

[A] Percent reduction goals are for informational purposes only, and should not be viewed as the TMDL.

Figure 6-1. Spatial distribution of estimated mean annual existing nitrate-N loading in TMDL project area.



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 6-2 (including percent reduction from the existing load to meet the loading capacity of the waterbody) and Figure 6-3.

It is noteworthy that loading patterns for the dry season are substantially different than observed on a mean annual basis. This is due to the hydrologic, climate, and land use conditions noted previously in Section 2. Dry season nitrate loading in the lowermost Salinas River (downstream of Spreckels) appears mostly attributable to the Blanco Drain, and possibly other nonpoint sources in the lowermost reaches of the Salinas River. Also, nitrate export out of the TMDL project area, and into the Elkhorn Slough during the dry season is evidently largely attributable to the Tembladero Slough, and its upstream agricultural tributaries. Dry season flux of nitrate as N at the confluence of the Old Salinas River (at Monterey Dunes) and Tembladero Slough is estimated at approximately half a million pounds, with the overwhelming majority (>400,000 pounds) attributable to the Tembladero Slough (see Figure 6-2). Figure 6-3 presents the spatial distribution of estimated mean dry season nitrate fluxes throughout the project area as a whole. Figure 6-4 illustrates the estimated dry season loads as pie charts for stream reaches within the Reclamation Canal-Tembladero Slough drainage, and the Lower Salinas River drainage.

Table 6-2. Tabulation of estimated mean dry season (May 1 – Oct. 31) existing nitrate loads.

Waterbody-Site	Estimated Mean Dry Flow (cfs)	Mean Dry Season Conc. (mg/L)	Mean Dry Existing Load (lbs.)	Mean Dry Loading Capacity (lbs.)	% Reduction Goal [A]	NO3-N Numeric Target Used for Loading Capacity (mg/L)
Salinas River-309 DAV	5.98	17.24	101,497	8,242	92%	dry Season Biostim (1.4)
Salinas River-309SBR	26.3	19.02	492,471	36,249	93%	dry Season Biostim (1.4)
Salinas River-309SAC	57.33	1.59	88,664	564,412	0%	MUN
Old Salinas River-OLS-MON	7.08	19.47	135,711	21,608	84%	dry Season Biostim (3.1)
Tembladero Slough-309TEH	14.2	28.72	401,501	89,471	78%	dry Season Biostim (6.4)
Moro Cojo Slough-306MOR	4.15	4.5	18,386	6,946	62%	dry Season Biostim (1.7-TN)
Chualar Creek-309CRR	0.95	106.42	99,139	9,353	91%	MUN (10)
Quail Creek-309QUI	1.99	28.32	55,444	19,592	65%	MUN (10)
Blanco Drain-BLA-PUM	5.6	57.67	317,945	35,285	89%	dry Season Biostim (6.4)
Lower Reclamation Canal-309JON	3.73	7.72	28,349	23,502	17%	dry Season Biostim (6.4)
Upper Reclamation Canal-309ALG	2.4	18.06	42,667	15,122	65%	dry Season Biostim (6.4)
Natividad Creek-309NAD	0.33	25.91	8,418	650	92%	dry Season Biostim (2.0)
Gabilan Creek-309GAB	0.69	7.27	4,939	1,359	72%	dry Season Biostim (2.0)
Alisal Creek – 309HRT & 309UAL	0.5	23.1	11,371	984	91%	dry Season Biostim (2.0)
Alisal Slough-209ASB	1.29	42.13	53,505	16,256	70%	dry Season Biostim (6.4)
Espinosa Slough-309ESP	1.71	36.82	61,986	10,775	83%	dry Season Biostim (6.4)
Merrit Ditch-309MER	3.7	30.98	47,604	12,350	74%	dry Season Biostim (6.4)

[A] Percent reduction goals are for informational purposes only, and should not be viewed as the TMDL

Figure 6-2. Estimated mean dry season (May 1-Oct. 31) nitrate-N flux @ confluence of Old Salinas River and Tembladero Slough.

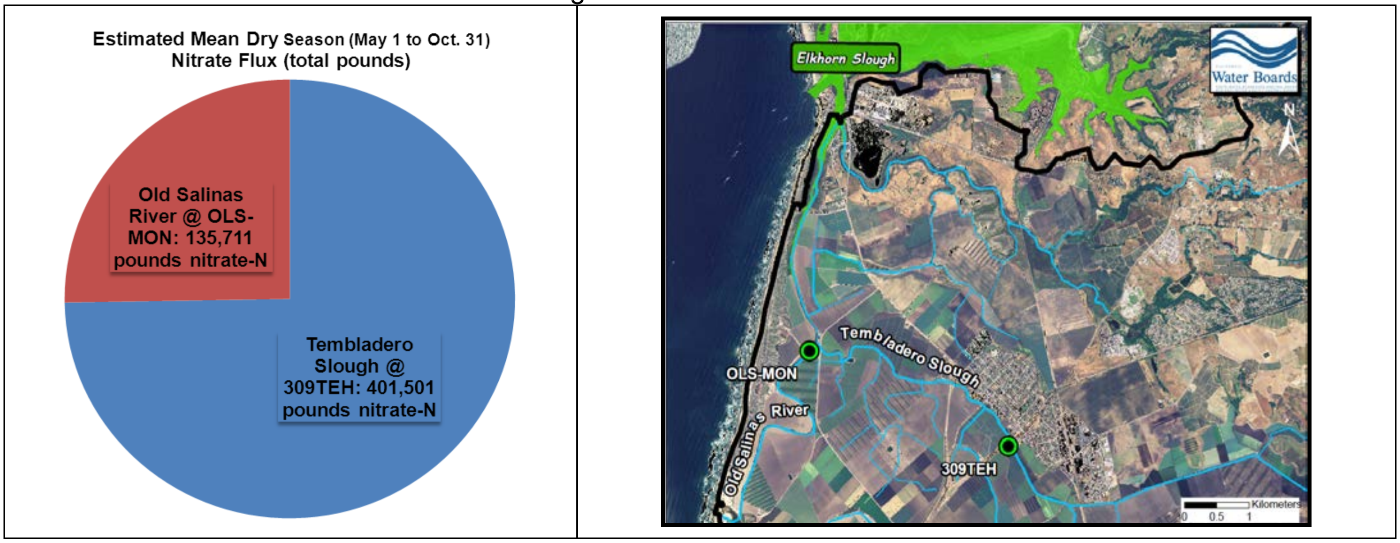


Figure 6-3. Spatial distribution of estimated dry season (May 1 – Oct 31) existing nitrate-N loading in TMDL project area.

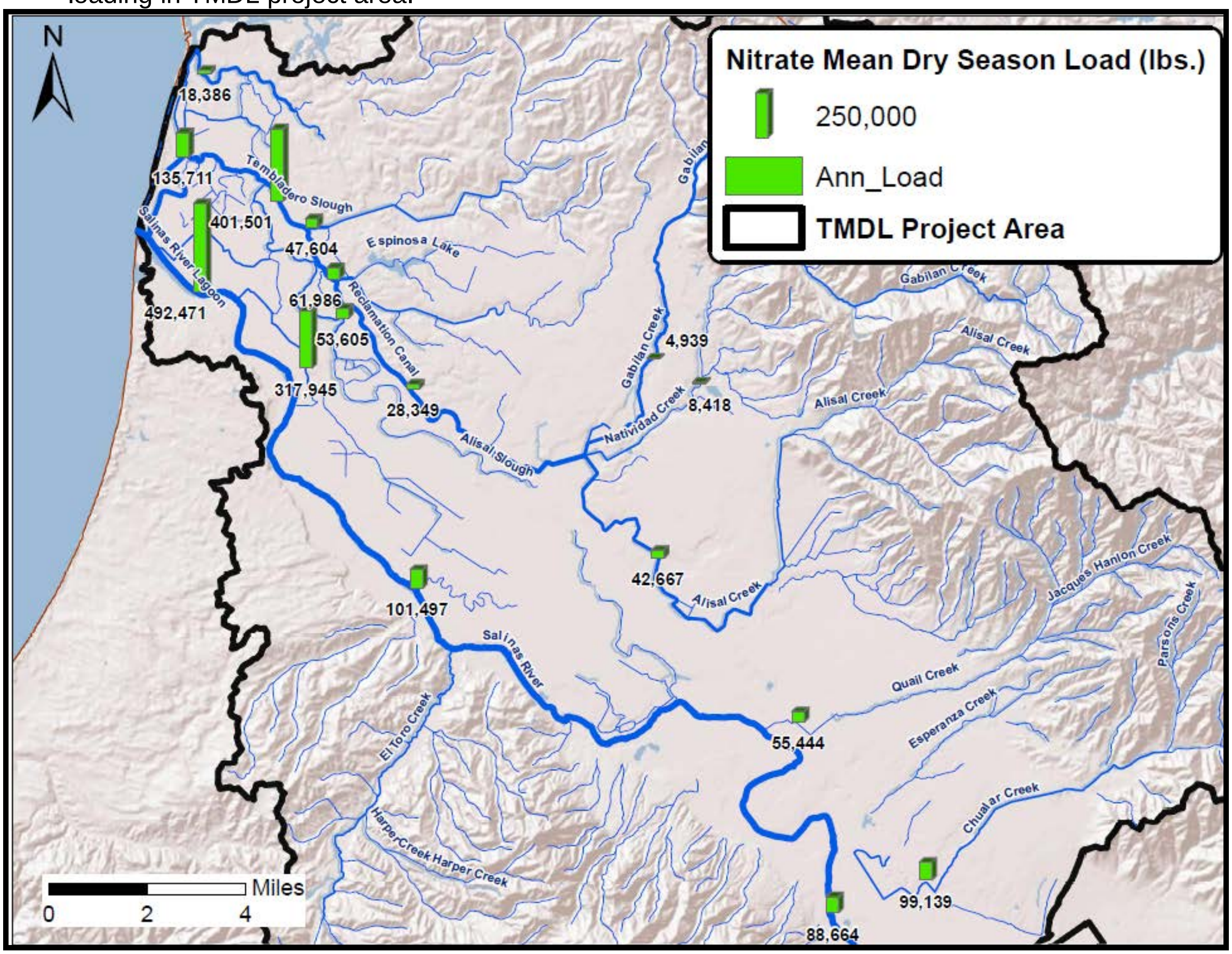
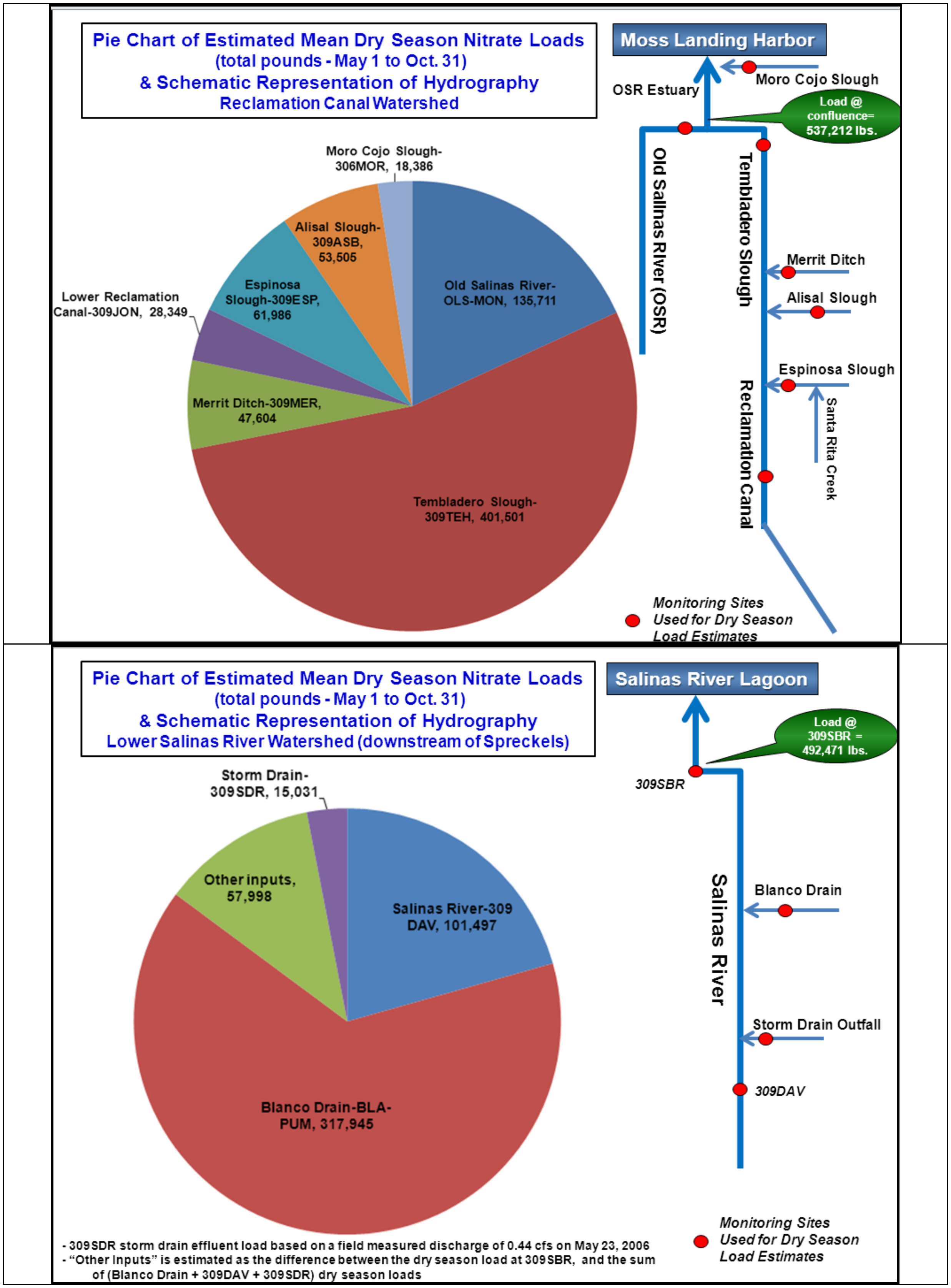


Figure 6-4. Pie charts of dry season loads, Reclamation Canal and Lower Salinas River watersheds.



6.2.1 Nitrate Yields

Mean annual yields can provide insight into the nexus between land use and pollutant loading rates. Mean annual yield is estimated by dividing the mean annual load, as estimated previously in Section 6.2.1, by the upstream drainage-basin area. Mean annual yields for representative stream reaches in the project area are presented in Table 6-3. These representative stream reaches appear to indicate that nitrate yields are typically highest from areas draining predominantly cultivated cropland. The lowest nitrate yields in the project area appear generally to be from rangelands and undeveloped upper watershed reaches.

Table 6-3. Estimated mean annual nitrate yields.

Waterbody-Monitoring Site	Primary Land Use Draining to Site	Upstream drainage-area (acres)	Annual Nitrate Yield (pounds per acre)
Gabilan Creek-(GAB-OSR)	Grazing lands, forest, undeveloped	10,213[A]	**1.5**
Blanco Drain (BLA-PUM)	Cultivated cropland	4,442[B]	**60.2**
Alisal Slough (309ASB)	Cultivated cropland	4,621[C]	**11.6**
Reclamation Canal (309-JON)	Mixed urban and cropland	35,,385[D]	**12.3**
Espinosa Slough (309-ESP)	Mixed cropland and urban	9,003[E]	**6.9**
Tembladero Slough (309TEH)	Majority is cultivated cropland, some urban inputs	91,690 [F]	**21.0**

[A] Drainage area based on Calwater22 PWS watershed unit = East Gabilan Creek
[B] Drainage area based on Blanco Drain subwatershed area.
[C] Drainage area based on Alisal Slough subwatershed area
[D] Drainage area based on lower and upper Reclamation Canal subwatershed area..
[E] Drainage area based on sum of Espinosa Slough and Santa Rita Creek subwatershed areas
[E] Drainage area based on sum of all subwatershed areas draining to Tembladero Slough

6.2.2 TMDLs

The TMDLs (loading capacity) for waterbody segments in the TMDL project area is the amount of nitrate, unionized ammonia, and/or orthophosphate that can be assimilated without exceeding the water quality objectives. The Basin Plan contains water quality objectives for nitrate, unionized ammonia, and narrative water quality objectives for biostimulatory substances and thus the loading capacities for the waterbodies are:

For waterbodies designated with the Municipal and Domestic Supply (MUN) beneficial use in the project area:

Including, but not limited to:

- Lower Salinas River (downstream of Gonzalez)
- Old Salinas River
- Merrit Ditch
- Alisal Slough
- Santa Rita Creek
- Gabilan Creek

- Natividad Creek
- Alisal Creek,
- Quail Creek
- Esperanza Creek
- Chualar Creek

Waters shall not contain concentrations of nitrate as nitrogen in excess of 10 mg/L nitrate as nitrogen.

For all inland surface waters, and estuaries in the project area:

Including, but not limited to:

- Lower Salinas River (downstream of Gonzalez)
- Old Salinas River
- Moro Cojo Slough
- Tembladero Slough
- Merrit Ditch
- Reclamation Canal
- Alisal Slough
- Blanco Drain
- Espinosa Slough
- Santa Rita Creek
- Gabilan Creek
- Natividad Creek
- Alisal Creek
- Quail Creek
- Chualar Creek

The discharge of wastes shall not cause concentrations of unionized ammonia (NH3) to exceed 0.025 mg/l (as N) in receiving waters.

For waterbodies not achieving the Water Quality Objective for Biostimulatory Substances in the project area:

Receiving waters shall not contain concentrations of nitrate (as N), orthophosphate (as P), or total nitrogen (as N) in accordance with the stream reach/water column concentration pairs presented in Table 6-4.

Table 6-4. TMDLs for biostimulatory substances.

Project Area Stream Reaches	Allowable Nitrate-N (mg/L)	Allowable Orthophosphate-P (mg/L)
Lower Salinas River – Downstream of Spreckels to and including Salinas River Lagoon (north)	**1.4** Dry Season Samples (May 1-Oct. 31) **8.0** Wet Season Samples (Nov. 1-Apr. 30)	**0.07** Dry Season Samples (May 1-Oct. 31) **0.3** Maximum Wet Season Samples (Nov. 1-Apr. 30)
Tembladero Slough all reaches Blanco Drain all reaches Merritt Ditch dwnstrm of Merritt Lake Reclamation Canal downstream of Hartnell Rd. to confluence w/Tembladero Slough Alisal Slough all reaches Espinosa Slough from Espinosa lake to confluence with Reclamation Canal Santa Rita Creek all reaches	**6.4** Dry Season Samples (May 1-Oct. 31) **8.0** Wet Season Samples (Nov. 1-Apr. 30)	**0.13** Dry Season Samples (May 1-Oct. 31) **0.3** Wet Season Samples (Nov. 1-Apr. 30)
Gabilan Creek all reaches downstream of Crazy Horse Road to confluence with Reclamation Canal Natividad Creek all reaches Alisal Creek all reaches to confluence with Reclamation Canal at Hartnell Rd.	**2.0** Dry Season Samples (May 1-Oct. 31) **8.0** Wet Season Samples (Nov. 1-Apr. 30)	**0.07** Dry Season Samples (May 1-Oct. 31) **0.3** Wet Season Samples (Nov. 1-Apr. 30)
Old Salinas River from outflow @ Salinas River Lagoon to Old Salinas River at Potrero Rd.	**3.1** Dry Season Samples (May 1-Oct. 31) **8.0** Wet Season Samples (Nov. 1-Apr. 30)	**0.07** Dry Season Samples (May 1-Oct. 31) **0.3** Wet Season Samples (Nov. 1-Apr. 30)
Project Area Stream Reaches	**Allowable Total Nitrogen (mg/L)**	**Allowable Orthophosphate-P (mg/L)**
Moro Cojo Slough, all reaches	**1.7** (total nitrogen) Dry Season Samples (May 1-Oct. 31) **8.0** Wet Season Samples (Nov. 1-Apr. 30)	**0.13** Dry Season (May 1-Oct. 31) **0.3** Wet Season Samples (Nov. 1-Apr. 30)

6.2.1 USEPA Guidance on Daily Load Expressions

In light of a court decision (Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, D.C. Cir. 2006), USEPA recommends incorporating a daily load expression for certain types of TMDLs which are based on a concentration-based loading capacity (USEPA, 2007); e.g., when the concentration-based numeric loading capacity has a time-step, or temporal component embedded in the numeric target (for example, the 30-day geometric mean Basin Plan numeric objective for fecal coliform). In other words, a loading capacity based on a 30-day average, a seasonal mean, or a mean annual numeric target does not represent a "daily load." However, the loading capacities for this TMDL are based on the Basin Plan nitrate water quality objective, the Basin Plan unionized ammonia objective, and single sample numeric water quality targets for biostimulatory substances. These are instantaneous water quality targets. USEPA considers an instantaneous water quality numeric target to be equivalent to daily-time step measurement and therefore representative of a daily load expression (USEPA, 2007a).

6.3 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 as concentrations of nutrients that will prevent 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.

6.4 Allocations

Owners and operators of irrigated lands, municipal storm water entities, natural sources, and owners/operators of livestock and domestic animals are assigned unionized ammonia, nitrate, and orthophosphate allocations equal to the TMDL and numeric targets. Table 6-5 (see Section 6.4.2) shows the final allocations assigned to implementing parties. The allocations are equal to the TMDLs; the TMDL were previously presented in Section 6.2.2. The allocations are receiving water allocations. The final allocations are equal to the TMDLs and should be achieved 30-years after the TMDL effective date.

Unlike the load-based TMDL method, 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. Final allocations should be achieved 30 years after the effective date of this TMDL (which is upon approval by the Office of Administrative Law).

6.4.1 Summary of Allocations

The following allocations will result in attainment of water quality standards and will rectify impairments described in the Problem Statement.

The unionized ammonia allocations for all sources discharging to waterbodies and reaches of the TMDL project area including Morro Cojo Slough, Merrit Ditch, the Reclamation Canal, Alisal Slough, Santa Rita Creek, Natividad Creek, Alisal Creek, Quail Crek and Chualar Creek is:

- Unionized ammonia concentration shall not exceed 0.025 mg/L-N in receiving waters.

The nitrate allocations for all sources discharging to for all waterbodies and reaches of the TMDL project area required to support MUN beneficial uses, including, Lower Salinas River (downstream of Gonzalez), Old Salinas River, Merrit Ditch, Alisal Slough, Santa Rita Creek, Gabilan Creek, Natividad Creek, Alisal Creek, Quail Creek, Esperanza Creek, Chualar Creek
is:

- Nitrate concentration shall not exceed 10 mg/L-N in receiving waters.

The nitrate and orthophosphate allocations for all sources discharging to the lower Salinas River (all reaches from downstream of Spreckels to and including the Salinas River Lagoon) are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 1.4 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.07 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 water; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving water.

The nitrate and orthophosphate allocations for all sources discharging to Espinosa Slough (all reaches from Espinosa Lake to confluence with Reclamation Canal), for the Reclamation Canal (all reaches downstream of Hartnell Rd to confluence with Tembladero Slough), for Merrit Ditch (all reaches downstream of Merrit Lake), and for all reaches of Alisal Slough, Santa Rita Creek, and Tembladero Slough are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 6.4 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.13 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 water; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving water.

The nitrate and orthophosphate allocations for all sources discharging to Gabilan Creek (all reaches downstream of Crazy Horse Road to confluence with Reclamation Canal), and for all reaches of Alisal Creek, and Natividad Creek are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 2.0 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.07 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 water; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving water.

The nitrate and orthophosphate allocations for all sources discharging to the Old Salinas River (from outflow at Salinas River Lagoon to Old Salinas River at Potrero Rd. are:

- For dry season (May 1 to October 31): Nitrate-N concentration shall not exceed 3.1 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.07 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 water; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving water.

The total nitrogen and orthophosphate allocations for all sources discharging to all reaches of the Moro Cojo Slough are:

- For dry season (May 1 to October 31): total Nitrogen-N concentration shall not exceed 1.7 mg/L in receiving waters; orthophosphate-P concentration shall not exceed 0.13 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 water; orthophosphate-P concentration shall not exceed 0.3 mg/L in receiving water.

6.4.2 Allocation Tables

Table 6-5 presents a summary tabulation of final waste load allocations (WLAs) and load allocations (LAs) for pollutant source categories associated with relevant stream reaches. A description of the numeric value of each type of allocation is presented in Table 6-6. Recognizing that achievement of the more stringent dry season biostimulatory target allocation embedded in Table 6-5 may locally require a significant amount of time to achieve, Table 6-7 therefore presents interim allocations which will be used as benchmarks is assessing progress and gauging ultimate achievement of the final allocations.

Table 6-5. Final Wasteload Allocations and Final Load Allocations.

FINAL WASTE LOAD ALLOCATIONS (WLAs)					
Waterbody the responsible party is discharging to	**Party Responsible for Allocation & NPDES/WDR number**	**Receiving Water Nitrate as N WLA (mg/L)**	**Receiving Water Orthophosphate as P WLA (mg/L)**	**Receiving Water Total Nitrogen as N WLA (mg/L)**	**Receiving Water Unionized Ammonia as N WLA (mg/L)**
Salinas River downstream of Spreckels, CA[1]	City of Salinas (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CA00049981 County of Monterey (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	Allocation-1 *(see descriptions of allocations in Table 6-6*	Allocation-2	Not Applicable	Allocation-5

FINAL WASTE LOAD ALLOCATIONS (WLAs)					
Waterbody the responsible party is discharging to	**Party Responsible for Allocation & NPDES/WDR number**	**Receiving Water Nitrate as N WLA (mg/L)**	**Receiving Water Orthophosphate as P WLA (mg/L)**	**Receiving Water Total Nitrogen as N WLA (mg/L)**	**Receiving Water Unionized Ammonia as N WLA (mg/L)**
Santa Rita Creek[2], Reclamation Canal[3]	City of Salinas (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CA00049981 County of Monterey (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	Allocation-3	Allocation-4	Not Applicable	Allocation-5
Gabilan Creek[4]	City of Salinas (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CA00049981 County of Monterey (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	Allocation-6	Allocation-2	Not Applicable	Allocation-5
Natividad Creek[5] Alisal Creek[6]	City of Salinas (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CA00049981 County of Monterey (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	Allocation-6	Allocation-2	Not Applicable	Allocation-5

FINAL LOAD ALLOCATIONS (LAs)					
Waterbody the responsible party is discharging to	**Party Responsible for Allocation (Source)**	**Receiving Water Nitrate as N LA (mg/L)**	**Receiving Water Orthophosphate as P LA (mg/L)**	**Receiving Water Total Nitrogen as N LA (mg/L)**	**Receiving Water Unionized Ammonia as N LA (mg/L)**
Salinas River downstream of Spreckels, CA[1]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-1	Allocation-2	Not Applicable	Allocation-5

FINAL LOAD ALLOCATIONS (LAs)

Waterbody the responsible party is discharging to	Party Responsible for Allocation (Source)	Receiving Water Nitrate as N LA (mg/L)	Receiving Water Orthophosphate as P LA (mg/L)	Receiving Water Total Nitrogen as N LA (mg/L)	Receiving Water Unionized Ammonia as N LA (mg/L)
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)	*(see descriptions of allocations in Table 6-6)*			
	No responsible party (Natural sources)				
Salinas River upstream of Spreckels, CA[17]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-9	Not Applicable	Not Applicable	Allocation-5
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)				
	No responsible party (Natural sources)				
Merrit Ditch[7], Reclamation Canal[3], Alisal Slough[8], Santa Rita Creek[2,], Espinosa Slough[16]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-3	Allocation-4	Not Applicable	Allocation-5
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)				
	No responsible party (Natural sources)				
Tembladero Slough[9], Blanco Drain[10]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-3	Allocation-4	Not Applicable	Allocation-5

FINAL LOAD ALLOCATIONS (LAs)					
Waterbody the responsible party is discharging to	**Party Responsible for Allocation (Source)**	**Receiving Water Nitrate as N LA (mg/L)**	**Receiving Water Orthophosphate as P LA (mg/L)**	**Receiving Water Total Nitrogen as N LA (mg/L)**	**Receiving Water Unionized 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)				
Gabilan Creek[4]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-6	Allocation-2	Not Applicable	Allocation-5
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)				
	No responsible party (Natural sources)				
Natividad Creek[5] Alisal Creek[6]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-6	Allocation-2	Not Applicable	Allocation-5
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)				
	No responsible party (Natural sources)				
Old Salinas River[11]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-7	Allocation-2	Not Applicable	Allocation-5

FINAL LOAD ALLOCATIONS (LAs)					
Waterbody the responsible party is discharging to	**Party Responsible for Allocation (Source)**	**Receiving Water Nitrate as N LA (mg/L)**	**Receiving Water Orthophosphate as P LA (mg/L)**	**Receiving Water Total Nitrogen as N LA (mg/L)**	**Receiving Water Unionized 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)				
Moro Cojo Slough[12]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Not applicable *(biostimulation will be assessed on the basis of total nitrogen)*	Allocation-4	Allocation-8	Allocation-5
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)				
	No responsible party (Natural sources)				
Chualar Creek[13], Quail Creek[14]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-9	Not Applicable	Not Applicable	Allocation-5
	Owners/operators of land used for/containing domestic animals/livestock (Domestic animals/livestock waste not draining to MS4s)				
	No responsible party (Natural sources)				
Esperanza Creek[15]	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Allocation-9	Not Applicable	Not Applicable	Allocation-5

FINAL LOAD ALLOCATIONS (LAs)					
Waterbody the responsible party is discharging to	Party Responsible for Allocation (Source)	Receiving Water Nitrate as N LA (mg/L)	Receiving Water Orthophosphate as P LA (mg/L)	Receiving Water Total Nitrogen as N LA (mg/L)	Receiving Water Unionized 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)				

* Responsible parties shall meet allocations in all receiving surface waterbodies receiving the responsible parties' discharges.
** Federal and State anti-degradation requirements apply to all waste load and load allocations.

[1] Salinas River: all reaches from downstream of Spreckels (downstream of monitoring site 309SSP) to the confluence with the Pacific Ocean including Salinas River Lagoon (North)
[2] Santa Rita Creek: all reaches and tributaries, from the confluence with the Reclamation Canal to the uppermost reach of the waterbody.
[3] Reclmation Canal: all reaches and tributaries, which includes from confluence with Tembladero Slough, to upstream confluence with Alisal Creek.
[4] Gabilan Creek: all reaches and tributaries downstream of Crazy Horse Rd.
[5]Natividad Creek: all reaches and tributaries, from the confluence with Carr Lake to the uppermost reach of the waterbody.
[6] Alisal Creek: all reaches and tributaries from the confluence with the Reclamation Canal to the uppermost reach of the waterbody.
[7] Merrit Ditch: all reaches and tributaries from the confluence with the Reclamation Canal to the uppermost reach of the waterbody.
[8] Alisal Slough: all reaches and tributaries of the waterbody.
[9] Tembladero Slough: all reaches and tributaries from the confluence with the Salinas Reclamation Canal downstream to its confluence with the Old Salinas River.
[10] Blanco Drain: all reaches and tributaries of the waterbody.
[11] Old Salinas River: all reaches and tributaries from the slide gate at the head of the Old Salinas River adjacent to Mulligan Hill, downstream to Potrero Road.
[12] Moro Cojo Slough: all reaches and tributaries, from the confluence with Moss Landing Harbor to the uppermost reach of the waterbody.
[13] Chualar Creek: all reaches and tributaries, from the confluence with the Salinas River to the uppermost reach of the waterbody.
[14] Quail Creek: all reaches and tributaries, from the confluence with the Salinas River to the uppermost reach of the waterbody.
[15] Esperanza Creek: all reaches and tributaries, from the confluence with the Salinas River to the uppermost reach of the waterbody.
[16] Espinosa Slough all reaches and tributaries, from the confluence with the Reclamation Canal to the uppermost reach of the waterbody.
[17] Salinas River: all reaches from upstream of Spreckels (upstream of monitoring site 309SSP) to Gonzalez, CA

Table 6-6. Numeric concentration value of allocations.

Allocation [A]	*Compound*	*Concentration (mg/L)* [B]
Allocation 1	Nitrate as N	Dry Season (May 1-Oct. 31): **1.4** Wet Season (Nov. 1-Apr. 30): **8.0**

Allocation [A]	*Compound*	*Concentration (mg/L)* [B]
Allocation 2	Orthophosphate as P	Dry Season (May 1-Oct. 31): **0.07** Wet Season (Nov. 1-Apr. 30): **0.3**
Allocation 3	Nitrate as N	Dry Season (May 1-Oct. 31): **6.4** Wet Season (Nov. 1-Apr. 30): **8.0**
Allocation 4	Orthophosphate as P	Dry Season (May 1-Oct. 31): **0.13** Wet Season (Nov. 1-Apr. 30): **0.3**
Allocation 5	Unionized Ammonia as N	Year-round: **0.025**
Allocation 6	Nitrate as N	Dry Season (May 1-Oct. 31): **2.0** Wet Season (Nov. 1-Apr. 30): **8.0**
Allocation 7	Nitrate as N	Dry Season (May 1-Oct. 31): **3.1** Wet Season (Nov. 1-Apr. 30): **8.0**
Allocation 8	Total Nitrogen as N	Dry Season (May 1-Oct. 31): **1.7** Wet Season (Nov. 1-Apr. 30): **8.0**
Allocation 9	Nitrate as N	Year-round: **10**

[A] Federal and State anti-degradation requirements apply to all waste load and load allocations.

[B] Achievement of final wasteload 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* (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.

Table 6-7. Interim Waste Load and Load Allocations.

INTERIM WASTE LOAD ALLOCATIONS (WLAs)			
Waterbody	**Party Responsible for Allocation (Source)**	**First Interim WLA**	**Second Interim WLA**
All waterbodies given wasteload allocations (WLAs) in Table 6-5	City of Salinas (Storm drain discharges to MS4s) Storm Water Permit NPDES No. CA00049981 County of Monterey (Storm drain discharges to MS4s) Storm Water General Permit NPDES No. CAS000004	Achieve **MUN standard-based** and **Unionized Ammonia objective-based** allocations: Allocation-5 Allocation-9 **12 years after effective date of TMDL**	Achieve **Wet Season** (Nov. 1 to Apr. 30) **Biostimulatory target-based** TMDL allocations: Wet Season Allocation/Waterbody combinations as identified in **Error! Reference source not found.** **20 years after effective date of TMDL**

INTERIM LOAD ALLOCATIONS (LAs)			
Waterbody	**Party Responsible for Allocation (Source)**	**First Interim LA**	**Second Interim LA**
All waterbodies given load allocations (LAs) in Table 6-5	Owners/operators of irrigated agricultural lands (Discharges from irrigated lands)	Achieve **MUN standard-based** and **Unionized Ammonia objective-based** allocations: Allocation-5 Allocation-9 **12 years after effective date of TMDL**	Achieve **Wet Season** (Nov. 1 to Apr. 30) **Biostimulatory target-based** TMDL allocations: Wet Season Allocation/Waterbody combinations as identified in **Error! Reference source not found.** **20 years after effective date of TMDL**

6.4.3 Antidegradation Requirements

It is important to emphasize that state water quality standards, and thus the receiving water-based allocations identified in Table 6-5 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 7.2.3. 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-N, and if current or future identified water quality in the stream reach is in fact *well under* 10 mg/L nitrate-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-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 (SWRCB, 2004).

6.4.4 Alternative Pollutant Load Expressions to Facillitate Implementation

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 Wasteload 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 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 back to Section 6.2.1).

Alternative non-daily mass based load expressions and estimated load reductions to facilitate implementation of the TMDLs and allocations are presented in Appendix G. 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., USGS gages or hydrologic modeling), there could be a high degree of error associated with estimated daily flows from limited amounts of instantaneous flows[110]. According to USEPA, the potential for error is particularly pronounced in arid areas, areas with few USGS gages, and areas where flows are highly modified by human activities (e.g., impoundments, regulated flows, irrigation return flows)[111]. Therefore, as noted previously, this TMDL and associated load allocation are based on instantaneous concentration-based loads – this satisifies the USEPA guidance to incorporate a daily time-step load. Also,

[110] U.S. Environmental Protection Agency, 2007. Options for Expression Daily Loads in TMDLs. June 22, 2007.
[111] *Ibid.*

concentration is generally a more direct linkage to the protection of aquatic habitat, than annual or seasonal mass loads.

6.5 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 designed a monitoring plan (see Section 7.9) to evaluate the effectiveness of implemented management practices and 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 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.

6.6 Critical Conditions and 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 project area waterbodes 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 3.7.4 and Section 3.7.5. 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.

7 IMPLEMENTATION AND MONITORING

7.1 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.

7.2 Legal Authority and 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
- Antidegradation Policies
- Point Source Discharges (MS4 entities)
- Nonpoint Source Discharges

7.2.1 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.

7.2.2 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 project 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.

7.2.3 Anti-degradation Policies

State and federal antidegradation 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[112].

[112] 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).

Both the U.S. Environmental Protection Agency (40 CFR 131.12) and the State of California (State Board Resolution 68-16) have adopted antidegradation 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 112). 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 antidegradation policies through cumulative effects.

Federal Antidegradation 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.
>
> (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 Antidegradation 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

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**, **<u>such existing quality shall be maintained</u>*** 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, antidegradation policies pertain to the proposed concentration-based wasteload and load allocations in this TMDL, and can be summarized as follows:

Summary of TMDL Anti-degradation Requirements

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 antidegradation 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, SWRCB 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"*[113] (SWRCB, 2004).

Practically speaking, this means that, for example, stream reaches or waterbodies that have a concentration-based TMDL allocation of 10 mg/L nitrate-N, and if current water quality data or future water quality assessments in the stream reach indicate nitrate-N concentrations in fact well under 10 mg/L nitrate-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-N. Data demonstrating trends of declining water quality in these reaches may constitute non-compliance with anti-degradation requirements, where applicable.

7.2.4 Point Sources

The National Pollutant Discharge Elimination System (NPDES) permit is the mechanism for translating wasteload 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 regulations require that a TMDL include wasteload allocations (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[114] 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. USEPA policy explicitly specifies NPDES-regulated stormwater discharges are point source discharges and, therefore, must be

[113] Section 3.10 of the California Impaired Waters 303(d) Listing Policy (adopted, Sept. 20, 2004, SWRCB Resolution No. 2004-0063)

[114] 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.

addressed by the WLA component of a TMDL.[115] The Water Board is the permitting authority for NPDES stormwater permits in the Central Coast region.

7.2.5 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 (LA) component of a TMDL. The LA 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. While point source discharges are not controlled directly by the federal Clean Water Act's NPDES permit program, direct control of nonpoint source pollution is left to 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.

[115] 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"*

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.

7.3 Implementation for Discharges from Irrigated Lands

The Conditional Waiver of Waste Discharge Requirements for Irrigated Lands (Order R3-2012-0011) requires dischargers from irrigated lands to implement practices to achieve water quality objectives. Executive Officer Order R3-2012-0011 (Agricultural Order) also requires dischargers to implement Monitoring and Reporting Programs in accordance with Orders R3-2012-0011-01, R3-2012-0011-02, and R3-2012-0011-03. The requirements in these orders, and their renewals or replacements in the future, will implement the TMDLs and rectify the impairments addressed in this TMDL. Implementing parties will comply with the Agricultural Order, and if/where appropriate, consistent with the current Agricultural Order, renewals or replacements of the Agricultural Order, and this TMDL.

Note that the current Agricultural Order requires dischargers to comply with applicable TMDLs. If the Agricultural Order did not provide the necessary requirements to implement this TMDL, staff would propose modifications of the Agricultural Order in order to achieve this TMDL. Staff has concluded that the current Agricultural Order provides the requirements necessary to implement this TMDL. Therefore, no new requirements are proposed as part of this TMDL.

Note that the Agricultural Order states that compliance is determined by a) management practice implementation and effectiveness, b) treatment or control measures, c) individual discharge monitoring results, d) receiving water monitoring results, and e) related reporting. The Agricultural Order also requires that dischargers comply by implementing and improving management practices and complying with the other conditions, including monitoring and reporting requirements, which is consistent with the Nonpoint Source Pollution Control Program (NPS Policy, 2004). Finally, the Agricultural Order states that dischargers shall implement management practices, as necessary, to improve and protect water quality and to achieve compliance with applicable water quality objectives. Therefore, compliance with this TMDL is demonstrated through compliance with the Agricultural Order, which provides several avenues for demonstrating compliance, including management practices that improve water quality that lead to ultimate achievement of water quality objectives.

The following are recommendations to help facilitate TMDL implementation. The Agricultural Order should prioritize implementation and monitoring efforts in waterbodies impaired due to nutrient compounds and biostimulatory impairments. The impaired waterbodies and load allocations addressed in this TMDL are listed in Table 6-5.

Central Coast Water Board staff will conduct a review of implementation activities when 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, as necessary, to address remaining impairments resulting from nitrogen compounds or orthophosphate during the TMDL implementation phase.

7.3.1 Implementing Parties

Table 7-1 presents the implementing parties responsible for implementation load allocations for discharges of agricultural fertilizer.

Table 7-1. Implementing Parties for Discharges of Agricultural Fertilizer.

Source Category	**Implementing Parties**	**Land Use Category**[1]
Agricultural Fertilizer	Owners/operators of irrigated lands	Farmland – cultivated crops

[1] FMMP, 2008 and NLCD, 2001 landuse/land cover datasets

7.3.2 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 (see for example, Section 6.2.1);
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 (e.g., Elkhorn Slough);
3) Crops that are grown that require high fertilizer inputs (see for example Table 5-3 and Figure 5-7);
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, staff provisionally anticipates that the following areas will require high priority mitigation efforts, on the basis of magnitude of dry season nitrate loading (when the risk of biostimulation is the highest), on the basis of estimated density of artificial drainage practices, estimated nitrate yield, and the estimated spatial distribution of risk associated of nutrient export (for example, refer to Figure 2-7. Figure 5-20, Section 6.2.1 Table 6-3, and Figure 6-4.

<u>Reclamation Canal Watershed Priority Stream Reaches</u>

<u>Tembladero Slough</u>: Tembladero Slough is estimated to be the major contributor of dry season nitrate loads fluxing from the TMDL project area and into the ecologically sensitive Elkhorn Slough estuary. Elevated nutrient loads found in Tembladero Slough are also attributable to its upstream tributaries and reaches: 1) Alisal Slough; 2) Espinosa Slough; 3) Merrit Ditch; and 4) the Reclamation Canal (refer back to Figure 6-4).

Lower Salinas River Watershed (downstream of Spreckels) Priority Stream Reaches

Blanco Drain: Exceedances of water quality objectives and elevated dry season nutrient loads (when the risk of biostimulation is greatest) observed at monitoring site 309SBR and entering the Salinas River lagoon are likely largely attributable to discharges from the Blanco Drain, and other agricultural nonpoint sources in the lowermost Salinas River downstream of Davis Road (refer back to Figure 6-4). To some extent, discharge from the City of Salinas storm sewer system outfall near Davis Road may be contributing to excessive nutrient loading in the lowermost reach of the Salinas River (see implementation section for MS4 entities, Section 7.4).

Old Salinas River: This stream reach is also highly impacted by nutrient loads; some of these loads are likely attributable to inflow originating from the Salinas River Lagoon at the slide gate near Mulligan Hill. The extent to which internal nutrient loading is occurring from sources strictly within/adjacent to the Old Salinas River channel (upstream of its confluence with Tembladero Slough) is uncertain currently. Nitrate loads in the Old Salinas River channel downstream of Monterey Dunes are highly influenced by nitrate-rich inputs attributable to the Tembladero Slough.

Priority Pollutant

With regard to pollutant prioritization, regional studies and estuarine researchers suggest that currently, control of nitrogen in this system may be considerably more important than control of phosphorus. TetraTech scientists found that streams in nutrient subecoregion 6 are more often limited by nitrogen than by phosphorus, which may explain by there is a strong water quality correlation between water quality impairment and nitrate levels in subecoregion 6[116]. Also, central coast researchers and resource professionals have noted that nitrogen control is considered a higher priority than phosphorus control in coastal watersheds of the region (Largay et al., 2008). Further, an estuarine researcher with the Elkhorn Slough National Estuary Research Reserve reported that phosphorus control is not as important as nitrogen control with respect to downstream impacts on Elkhorn Slough. The types of ephemeral macroalgae found in some reaches of Elkhorn Slough thrive readily in high nitrogen conditions but are relatively insensitive to phosphorus inputs[117] (personal communication, Brent Hughes, ESNERR, August 10, 2011). Also, since there are several unionized ammonia impairments in the TMDL project area, control of nitrogen will presumably be helpful in addressing unionized ammonia impairments. 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.

[116] See TetraTech (2004). *2004 Overview of Nutrient Criteria Development and Relationship to TMDLs*

[117] This information is specific to downstream receiving waters in some reaches of Elkhorn Slough, and does not definitively indicate that phosphorus control is not important in inland waterbodies of the Salinas Valley.

Also, noteworthy is that research has shown that in some areas of the Salinas Valley, P-fertilization is ineffective in improving lettuce growth in areas that have high P content, rendering the need for P-fertilization uneccessary:

> *"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.

7.3.3 Implementation Actions

The primary irrigated agricultural land TMDL implementation mechanism under direct Water Board regulatory authority is the Conditional Waiver of Discharge Requirements for Discharges from Irrigated Lands [Agricultural Order No. R3-2012-0011 (Agricultural Order) including any pending and future renewals or revisions of the Agricultural Order. Irrigated agricultural operations must sign a Notice of Intent to comply with the Ag. Order and submit it directly to the Water Board. Owners and operators of irrigated lands in the project area are required to comply with the conditions and requirements of the current Agricultural Order and any renewals thereof. As such, load allocations for irrigated lands for this TMDL will be implemented through the Agricultural Order. The requirements in these orders, and their renewals, will implement the TMDLs and rectify the impairments addressed in this TMDL. Implementing parties will comply with the Agricultural Order if/where appropriate consistent with the current Agricultural Order, renewals of the Agricultural Order[118] and this TMDL. Implementation and monitoring requirements are established in the Agricultural Order including any pending and future renewals or revisions of the Agricultural Order; the following are recommendations to help facilitate TMDL implementation. The goals of implementing these load allocations can be summarized as follows:

1) Control discharges of nitrate to impaired waterbodies and groundwater[119]; and
2) Implement management practices capable of achieving interim and final Load Allocations identified in this TMDL.

Implementing parties will comply with the Agricultural Order, <u>and if/where appropriate and as consistent with the current Agricultural Order and their renewals or replacements of the Agricultural Order[120]</u>, owners/operators of irrigated lands in the project area will implement management measures as identified in Table 7-2:

[118] Proposed revisions of the Agricultural Order are intended to address the fact that not all irrigated lands, and not all farming operations pose the same level of risk to water quality, and will likely have tiered-regulatory and reporting requirements depending on level of risk.
[119] Shallow, recently recharged groundwater is identified in this TMDL as a substantial source contributor of nitrate loads to creek waters of the TMDL project area.
[120] Proposed revisions of the Agricultural Order are intended to address the fact that not all irrigated lands, and not all farming operations pose the same level of risk to water quality, and will likely have tiered-regulatory and reporting requirements depending on level of risk.

Table 7-2. Implementation Actions for Irrigated Lands.

Implementation Action [A]	When
Protect existing aquatic/riparian habitat to prevent/mitigate nutrient loading to receiving waters	Immediately and ongoing
Develop/update and implement Farm Plan	Within one year of TMDL approval, or as consistent with the Agricultural Order
Implement, and update as necessary, management practices to achieve compliance with the Agricultural Order and to make progress towards achieving Load Allocations	Within one year of TMDL approval, or as consistent with the Agricultural Order
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.	Within three years of TMDL approval, or as consistent with the Agricultural Order, Order or revisions of the Agricultural Order
Monitoring and Reporting	**When**
In accordance with the Agricultural Order, owners and operators of irrigated agricultural lands will perform monitoring and reporting in accordance with Monitoring and Reporting Program Orders R3-2012-0011-01, R3-2012-0011-02, and R3-2012-0011-03, as applicable to the operation, that should include:	
Submition of a Sampling and Analysis Plan and Quality Assurance Plan for approval by the Executive Officer	Within one year of TMDL approval, or as consistent with the Agricultural Order
Submit groundwater monitoring results and information	First year after TMDL approval: Spring and Summer. Every year thereafter: annually
Submit INMP elements, including nitrogen balance ratio.	Within three years of TMDL approval, or as consistent with the Agricultural Order and annually thereafter
Receiving water nitrate concentration [B]	Quarterly beginning one year after TMDL approval Sampling shall be sufficient to capture a range of seasonal and flow conditions.
[A] The degree and scope of necessary implementation actions on a site-specific basis will be based on the level of risk to water quality, for example as identified in the Agricultural Order No. R3-2012-0011 [B] Currently, staff anticipates that monitoring conducted by the Cooperative Monitoring Program is collecting receiving water data of sufficient spatial and temporal quality on behalf of growers to assess progress towards achieving identified Load Allocations. Therefore, at this time Staff does not anticipate the need for additional receiving water monitoring, pursuant to this TMDL, above and beyond what is already being collected.	

7.3.4 Determination of Compliance with 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 TMDL project area (refer back to Section 5). 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[121]. California's Nonpoint Source Pollution Control Program was previously

[121] See USEPA, "Establishing and Implementing TMDLs" at http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/TMDL-ch3.cfm

described in Section 7.2.5. In practical terms, this means load allocations are addressed though the implementation of management practices (e.g., land, irrigation and nutrient management practices)[122]. 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 (see Section 7.9)

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. 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 a surface water impairment. 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.

To allow for flexibility, compliance with load allocations can be demonstrated and determined in several ways, using one or a combination of the following:

<u>DEMONSTRATING COMPLIANCE WITH LOAD ALLOCATIONS</u>

Water Board staff will assess compliance with load allocations using one or a combination of the following:

a) attaining the nutrient load allocations in the receiving water;
b) attainment of 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 which may constitute a proxy 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 using riparian vegetation, as appropriate, 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) Annual and seasonal receiving water mass load reductions consistent with

[122] See USEPA, Protocol for Developing Nutrient TMDLs. EPA 841-B-99-007 (November, 1999)

current load reduction estimates contained in Appendix G of the TMDL project report, or as consistent with reliable and credible flow estimates developed in the future;

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.

7.4 Implementation for Discharges from MS4 Stormwater Entities

Wasteload allocations (WLAs) will be incorporated into NPDES MS4 stormwater permits. Municipal separate storm sewer systems (MS4s) are considered relatively minor loads of nitrogen compounds and orthophosphate in the TMDL project area as a whole, based on the source analysis presented in Section 5, and on storm drain effluent data (see Section 3.7.4). However, because these sources can potentially have significant localized effect on water quality they are allocated wasteload allocations. The Central Coast Water Board will address nitrogen compounds and orthophosphate discharged from the City of Salinas's and the County of Monterey's municipal separate storm sewer systems (MS4s) by regulating the MS4 entities under the provisions of an individual municipal stormwater permit, or the State Water Resource Control Board's General Permit for the Discharges of Storm Water from Small Municipal Separate Storm Sewer Systems (General Permit). As enrollees under the an individual municipal stormwater permit or the General Permit, they must develop and implement a Storm Water Management Plan (SWMP) that controls urban runoff discharges into and from their MS4s. To address the MS4 TMDL wasteload allocations, the Central Coast Water Board will require the enrollees to specifically nitrogen compounds and orthophosphate in urban runoff through incorporation of a Wasteload Allocation Attainment Program in their SWMPs.

7.4.1 Implementing Parties

Table 7-3 presents the implementing parties responsible for implementation load allocations for discharges of agricultural fertilizer.

Table 7-3. Implementing Parties for Discharges from MS4 Entities.

Source Category & Potential Contributing Controllable Sources	Implementing Parties (MS4 Entities)	Land Use Category[1]
<u>MS4 Discharges:</u> Residential fertilizer application Commercial fertilizer application Grass clippings and greenwaste Domestic Animal/Pet waste	City of Salinas County of Monterey	Urban (areas draining to MS4 system)

[1] FMMP, 2008 and NLCD, 2001 landuse/land cover datasets

7.4.1 Potential Priority Areas & Priority Pollutant

Stakeholders in the municipal stormwater entities and local resource professionals are in the best position to ultimately assess priorities and problem areas. However, based on available storm drain effluent monitoring data it appears that nitrate and unionized ammonia excedances of water quality numeric criteria in effluent are localized, but not pervasive to all the monitored storm drains. Many of the City of Salinas' stormwater outfalls appear to be easily achieving proposed nitrate wasteload allocations on the basis of concentrations of effluent in the outfalls. Unfortunately, staff only had storm drain outfall data for the City of Salinas, but not for MS4 storm water entities elsewhere in the project area. Problematic areas for the City of Salinas include the stormwater outfall on the Salinas River (309SDR); the effluent at this outfall routinely has very high nitrate concentrations and is likely impacting the lowermost Salinas River (refer back to Section 3.7.4). Also, on the upper Reclamation Canal effluent from storm drain 309AXX is routinely high in nitrate and unionized ammonia.

In contrast to nitrate, orthophosphate in storm drain effluent routinely exceeds numeric criteria in all the City of Salinas' monitored outfalls. It should be noted that phosphorus, unlike nitrate, is relatively insoluble and readily binds to sediment. In general, monitoring data from the Salinas River hydrologic unit show that orthophosphate concentrations are often (but not universally) higher when total suspended solids concentrations are higher. As such, there is potentially some linkage between sediment and phosphorus discharges from urban areas. According to statistical analysis of event mean concentration runoff data from urban areas of Los Angeles County, transportation and single family residential urban land use categories are typically the highest sources of phosphorus loads (refer back to Figure 5-3); however local knowledge and expertise regarding urban areas of the lower Salinas Valley should be taken into account.

It should be noted that the City of Salinas' stormwater outfall on the Salinas River (site ID 309SDR) is conveyed from a pump stations through a pipe approximately one mile in length and passes beneath agricultural lands. City staff have reportedly detected groundwater intrusion into the pipe at several locations through video inspection of the pipe. It is likely that groundwater entering the pipe as it passes through agricultural land is contaminated with nutrients associated with agriculture[123]. The stormwater pump stations, discharge pipe, and outfall on the Salinas River are part of the City's MS4 because they are owned and operated by the City, who is responsible for discharges from its MS4 to receiving waters.

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). Therefore, it may ultimately be advantageous in the future to revise waste load allocations on the basis of total phosphorus rather than orthophosphate waste load allocations (see Section 7.11 for information on reconsideration of the TMDL and waste load allocations). 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 4.3.1 for an explanation of the use of orthophosphate as water quality targets in this TMDL.

Priority Pollutant

With regard to pollutant prioritization, regional studies and estuarine researchers suggest that currently, control of nitrogen in this system may be considerably more important than control of phosphorus. TetraTech scientists found that streams in nutrient subecoregion 6 are more often limited by nitrogen than by phosphorus, which may explain by there is a

[123] See: Fact Sheet/Rationale Technical Report for Order No. R3-2012-0005 NPDES Permit No. CA0049981, Waste Discharge Requirements for City of Salinas Municipal Storm Water Discharges.

strong water quality correlation between water quality impairment and nitrate levels in subecoregion 6[124]. Also, central coast researchers and resource professionals have noted that nitrogen control is considered a higher priority than phosphorus control in coastal watersheds of the region (Largay et al., 2008). Further, an estuarine researcher with the Elkhorn Slough National Estuary Research Reserve reported that phosphorus control is not as important as nitrogen control with respect to downstream impacts on Elkhorn Slough. The types of ephemeral macroalgae found in some reaches of Elkhorn Slough thrive readily in high nitrogen conditions but are relatively insensitive to phosphorus inputs[125] (personal communication, Brent Hughes, ESNERR, August 10, 2011). Also, since there are several unionized ammonia impairments in the TMDL project area, control of nitrogen will presumably be helpful in addressing unionized ammonia impairments. 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.

7.4.2 Implementation Actions

The overall goal of developing a Wasteload Allocation Attainment Program is to Implement management practices capable of achieving interim and final Wasteload Allocations identified in this 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:

1. Development of an implementation and assessment strategy;
2. Source identification and prioritization;
3. Best management practice identification, prioritization, implementation schedule, analysis, and effectiveness assessment;
4. Monitoring program development and implementation;
5. Reporting; including evaluation whether current best management practices are progressing towards achieving the wasteload allocations within thirteen years of the date that the TMDLs are approved by the Office of Administrative Law;
6. Coordination with stakeholders; and
7. 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. The Central Coast Water Board will require the Wasteload Allocation Attainment Program to be submitted at one of the following milestones, whichever occurs first:

[124] See TetraTech (2004). *2004 Overview of Nutrient Criteria Development and Relationship to TMDLs*

[125] This information is specific to downstream receiving waters in some reaches of Elkhorn Slough, and does not definitively indicate that phosphorus control is not important in inland waterbodies of the Salinas Valley.

1. Within one year of approval of the TMDLs by the Office of Administrative Law;
2. When required by any other Water Board-issued storm water requirements (e.g., when the Phase II Municipal Storm Water Permit is renewed).

In accordance with the milestones listed above, the City of Salinas and the County of Monterey shall each develop, submit, and begin implementation of a Wasteload Allocation Attainment Program that identifies the actions they will take to attain their wasteload allocations. The Wasteload Allocation Attainment Programs shall include the elements identified in Table 7-4.

Table 7-4. Proposed TMDL implementation action plan for MS4 Entities, and required components of Wasteload Allocation Attainment Programs.

Proposed Actions & Proposed Wasteload Allocation Attainment Program Requirements	**Regional Board Authority**
Pollutant Source Category: MS4 Entities	
PROPOSED ACTIONS **<u>Implementing Parties</u>: Implement a strategy and management practices consistent with NPDES permit conditions and an approved Wasteload Allocation Attainment Program, capable of achieving interim and final Wasteload Allocations.** **<u>Water Board Actions</u>: The Water Board will require the Wasteload Allocation Attainment Program to be submitted at one of the following milestones, whichever occurs first:** 1. Within one year of approval of the TMDLs by the Office of Administrative Law; 2. When required by any other Water Board-issued storm water requirements (e.g., when the Phase II Municipal Storm Water Permit is renewed).	Storm Water Permit NPDES No. CA00049981 Storm Water General Permit NPDES No. CAS000004
WASTELOAD ALLOCATION ATTAINMENT PROGRAM REQUIRED ELEMENTS: a) A detailed description of the MS4's strategy for BMP selection, assessment, and implementation, to ensure that implemented BMPs will effectively abate pollutant sources, reduce pollutant discharges, and achieve wasteload allocations according to TMDL schedule. b) Identification of sources of the impairment within the Permit coverage area, including specific information on various source locations and their magnitude within the Permit coverage area. c) Prioritization of sources within the Permit coverage area, based on suspected contribution to the impairment, ability to control the source, and other pertinent factors. d) Identification of BMPs that will address the sources of impairing pollutants and reduce the discharge of impairing pollutants. e) Prioritization of BMPs, based on expected effectiveness at abating sources and reducing impairing pollutant discharges, as well as other pertinent factors. f) A detailed BMP 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 the MS4 will use to assess BMP effectiveness. The MS4 shall include expected BMP implementation for future implementation years, with the understanding that future BMP implementation plans may change as new information is obtained. g) A quantifiable numeric analysis demonstrating the BMPs selected for implementation will likely achieve, based on published BMP pollutant removal performance estimates, best professional judgment, and other available tools, the MS4's wasteload allocation according to the schedule identified in the TMDL. This analysis will most likely necessitate 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 the TMDL monitoring program, the MS4 shall incorporate water quality data into the numeric analyses to validate BMP implementation plans. h) A detailed description, including a schedule, of the monitoring program the MS4 will implement or use to assess discharge and receiving water quality, BMP effectiveness, and progress	

Proposed Actions & Proposed Wasteload Allocation Attainment Program Requirements	Regional Board Authority
towards any interim targets and ultimate attainment of the MS4's wasteload allocation. The monitoring program shall be consistent with any monitoring program information included in the TMDL documentation. The monitoring program shall be designed to validate BMP implementation efforts and quantitatively demonstrate interim target and wasteload allocation attainment. i) A detailed description of how the MS4 will assess BMP and plan effectiveness. The description shall incorporate assessment methods described in the CASQA Municipal Stormwater Program Effectiveness Assessment Guide. j) A description of how the MS4 will modify the plan to improve upon BMPs that the effectiveness assessment highlights as ineffective. k) A detailed description of information the MS4 will include in Annual Reports to illustrate progress towards meeting wasteload allocations according to TMDL schedule. l) A detailed description of how the MS4 will collaborate with other agencies, stakeholders, and the public to develop and implement the Wasteload Allocation Attainment Plan. m) Any other items identified by the TMDL Project Report or Resolution or currently being implemented to address TMDL provisions.	

[1] Indicators of progress towards milestones in achieving wasteload allocations include, but are not limited to data and information related to: a) management practice implementation and effectiveness,; b) treatment or control measures ;c) individual discharge monitoring results; d) receiving water monitoring results; and e) related reporting.

7.4.3 Determination of Compliance with Wasteload Allocations

USEPA guidance[126] states that if the State or USEPA establishes a TMDL for impaired waters that include wasteload allocations (WLAs) 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. [127] Compliance with wasteload 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 WLA (where and if feasible), or the effluent limitations may be expressed as Best Management Practices (BMPs). 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 WLAs, including adequate monitoring, numeric benchmarks, or specific protocols to determine if the BMPs are performing as necessary (refer to footnote 126).

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 wasteload allocations (WLAs) can be demonstrated and determined in several ways, as follows:

[126] 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"*
[127] See 40 CFR 122.44(d)(1)(vii)(B).

<u>DEMONSTRATING COMPLIANCE WITH WASTELOAD ALLOCATIONS</u>

Water Board staff will assess compliance with wasteload allocations using one or a combination of the following:

a) attainment the nutrient wasteload allocations (WLAs) in the receiving water; or
b) attainment of 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 which may constitute a proxy demonstration of the attainment of the nitrate, nitrogen and orthophosphate-based seasonal biostimulatory WLAs. Note that implementing parties are strongly encouraged to maximize overhead riparian canopy using riparian vegetation, as appropriate, because doing so could result in achieving nutrient-response indicator targets before allocations are achieved (resulting in a less stringent allocation); or
c) demonstrations of compliance by measuring concentrations in stormwater outfalls; or
d) demonstrations of compliance by demonstrating load reductions on mass basis at stormdrain outfalls; or
e) MS4s may be deemed in compliance with WLAs through implementation and assessment of pollutant loading reduction projects (BMPs), capable of achieving interim and final Wasteload Allocations identified in this TMDL in combination with water quality monitoring for a balanced approach to determining program effectiveness; or
f) Any other effluent limitations and conditions which are consistent with the assumptions and requirements of the WLAs.

7.5 Implementation for Discharges from Domestic Animals

The water quality data available to staff from stream reaches that exclusively drain grazing lands, or lands where grazed animals and farm animals can be expected to occur[128], indicate the nitrogen compounds and orthophosphate proposed water quality targets, and thus load allocations, are being met in these reaches. Nitrogen compounds and orthophosphate appear to be marginally elevated relative to undisturbed or natural background conditions found elsewhere in the Salinas River Basin, potentially indicating an incremental amount of degradation by livestock activities. However, pending the acquisition of more data, **this source category appears to be meeting their load allocation**.

As such no new regulatory requirements are deemed necessary or are being proposed.

Staff's conclusions are supported by an independent line of research available from scientists at the Watershed Institute at California State University-Monterey Bay; these researchers concluded that data from southern Monterey Bay watersheds indicate that grazed lands are not significant nitrate or phosphate sources (Anderson et al., 2003).

It is important to note that lower Salinas River Watershed is in fact subject to the Domestic Animal Waste Discharge Prohibition and are subject to compliance with an approved

[128] Towne Creek, Big Oak Creek (Towne Creek tributary), Gabilan Creek @ Old Stage Rd., Chualar Creek and Chular Canyon.

indicator bacteria TMDL load allocation[129]. 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 project report does not conclusively demonstrate that all domestic animal operations are currently meeting load allocations; there are potentially unpermitted confined animal facilities, equestrian facilities, or grazing animal operations that do not meet load allocations. More information will be obtained, if merited, during the implementation phase of the TMDL to further assess the level of nutrient contribution from these source categories, and to identify any actions if necessary to reduce loading.

7.6 Non-regulatory Interim Reduction Goals

The goal date to achieve the TMDLs is 30 years from the date of TMDL approval by the Office of Administrative Law. Implementing parties must demonstrate progress towards achieving their allocations. Interim goals are a tool to gauge progress during the 30-year implementation phase. Interim goals are not waste load allocations or load allocations, and are not enforceable water quality standards. MS4 implementing parties may develop and propose interim goals as part of their WAAP as demonstration of progress. Future assessments of progress towards goals should be measured against a selected baseline of recent or current water quality information which can be determined with the input of stakeholders, resource professionals, and/or others. While there is already a well-defined permitting process to obtain feedback from MS4 entities, it is incumbent on water board staff to obtain the input of agricultural representatives as to feasible interim goals and identification of a credible baseline standard of measurement, prior to defaulting to the identified non-regulatory interim goals.

If implementing parties choose not to develop and propose interim goals, the following interim goals, relative to an appropriate baseline condition, are expected as demonstration of progress towards achieving waste load allocations and load allocations:

- 25% percent progress toward achieving load allocation within 3-years following the effective date of the TMDL;
- 50% percent progress toward achieving load allocation within 6-years following the effective date of the TMDL;
- 75% percent progress toward achieving load allocation within 9-years following the effective date of the TMDL;
- 100% percent progress toward achieving load allocation within 12-years following the effective date of the TMDL.

Interim goal for achieving the wet season biostimulatory goal based allocation within 20 years:

- 25% percent progress toward achieving load allocation within 5-years following the effective date of the TMDL;
- 50% percent progress toward achieving load allocation within 10-years following the effective date of the TMDL;
- 75% percent progress toward achieving load allocation within 15-years following the effective date of the TMDL;

[129] Central Coast Water Board Resolution No. R3-2010-0017 (Sept. 2010).

- 100% percent progress toward achieving load allocation within 20-years following the effective date of the TMDL.

Interim goal for achieving the dry season biostimulatory goal based allocation within 30 year:

- 25% percent progress toward achieving load allocation within 7-years following the effective date of the TMDL;
- 50% percent progress toward achieving load allocation within 15-years following the effective date of the TMDL;
- 75% percent progress toward achieving load allocation within 22-years following the effective date of the TMDL.
- 100% percent progress toward achieving load allocation within 30-years following the effective date of the TMDL.

7.7 Metrics to Assess Interim Progress towards TMDL Achievement

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[130], 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.

Other metrics that can provide insight on interim progress to reduce nutrient pollution may be utilized, for example:

- assessments of mass-based load reductions;
- improvements in flow-weighted concentrations;
- estimates of the percent/scope/degree of implementation of management practices capable of ultimately achieving load allocations;
- improvements in receiving water nutrient-response indicators (i.e., dissolved oxygen, chlorophyll *a*, microcystins), etc.

In addition, while the waste load and load allocations are based on the MUN water quality standard of 10 mg/L, or biostimulatory numeric criteria, restoration of the AGR beneficial use (based on the 30 mg/L nitrate-N Basin Plan guideline value) during TMDL implementation can be used as an indication of interim progress.

7.8 Suggested Management Measures

7.8.1 Potential Management Measures for Agricultural Sources

The SWRCB, California Coastal Commission and other State agencies have identified management measures (MMs) to address agricultural sources of nutrient pollution that affect State waters. 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

[130] 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

(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 7.2.2, 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 Resources Control Board's (SWRCB) 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 SWRCB 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 manure, 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 manure 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 Encyclopedia.[131]

Further, in a letter to Water Board staff dated November 10, 2011 the National Marine Fisheries Service (NMFS) provided input on treatment alternatives that could be implemented to restore water quality standards and protect aquatic habitat in the lower Salinas Valley; this input from NMFS is reproduced below:

> *NMFS suggests creating constructed wetlands in the proposed geographic scope of the TMDL, similar to those used for waste water treatment plants. Wetlands have a multitude of functions that benefit both humans and ecosystems by improving water quality and providing functional habitat conditions for aquatic and terrestrial wildlife (Allen et al., 1998).*
>
> *Nutrient loading during stormwater runoff events could be curtailed by establishing wetland ponds that retain contaminant laden water, and treat it through a series of complex biological and chemical processes. Compared to other engineered, mechanical methods of treating impaired surface water, constructed wetlands are often cost-effective and may require minimal management and maintenance costs once implemented. If constructed treatment wetlands are employed to treat 303(d) listed waterbodies, they should adhere to the Environmental Protection Agency's (EPA) criteria and guidance principles (EPA 2000).*
>
> *The use of retention ponds and/or aeration should also be explored for nutrient laden agricultural discharges. Impermeable ponds may be more suited to some locations than*

[131] http://www.swrcb.ca.gov/water_issues/programs/nps/encyclopedia/6c_vts.shtml

> *vegetated treatment systems and may offer agricultural operations the ability to treat and re-use their runoff on-site. Captured sediments can be returned to the field at a later time.*
>
> From: National Oceanic and Atmospheric Administration-National Marine Fisheries Service (letter dated Nov. 10, 2011).

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[132] 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%.

7.8.2 Potential Management Measures for Urban Sources

As described in Section 7.2.2, the Water Board cannot specify or mandate the specific type or design of onsite actions (e.g., BMPs) necessary to reduce nutrient loading to waterbodies; however the California Nonpoint Source Pollution Control Program[133] 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

Further, the State Water Resources Control Board's (SWRCB) 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 SWRCB 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/

7.9 Proposed Monitoring Requirements

Monitoring and reporting are proposed to include the following:

[132] Davidson et al. (2012) define existing mitigation strategies as those that could be accomplished under the current agricultural subsidy system.

[133] 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.

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 7.3 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 TMDL project area monitoring sites and proposed TMDL compliance sites. This is more than sufficient to satisfy the sampling frequencies shown below. 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 permits that have WLAs associated with this TMDL shall contain effluent limits, conditions, and monitoring/reporting elements consistent with the requirement and assumptions of the WLAs in the TMDL (refer back to 7.4.3 for information on implementation of wasteload allocations).

The plethora of current monitoring efforts in the TMDL project area, including the Cooperative Monitoring Program, the City of Salinas, the Water Board's Central Coast Ambient Monitoring Program, and the ESNERR monitoring program, may be used synergistically to help demonstrate compliance and progress by implementing parties. It is also important to reiterate that the Cooperative Monitoring Program is already currently collecting monthly nitrate data from many of the impaired waterbodies, and this is sufficient to meet the proposed receiving water quality monitoring frequency requirement.

The monitoring frequency required at a receiving water site must satisfy a sufficient number of samples needed to evaluate progress towards, and achievement of both the wet-season and dry-season targets for nitrate and orthophosphate, and evaluation of the single sample maximum water quality objective for unionized ammonia. As this TMDL is addressing biostimulatory impairments by setting allocations for nitrate and orthophosphate, staff anticipates that chlorophyll impairments and dissolved oxygen impairments that are related to biostimulation will be evaluated with data from existing and ongoing monitoring programs (CCAMP, CMP), thus chlorophyll and dissolved oxygen monitoring requirements are not being proposed for this TMDL at this time.

Monitoring and reporting should include:

Receiving Waters

1. Subwatershed scale receiving water monitoring for all the impaired waterbodies assigned TMDLs (see Table 7-5).
2.
    a) Waterbodies with Biostimulatory Impairments: This TMDL established seasonal targets for nitrate and orthophosphate in reaches identified as having biostimulatory impairments
    - ✓ Wet Season: Nov. 1 through May 31: Two samples from receiving waters to establish progress and achievement of the wet-season single-sample maximum target for nutrients..
    - ✓ Dry Season: June 1 through October 31: Monthly sampling to establish progress and achievement of the dry-season geomean target for nutrients.

    b) Waterbodies with Drinking Water (Nitrate) Impairments
    - ✓ Quarterly: One receiving water sample, quarterly.

c) Waterbodies with Unionized Ammonia Impairments
   - ✓ Quarterly: One receiving water sample, quarterly.

3. Dissolved oxygen and chlorophyll samples for waterbodies exhibiting biostimulatory impairments are recommended for use as supplementary or proxy indicators of attainment or non-attainment of biostimulatory water quality objectives, consistent with numeric targets identified for these constituents in this TMDL (see Section 4.4, Section 7.3.4 and Section 7.4.3).
4. Laboratory analytical methods rigorous enough for data comparison with the numeric targets.
5. If samples are not collected or available for the recommended frequencies recommended above, the available data shall be evaluated consistent with Section 6.1.5.6 of the SWRCB Listing Policy (*Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List*, SWRCB 2004)

Total Nitrogen Monitoring in Moro Cojo Slough

Staff are proposing that total nitrogen (rather than nitrate) be monitored and used as a water quality target for Moro Cojo Slough, for the following reason:

While monitoring of nitrate is recommended for most project area stream reaches (consistent with USEPA guidance) ***monitoring of total nitrogen is recommended for the tidal flat-estuarine environment of Moro Cojo Slough.*** *This is because water column nitrate in the estuarine environment at site 306MOR evidently does 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*[134] *(refer back to Section 4.3.1 and Figure 4-1).*

It 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 this 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.
(see attachment 5 to the TMDL staff report)

Receiving water monitoring sites in subwatersheds should be located in the lower portions of the watershed, whenever feasible. Use of previously established monitoring sites would be useful for showing trends. Recommended watershed monitoring sites are listed in Table 7-5. These or similar sites should be used to assess progress toward achieving the TMDLs

[134] Monitored lagoons and estuaries of the central coast region appear to indicate that nitrate is generally only about half of all water column total nitrogen. At Moro Cojo Slough (site 306MOR), available data indicate that nitrate is only about one-third of total water column nitrogen. In contrast, nitrate in agricultural inland valley streams of the lower Salinas Valley typically comprises over 98% of total water column nitrogen. Refer back to Figure 4-1.

assigned to the impaired waterbodies.

Table 7-5. Recommended receiving water monitoring sites for TMDL progress assessment for discharges from irrigated lands.

Impaired Waterbody	Impairment(s) / Water Quality Objective	Recommended Monitoring Site
Quail Creek	Nitrate (Drinking water standard)	309QUA
Chualar Creek	Nitrate (Drinking water standard)	309CRR
Esperanza Creek	Nitrate (Drinking water standard)	ESZ-HWY
Old Salinas River	Nutrients (biostimulatory substances objective)	309OLD
Tembladero Slough	Nutrients (biostimulatory substances objective)	309TEH
Alisal Slough	Nutrients (biostimulatory substances objective)	309SSB
Blanco Drain	Nutrients (biostimulatory substances objective)	309BLA
Salinas Reclamation Canal (Upper)	Nutrients (biostimulatory substances objective) Unionized Ammonia (toxicity objective)	309ALG
Salinas Reclamation Canal (Lower)	Nutrients (biostimulatory substances objective) Unionized Ammonia (toxicity objective)	309JON
Salinas River (above Spreckels	Nitrate (Drinking water standard)	309SSP
Salinas River (below Spreckels	Nutrients (biostimulatory substances objective)	309SBR
Espinosa Slough	Nutrients (biostimulatory substances objective)	309ESP
Natividad Creek	Nutrients (biostimulatory substances objective)	309NAD
Merrit Ditch	Nutrients (biostimulatory substances objective)	309MER
Gabilan Creek	Nutrients (biostimulatory substances objective)	309GAB, or public access point at downstream outlet of Creek
Moro Cojo Slough	Nutrients (biostimulatory substances objective) Unionized Ammonia (toxicity objective)	306MOR

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 4.3.1 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. Currently, the Water Board is funding the collection of baseline microcystin data for the central coast region and the lower Salinas Valley, which may be used to assess water quality conditions and attainment of water quality standards.

7.10 Timeline and Milestones

7.10.1 Timeline to Achieve Loading Capacity

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. Staff recognizes that immediate compliance with water quality standards is not feasible, and are proposing milestones as follows.

Table 7-6 presents temporal bench marks to establish progress towards achievement of the final wasteload allocations and load allocations previously presented in Table 6-5. . These benchmarks can be summarized as follows:

- First Interim Waste Load and Load Allocations: Achieve the nitrate MUN nitrate standard (10 mg/L nitrate-N in receiving waters that are designated MUN) and the unionized ammonia water quality objective-based allocations within 12 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 20 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 30 years of the effective date of the TMDL;

The 12 year timeframe to achieve the MUN nitrate standard and the Basin Plan objective for unionized ammonia is based primarily on the expectation that nearly all landowners and operators of irrigated agricultural activities will have completed Farm Water Quality Plans and be implementing management practices by the end of the first waiver cycle (5 years). 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. Water Board staff believes 12 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 12 year benchmark is also consistent with the Water Board's vision for the central coast region of healthy, functioning watersheds by the year 2025.

The 20 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.

30-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 project area surface waters for several decades.[135] Therefore, staff anticipates that it will take a significant amount of time for legacy pollutant loads in shallow groundwater, and the subsequent baseflow pollutant loads to stream reaches, to attenuate. Refer to Section 2.9 for information on groundwater quality and residence time of baseflow in the subsurface. Further, supplementary information from a local water agency indicates that shallow and perched groundwater zones are widely present in the Salinas Valley, and typically have low to moderate permeabilities. Low permeabilities suggest that a substantial amount of time is required to realize attenuation of nutrient pollution in these shallow hydrogeologic zones:

> *"Recent Alluvium is present in the more established drainages, and typically have low to moderate permeability. Recent Alluvium also* ***includes perched groundwater zones**** *that have not generally been affected by seawater intrusion, but have, in some cases, been impacted by percolation from agriculture."*
>
> *Monterey County Groundwater Management Plan, Salinas Valley Groundwater Basin, May 2006. Prepared for the Monterey County Water Resources Agency.*
>
> ***** *emphasis added*

In addition to these TMDL benchmarks, the Agricultural Order should establish timeframes for individual dischargers to achieve water quality standards; achieving water quality standards will result in achieving TMDL allocations based on a tiered-approach. Highest priority dischargers should have the shortest timeframe, such as those dischargers who pose the greatest risk to water quality due to discharges of nutrients. Lower prioritized dischargers that are also contributing to the impairments could have a longer timeframe, with the ultimate goal of verifiable progress towards achieving final load allocations, and therefore the TMDL, no later than thirty years from the effective date of the TMDL. Regarding urban stormwater sources, wasteload allocations (WLAs) will be incorporated into NPDES MS4 stormwater permits, and compliance with achieving wasteload allocations and timeline benchmarks will be implemented consistent with the requirements proposed in Section 7.10.

[135] For example, the U.S. Geological Survey (USGS) 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. USGS 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"* USGS News Release dated 08/09/2011).

Table 7-6. Proposed Timelines to Achieve Interim and Final TMDL Allocations[A]

<table>
<tr><th colspan="4">MILESTONES FOR WASTE LOAD ALLOCATIONS (WLAs)</th></tr>
<tr><th>Waterbody</th><th>First Interim WLA[136]</th><th>Second Interim WLA</th><th>Final WLA</th></tr>
<tr><td>All waterbodies given wasteload allocations (WLAs) in Table 6-1</td><td>Achieve MUN standard-based and Unionized Ammonia objective-based allocations:
Allocation-5
Allocation-9
12 years after effective date of TMDL</td><td>Achieve Wet Season (Nov. 1 to Apr. 30) Biostimulatory target-based TMDL allocations:
Wet Season Allocation/Waterbody combinations as identified in Table 6-1
20 years after effective date of TMDL</td><td>Achieve Dry Season (May 1 to Oct. 31) Biostimulatory target-based TMDL allocations:
Wet Season Allocation/Waterbody combinations as identified in Table 6-1
30 years after effective date of TMDL</td></tr>
<tr><th colspan="4">MILESTONES FOR LOAD ALLOCATIONS (LAs)</th></tr>
<tr><th>Waterbody</th><th>First Interim LA</th><th>Second Interim LA</th><th>Final LA</th></tr>
<tr><td>All waterbodies given load allocations (LAs) in Table 6-1</td><td>Achieve MUN standard-based and Unionized Ammonia objective-based allocations:
Allocation-5
Allocation-9
12 years after effective date of TMDL</td><td>Achieve Wet Season (Nov. 1 to Apr. 30) Biostimulatory target-based TMDL allocations:
Wet Season Allocation/Waterbody combinations as identified in Table 6-1
20 years after effective date of TMDL</td><td>Achieve Dry Season (May 1 to Oct. 31) Biostimulatory target-based TMDL allocations:
Wet Season Allocation/Waterbody combinations as identified in Table 6-1
30 years after effective date of TMDL</td></tr>
<tr><th colspan="4">Anticipated Load Reductions & Critical Conditions to Achieve Allocations</th></tr>
<tr><th></th><th>First Interim LA</th><th>Second Interim LA</th><th>Final LA</th></tr>
<tr><td>Anticipated Range of Percent Load Reductions in TMDL project area to achieve interim and final allocations
(percent reductions are provided for informational purposes only, and should not be viewed as the TMDL)</td><td colspan="2">Average Reduction for all TDML Project Area Waterbodies:
48%
Range of Anticipated Reductions Based on Discrete Stream Reaches
0% to 89%
(refer to Table 6-1)
Critical Conditions: largest percent load reductions generally anticipated in low to moderate flow regime
(refer to Section 3.7.5)</td><td>Average Reduction for all TDML Project Area Waterbodies:
64%
Range of Anticipated Reductions Based on Discrete Stream Reaches
0% to 93%
(refer to Table 6-2)
Critical Conditions: largest percent load reductions generally anticipated in low to moderate flow regime
(refer to section 3.7.5)</td></tr>
<tr><td colspan="4">[A] Refer back to Section 6.4 for a complete tabulation and description of the wasteload allocations and load allocations for the identified pollutant/waterbody combinations</td></tr>
</table>

[136] It is important to recognize that the MUN standard for nitrate does not apply to all waterbodies in the project area (refer back to Table 3-1). Some of the most severly nitrate-impaired waterbodies, such as Tembladero Slough, Blanco Drain, and the Reclamation Canal are not designated for MUN, therefore in these waterbodies the implementation goal will be to achieve the second interim target for nutrients at the 20 year benchmark. Refer to **Error! Reference source not found.** for a tabulation of the waste load allocations and load allocations for identified waterbody/pollutant combinations. . Note however, that unionized ammonia is a general Basin Plan objective, and all waterbodies would be required to meet this objective at the 12-year, first interim TMDL target benchmark.

7.10.2 Evaluation of Progress

Water Board staff anticipate reviewing data and evaluating implementation efforts every three years. Water Board staff will utilize information submitted pursuant to the Agricultural Order to evaluate efforts on croplands. When and as appropriate, Water Board staff will rely on information generated by the County Farm Bureaus, University of California Cooperative Extension, and/or Natural Resources Conservation Service as part of existing and future projects (i.e. Clean Water Act Section 319(h) grants) to determine that existing efforts continue to protect or improve water quality. Staff will also review annual reports submitted under the Phase II NPDES MS4 General Permit and the monitoring and reporting program to evaluate if MS4 entities are continuing to meet waste load allocations.

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 (refer back to footnote 130), 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.

Other metrics that can provide insight on interim progress to reduce nutrient pollution may be utilized, for example:

- assessments of mass-based load reductions;
- improvements in flow-weighted concentrations;
- estimates of the percent/scope/degree of implementation of management practices capable of ultimately achieving load allocations;
- improvements in receiving water nutrient-response indicators (i.e., dissolved oxygen, chlorophyll *a*, microcystins), etc.

In addition, while the waste load and load allocations are based on the MUN water quality standard of 10 mg/L, or biostimulatory numeric criteria, restoration of the AGR beneficial use (based on the 30 mg/L nitrate-N Basin Plan guideline value) during TMDL implementation can be used as an indication of interim progress.

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 three-year review that to date, 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.

7.11 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 this TMDL. The results of special studies may be used to reevaluate waste load allocations and load allocations proposed in this TMDL. 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 wasteload or load allocations that are protective against biostimulatory impairments, implementation timelines, and/or downstream impacts.

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, Geosyntec Consultants, September 25, 2012). Therefore, it may ultimately be advantageous in the future to revise waste load allocations on the basis of total phosphorus rather than orthophosphate waste load allocations. 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 4.3.1 for an explanation of the use of orthophosphate as water quality targets in this TMDL. Further, an engineering consultant indicates that meeting the more stringent proposed dry season waste load allocations for dissolved phosphate (orthophosphate) in urban BMP effluent could be a challenge for municipalities (personal communication to Water Board staff from Geosyntec Consultants, September 25, 2012).

Also, Agricultural stakeholders have underscored the need to consider uncertainties and periodically re-evaluate the TMDL, including the proposed load allocations:

> *"While we appreciate that the targets are considered within a 15-40 year timeframe, due to the fact that these problems are complex, and in light of the amount of research that will be needed, we believe that this is too short a process. These goals are unachievable based upon scientific research currently available. A re-evaluation of the goals, current research, and technology available must be conducted every 5-years. We may not be able to achieve goals if science isn't in place."*
>
> *Abby Taylor-Silva, Vice President, Grower-Shipper Assoc. of Central California*
> *Norm Groot, Executive Director, Monterey County Farm Bureau*
> *Benny Jefferson, Chairman, Salinas River Channel Coalition*
>
> In a letter to Water Board Staff dated Nov. 3, 2011

> *"It may not be possible to grow a leafy green vegetable or strawberry crop and comply with TMDL targets. These crops require soil solution concentrations in excess of the proposed targets and it will not be possible to completely eliminate system "leakage" in excess of numeric targets."*
>
> *Kay Mercer, agricultural consultant*
> *President, KMI*
>
> In a letter to Water Board staff dated Aug. 9, 2012

Staff concurs in principle about the need to periodically re-evaluate the TMDL and water quality targets. Several potentially significant uncertainties associated with TMDL implementation were previously outlined in Section 7.7. At this time, based on the information and analyses presented in this TMDL Project Report staff maintains there is sufficient information to begin to implement the TMDL and make progress towards nutrient pollution reductions and attainment of water quality standards and the proposed allocations. It should be reiterated that immediate compliance with water quality objectives and attainment of water quality standards is not required nor expected. 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 TMDL, which is upon approval by the Office of Administrative Law (OAL) – see Table 7-7..

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[137].
- 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[138]. 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 Title 40 of the Code of Federal Regulations and Article 3 of Division 7, Chapter 4 of the California Water Code.

Table 7-7. Proposed time schedule for optional studies and Water Board reconsideration of WLAs and LAs.

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 Executive Officer	By five years after the effective date of the TMDL
Final optional studies	Optional studies completed and final report submitted for Executive Officer approval.	By eight 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 ten years after the effective date of the TMDL

Based on feedbak from stakeholders (see below), optional studies could include, but are not limited to:

137 See: U.S. Environmental Protection Agency, Water Quality Handbook, March 2012. EPA-823-8-12-002.

138 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.

- The significance and impact of legacy loads associated with historic confined animal facilities, such as historic dairies, in the Salinas Valley;
- Mineralization of nutrients and their impact on nutrient loads to receiving waters are not well understood, and mineralization might lead to nitrate pulses during the warmer seasons;
- It is important to understand the inter-relationship between surface water leaching to groundwater quality and groundwater inputs to surface water quality. It is important that this inter-relationship be modeled in an effort to improve implementation efforts;
- A stakeholder has suggested another set of data necessary for multi-variant analysis of impairments, bio-indicator assessments and development of meaningful implementation strategies. It is critical that historical land use changes be noted and included in any sort of multi-variant analysis. If fish habitat over-time and legacy nitrate and phosphorous loading over-time are significant when evaluating impairments and/or implementation plans, then land use over-time (e.g. the presence of dairies and land use conversions from ag or open space to urban and rural residential developments) is likely to be as critical a variable;
- A stakeholder has suggested resolution of uncertainties relating to Historical flood control efforts (e.g. reservoir impoundments, creek channelization; historical groundwater recharge efforts to offset impacts of drought (e.g. year round reservoir releases; efforts to create aquatic life habitat (e.g. year-round water releases); increased land conversion (e.g. from crop or grazing lands to rural residential and/or urban land uses); degraded riparian habitat resulting from past watershed management efforts; Excessive and unmanaged riparian habitat resulting from curtailed management efforts;
- Due to uncertainties and climatic variablities pertaining to the nexus between nutrient fluxes and Meditteranean-like climates, the TMDL assumptions about wet-season / dry-season nutrient numeric targets could be evaluated in a more probabilistic way in the future to account for interannual and intra-seasonal variability in climatic regimes often associated with Meditteranean-like climates;
- A stakeholder has suggested a more sophisticated analysis of the geology, headwaters and sediment geochemistry, spatial and temporal analysis be done to better characterize P dynamics in the watersheds. Phosphorous concentrations in the water column can at best be thought of in terms of being in equilibrium, with inputs and outputs, uptake and release from water column and benthic taxa, and adsorption/desorption at the water-sediment interface. these exchanges have the potential to mask loading or exaggerate loading estimates, thus handicap the ability to meet water quality goals.

7.12 Assessing TMDL Achievement & Delisting Decisions

Achieving surface water nutrient reductions of the scale identified in this TMDL and in an agricultural watershed is necessarily subject to uncertainties. Agricultural stakeholders have noted some of these uncertainties, as reproduced below:

> *"It may not be possible to grow a leafy green vegetable or strawberry crop and comply with TMDL targets. These crops require soil solution concentrations in excess of the proposed targets and it will not be possible to completely eliminate system "leakage" in excess of numeric targets."*
>
> *Kay Mercer, agricultural consultant*
> *President, KMI*
>
> In a letter to Water Board staff dated Aug. 9, 2012

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 wasteload 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.

Also, various metrics of assessing interim progress towards TMDL achievement were presented in Section 7.7.

In terms of ultimately assessing TMDL achievement in waterbodies, evaluating exceedances of TMDL numeric targets identified herein (refer back to Section 4) 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", SWRCB, 2004), or as consistent with any relevant revisions of the Listing Policy promulgated in the future.

7.12.1 An Important Note about Nutrient Water Quality Targets & Allocations

It is important to recognize the proposed nutrient water quality biostimulatory targets developed in this TMDL are predictions of the nutrient concentration levels necessary to be protective against biostimulation *based on current conditions*. 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. For example, it is well known that invasive plants such as tamarisk are proliferating in riparian areas of the Salinas River and elsewhere in Monterey County, and that tamarisk is detrimental to aquatic habitat, water quality, and water supply[139]. Resource professionals report that tamarisk removal can increase surface water flows[140] − recall that increased surface flows can improve aeration of the water column and potentially reduce the risk of biostimulatory problems (refer back to

[139] See: California Invasive Plant Council website. Online linkage: http://www.cal-ipc.org/ip/inventory/

[140] Meeting minutes of Pajaro River Watershed Council Local Working Group - meeting date July 6, 2011 in Hollister, CA.

Section 3.9.3). 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[141].

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.

7.13 Case Studies, Success Stories, and Existing Implementation Efforts

Protecting California's water resources depends on the proactive engagement of citizens, land owners, researchers, and businesses. Proactive efforts by citizens that may result in improved water quality protection are commendable and should be recognized.

7.13.1 Grower Activities (Information provided by MCWRA)

During TMDL development, Staff solicited voluntary information about grower practices to reduce nutrient loads in the lower Salinas River and Reclamation Canal basin for potential incorporation in this project report The following comments from a grower regarding their management practices were provided to staff by the Monterey County Water Resources Agency:

<u>Grower Comment</u>: I have been implementing the following practices:

1. taking water from the end of fields and pumping the water into pasturelands.
2. planting overwinter cover crops therefore allowing for less soil erosion.
3. certified organic farming of sloping lands that are more likely to have more water runoff of soil particulates
4. grass buffers and filter strips between areas at ends of fields to impede any of those waters from going into nearby drainage ditches
5. farming sidehill beds instead of running the beds directly downhill so as to absorb the water into the soil better and avoid more water runoff.
6. installation of water - purifying devices like OMNI enviro, that allows for less water requirement for crops.
7. Increasing use of drip irrigation, which allows for less water runoff on sloping lands

These measures have helped chiefly with water quality protection and a side effect of better nutrient management in some ways. My nutrient management has always been as tight as can be in the first place and there is no room for letting up on fertilizers. Most of my soil analysis reports say I need to be putting in more fertilizer than I regularly do, but because of some of the above practices, it compensates for that flaw.

[141] 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)

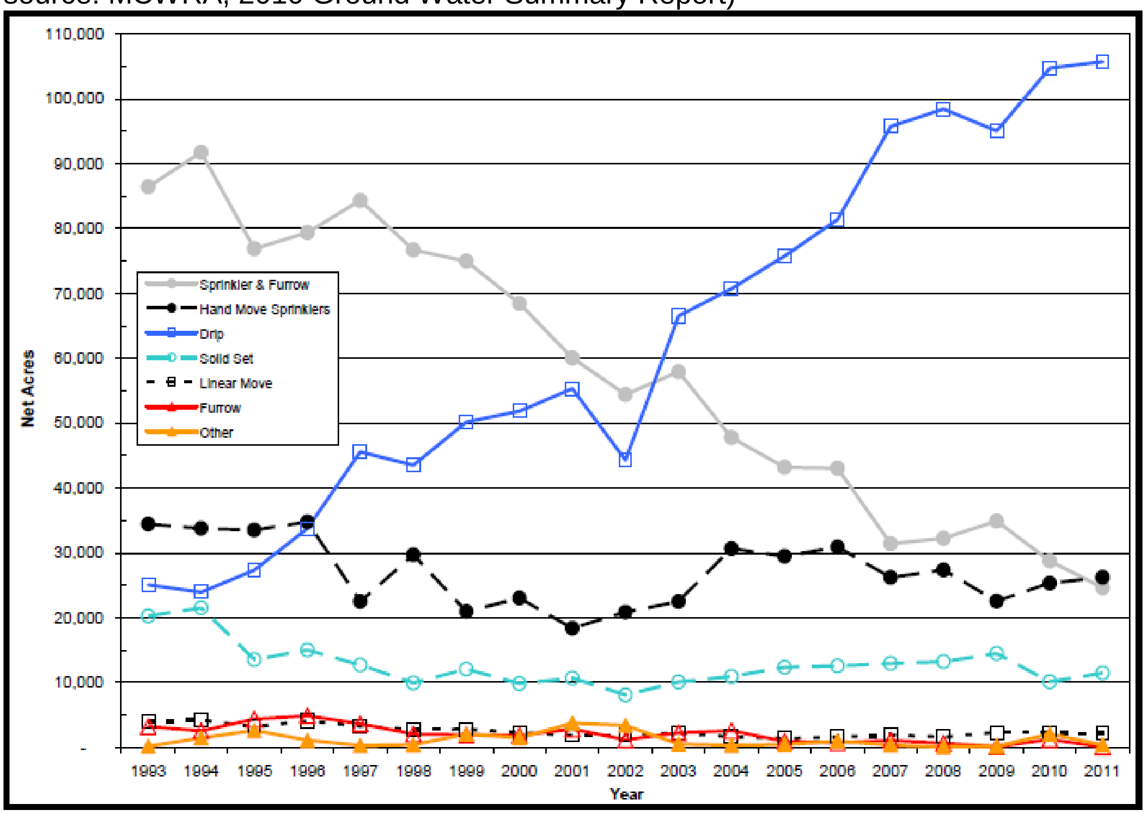
7.13.2 Grower Irrigation Efficiency Improvements and Trends

Information provided by a prominent grower in the Salinas Valley assisted staff in obtaining and reporting data on improved irrigation efficiency in the TMDL project area. Improved irrigation efficiency is not only potentially a good business practice, but may ultimately result in water quality improvements, by reducing runoff and/or reducing nitrogen leaching to groundwater.

The Monterey County Water Resources Agency reports annually on the net acre distribution of irrigation methods and trends in the Salinas Valley (MCWRA, 2011). While these trends do not report the actual amount of water usage, they do indicate trends in the net acreage using various irrigation method types. Between 1993 and 2011 there was a 321% increase in the net acreage using drip irrigation. Further, use of drip irrigation in the Salinas Valley has been accelerating in the last decade, as shown in Figure 7-1; between 2002 and 2011 there was a 140% increase in the net acreage using drip irrigation compared to an increase of 75% in drip between 1993 and 2002. Additionally, use of sprinkler and furrow irrigation methods has dropped by 73% from 1993 to 2011.

These trends are encouraging from the perspective of water quality, because improved irrigation efficiency (such as drip irrigation, microirrigation) is an important nutrient source control method since these methods can reduce the risk of nutrient loss from farms in surface runoff and leaching to groundwater.

Figure 7-1. Irrigation methods and trends in the Salinas Valley (Used with permission-source: MCWRA, 2010 Ground Water Summary Report)



7.13.3 Molera Road Treatment Wetland[142]

Location: Confluence of Tembladero Slough and the Old Salinas River, near Castroville on a parcel of county land that is operated as a research facility by the Watershed Institute at California State University, Monterey Bay and the Habitat Restoration Group as Moss Landing Marine Labs. The Molera Wetland operates as an off-line, downstream experimental watershed pollution treatment system. This is an ongoing project and results are preliminary. Results to date indicate the engineered wetland reduces nitrate concentrations by between 5 to 20 mg/L. Most nitrate is probably removed permanently by denitrification. Nitrate removal could likely be enhanced by adding carbon, e.g. dead plant matter. Ammonia and phosphate reductions have been noted in the upper portion of the constructed channel, however sometimes their concentrations increased again in the lower channel.

7.13.4 Moro Cojo Slough Management and Enhancement Plan

This project included the enhancement, restoration, and protection of 350-600 acres of wetlands, floodplains, and adjacent uplands and demonstrates the uses and advantages of agricultural best management practices (Coastal Conservation and Research, Inc., 2008). The project included engineered wetlands, water conveyance modification, and revegetation. Water quality monitoring results indicated that the wetlands were very successful in reducing nitrates, ammonia, and phosphate. Agricultural runoff that ran through wetlands (constructed and natural) revealed greatly reduced levels of nitrate. Nitrate levels adjacent to the farm edge at Middle Moro Cojo average approximately 60 mg/L whereas nitrate concentrations at the sampling site furthest from the farm edge averaged approximately 4 mg/L.

7.13.5 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-irrigaged 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.

[142] Dr. Fred Watson, California State University, Monterey Bay provided information to staff on the Molera Road Treatment Wetland project results in a Fact Sheet entitled “The Molera Road Treatment Wetland: Overview and brief summary of water quality results to date”, dated March 9, 2011.

7.13.6 Central Coast Wetlands Group

Mr. Ross Clark, Director of the Central Coast Wetlands Group (CCWG) at Moss Landing Marine Labs provided staff a map showing current and proposed CCWG water quality enhancement projects in the northern part of the TMDL project area (see Figure 7-2). Mr. Clark reports (personal communication to Water Board staff, Oct. 26, 2011) that the Coastal Wetlands Group is currently talking with many of the land owners in this area about the design and construction of additional wetland treatment systems along their portions of the drainage.

Figure 7-2. Water quality enhancement projects, northern Monterey County.

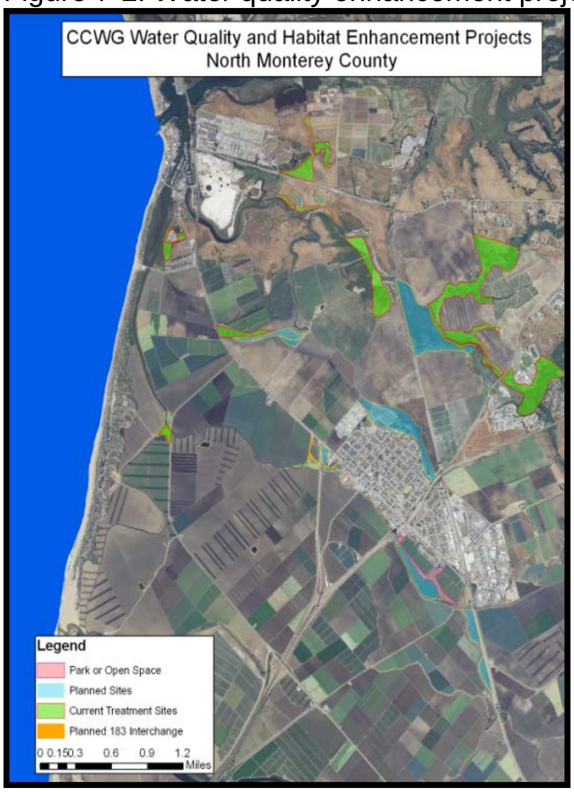


Figure courtesy of Ross Clark, Moss Landing Marine Labs

7.13.7 Prop. 13 Project in the Gabilan Creek Watershed

This was a Proposition 13-funded project completed by Moss Landing Marine Labs, the Watershed Institute at CSUMB, the RCD of Monterey County, the Community Alliance with Family Farmers, and Coastal Conservation and Research, Inc. The goal of this project was to improve water quality through wetland restoration, and education, outreach, implementation and monitoring of on-farm practices aimed at reducing source pollution. These practices included critical area planting, road seeding, filter strips, hedgerows, and other practices. Results of the project indicated that the wetland was effective at removing large fractions of nitrate and suspended sediment. It was also effective at removing ammonia and phosphate but over longer retention times.

7.13.8 Salinas River Diversion Facility

In a letter to Water Board staff dates Nov. 3, 2011, the Monterey County Water Quality and Operations Committee reported that the Salinas River Diversion Facility (SRDF) became operational in 2010, and reportedly has significantly changed summer flow conditions in the lower Salinas River, and reduced nutrient loads downstream of the SRDF compared to pre-

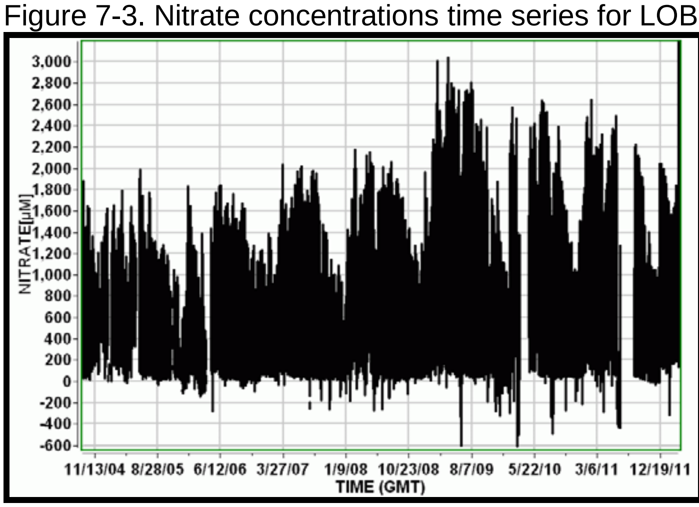
2010 data. In an letter dated March 7, 2012 the Monterey County Water Quality and Operations Committee (MCWQOC) provided water quality information associated with the SRDF to staff for inclusion in this project report. According to the data summary provided by MCWQOC, the amount of nitrate-N load being diverted from the Salinas River and the Blanco Drain during 2010 and 2011 and subsequently used for irrigation (after dilution with recycled water) ranged from 66,220 pounds to 205,958 pounds per year. Future diversions of water column nitrate-N loads in future years are projected by MCWQOC to be on the order of 200,000 to 244,00 pounds per year. Based on the estimates provided, diversion of water column nitrate-N loads from the Blanco Drain should be very helpful in protecting and enhancing aquatic habitat in the Salinas River Lagoon and lowermost Salinas River.

Table 7-8. SRDF nitrate load diversion summary as provided by MCWQOC.

SRDF Water Quality	2010	2011	Near Term	Possible Future Years
Weighted Average ppm NO3-N	17.28	7.05	15.00	15.00
Average lbs. NO3-N per AF	46.83	19.10	40.65	40.65
Total AF diverted	4,398	3,467	5,000	6,000
Total lbs. NO3-N diverted	205,958	66,220	203,250	243,900

Additionally, as previously noted in Section 3.11.2, recent monitoring data from LOBO sensor L03[143] at the Old Salinas River (OSR) estuary has indicated drops in nitrate concentrations during the years 2010 and 2011 (see Figure 7-3). These happen to be the years the SRDF went into operation. Note that the OSR channel receives flow inputs from the Salinas River lagoon via the slide gate near Mulligan Hill. While definitive conclusions cannot be drawn about the nature of the recent apparent drop in nitrate concentrations in the OSR, Staff speculates that it may be partially attributable to operation of the Salinas River Diversion Facility, and the nitrate load reductions/diversions as reported by MCWQOC.

Figure 7-3. Nitrate concentrations time series for LOBO sensor L03.



7.13.9 Natividad Creek Restoration and Preservation Projects

In recent years, local citizens, the City of Salinas, and researchers, through a community-based habitat restoration approach (known as "Return of the Natives", or RON), have made substantial environmental improvements to urban watersheds in the City of Salinas including

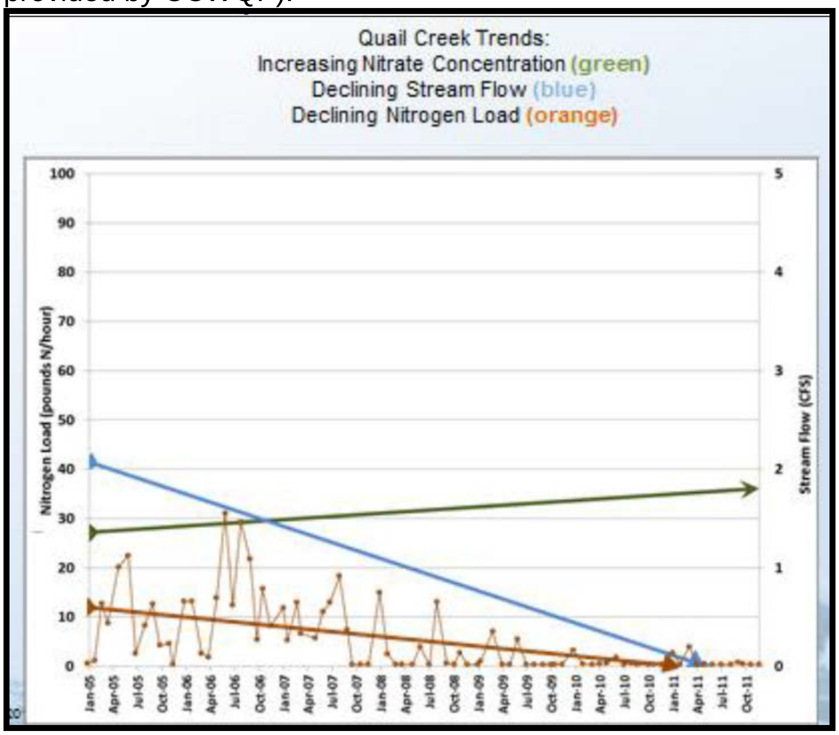
[143] Graph is from Monterey Bay Aquarium Research Institute LOBO webpage – negative concentration values are artifacts of optical interference and should be considered invalid data.

Natividad Creek[144]. The goals of RON project include restoring a natural state to urban riparian corridors in Natividad Creek. In years past, Natividad Creek had turned into a trash-laden flood control ditch. Over the past ten years, City of Salinas engineers have improved creek hydrology by rerouting Natividad Creek back to its natural streambed and the RON project has replanted 17 acres of Natividad creek with over 20,000 native plants and made other improvements, funded by a $160,000 grant from the California Dept. of Resources and local nurseries. Also noteworthy, is that RON has made substantial habitat, wetland, and environmental improvements at Carr Lake located in the City of Salinas. Increased tree canopy, natural, vegetated riparian corridors, and wetland enhancements typically contribute to improved water quality and reduce the risk of biostimulation due to nutrients.

7.13.10 Quail Creek: Reported Reductions in Nitrogen Loading

According to information submitted by Central Coast Water Quality Preservation, Inc. (CCWQP) nitrogen loading measured on a mass basis to Quail Creek has been substantially reduced between 2005 and 2011 (see Figure 7-4) reportedly due to changes in management decisions and practices.

Figure 7-4. Illustration of CCWQP-reported nitrogen load reduction in Quail Creek (figure provided by CCWQP).



7.13.11 Prop. 84 Salinas Valley Irrigation & Nutrient Management Program

In fiscal year 2011, $1,250,000 in grant funding was made available through the Proposition 84 Agricultural Water Quality Grant Program to implement irrigation and nutrient management programs in the lower Salinas Valley. This program will assist growers in developing and implementing irrigation and nutrient management site plans, cost estimates, and applications. Practices may include, but are not limited to the following types: large

144 Information from Return of the Natives (RON) website: http://ron.csumb.edu/natividad

scale wetland treatment systems, equipment upgrades, irrigation system infrastructure, and backflow prevention devices.

7.13.12 Greater Monterey County Integrated Regional Water Management Plan

According to the June 2012 draft version of this plan, implementation of projects in the Integrated Regional Water Management (IRWM) Plan will reportedly result in significant water resource and environmental benefits for the Greater Monterey County planning region. The Greater Monterey County IRWM Plan includes the following types of projects: *Water quality improvement programs*, including farm water quality assistance, on-farm erosion control, irrigation and nutrient management evaluation, and implementation of BMPs on livestock facilities and rangelands (led by the RCD of Monterey County); BMP implementation in Santa Rita Creek (led by the Monterey Bay Sanctuary Foundation, RCD of Monterey County, and Central Coast Wetlands Group); implementation of a Green Gardener Program (led by Ecology Action and the RCD of Monterey County); and a regional project tracking program to monitor progress in addressing the goals of improved water quality, water supply, flood control and environmental protection outlined in the IRWM Plan (led by the Monterey Bay National Marine Sanctuary). *Major wetland and dune restoration projects* in Tembladero Slough, Moro Cojo Slough, and the dunes near Moss Landing (all led by the Central Coast Wetlands Group), and in Elkhorn Slough (led by the Elkhorn Slough Foundation).

7.13.13 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.pacinst.org/reports/success_stories/

7.14 Cost Estimates

7.14.1 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 SWRCB Office of Chief Counsel notes that the economic impact was already previously determined when the water quality standard was adopted[145] 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 (SWRCB, Office of Chief Counsel, 2002). Therefore, not only would an in-depth economic analysis be redundant, it would be inconsistent with federal law (SWRCB, Office of Chief Counsel,

[145] 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"*

2002). Further, the SWRCB 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 (SWRCB, Office of Chief Counsel, 1997).

7.14.2 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. 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 7.14.1).

There is substantial uncertainty in calculating total costs associated with TMDL implementation measures. This is in part, due to the uncertainty surrounding the number of facilities and farms that will require TMDL implementation. Also, it is important to note that the Water Board cannot mandate or designate the specific types of on-site actions[146] necessary to reduce nutrient loading, or to meet allocations by the various responsible parties. Specific actions or management measures that are described or identified in the project report can only be suggestions or examples of actions that are known to be effective at reducing loading.

Further, it is should be recognized that implementation measures to reduce nutrient pollution are already required 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 7.3, 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. In part, the TMDL can be considered an informational tool to focus and facilitate implementation, and assist the Water Board in making its plan to implement state water quality standards.

In addition, the proposed TMDL is not anticipated to incur additional, incremental costs to owners/operators of irrigated lands on the basis of surface receiving water quality monitoring. The Cooperative Monitoring Program (an entity that collects data on behalf of growers to comply with the Agricultural Order) at this time appears to be collecting data at a sufficient temporal and spatial scale to allow determination of progress towards achievement of the TMDL.

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 SWRCB, Office of Chief Counsel, 1997) and these estimates thus constitute gross out-of-pocket 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). 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 7.15. For example, in Fiscal Year 2011, just one grant funding source (i.e., the Proposition 84 Agricultural Water Quality Grant Program)

[146] Porter-Cologne Water Quality Control Act §13360.(a)

made $1,250,000 available to assist growers with irrigation and nutrient management in the lower Salinas Valley.

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.

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 lower Salinas Valley, staff anticipates a higher degree and scope of nutrient pollution mitigation measures will occur in the lower Salinas Valley - either voluntarily 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 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 7-9 presents the cost estimates to implement the Agricultural Order throughout the entire Central Coast Region.

Table 7-9. Cost estimates to implement Agricultural Order for CENTRAL COAST REGION.

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 this TMDL, by using the information in Table 7-9. Accordingly staff: (1) scaled down the acreage in Table 7-9 requiring implementation of management practices to the scale of the TMDL project area; and (2) staff scaled up some of the correction factors[147] found in Table 7-9 in recognition of the fact that the magnitude of nutrient pollution exceeds most other areas of the central coast region and likely will require more concerted and sustained efforts to address.

Table 7-10. Farmland acreage and correction factors for Central Coast Region vs. TMDL project area.

	Amount of farmland[A] (acres)	Regional Correction Factor[B] Used for Agricultural Order	Correction Factor used for TMDL Project Area	Basis for Scaling Up Correction Factor in TMDL Project Area
Central Coast Region (Region 3)	738,429	50%	**50%**	Not scaled up: TMDL project area growers have already substanitally improved irrigation efficiency in recent years see Section 7.13.2
TMDL project area	88,139	20%	**60%**	Scaled up by factor of 3 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.

[147] Correction factors are an estimate of the ratio of irrigated acres that might be subject to actual management to reduce pollutant discharges.

	Amount of farmland[A] (acres)	Regional Correction Factor[B] Used for Agricultural Order	Correction Factor used for TMDL Project Area	Basis for Scaling Up Correction Factor in TMDL Project Area
Farmland Acreage Ratio: TMDL Project Area compared to Region 3	11.9% 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.

Table 7-11 presents the geographically scaled-down, estimated compliance costs associated with the Agricultural Order that may be incurred for farmland within the TMDL project area (based on the regional estimates from Table 7-9).

Table 7-12 illustrates estimated summed costs are that are associated with compliance with the Agricultural Order, plus incremental costs potentially attributable to TMDL implementation.

Table 7-11. Cost estimates based on standard compliance with Agricultural Order in TMDL PROJECT AREA.

Management Practice Category	Area Basis (Acres)[A]	Acres	Correction Factor	Acres Practice Applied to:	Cost per Acre	Cost - Year 1	% Year 1 Cost in Yrs 2-5	Cost Years 2-5	Ag Order Cost 5 Years
Irrigation Management	12% of corresponding acreage from Table 7-9	8,895	50%	4,447	$903	$4,016,092.50	10%	$1,606,256	$5,621,897
Nutrient Management	12% of corresponding acreage from Table 7-9	53,333	20%	32,000	$56	$597,329.60	25%	$597,330	$1,194,659
Aquatic Habitat Protection	12% of corresponding acreage from Table 7-9	1,200	50%	1,200	$1,184	$710,400	10%	$284,160	$994,560

[A] The 12% fraction in this column is the ratio (%) of FMMP farm acres in the TMDL area compared to FMMP farm acres in all of Region 3

Table 7-12.Cost estimates associated w/ Agricultural Order compliance plus estimated incremental TMDL implementation costs in the TMDL PROJECT AREA

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	Ag Order plus TMDL Cost 5 Years
Irrigation Management	12% of corresponding acreage from Table 7-9	8,895	50%	4,447	$903	$4,015,641	10%	$1,606,256	$5,621,897
Nutrient Management	12% of corresponding acreage from Table 7-9	53,333	60%	32,000	$56	$1,792,000	25%	$1,792,000	$3,584,000
Aquatic Habitat Protection	12% of corresponding acreage from Table 7-9	1,200	100%	1,200	$1,184	$1,420,800	10%	$568,320	$1,989,120

[A] The 12% fraction in this column is the ratio (%) of FMMP farm acres in the TMDL area compared to FMMP farm acres in all of Region 3

Based on the information presented in Table 7-11 and Table 7-12, the incremental costs associated with TMDL implementation for five years are approximately 3.4 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.

Table 7-13. Incremental costs attributable to TMDL implementation.

A. Management Practice Category	B. Ag Order Standard Compliance Cost Estimate 5 Years	C. Ag Order plus TMDL Implementation Cost 5 Years	D. Incremental Cost Attributable to TMDL Implementation 5 Years *(Column B subtracted from Column c)*
Irrigation Management	$5,621,897	$5,621,897	$0
Nutrient Management	$1,194,659	$3,584,000	$2,389,341
Aquatic Habitat Protection	$994,560	$1,989,120	$994,560
Total	$7,811,116	$11,195,017	
Total Incremental Cost Attributable to TMDL Implementation* (5 Years)			**$3,383,901**

* *Total from Column B subtracted from Total from Column C*

Based on information in the 2011 technical documentation for the Agricultural Order and information developed in this section, an estimated incremental cost attributable to TMDL implementation for irrigated agriculture over 5 years is approximately **$3.4 million.** This represents, on average, an estimated unit-area cost of **$39 per acre of farmland*** in the TMDL project area **over a period of five years of implementation**.

These represent incremental costs specifically associated with TMDL implementation; it should be reiterated that implementation measures to reduce nutrient pollution are already required by compliance with an existing regulatory program (Agricultural Order No. R3-2012-0011) regardless of whether or not there is a TMDL.

* *as represented by the Calif. Dept. of Water Resource's 2008 FMMP spatial dataset*

7.14.3 Cost Estimates 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. Further, implementation to reduce nitrate loadings to the Salinas River from the City's stormwater outfall near Davis Road is already required pursuant to an existing NPDES permit.

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)[148]. 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 7-4 and Figure 7-5, 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 indeed what percentage of this area will receive implementation with or without a TMDL pursuant to existing permits and other environmental projects. Implementation over 100% of the MS4 footprint is clearly impractical, and cost-prohibitive. Implementation will undoubtedly be focused are 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.

[148] Online linkage: http://www.sbpat.net/

Figure 7-5. Estimated unit BMP capital costs by design volume, flow rate, and footprint area.

	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 7-6. Estimated unit BMP annual maintenance costs by design volume, flow rate, and footprint area.

	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

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 7-4 and Figure 7-5). 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 compliance are reasonably foreseeable to attain the allocations; and 2) what are the *costs of these methods* (SWRCB, Office of Chief Counsel, 1997).

Therefore, for implementation of this TMDL 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 7-14.:

Table 7-14. Unit costs for MS4 TMDL implementation

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

7.15 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:

7.15.1 Federal Farm Bill

Title II of the 2008 Farm Bill (the Food, Conservation, and Energy Act of 2008, in effect through 2012) authorizes funding for conservation programs such as the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program. Both of these programs provide financial and technical assistance for activities that improve water quality on agricultural lands. For example, the NRCS provides financial and technical assistance to growers to improve water quality.

The assistance is through the Agricultural Water Enhancement Program, an element of the NRCS EQIP. The program is a voluntary conservation initiative in which NRCS develops partnership agreements with eligible growers. Farm bills typically are in place for four to five years. Subsequent farm bills may expand, reduce, eliminate, or replace EQIP. Farm bills or other future legislation may authorize spending for direct grants, loans, or cost sharing for irrigation practices that improve water quality.

More information is also available from the local NRCS or RCD office or at the Monterey County RCD website at
http://www.rcdmonterey.org/Growers_Ranchers_Landowners/funding_services.html

7.15.2 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 is also available from the California State Water Resources Control Board site at http://www.swrcb.ca.gov/water_issues/programs/grants_loans/319h/index.shtml, or contact Melenee Emanuel, State Board Division of Water Quality, 319(h) Grants Program at (916) 341-5271.

7.15.3 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 at:

http://www.waterboards.ca.gov/water_issues/programs/grants_loans/awqgp/index.shtml

7.15.4 Safe, Clean, and Reliable Drinking Water Supply Act of 2010

This act was passed by the Legislature as SBX 7_2, and if approved by voters in November of 2010, would provide grant and loan funding for a wide range of water related activities, including agricultural water quality improvement, watershed protection, and groundwater quality protection. The actual amount and timing of funding availability will depend on its passage, on the issuance of bonds and the release of funds and on the kinds of programs and projects proposed and approved for funding.

7.15.5 Other Sources of Funding for Growers and Landowners

The Monterey County RCD 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 at the Monterey County RCD website at:

http://www.rcdmonterey.org/Growers_Ranchers_Landowners/index.html.

8 PUBLIC PARTICIPATION

8.1 Public Meetings & Stakeholder Engagement

Staff conducted stakeholder outreach efforts during TMDL development. Staff conducted public workshops in the city of Salinas in June 2010, April 2011, October 2011 and November 2012, and staff engaged with stakeholders during the development of the TMDL through informal meetings, correspondence, and telephone contact.

In particular, extremely helpful information, and data were provided individuals affiliated with the Elkhorn Slough National Estuarine Research Reserve (ESNERR), the Monterey County Water Resources Agency, the California State University Monterey Bay (CSUMB) Watershed Institute (MBARI), the Central Coast Wetlands Group at Moss Landing Marine Labs, the Monterey Bay Aquarium Research Institute, and the Monterey County Water Quality and Operations Committee. Scientists and resource professionals who shared data regarding downstream nutrient impacts to Elkhorn Slough include Grey Hayes, Brent Hughes and others from the ESNERR; Dr. Ken Johnson of MBARI, and Dr. Jane Caffrey of the University of West Florida. Data and information on wetland treatment systems and nutrient pollution was kindly provided by Dr. Fred Watson of CSUMB and Ross Clark, Director of the Central Coast Wetlands Group at Moss Landing Marine Labs. Technical feedback was also kindly provided by Dr. Marc Los Huertos of CSUMB. Information and data on improvements in irrigation efficiency, water quality and farm management practices were provided by individual growers, the Cooperative Monitoring Program, and the Monterey County Water Resources Agency. Helpful information on aquatic habitat in the TMDL project area was provided by federal fisheries biologists affiliated with the U.S. National Marine Fisheries Service.

A tabulation of individuals and entities staff engaged with during public workshops or during TMDL development are as follows:

- Monterey County Water Resources Agency
- City of Salinas
- Costa Farms, Inc.
- Monterey Bay Aquarium Research Institute
- University of Calif. Cooperative Extension
- Resource Conservation District of Monterey County
- Representatives of commercial farms and ranches
- Agricultural consultants
- Representative for State Senator Sam Blakeslee
- Monterey County of Public Works

- Researchers and Resource Professionals from the Elkhorn Slough National Estuarine Research Reserve
- Researchers from California State University-Monterey Bay, the University of California-Santa Cruz, and the University of West Florida
- Central Coast Water Quality Preservation, Inc.
- Staff of the Cooperative Monitoring Program
- U.S. National Marine Fisheries Service
- Monterey CoastKeeper
- Monterey County Farm Bureau
- Monterey Bay National Marine Sanctuary
- Moss Landing Marine Labs
- Monterey County Water Quality and Operations Committee

Staff also conducted a California Environmental Quality Act (CEQA) stakeholder scoping meeting on October 3, 2011. Staff addressed questions and comments from attendees.

8.2 Stakeholder Contributions to TMDL Development

Valuable input, information and feedback provided by stakeholders that assisted in TMDL development are outlined below. These are not a complete or exhaustive summary of stakeholder contributions, but are provided in acknowledgement of their valuable proactive engagement:

- Contributions that further informed staff on case studies, pilot projects, and success stories demonstrating the efficacy and implementation of nutrient pollution control efforts and methodologies implemented by growers, researchers, citizens, and municipalities;
- Contributions that further informed staff on downstream nutrient pollution impacts to receiving waterbodies of the Elkhorn Slough estuary system;
- Contributions that further informed staff on the need to consider relatively long implementation timelines that allow for attenuation of existing and legacy pollution of shallow groundwater;
- Contributions that further informed staff in the development of nutrient water quality numeric targets;
- Contributions that further informed staff on aquatic habitat in the lower Salinas valley;
- Contributions that further informed staff on the potentially substantial adverse environmental changes that are considered in the CEQA analysis;
- Contributions that further informed staff on the hydrology of the TMDL project area;
- Contributions that further informed staff on the need to consider a variety of metrics to assess the progress towards attainment of water quality standards; including but not limited to assessments of mass-based load reductions, flow-weighted concentrations, implementation of management practices capable of ultimately achieving load allocations, etc. (for example, refer back to footnote 130 on page 266);
- Some stakeholders suggested that TMDL goals and water quality targets should be periodically re-evaluated. Staff concurs with the suggestion in principal, and modified the TMDL accordingly. 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 the TMDL 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 TMDL, which is upon approval by the Office of Administrative Law (OAL).

Central Coast Water Board staff solicited written public comment prior to the Central Coast Water Board public hearing considering adoption of this TMDL. The Central Coast Water Board accepted public comments and provided written response for the Water Board public hearing.

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Appendix A Monitoring Sites

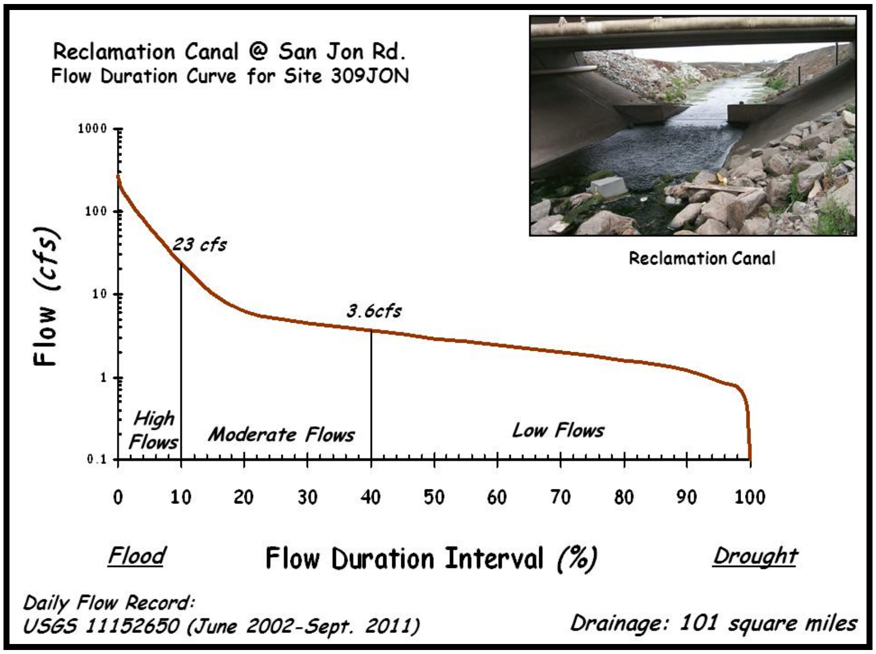
This appendix contains TMDL project area monitoring site location information. Due to the large volume of the water quality data used (greater than 30,000 electronic records of monitoring events for pollutant-monitoring site pairs), the water quality data used in this project will be stored electronically with the administrative record.

Table 1. Monitoring Site Tags - Locations.

Site Tag	Waterbody - Location
309SAG	309SAG - Salinas River at Gonzales River Rd. bridge
309SOS	309SOS - Chualar Creek at Old Stage Rd
309SAC	309SAC-Salinas River at Chualar bridge on River Road
309SBC	309SAT-Salinas River at Highway 41 bridge
309CRR	309CRR - Chualat Creek at River Road
309NOS	309NOS-Chualar Crk Old Stage Rd
ESZ-HWY	Between Hwy 101 & Railway, South of Esperanza Rd
ESZ-OSR	Old Stage Rd
CHU-CCR	Chualar Canyon Rd
309QUI	309QUI - Quail Creek at HWY 101, btwn Spence and Potter Roads (trib. to Salinas R.)
309QUA	309QUA-Quail Creek at Potter Road
309UQA	309UQA-Quail Creek at Old Stage Road
309SSP	309SSP - Salinas River at Spreckles
309HRT	309HRT-Alisal Creek at Hartnell Rd
309UAL	309UAL-Alisal Creek at Old Stage Road
309SDR	309SDR-Salinas Storm Drain u/s Davis Road
309DAV	309DAV-Salinas River at Davis Road
309ALG	309ALG - Salinas Reclamation Canal at La Guardia
309ALU	309ALU-Salinas Reclamation Canal at Airport Road
309AXX	309AXX-Salinas Reclamation Canal Storm Drain at Airport Road
SAL-BLA	Blanco Rd
309-ALISA-32	309-ALISA-32 - Upper Alisal Creek
PIP-VIC	Drains into Rec. Ditch at Victor Rd
309AVR	309AVR - Reclamation Canal at Victor Rd
D2126450	NATIVIDAD C A E LAUREL DRI
309ALD	309ALD-Salinas Reclamation Canal at Boranda Road
D2125550	ALISAL CREEK AT OLD STAGE ROAD
GAB-VET	Veterans Park Bridge
NAT-LAS	Las Casitas
BLA-COO	Blanco drain at Cooper Rd
D2126650	NATIVIDAD DRAINAGE A OLD STAGE RD
NAT-FRE	Freedom Blvd.
NAT-BOR	Boronda Rd
309JON	309JON - Salinas Reclamation Canal at San Jon Road
D2112050	SALINAS RIVER ABOVE HWY 1 BRIDGE
309-GABIL-31	309-GABIL-31 - Gabilan Creek at Independence
309NAD	309NAD - Natividad Creek up stream of Salinas Reclamation Canal
BLA-PUM	Pump station
309GAB	309GAB-Gabilan Creek at Independence Road and East Boranda Road
D2111070	SALINAS RIVER AT TWIN BRIDGES
309-SRITA-36	309-SRITA-36 - Santa Rita Creek at North Main St. and E. Bolivar Street

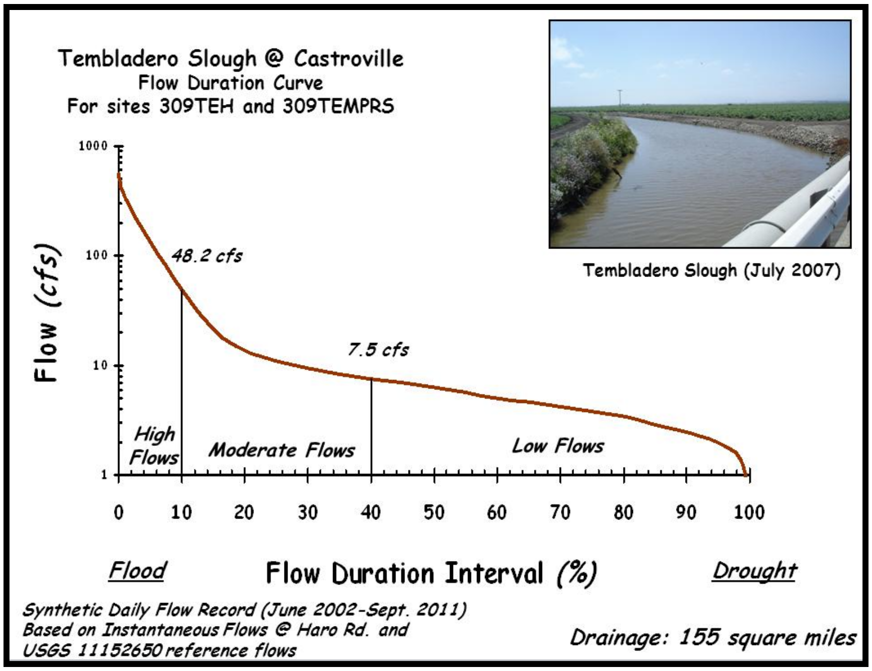
309RTA	309RTA - Santa Rita Creek at Santa Rita Park
309ASB	309ASB - Alisal Slough at White Barn
309-SRITA-32	309-SRITA-32 - Santa Rita Creek at Bellizona
GAB-NAT	Natividad Rd
309SBR	309SBR-Salinas River at Highway 1
309SLRLAG	309SLRLAG - Salinas River Lagoon
309-SRITA-34	309-SRITA-34 - Santa Rita Creek at Russell Road
309ESP	309ESP - Espinosa Slough up stream Highway 183
EP1-ROG	Rodgers Rd
REC-183	Hwy 183
309-ALISA-31	309-ALISA-31 - Alisal Slough at 1703 Hwy 187
EPL-EPL	Espinosa Lake
SAL-MOU	mouth of lagoon
309MER	309MER - Merrit Ditch upstream Highway 183
GAB-HER	Herbert Rd
309TEH	309TEH - Tembladero Slough at Haro
309-TEMBL-34	309-TEMBL-34 - Upper Tembladero Cr at Anderson Property
309TEMPRS	309TEMPRS - Tembladero Slough@preston
GAB-CRA	Crazy Horse Rd
OLS-MON	Monterey Dunes Colony Rd
309TDW	309TDW-Tembladero Slough at Molera Road
GAB-OSR	Old Stage Rd
306-MOROC-31	306-MOROC-31 - Moro Coho Slough Upper
D1311330	MORRO COJO SLU EB A RR S DOLAN
OLS-POT	Potero Rd (Tide Gates)
306-MOROC-32	306-MOROC-32 - Moro Coho Slough at Castroville Slough Confluence
306MOR	306MOR-Moro Cojo Slough at Highway 1
BOC-OSR	Old Stage Rd
MOS-SAN	Moss Landing Harbor at Sandholt Rd
306MORMLN	306MORMLN - Moss Landing Road, North
TOW-OSR	Small br nr Old Stage Rd

Appendix B Flow Duration Record Summary & Instantaneous Flow Records



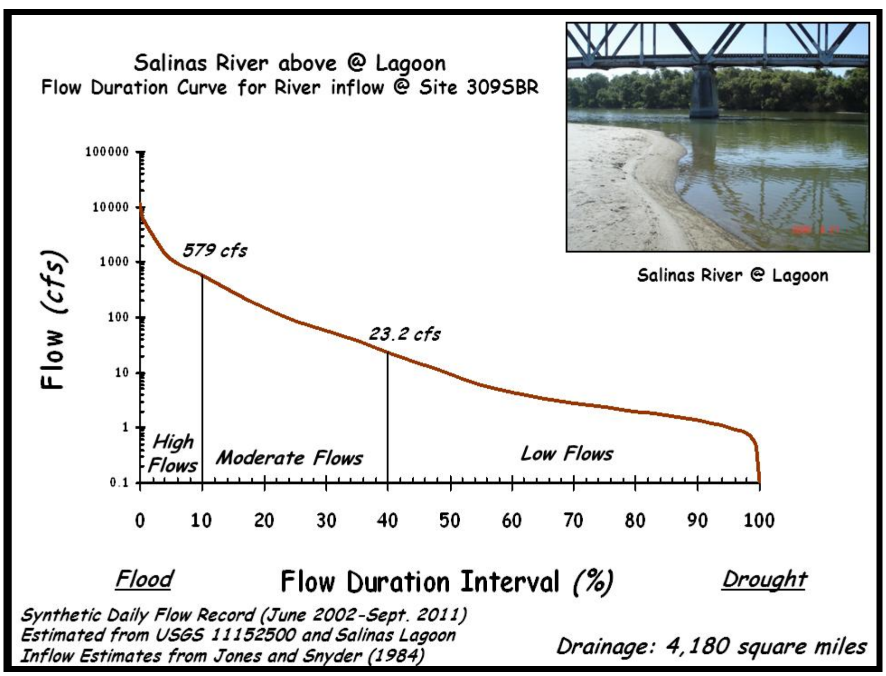
	A	B	C
1	FLOW DURATION SUMMARY		
2		Peak to Low	
3		cfs	mm
4	0.029%	270.0	4.79
5	0.01%	270.0	4.79
6	0.27%	232.0	4.12
7	1%	160.7	2.85
8	5%	63.0	1.12
9	10%	23.0	0.41
10	15%	10.0	0.18
11	20%	6.3	0.11
12	25%	5.1	0.09
13	30%	4.4	0.08
14	35%	4.0	0.07
15	40%	3.6	0.06
16	45%	3.3	0.06
17	50%	2.9	0.051
18	55%	2.7	0.05
19	60%	2.4	0.04
20	65%	2.2	0.04
21	70%	2.0	0.04
22	75%	1.8	0.03
23	80%	1.6	0.03
24	85%	1.4	0.02
25	90%	1.2	0.02
26	95%	0.9	0.02
27	99%	0.6	0.01
28	100%	0.1	0.002
29			
30	14.5%	11.4	0.20
31			
32			
33			

Site Info | Raw



	A	B	C
2		Peak to Low	
3		cfs	mm
4	0.029%	565.9	0.66
5	0.01%	565.9	0.66
6	0.27%	486.2	0.57
7	1%	339.4	0.39
8	5%	132.0	0.15
9	10%	48.2	0.06
10	15%	21.0	0.02
11	20%	13.6	0.02
12	25%	10.9	0.01
13	30%	9.4	0.01
14	35%	8.4	0.01
15	40%	7.5	0.01
16	45%	6.9	0.01
17	50%	6.3	0.007
18	55%	5.7	0.01
19	60%	5.0	0.01
20	65%	4.6	0.01
21	70%	4.2	0.00
22	75%	3.8	0.00
23	80%	3.4	0.00
24	85%	2.9	0.00
25	90%	2.5	0.00
26	95%	2.0	0.00
27	99%	1.2	0.00
28	100%	0.2	0.000
29			
30	14.6%	23.8	0.03
31			
32			
33			
34			

Site Info | Raw_



	A	B	C
1	FLOW DURATION SUMMARY		
2		Peak to Low	
3		cfs	mm
4	0.029%	11665.2	13.57
5	0.01%	11599.7	13.49
6	0.27%	8151.5	9.48
7	1%	4546.8	5.29
8	5%	1150.0	1.34
9	10%	578.5	0.67
10	15%	288.2	0.34
11	20%	146.7	0.17
12	25%	87.9	0.10
13	30%	56.4	0.07
14	35%	37.7	0.04
15	40%	23.2	0.03
16	45%	14.7	0.02
17	50%	9.2	0.011
18	55%	6.1	0.01
19	60%	4.3	0.01
20	65%	3.3	0.00
21	70%	2.8	0.00
22	75%	2.4	0.00
23	80%	2.0	0.00
24	85%	1.7	0.00
25	90%	1.3	0.00
26	95%	1.0	0.00
27	99%	0.6	0.00
28	100%	0.1	0.000
29			
30	16.3%	249.8	0.29

Site Info | Raw_Da

Instantaneous Flow Records

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	306MOR	1/26/2005	3.94
CCWQP	306MOR	2/16/2005	9.94
CCWQP	306MOR	2/22/2005	5.40
CCWQP	306MOR	3/21/2005	19.10
CCWQP	306MOR	4/12/2005	65.89
CCWQP	306MOR	5/24/2005	2.52
CCWQP	306MOR	6/28/2005	2.76
CCWQP	306MOR	7/26/2005	3.00
CCWQP	306MOR	8/30/2005	3.12
CCWQP	306MOR	9/27/2005	4.12
CCWQP	306MOR	10/25/2005	3.17
CCWQP	306MOR	11/29/2005	3.39
CCWQP	306MOR	12/13/2005	3.08
CCWQP	306MOR	1/24/2006	10.78
CCWQP	306MOR	2/22/2006	3.35
CCWQP	306MOR	3/29/2006	3.61
CCWQP	306MOR	4/25/2006	3.42
CCWQP	306MOR	5/25/2006	2.85
CCWQP	306MOR	6/27/2006	15.37
CCWQP	306MOR	7/25/2006	7.67
CCWQP	306MOR	8/23/2006	7.92
CCWQP	306MOR	9/27/2006	10.35
CCWQP	306MOR	10/24/2006	9.90
CCWQP	306MOR	11/14/2006	8.97
CCWQP	306MOR	12/12/2006	10.08
CCWQP	306MOR	1/30/2007	7.92
CCWQP	306MOR	2/14/2007	8.10
CCWQP	306MOR	3/21/2007	12.72
CCWQP	306MOR	4/4/2007	12.56
CCWQP	306MOR	5/29/2007	2.40
CCWQP	306MOR	6/26/2007	2.82
CCWQP	306MOR	7/23/2007	2.84
CCWQP	306MOR	8/28/2007	4.19
CCWQP	306MOR	9/25/2007	0.43
CCWQP	306MOR	10/23/2007	1.58
CCWQP	306MOR	11/27/2007	0.68
CCWQP	306MOR	12/16/2007	0.68
CCWQP	306MOR	1/27/2008	3.76
CCWQP	306MOR	2/22/2008	1.43
CCWQP	306MOR	3/26/2008	0.00
CCWQP	306MOR	4/18/2008	0.00
CCWQP	306MOR	5/28/2008	0.00
CCWQP	306MOR	6/25/2008	0.00
CCWQP	306MOR	7/30/2008	0.00
CCWQP	306MOR	8/28/2008	0.00
CCWQP	306MOR	10/1/2008	0.00
CCWQP	306MOR	10/28/2008	1.01
CCWQP	306MOR	11/19/2008	0.00
CCWQP	306MOR	12/17/2008	0.00
CCWQP	306MOR	1/27/2009	0.00

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	306MOR	2/6/2009	19.01
CCWQP	306MOR	3/25/2009	0.00
CCWQP	306MOR	4/29/2009	8.58
CCWQP	306MOR	5/27/2009	0.00
CCWQP	306MOR	6/24/2009	0.00
CCWQP	306MOR	7/29/2009	0.00
CCWQP	306MOR	8/26/2009	0.00
CCWQP	306MOR	9/30/2009	0.00
CCWQP	306MOR	10/28/2009	0.00
CCWQP	306MOR	11/10/2009	0.00
CCWQP	306MOR	12/8/2009	0.00
CCWQP	306MOR	1/19/2010	0.00
CCWQP	306MOR	2/23/2010	0.00
CCWQP	306MOR	3/31/2010	0.00
CCWQP	306MOR	4/29/2010	7.32
CCWQP	306MOR	5/25/2010	0.00
CCWQP	306MOR	6/30/2010	2.28
CCWQP	306MOR	7/28/2010	0.00
CCWQP	306MOR	8/25/2010	0.00
CCWQP	306MOR	9/29/2010	0.00
CCWQP	306MOR	10/27/2010	0.00
CCWQP	306MOR	11/16/2010	0.00
CCWQP	306MOR	12/13/2010	0.00
CCWQP	306MOR	1/26/2011	0.00
CCWQP	306MOR	2/23/2011	66.01
CCWQP	306MOR	3/30/2011	0.00
CCWQP	306MOR	4/27/2011	2.18
CCWQP	306MOR	5/26/2011	0.97
CCWQP	306MOR	6/22/2011	-1.28
CCOWS	309ALD	4/14/2000	22.46
CCAMP	309ALD	1/24/2006	2.59
CCAMP	309ALD	2/28/2006	12.71
CCAMP	309ALD	3/28/2006	26.15
CCAMP	309ALD	5/23/2006	19.90
CCAMP	309ALD	6/21/2006	5.16
CCAMP	309ALD	7/19/2006	4.83
CCAMP	309ALD	8/15/2006	2.63
CCAMP	309ALD	9/20/2006	3.74
CCAMP	309ALD	10/18/2006	1.34
CCAMP	309ALD	11/8/2006	1.84
CCAMP	309ALD	1/8/2007	2.39
CCAMP	309ALD	2/14/2007	0.00
CCWQP	309ALG	1/27/2005	0.38
CCWQP	309ALG	2/17/2005	5.79
CCWQP	309ALG	2/22/2005	10.14
CCWQP	309ALG	3/22/2005	37.26
CCWQP	309ALG	4/13/2005	4.15
CCWQP	309ALG	5/24/2005	1.69
CCWQP	309ALG	6/28/2005	3.37
CCWQP	309ALG	7/27/2005	2.10
CCWQP	309ALG	8/30/2005	3.90
CCWQP	309ALG	9/27/2005	2.71
CCWQP	309ALG	10/25/2005	0.45
CCWQP	309ALG	11/29/2005	0.22

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309ALG	12/13/2005	0.00
CCWQP	309ALG	1/24/2006	0.05
CCWQP	309ALG	2/22/2006	1.64
CCWQP	309ALG	3/30/2006	8.82
CCWQP	309ALG	4/25/2006	1.17
CCWQP	309ALG	5/25/2006	1.46
CCWQP	309ALG	6/27/2006	2.44
CCWQP	309ALG	7/25/2006	6.35
CCWQP	309ALG	8/24/2006	4.30
CCWQP	309ALG	9/27/2006	5.27
CCWQP	309ALG	10/24/2006	2.06
CCWQP	309ALG	11/14/2006	7.93
CCWQP	309ALG	12/12/2006	3.99
CCWQP	309ALG	1/30/2007	0.28
CCWQP	309ALG	2/15/2007	0.47
CCWQP	309ALG	3/22/2007	0.27
CCWQP	309ALG	4/6/2007	0.52
CCWQP	309ALG	4/16/2007	0.18
CCWQP	309ALG	5/29/2007	0.93
CCWQP	309ALG	6/26/2007	1.13
CCWQP	309ALG	7/24/2007	1.48
CCWQP	309ALG	8/28/2007	2.07
CCWQP	309ALG	9/26/2007	0.98
CCWQP	309ALG	10/23/2007	0.03
CCWQP	309ALG	11/27/2007	0.01
CCWQP	309ALG	12/16/2007	0.17
CCWQP	309ALG	1/26/2008	2.92
CCWQP	309ALG	2/24/2008	16.03
CCWQP	309ALG	3/26/2008	0.42
CCWQP	309ALG	4/18/2008	0.61
CCWQP	309ALG	5/28/2008	1.38
CCWQP	309ALG	6/26/2008	1.23
CCWQP	309ALG	7/30/2008	0.00
CCWQP	309ALG	8/27/2008	0.49
CCWQP	309ALG	10/1/2008	0.05
CCWQP	309ALG	10/29/2008	0.00
CCWQP	309ALG	11/19/2008	0.00
CCWQP	309ALG	12/17/2008	0.00
CCWQP	309ALG	1/26/2009	0.75
CCWQP	309ALG	2/6/2009	2.14
CCWQP	309ALG	3/24/2009	0.38
CCWQP	309ALG	4/28/2009	0.45
CCWQP	309ALG	5/26/2009	0.00
CCWQP	309ALG	6/23/2009	0.00
CCWQP	309ALG	7/28/2009	0.00
CCWQP	309ALG	8/25/2009	0.23
CCWQP	309ALG	9/29/2009	0.00
CCWQP	309ALG	10/27/2009	0.00
CCWQP	309ALG	11/9/2009	0.00
CCWQP	309ALG	12/7/2009	0.00
CCWQP	309ALG	1/18/2010	7.44
CCWQP	309ALG	2/22/2010	0.00
CCWQP	309ALG	3/30/2010	0.41
CCWQP	309ALG	4/28/2010	0.45

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309ALG	5/24/2010	0.00
CCWQP	309ALG	6/29/2010	2.30
CCWQP	309ALG	7/27/2010	0.54
CCWQP	309ALG	8/24/2010	0.18
CCWQP	309ALG	9/28/2010	0.80
CCWQP	309ALG	10/26/2010	0.00
CCWQP	309ALG	11/15/2010	0.00
CCWQP	309ALG	12/12/2010	0.00
CCWQP	309ALG	1/25/2011	0.00
CCWQP	309ALG	2/22/2011	4.63
CCWQP	309ALG	3/29/2011	5.55
CCWQP	309ALG	4/26/2011	0.47
CCWQP	309ALG	5/25/2011	0.90
CCWQP	309ALG	6/23/2011	0.61
CCWQP	309ASB	1/26/2005	2.67
CCWQP	309ASB	2/16/2005	13.90
CCWQP	309ASB	2/22/2005	4.92
CCWQP	309ASB	3/21/2005	1.50
CCWQP	309ASB	4/11/2005	0.00
CCWQP	309ASB	5/24/2005	1.60
CCWQP	309ASB	6/28/2005	2.77
CCWQP	309ASB	7/27/2005	0.96
CCWQP	309ASB	8/30/2005	1.80
CCWQP	309ASB	9/27/2005	0.96
CCWQP	309ASB	10/25/2005	0.58
CCWQP	309ASB	11/29/2005	0.33
CCWQP	309ASB	12/13/2005	0.26
CCWQP	309ASB	1/24/2006	1.74
CCWQP	309ASB	2/22/2006	0.72
CCWQP	309ASB	3/29/2006	2.89
CCWQP	309ASB	4/25/2006	1.53
CCWQP	309ASB	5/24/2006	0.63
CCWQP	309ASB	6/27/2006	0.86
CCWQP	309ASB	7/25/2006	3.80
CCWQP	309ASB	8/23/2006	1.22
CCWQP	309ASB	9/27/2006	1.05
CCWQP	309ASB	10/24/2006	1.08
CCWQP	309ASB	11/14/2006	0.83
CCWQP	309ASB	12/12/2006	1.60
CCWQP	309ASB	1/30/2007	0.47
CCWQP	309ASB	2/14/2007	0.27
CCWQP	309ASB	3/21/2007	3.57
CCWQP	309ASB	4/4/2007	0.91
CCWQP	309ASB	5/29/2007	1.22
CCWQP	309ASB	6/26/2007	1.30
CCWQP	309ASB	7/23/2007	1.07
CCWQP	309ASB	8/28/2007	1.16
CCWQP	309ASB	9/25/2007	0.77
CCWQP	309ASB	10/23/2007	0.37
CCWQP	309ASB	11/27/2007	0.17
CCWQP	309ASB	12/16/2007	1.23
CCWQP	309ASB	1/26/2008	2.00
CCWQP	309ASB	2/22/2008	1.69
CCWQP	309ASB	3/25/2008	1.11

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309ASB	4/16/2008	1.80
CCWQP	309ASB	5/28/2008	1.78
CCWQP	309ASB	6/25/2008	1.80
CCWQP	309ASB	7/30/2008	1.78
CCWQP	309ASB	8/28/2008	1.67
CCWQP	309ASB	10/1/2008	0.47
CCWQP	309ASB	10/28/2008	0.38
CCWQP	309ASB	11/19/2008	0.29
CCWQP	309ASB	12/17/2008	1.19
CCWQP	309ASB	1/27/2009	0.82
CCWQP	309ASB	2/6/2009	4.60
CCWQP	309ASB	3/25/2009	1.78
CCWQP	309ASB	4/29/2009	2.27
CCWQP	309ASB	5/27/2009	2.19
CCWQP	309ASB	6/24/2009	0.90
CCWQP	309ASB	7/29/2009	2.02
CCWQP	309ASB	8/26/2009	0.80
CCWQP	309ASB	9/30/2009	0.58
CCWQP	309ASB	10/28/2009	0.81
CCWQP	309ASB	11/10/2009	0.47
CCWQP	309ASB	12/8/2009	0.75
CCWQP	309ASB	1/19/2010	4.83
CCWQP	309ASB	2/23/2010	5.14
CCWQP	309ASB	3/31/2010	1.29
CCWQP	309ASB	4/29/2010	0.25
CCWQP	309ASB	5/25/2010	0.76
CCWQP	309ASB	6/30/2010	1.19
CCWQP	309ASB	7/28/2010	1.14
CCWQP	309ASB	8/25/2010	0.78
CCWQP	309ASB	9/29/2010	0.44
CCWQP	309ASB	10/27/2010	0.02
CCWQP	309ASB	11/16/2010	0.00
CCWQP	309ASB	12/13/2010	0.00
CCWQP	309ASB	1/26/2011	0.00
CCWQP	309ASB	2/23/2011	4.32
CCWQP	309ASB	3/30/2011	8.90
CCWQP	309ASB	4/27/2011	0.48
CCWQP	309ASB	5/26/2011	1.15
CCWQP	309ASB	6/22/2011	0.37
CCOWS	309AVR	10/26/2000	7.96
CCOWS	309AVR	1/7/2001	1.28
CCOWS	309AVR	1/8/2001	3.90
CCOWS	309AVR	1/8/2001	33.71
CCOWS	309AVR	1/8/2001	35.46
CCOWS	309AVR	1/8/2001	46.46
CCOWS	309AVR	1/9/2001	9.85
CCOWS	309AVR	1/10/2001	10.11
CCOWS	309AVR	1/10/2001	49.38
CCOWS	309AVR	1/26/2001	51.74
CCWQP	309AVR	1/26/2008	43.62
CCWQP	309AVR	2/22/2008	83.10
CCWQP	309AVR	3/26/2008	1.95
CCWQP	309AVR	4/15/2008	0.62
CCWQP	309AVR	5/28/2008	0.46

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309AVR	6/25/2008	0.29
CCWQP	309AVR	7/30/2008	1.00
CCWQP	309AVR	8/27/2008	1.01
CCWQP	309AVR	9/30/2008	1.58
CCWQP	309AVR	10/28/2008	0.25
CCWQP	309AVR	11/19/2008	1.60
CCWQP	309AVR	12/17/2008	19.03
CCWQP	309BLA	1/26/2005	14.16
CCWQP	309BLA	2/16/2005	19.27
CCWQP	309BLA	2/22/2005	4.05
CCWQP	309BLA	3/21/2005	3.74
CCWQP	309BLA	4/13/2005	3.96
CCWQP	309BLA	5/24/2005	6.66
CCWQP	309BLA	6/28/2005	7.31
CCWQP	309BLA	7/27/2005	9.60
CCWQP	309BLA	8/30/2005	5.74
CCWQP	309BLA	9/27/2005	2.25
CCWQP	309BLA	10/25/2005	2.06
CCWQP	309BLA	11/29/2005	1.21
CCWQP	309BLA	12/13/2005	2.94
CCWQP	309BLA	1/24/2006	3.31
CCWQP	309BLA	2/22/2006	2.81
CCWQP	309BLA	3/29/2006	11.75
CCWQP	309BLA	4/25/2006	9.77
CCWQP	309BLA	5/24/2006	3.50
CCWQP	309BLA	6/27/2006	14.63
CCWQP	309BLA	7/25/2006	36.40
CCWQP	309BLA	8/23/2006	8.42
CCWQP	309BLA	9/27/2006	15.78
CCWQP	309BLA	10/24/2006	11.30
CCWQP	309BLA	11/14/2006	9.41
CCWQP	309BLA	12/12/2006	6.13
CCWQP	309BLA	1/30/2007	4.40
CCWQP	309BLA	2/14/2007	4.62
CCWQP	309BLA	3/21/2007	5.17
CCWQP	309BLA	4/5/2007	2.77
CCWQP	309BLA	5/29/2007	3.51
CCWQP	309BLA	6/26/2007	5.34
CCWQP	309BLA	7/23/2007	4.43
CCWQP	309BLA	8/28/2007	3.01
CCWQP	309BLA	9/25/2007	4.55
CCWQP	309BLA	10/23/2007	0.84
CCWQP	309BLA	11/27/2007	2.50
CCWQP	309BLA	12/16/2007	1.05
CCWQP	309BLA	1/26/2008	7.57
CCWQP	309BLA	2/23/2008	3.30
CCWQP	309BLA	3/25/2008	8.17
CCWQP	309BLA	4/16/2008	5.57
CCWQP	309BLA	5/28/2008	1.70
CCWQP	309BLA	6/25/2008	5.19
CCWQP	309BLA	7/30/2008	0.49
CCWQP	309BLA	8/27/2008	3.18
CCWQP	309BLA	9/30/2008	1.73
CCWQP	309BLA	10/28/2008	1.14

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309BLA	11/19/2008	1.54
CCWQP	309BLA	12/17/2008	2.27
CCWQP	309BLA	1/27/2009	0.45
CCWQP	309BLA	2/6/2009	0.24
CCWQP	309BLA	3/25/2009	4.05
CCWQP	309BLA	4/29/2009	2.45
CCWQP	309BLA	5/27/2009	4.47
CCWQP	309BLA	6/24/2009	3.12
CCWQP	309BLA	7/29/2009	15.70
CCWQP	309BLA	8/26/2009	3.67
CCWQP	309BLA	9/30/2009	2.09
CCWQP	309BLA	10/28/2009	0.65
CCWQP	309BLA	11/10/2009	4.06
CCWQP	309BLA	12/8/2009	3.22
CCWQP	309BLA	1/19/2010	0.00
CCWQP	309BLA	2/23/2010	14.16
CCWQP	309BLA	3/31/2010	6.79
CCWQP	309BLA	4/29/2010	0.92
CCWQP	309BLA	5/25/2010	12.10
CCWQP	309BLA	6/30/2010	5.73
CCWQP	309BLA	7/28/2010	15.32
CCWQP	309BLA	8/25/2010	0.93
CCWQP	309BLA	9/29/2010	5.98
CCWQP	309BLA	10/27/2010	2.88
CCWQP	309BLA	11/16/2010	0.79
CCWQP	309BLA	12/13/2010	0.69
CCWQP	309BLA	1/26/2011	1.37
CCWQP	309BLA	2/23/2011	14.31
CCWQP	309BLA	3/30/2011	0.00
CCWQP	309BLA	4/27/2011	13.06
CCWQP	309BLA	5/26/2011	6.19
CCWQP	309BLA	6/22/2011	3.56
CCOWS	309CRR	10/30/2001	0.03
CCOWS	309CRR	11/30/2001	0.03
CCOWS	309CRR	12/30/2001	0.03
CCWQP	309CRR	1/27/2005	0.00
CCWQP	309CRR	2/17/2005	0.00
CCWQP	309CRR	2/23/2005	0.00
CCWQP	309CRR	3/22/2005	2.91
CCWQP	309CRR	4/14/2005	0.00
CCWQP	309CRR	5/24/2005	2.08
CCWQP	309CRR	6/29/2005	0.08
CCWQP	309CRR	7/27/2005	0.00
CCWQP	309CRR	8/30/2005	0.00
CCWQP	309CRR	9/28/2005	0.00
CCWQP	309CRR	10/25/2005	0.00
CCWQP	309CRR	11/29/2005	0.00
CCWQP	309CRR	12/13/2005	0.00
CCWQP	309CRR	1/24/2006	0.00
CCWQP	309CRR	2/23/2006	0.00
CCWQP	309CRR	3/30/2006	0.00
CCWQP	309CRR	4/25/2006	0.20
CCWQP	309CRR	5/25/2006	2.95
CCWQP	309CRR	6/27/2006	0.34

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309CRR	7/25/2006	0.00
CCWQP	309CRR	8/24/2006	0.00
CCWQP	309CRR	9/28/2006	0.00
CCWQP	309CRR	10/24/2006	0.00
CCWQP	309CRR	11/14/2006	0.05
CCWQP	309CRR	12/13/2006	0.00
CCWQP	309CRR	1/30/2007	0.00
CCWQP	309CRR	2/15/2007	0.00
CCWQP	309CRR	3/22/2007	0.00
CCWQP	309CRR	4/6/2007	3.11
CCWQP	309CRR	4/16/2007	0.00
CCWQP	309CRR	5/30/2007	0.03
CCWQP	309CRR	6/27/2007	0.04
CCWQP	309CRR	7/24/2007	0.17
CCWQP	309CRR	8/28/2007	0.00
CCWQP	309CRR	9/26/2007	0.00
CCWQP	309CRR	10/24/2007	0.00
CCWQP	309CRR	11/27/2007	0.18
CCWQP	309CRR	12/17/2007	0.00
CCWQP	309CRR	1/25/2008	0.02
CCWQP	309CRR	2/24/2008	1.44
CCWQP	309CRR	3/26/2008	0.00
CCWQP	309CRR	4/17/2008	0.46
CCWQP	309CRR	5/29/2008	1.75
CCWQP	309CRR	6/24/2008	0.00
CCWQP	309CRR	7/29/2008	0.03
CCWQP	309CRR	8/26/2008	0.21
CCWQP	309CRR	10/2/2008	0.00
CCWQP	309CRR	10/29/2008	0.00
CCWQP	309CRR	11/19/2008	0.00
CCWQP	309CRR	12/17/2008	0.00
CCWQP	309CRR	1/26/2009	99.00
CCWQP	309CRR	2/7/2009	99.00
CCWQP	309CRR	3/24/2009	0.17
CCWQP	309CRR	4/28/2009	0.00
CCWQP	309CRR	5/26/2009	0.00
CCWQP	309CRR	6/23/2009	0.00
CCWQP	309CRR	7/28/2009	0.40
CCWQP	309CRR	8/25/2009	0.43
CCWQP	309CRR	9/29/2009	0.00
CCWQP	309CRR	10/27/2009	0.00
CCWQP	309CRR	11/9/2009	0.00
CCWQP	309CRR	12/7/2009	0.00
CCWQP	309CRR	1/18/2010	3.97
CCWQP	309CRR	2/22/2010	0.00
CCWQP	309CRR	3/30/2010	0.00
CCWQP	309CRR	4/28/2010	0.00
CCWQP	309CRR	5/24/2010	0.11
CCWQP	309CRR	6/29/2010	0.13
CCWQP	309CRR	7/27/2010	0.89
CCWQP	309CRR	8/24/2010	0.53
CCWQP	309CRR	9/28/2010	0.07
CCWQP	309CRR	10/26/2010	0.26
CCWQP	309CRR	11/15/2010	0.00

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309CRR	12/12/2010	0.00
CCWQP	309CRR	1/25/2011	0.00
CCWQP	309CRR	2/22/2011	0.00
CCWQP	309CRR	3/29/2011	0.00
CCWQP	309CRR	4/26/2011	0.00
CCWQP	309CRR	5/25/2011	0.00
CCWQP	309CRR	6/23/2011	0.14
CCOWS	309DAV	6/27/2000	0.85
CCOWS	309DAV	1/10/2001	88.67
CCOWS	309DAV	1/10/2001	134.63
CCOWS	309DAV	2/15/2001	241.65
CCOWS	309DAV	2/16/2001	262.61
CCOWS	309DAV	2/28/2001	863.27
CCOWS	309DAV	11/12/2001	15.17
CCOWS	309DAV	7/8/2002	4.29
CCOWS	309DAV	9/13/2002	9.33
CCOWS	309DAV	11/8/2002	55.96
CCAMP	309DAV	5/3/2005	229.70
CCAMP	309DAV	6/1/2005	56.03
CCAMP	309DAV	6/28/2005	0.00
CCAMP	309DAV	8/2/2005	4.61
CCAMP	309DAV	8/30/2005	0.00
CCAMP	309DAV	9/28/2005	0.00
CCAMP	309DAV	10/26/2005	0.00
CCAMP	309DAV	11/21/2005	33.25
CCAMP	309DAV	6/21/2006	42.86
CCAMP	309DAV	7/19/2006	10.99
CCAMP	309DAV	8/15/2006	1.40
CCAMP	309DAV	9/20/2006	0.00
CCAMP	309DAV	10/18/2006	0.00
CCAMP	309DAV	11/8/2006	0.00
CCAMP	309DAV	12/12/2006	8.60
CCAMP	309DAV	1/8/2007	117.81
CCAMP	309DAV	2/14/2007	33.69
CCAMP	309DAV	3/20/2007	0.48
CCAMP	309DAV	4/17/2007	0.70
CCAMP	309DAV	5/14/2007	1.68
CCAMP	309DAV	9/18/2007	0.00
CCAMP	309DAV	10/22/2007	0.03
CCAMP	309DAV	11/26/2007	0.29
CCAMP	309DAV	4/14/2008	3.35
CCAMP	309DAV	5/12/2008	0.55
CCAMP	309DAV	6/9/2008	0.50
CCAMP	309DAV	7/14/2008	0.12
CCAMP	309DAV	8/11/2008	0.39
CCAMP	309DAV	9/17/2008	0.05
CCAMP	309DAV	10/14/2008	0.00
CCAMP	309DAV	11/4/2008	0.24
CCAMP	309DAV	5/6/2009	4.83
CCAMP	309DAV	11/9/2009	0.00
CCWQP	309ESP	1/26/2005	2.96
CCWQP	309ESP	2/16/2005	24.30
CCWQP	309ESP	2/22/2005	14.64
CCWQP	309ESP	3/21/2005	6.12

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309ESP	4/12/2005	6.80
CCWQP	309ESP	5/24/2005	2.82
CCWQP	309ESP	6/28/2005	3.01
CCWQP	309ESP	7/26/2005	0.90
CCWQP	309ESP	8/30/2005	0.64
CCWQP	309ESP	9/27/2005	2.96
CCWQP	309ESP	10/25/2005	4.43
CCWQP	309ESP	11/29/2005	15.50
CCWQP	309ESP	12/13/2005	0.00
CCWQP	309ESP	1/24/2006	9.45
CCWQP	309ESP	2/22/2006	0.10
CCWQP	309ESP	3/29/2006	11.30
CCWQP	309ESP	4/25/2006	17.42
CCWQP	309ESP	5/24/2006	2.73
CCWQP	309ESP	6/27/2006	1.96
CCWQP	309ESP	7/25/2006	1.51
CCWQP	309ESP	8/23/2006	0.76
CCWQP	309ESP	9/27/2006	0.71
CCWQP	309ESP	10/24/2006	0.32
CCWQP	309ESP	11/14/2006	11.76
CCWQP	309ESP	12/12/2006	7.33
CCWQP	309ESP	1/30/2007	0.15
CCWQP	309ESP	2/14/2007	2.99
CCWQP	309ESP	3/21/2007	0.90
CCWQP	309ESP	4/5/2007	0.79
CCWQP	309ESP	5/29/2007	1.00
CCWQP	309ESP	6/26/2007	2.39
CCWQP	309ESP	7/23/2007	2.69
CCWQP	309ESP	8/28/2007	1.65
CCWQP	309ESP	9/25/2007	0.33
CCWQP	309ESP	10/23/2007	0.00
CCWQP	309ESP	11/27/2007	0.07
CCWQP	309ESP	12/16/2007	0.00
CCWQP	309ESP	1/26/2008	3.42
CCWQP	309ESP	2/22/2008	11.58
CCWQP	309ESP	3/25/2008	0.00
CCWQP	309ESP	4/15/2008	0.00
CCWQP	309ESP	5/28/2008	0.00
CCWQP	309ESP	6/25/2008	0.00
CCWQP	309ESP	7/30/2008	0.00
CCWQP	309ESP	8/28/2008	3.11
CCWQP	309ESP	10/1/2008	0.00
CCWQP	309ESP	10/28/2008	0.01
CCWQP	309ESP	11/19/2008	0.24
CCWQP	309ESP	12/17/2008	7.87
CCWQP	309ESP	1/27/2009	0.77
CCWQP	309ESP	2/6/2009	14.44
CCWQP	309ESP	3/25/2009	0.00
CCWQP	309ESP	4/29/2009	3.16
CCWQP	309ESP	5/27/2009	0.05
CCWQP	309ESP	6/24/2009	0.00
CCWQP	309ESP	7/29/2009	0.00
CCWQP	309ESP	8/26/2009	0.09
CCWQP	309ESP	9/30/2009	0.00

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309ESP	10/28/2009	1.19
CCWQP	309ESP	11/10/2009	0.00
CCWQP	309ESP	12/8/2009	0.00
CCWQP	309ESP	1/19/2010	0.00
CCWQP	309ESP	2/23/2010	0.00
CCWQP	309ESP	3/31/2010	3.67
CCWQP	309ESP	4/29/2010	0.34
CCWQP	309ESP	5/25/2010	0.00
CCWQP	309ESP	6/30/2010	0.00
CCWQP	309ESP	7/28/2010	0.00
CCWQP	309ESP	8/25/2010	0.00
CCWQP	309ESP	9/29/2010	0.71
CCWQP	309ESP	10/27/2010	0.00
CCWQP	309ESP	11/16/2010	2.12
CCWQP	309ESP	12/13/2010	0.00
CCWQP	309ESP	1/26/2011	0.03
CCWQP	309ESP	2/23/2011	16.55
CCWQP	309ESP	3/30/2011	5.54
CCWQP	309ESP	4/27/2011	10.99
CCWQP	309ESP	5/26/2011	4.70
CCWQP	309ESP	6/22/2011	2.46
CCOWS	309GAB	3/8/2000	32.14
CCOWS	309GAB	4/13/2000	0.00
CCOWS	309GAB	4/14/2000	0.00
CCOWS	309GAB	4/15/2000	0.00
CCOWS	309GAB	4/16/2000	0.00
CCOWS	309GAB	4/17/2000	0.00
CCOWS	309GAB	4/17/2000	1.91
CCOWS	309GAB	4/18/2000	0.00
CCOWS	309GAB	2/12/2001	7.06
CCOWS	309GAB	2/12/2001	7.38
CCOWS	309GAB	2/19/2001	12.71
CCWQP	309GAB	1/27/2005	0.00
CCWQP	309GAB	2/17/2005	0.00
CCWQP	309GAB	2/22/2005	1.60
CCWQP	309GAB	3/22/2005	66.38
CCWQP	309GAB	4/13/2005	0.97
CCWQP	309GAB	5/24/2005	0.13
CCWQP	309GAB	6/28/2005	0.09
CCWQP	309GAB	7/27/2005	0.60
CCWQP	309GAB	8/30/2005	0.12
CCWQP	309GAB	9/27/2005	0.05
CCWQP	309GAB	10/25/2005	0.00
CCWQP	309GAB	11/29/2005	0.00
CCWQP	309GAB	12/13/2005	0.00
CCWQP	309GAB	1/24/2006	0.01
CCAMP	309GAB	1/24/2006	0.15
CCWQP	309GAB	2/22/2006	4.46
CCAMP	309GAB	2/28/2006	0.00
CCAMP	309GAB	3/28/2006	5.03
CCWQP	309GAB	3/29/2006	16.51
CCWQP	309GAB	4/25/2006	0.00
CCAMP	309GAB	5/23/2006	0.00
CCWQP	309GAB	5/25/2006	0.13

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309GAB	6/27/2006	0.11
CCWQP	309GAB	7/25/2006	0.00
CCWQP	309GAB	8/23/2006	0.00
CCWQP	309GAB	9/27/2006	0.00
CCWQP	309GAB	10/24/2006	0.00
CCWQP	309GAB	11/14/2006	0.00
CCWQP	309GAB	12/12/2006	0.01
CCAMP	309GAB	12/12/2006	2.01
CCAMP	309GAB	1/8/2007	0.00
CCWQP	309GAB	1/30/2007	0.00
CCWQP	309GAB	2/15/2007	0.00
CCWQP	309GAB	3/22/2007	0.00
CCWQP	309GAB	4/5/2007	0.00
CCWQP	309GAB	5/29/2007	0.00
CCWQP	309GAB	6/26/2007	0.00
CCWQP	309GAB	7/23/2007	0.00
CCWQP	309GAB	8/28/2007	0.00
CCWQP	309GAB	9/26/2007	0.00
CCWQP	309GAB	10/23/2007	0.00
CCWQP	309GAB	11/27/2007	0.00
CCWQP	309GAB	12/16/2007	0.00
CCWQP	309GAB	1/26/2008	0.00
CCWQP	309GAB	2/22/2008	0.06
CCWQP	309GAB	3/26/2008	0.00
CCWQP	309GAB	4/29/2008	0.00
CCWQP	309GAB	5/28/2008	0.00
CCWQP	309GAB	6/26/2008	0.00
CCWQP	309GAB	7/30/2008	0.00
CCWQP	309GAB	8/25/2008	0.00
CCWQP	309GAB	9/29/2008	0.00
CCWQP	309GAB	10/29/2008	0.00
CCWQP	309GAB	11/19/2008	0.00
CCWQP	309GAB	12/17/2008	0.00
CCWQP	309GAB	1/26/2009	99.00
CCWQP	309GAB	2/6/2009	99.00
CCWQP	309GAB	3/24/2009	99.00
CCWQP	309GAB	4/28/2009	0.00
CCWQP	309GAB	5/26/2009	0.00
CCWQP	309GAB	6/23/2009	0.00
CCWQP	309GAB	7/28/2009	0.00
CCWQP	309GAB	8/25/2009	0.00
CCWQP	309GAB	9/30/2009	0.00
CCWQP	309GAB	10/27/2009	0.00
CCWQP	309GAB	11/9/2009	0.00
CCWQP	309GAB	12/7/2009	0.00
CCWQP	309GAB	1/18/2010	6.54
CCWQP	309GAB	2/22/2010	2.33
CCWQP	309GAB	3/30/2010	0.00
CCWQP	309GAB	4/28/2010	0.00
CCWQP	309GAB	5/24/2010	0.00
CCWQP	309GAB	6/29/2010	0.00
CCWQP	309GAB	7/27/2010	0.00
CCWQP	309GAB	8/24/2010	0.00
CCWQP	309GAB	9/28/2010	0.00

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309GAB	10/26/2010	0.00
CCWQP	309GAB	11/15/2010	0.00
CCWQP	309GAB	12/12/2010	0.00
CCWQP	309GAB	1/25/2011	0.00
CCWQP	309GAB	2/22/2011	4.08
CCWQP	309GAB	3/29/2011	34.50
CCWQP	309GAB	4/26/2011	0.00
CCWQP	309GAB	5/25/2011	0.71
CCWQP	309GAB	6/22/2011	0.00
CCWQP	309HRT	1/25/2008	2.38
CCWQP	309HRT	2/24/2008	18.44
CCWQP	309HRT	3/26/2008	0.65
CCWQP	309HRT	4/17/2008	0.11
CCWQP	309HRT	5/28/2008	1.17
CCWQP	309HRT	6/25/2008	1.43
CCWQP	309HRT	7/29/2008	0.09
CCWQP	309HRT	8/27/2008	0.28
CCWQP	309HRT	10/1/2008	0.03
CCWQP	309HRT	10/30/2008	0.01
CCWQP	309HRT	11/19/2008	0.00
CCWQP	309HRT	12/17/2008	0.36
CCOWS	309JON	4/14/2000	16.95
CCOWS	309JON	4/14/2000	21.29
CCOWS	309JON	4/14/2000	24.51
CCOWS	309JON	4/16/2000	3.81
CCOWS	309JON	4/17/2000	50.08
CCOWS	309JON	10/25/2000	0.46
CCOWS	309JON	10/25/2000	3.25
CCOWS	309JON	10/26/2000	15.61
CCOWS	309JON	10/27/2000	102.13
CCOWS	309JON	1/8/2001	25.47
CCOWS	309JON	1/8/2001	89.78
CCOWS	309JON	1/9/2001	16.32
CCOWS	309JON	1/10/2001	5.58
CCOWS	309JON	1/12/2001	72.24
CCOWS	309JON	11/12/2001	37.33
CCOWS	309JON	7/8/2002	1.47
CCOWS	309JON	9/13/2002	1.35
CCOWS	309JON	9/25/2002	1.35
CCOWS	309JON	10/22/2002	1.75
CCOWS	309JON	11/8/2002	21.00
CCOWS	309JON	11/8/2002	125.00
CCOWS	309JON	11/11/2002	8.46
CCOWS	309JON	2/19/2003	5.70
CCOWS	309JON	2/20/2003	3.00
CCOWS	309JON	3/13/2003	1.00
CCOWS	309JON	3/17/2003	9.80
CCOWS	309JON	4/19/2003	3.00
CCOWS	309JON	6/10/2003	2.50
CCOWS	309JON	7/14/2003	77.69
CCOWS	309JON	8/3/2003	2.80
CCWQP	309JON	1/26/2005	0.00
CCWQP	309JON	2/16/2005	0.00
CCWQP	309JON	2/22/2005	64.71

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309JON	3/21/2005	4.61
CCWQP	309JON	4/11/2005	9.76
CCWQP	309JON	5/24/2005	5.55
CCWQP	309JON	6/28/2005	3.96
CCWQP	309JON	7/27/2005	5.12
CCWQP	309JON	8/30/2005	3.20
CCWQP	309JON	9/27/2005	3.42
CCWQP	309JON	10/25/2005	2.21
CCWQP	309JON	11/29/2005	35.35
CCWQP	309JON	12/13/2005	1.20
CCWQP	309JON	1/24/2006	2.82
CCWQP	309JON	2/22/2006	7.40
CCWQP	309JON	3/29/2006	91.69
CCWQP	309JON	4/25/2006	5.24
CCWQP	309JON	5/24/2006	10.24
CCWQP	309JON	6/27/2006	12.04
CCWQP	309JON	7/25/2006	56.86
CCWQP	309JON	8/23/2006	33.50
CCWQP	309JON	9/27/2006	15.19
CCWQP	309JON	10/24/2006	3.68
CCWQP	309JON	11/14/2006	101.32
CCWQP	309JON	12/12/2006	50.60
CCWQP	309JON	1/30/2007	3.74
CCWQP	309JON	2/14/2007	3.44
CCWQP	309JON	3/21/2007	1.37
CCWQP	309JON	4/5/2007	0.87
CCWQP	309JON	5/29/2007	2.24
CCWQP	309JON	6/26/2007	4.17
CCWQP	309JON	7/23/2007	1.75
CCWQP	309JON	8/28/2007	1.75
CCWQP	309JON	9/25/2007	1.84
CCWQP	309JON	10/23/2007	0.44
CCWQP	309JON	11/27/2007	0.79
CCWQP	309JON	12/16/2007	1.33
CCWQP	309JON	1/26/2008	39.26
CCWQP	309JON	2/22/2008	114.54
CCWQP	309JON	3/26/2008	0.83
CCWQP	309JON	4/16/2008	2.74
CCWQP	309JON	5/28/2008	2.00
CCWQP	309JON	6/25/2008	2.63
CCWQP	309JON	7/30/2008	2.32
CCWQP	309JON	8/27/2008	2.52
CCWQP	309JON	9/30/2008	1.95
CCWQP	309JON	10/28/2008	0.72
CCWQP	309JON	11/19/2008	2.22
CCWQP	309JON	12/17/2008	20.41
CCWQP	309JON	1/27/2009	4.99
CCWQP	309JON	2/6/2009	96.77
CCWQP	309JON	3/25/2009	0.82
CCWQP	309JON	4/29/2009	3.10
CCWQP	309JON	5/27/2009	3.59
CCWQP	309JON	6/24/2009	2.82
CCWQP	309JON	7/29/2009	3.86
CCWQP	309JON	8/26/2009	2.70

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309JON	9/30/2009	1.79
CCWQP	309JON	10/28/2009	0.95
CCWQP	309JON	11/10/2009	1.85
CCWQP	309JON	12/8/2009	3.85
CCWQP	309JON	1/19/2010	0.00
CCWQP	309JON	2/23/2010	141.80
CCWQP	309JON	3/31/2010	6.07
CCWQP	309JON	4/29/2010	0.74
CCWQP	309JON	5/25/2010	5.58
CCWQP	309JON	6/30/2010	1.23
CCWQP	309JON	7/28/2010	1.48
CCWQP	309JON	8/25/2010	1.48
CCWQP	309JON	9/29/2010	3.59
CCWQP	309JON	10/27/2010	1.15
CCWQP	309JON	11/16/2010	0.60
CCWQP	309JON	12/13/2010	0.45
CCWQP	309JON	1/26/2011	1.55
CCWQP	309JON	2/23/2011	11.14
CCWQP	309JON	3/30/2011	38.51
CCWQP	309JON	4/27/2011	7.92
CCWQP	309JON	5/26/2011	3.95
CCWQP	309JON	6/22/2011	3.78
CCOWS	309LOR	1/10/2001	7.41
CCWQP	309MER	1/26/2005	3.89
CCWQP	309MER	2/16/2005	0.00
CCWQP	309MER	2/22/2005	45.00
CCWQP	309MER	3/21/2005	35.56
CCWQP	309MER	4/12/2005	0.56
CCWQP	309MER	5/24/2005	0.41
CCWQP	309MER	6/28/2005	0.44
CCWQP	309MER	7/26/2005	0.31
CCWQP	309MER	8/30/2005	0.40
CCWQP	309MER	9/27/2005	0.31
CCWQP	309MER	10/25/2005	6.41
CCWQP	309MER	11/29/2005	3.25
CCWQP	309MER	12/13/2005	0.00
CCWQP	309MER	1/24/2006	0.00
CCWQP	309MER	2/22/2006	0.70
CCWQP	309MER	3/29/2006	2.37
CCWQP	309MER	4/25/2006	1.12
CCWQP	309MER	5/24/2006	1.21
CCWQP	309MER	6/27/2006	3.43
CCWQP	309MER	7/25/2006	2.40
CCWQP	309MER	8/23/2006	5.11
CCWQP	309MER	9/27/2006	2.11
CCWQP	309MER	10/24/2006	2.95
CCWQP	309MER	11/14/2006	19.92
CCWQP	309MER	12/12/2006	3.10
CCWQP	309MER	1/30/2007	6.75
CCWQP	309MER	2/14/2007	7.35
CCWQP	309MER	3/21/2007	1.80
CCWQP	309MER	4/4/2007	0.51
CCWQP	309MER	5/29/2007	6.73
CCWQP	309MER	6/26/2007	0.66

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309MER	7/23/2007	1.17
CCWQP	309MER	8/28/2007	0.54
CCWQP	309MER	9/25/2007	0.65
CCWQP	309MER	10/23/2007	0.00
CCWQP	309MER	11/27/2007	0.00
CCWQP	309MER	12/16/2007	1.13
CCWQP	309MER	1/26/2008	0.32
CCWQP	309MER	2/22/2008	25.41
CCWQP	309MER	3/25/2008	5.28
CCWQP	309MER	4/15/2008	1.33
CCWQP	309MER	5/28/2008	0.00
CCWQP	309MER	6/25/2008	0.00
CCWQP	309MER	7/30/2008	0.00
CCWQP	309MER	8/28/2008	0.00
CCWQP	309MER	10/1/2008	0.00
CCWQP	309MER	10/28/2008	0.00
CCWQP	309MER	11/19/2008	0.00
CCWQP	309MER	12/17/2008	0.00
CCWQP	309MER	1/27/2009	0.00
CCWQP	309MER	2/7/2009	0.00
CCWQP	309MER	3/25/2009	0.00
CCWQP	309MER	4/29/2009	0.00
CCWQP	309MER	5/27/2009	0.00
CCWQP	309MER	6/24/2009	0.00
CCWQP	309MER	7/29/2009	0.00
CCWQP	309MER	8/26/2009	0.00
CCWQP	309MER	9/30/2009	0.00
CCWQP	309MER	10/28/2009	0.00
CCWQP	309MER	11/10/2009	0.00
CCWQP	309MER	12/8/2009	0.45
CCWQP	309MER	1/19/2010	0.00
CCWQP	309MER	2/23/2010	8.17
CCWQP	309MER	3/31/2010	0.00
CCWQP	309MER	4/29/2010	0.07
CCWQP	309MER	5/25/2010	0.35
CCWQP	309MER	6/30/2010	0.00
CCWQP	309MER	7/28/2010	0.00
CCWQP	309MER	8/25/2010	0.00
CCWQP	309MER	9/29/2010	0.00
CCWQP	309MER	10/27/2010	0.00
CCWQP	309MER	11/16/2010	0.00
CCWQP	309MER	12/13/2010	0.00
CCWQP	309MER	1/26/2011	0.00
CCWQP	309MER	2/23/2011	0.00
CCWQP	309MER	3/30/2011	0.00
CCWQP	309MER	4/27/2011	0.00
CCWQP	309MER	5/26/2011	0.00
CCWQP	309MER	6/22/2011	0.00
CCWQP	309NAD	1/27/2005	0.11
CCWQP	309NAD	2/17/2005	3.28
CCWQP	309NAD	2/22/2005	2.98
CCWQP	309NAD	3/22/2005	33.91
CCWQP	309NAD	4/13/2005	0.81
CCWQP	309NAD	5/24/2005	1.25

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309NAD	6/28/2005	0.11
CCWQP	309NAD	7/27/2005	0.38
CCWQP	309NAD	8/30/2005	0.02
CCWQP	309NAD	9/27/2005	0.01
CCWQP	309NAD	10/25/2005	0.00
CCWQP	309NAD	11/29/2005	0.00
CCWQP	309NAD	12/13/2005	0.00
CCWQP	309NAD	1/24/2006	0.31
CCWQP	309NAD	2/22/2006	0.24
CCWQP	309NAD	3/30/2006	5.02
CCWQP	309NAD	4/25/2006	2.63
CCWQP	309NAD	5/25/2006	0.06
CCWQP	309NAD	6/27/2006	0.71
CCWQP	309NAD	7/25/2006	1.01
CCWQP	309NAD	8/23/2006	0.32
CCWQP	309NAD	9/27/2006	0.08
CCWQP	309NAD	10/24/2006	0.06
CCWQP	309NAD	11/14/2006	0.07
CCWQP	309NAD	12/12/2006	2.73
CCWQP	309NAD	1/30/2007	0.20
CCWQP	309NAD	2/15/2007	0.18
CCWQP	309NAD	3/22/2007	0.18
CCWQP	309NAD	4/5/2007	0.26
CCWQP	309NAD	5/29/2007	0.46
CCWQP	309NAD	6/26/2007	0.00
CCWQP	309NAD	7/23/2007	0.07
CCWQP	309NAD	8/28/2007	0.36
CCWQP	309NAD	9/26/2007	0.00
CCWQP	309NAD	10/23/2007	0.00
CCWQP	309NAD	11/27/2007	0.00
CCWQP	309NAD	12/16/2007	0.00
CCWQP	309NAD	1/26/2008	0.28
CCWQP	309NAD	2/24/2008	8.10
CCWQP	309NAD	3/26/2008	0.05
CCWQP	309NAD	4/30/2008	0.15
CCWQP	309NAD	5/29/2008	0.03
CCWQP	309NAD	6/26/2008	0.08
CCWQP	309NAD	7/30/2008	0.09
CCWQP	309NAD	8/25/2008	0.10
CCWQP	309NAD	9/29/2008	0.04
CCWQP	309NAD	10/29/2008	0.01
CCWQP	309NAD	11/19/2008	0.00
CCWQP	309NAD	12/17/2008	0.00
CCWQP	309NAD	1/26/2009	0.01
CCWQP	309NAD	2/6/2009	0.03
CCWQP	309NAD	3/24/2009	0.41
CCWQP	309NAD	4/28/2009	0.06
CCWQP	309NAD	5/26/2009	0.01
CCWQP	309NAD	6/23/2009	0.01
CCWQP	309NAD	7/28/2009	0.08
CCWQP	309NAD	8/25/2009	0.07
CCWQP	309NAD	9/30/2009	0.00
CCWQP	309NAD	10/27/2009	0.00
CCWQP	309NAD	11/9/2009	0.00

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309NAD	12/7/2009	1.16
CCWQP	309NAD	1/18/2010	2.85
CCWQP	309NAD	2/22/2010	5.72
CCWQP	309NAD	3/30/2010	0.15
CCWQP	309NAD	4/28/2010	0.08
CCWQP	309NAD	5/24/2010	0.04
CCWQP	309NAD	6/29/2010	0.30
CCWQP	309NAD	7/27/2010	0.26
CCWQP	309NAD	8/24/2010	0.00
CCWQP	309NAD	9/28/2010	0.57
CCWQP	309NAD	10/26/2010	0.00
CCWQP	309NAD	11/15/2010	0.02
CCWQP	309NAD	12/12/2010	0.00
CCWQP	309NAD	1/25/2011	0.11
CCWQP	309NAD	2/22/2011	0.19
CCWQP	309NAD	3/29/2011	6.23
CCWQP	309NAD	4/26/2011	0.42
CCWQP	309NAD	5/25/2011	0.07
CCWQP	309NAD	6/22/2011	0.12
CCOWS	309NOS	3/17/2002	0.67
CCOWS	309NOS	4/24/2002	0.00
CCOWS	309NOS	5/23/2002	0.00
CCOWS	309NOS	6/28/2002	0.00
CCOWS	309NOS	7/31/2002	0.15
CCOWS	309NOS	8/30/2002	0.00
CCOWS	309NOS	11/8/2002	4.66
CCOWS	309NOS	12/16/2002	44.00
CCOWS	309NOS	12/17/2002	13.42
CCWQP	309NOS	1/25/2008	0.46
CCWQP	309NOS	2/24/2008	10.55
CCWQP	309NOS	3/26/2008	0.42
CCWQP	309NOS	4/17/2008	0.03
CCWQP	309NOS	5/29/2008	0.00
CCWQP	309NOS	6/24/2008	0.00
CCWQP	309NOS	7/29/2008	0.00
CCWQP	309NOS	8/26/2008	0.00
CCWQP	309NOS	10/2/2008	0.00
CCWQP	309NOS	10/29/2008	0.00
CCWQP	309NOS	11/19/2008	0.00
CCWQP	309NOS	12/17/2008	0.00
CCWQP	309OLD	2/16/2005	46.69
CCWQP	309OLD	3/21/2005	11.93
CCAMP	309OLD	4/5/2005	42.76
CCWQP	309OLD	4/11/2005	0.66
CCAMP	309OLD	5/3/2005	20.16
CCAMP	309OLD	6/1/2005	11.35
CCAMP	309OLD	6/28/2005	6.32
CCWQP	309OLD	7/26/2005	38.56
CCAMP	309OLD	8/2/2005	16.77
CCWQP	309OLD	8/30/2005	0.00
CCAMP	309OLD	8/30/2005	10.36
CCWQP	309OLD	9/27/2005	0.80
CCAMP	309OLD	9/28/2005	0.10
CCAMP	309OLD	10/26/2005	3.78

Organization	Site Tag	Sample Date	Flow (cfs)
CCAMP	309OLD	11/21/2005	0.00
CCAMP	309OLD	1/23/2006	12.82
CCWQP	309OLD	2/22/2006	0.99
CCAMP	309OLD	3/28/2006	6.21
CCWQP	309OLD	3/29/2006	15.34
CCWQP	309OLD	5/25/2006	1.11
CCWQP	309OLD	8/23/2006	2.89
CCAMP	309OLD	9/20/2006	0.00
CCWQP	309OLD	9/27/2006	4.34
CCAMP	309OLD	11/8/2006	0.00
CCAMP	309OLD	12/12/2006	3.90
CCWQP	309OLD	1/30/2007	0.00
CCWQP	309OLD	2/14/2007	47.14
CCAMP	309OLD	2/14/2007	0.00
CCAMP	309OLD	3/20/2007	13.91
CCWQP	309OLD	3/21/2007	15.95
CCWQP	309OLD	4/4/2007	1.68
CCAMP	309OLD	4/17/2007	14.01
CCAMP	309OLD	5/14/2007	7.55
CCAMP	309OLD	6/20/2007	22.22
CCAMP	309OLD	7/9/2007	3.41
CCAMP	309OLD	8/21/2007	5.02
CCAMP	309OLD	9/18/2007	2.13
CCWQP	309OLD	9/25/2007	1.61
CCWQP	309OLD	10/22/2007	1.92
CCAMP	309OLD	10/22/2007	2.41
CCAMP	309OLD	11/26/2007	2.33
CCWQP	309OLD	1/27/2008	26.33
CCWQP	309OLD	2/22/2008	5.71
CCWQP	309OLD	4/18/2008	0.00
CCAMP	309OLD	6/9/2008	20.39
CCAMP	309OLD	7/14/2008	4.52
CCAMP	309OLD	8/11/2008	2.79
CCWQP	309OLD	8/28/2008	0.84
CCWQP	309OLD	10/1/2008	0.00
CCWQP	309OLD	1/27/2009	0.99
CCAMP	309OLD	2/4/2009	15.71
CCWQP	309OLD	2/6/2009	23.76
CCWQP	309OLD	8/26/2009	0.00
CCAMP	309OLD	9/8/2009	2.46
CCWQP	309OLD	9/30/2009	0.00
CCAMP	309OLD	11/9/2009	-0.53
CCWQP	309OLD	12/8/2009	0.00
CCAMP	309OLD	12/8/2009	11.17
CCAMP	309OLD	1/12/2010	-3.30
CCWQP	309OLD	1/19/2010	0.00
CCAMP	309OLD	2/8/2010	23.14
CCAMP	309OLD	3/15/2010	-2.91
CCWQP	309OLD	3/31/2010	3.26
CCAMP	309OLD	4/13/2010	-31.34
CCAMP	309OLD	5/12/2010	-2.93
CCWQP	309OLD	5/25/2010	1.17
CCAMP	309OLD	6/14/2010	2.80
CCWQP	309OLD	8/25/2010	5.76

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309OLD	9/29/2010	5.80
CCWQP	309OLD	2/23/2011	16.32
CCWQP	309OLD	3/30/2011	26.46
CCWQP	309OLD	6/22/2011	-7.45
CCAMP	309PSO	1/26/2006	42.50
CCWQP	309QCW	1/25/2008	2.41
CCWQP	309QCW	2/24/2008	1.37
CCWQP	309QCW	3/26/2008	0.00
CCWQP	309QCW	4/17/2008	0.06
CCWQP	309QCW	5/28/2008	3.02
CCWQP	309QCW	6/25/2008	0.69
CCWQP	309QCW	7/29/2008	0.10
CCWQP	309QCW	8/27/2008	1.11
CCWQP	309QCW	10/2/2008	0.02
CCWQP	309QCW	10/30/2008	0.09
CCWQP	309QCW	11/20/2008	0.69
CCWQP	309QCW	12/18/2008	0.00
CCAMP	309QUA	1/24/2006	0.00
CCAMP	309QUA	2/28/2006	0.00
CCAMP	309QUA	3/27/2006	0.00
CCAMP	309QUA	5/22/2006	0.00
CCAMP	309QUA	7/18/2006	0.64
CCAMP	309QUA	9/19/2006	1.09
CCAMP	309QUA	10/17/2006	0.00
CCAMP	309QUA	11/7/2006	0.00
CCAMP	309QUA	12/11/2006	0.09
CCAMP	309QUA	1/9/2007	0.00
CCAMP	309QUA	2/13/2007	0.00
CCWQP	309QUA	1/25/2008	0.59
CCWQP	309QUA	2/24/2008	0.73
CCWQP	309QUA	3/26/2008	0.00
CCWQP	309QUA	4/17/2008	0.11
CCWQP	309QUA	5/28/2008	0.10
CCWQP	309QUA	6/25/2008	0.13
CCWQP	309QUA	7/29/2008	0.00
CCWQP	309QUA	8/27/2008	0.01
CCWQP	309QUA	10/2/2008	0.00
CCWQP	309QUA	10/30/2008	0.04
CCWQP	309QUA	11/20/2008	0.00
CCWQP	309QUA	12/18/2008	0.00
CCWQP	309QUI	1/27/2005	0.13
CCWQP	309QUI	2/17/2005	0.00
CCWQP	309QUI	2/23/2005	0.48
CCWQP	309QUI	3/22/2005	4.51
CCWQP	309QUI	4/14/2005	1.45
CCWQP	309QUI	5/24/2005	2.23
CCWQP	309QUI	6/29/2005	2.09
CCWQP	309QUI	7/27/2005	0.30
CCWQP	309QUI	8/30/2005	0.81
CCWQP	309QUI	9/28/2005	1.56
CCWQP	309QUI	10/25/2005	1.07
CCWQP	309QUI	11/29/2005	0.67
CCWQP	309QUI	12/13/2005	0.00
CCWQP	309QUI	1/24/2006	1.66

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309QUI	2/23/2006	2.11
CCWQP	309QUI	3/30/2006	0.76
CCWQP	309QUI	4/25/2006	1.19
CCWQP	309QUI	5/25/2006	0.92
CCWQP	309QUI	6/27/2006	4.73
CCWQP	309QUI	7/25/2006	2.46
CCWQP	309QUI	8/24/2006	3.91
CCWQP	309QUI	9/28/2006	3.51
CCWQP	309QUI	10/24/2006	3.69
CCWQP	309QUI	11/14/2006	4.29
CCWQP	309QUI	12/13/2006	5.34
CCWQP	309QUI	1/30/2007	3.33
CCWQP	309QUI	2/15/2007	2.35
CCWQP	309QUI	3/22/2007	1.17
CCWQP	309QUI	4/6/2007	0.66
CCWQP	309QUI	4/16/2007	0.73
CCWQP	309QUI	5/30/2007	0.42
CCWQP	309QUI	6/27/2007	1.48
CCWQP	309QUI	7/24/2007	1.93
CCWQP	309QUI	8/28/2007	1.91
CCWQP	309QUI	9/26/2007	0.82
CCWQP	309QUI	10/24/2007	0.00
CCWQP	309QUI	11/27/2007	0.00
CCWQP	309QUI	12/17/2007	0.00
CCWQP	309QUI	1/25/2008	2.51
CCWQP	309QUI	2/24/2008	1.49
CCWQP	309QUI	3/26/2008	0.00
CCWQP	309QUI	4/17/2008	0.00
CCWQP	309QUI	5/28/2008	0.00
CCWQP	309QUI	6/25/2008	0.79
CCWQP	309QUI	7/29/2008	0.00
CCWQP	309QUI	8/27/2008	0.59
CCWQP	309QUI	10/2/2008	0.02
CCWQP	309QUI	10/30/2008	0.00
CCWQP	309QUI	11/20/2008	0.90
CCWQP	309QUI	12/18/2008	0.00
CCWQP	309QUI	1/26/2009	99.00
CCWQP	309QUI	2/7/2009	0.11
CCWQP	309QUI	3/24/2009	0.36
CCWQP	309QUI	4/28/2009	1.11
CCWQP	309QUI	5/26/2009	0.00
CCWQP	309QUI	6/23/2009	0.69
CCWQP	309QUI	7/28/2009	0.00
CCWQP	309QUI	8/25/2009	0.00
CCWQP	309QUI	9/29/2009	0.00
CCWQP	309QUI	10/27/2009	0.00
CCWQP	309QUI	11/9/2009	0.01
CCWQP	309QUI	12/7/2009	0.00
CCWQP	309QUI	1/18/2010	2.28
CCWQP	309QUI	2/22/2010	0.05
CCWQP	309QUI	3/30/2010	0.00
CCWQP	309QUI	4/28/2010	0.02
CCWQP	309QUI	5/24/2010	0.04
CCWQP	309QUI	6/29/2010	0.07

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309QUI	7/27/2010	0.00
CCWQP	309QUI	8/24/2010	0.05
CCWQP	309QUI	9/28/2010	0.00
CCWQP	309QUI	10/26/2010	0.00
CCWQP	309QUI	11/15/2010	0.00
CCWQP	309QUI	12/12/2010	0.00
CCWQP	309QUI	1/25/2011	0.74
CCWQP	309QUI	2/22/2011	0.00
CCWQP	309QUI	3/29/2011	3.72
CCWQP	309QUI	4/26/2011	0.00
CCWQP	309QUI	5/25/2011	0.03
CCWQP	309QUI	6/23/2011	0.00
CCAMP	309RTA	1/24/2006	1.37
CCAMP	309RTA	2/28/2006	0.16
CCAMP	309RTA	3/28/2006	0.51
CCAMP	309RTA	5/23/2006	0.00
CCAMP	309RTA	6/21/2006	0.47
CCAMP	309RTA	7/19/2006	0.13
CCAMP	309RTA	8/15/2006	0.00
CCAMP	309RTA	9/20/2006	0.00
CCAMP	309RTA	10/18/2006	0.00
CCAMP	309RTA	11/8/2006	0.00
CCAMP	309RTA	12/12/2006	4.58
CCAMP	309RTA	1/8/2007	0.00
CCAMP	309RTA	2/14/2007	0.00
CCOWS	309SAC	6/27/2000	18.44
CCOWS	309SAC	6/27/2000	34.93
CCOWS	309SAC	8/11/2000	65.33
CCOWS	309SAC	8/11/2000	75.89
CCWQP	309SAC	1/27/2005	0.00
CCWQP	309SAC	2/17/2005	748.13
CCWQP	309SAC	2/23/2005	769.50
CCWQP	309SAC	3/22/2005	513.00
CCWQP	309SAC	4/14/2005	549.21
CCWQP	309SAC	5/25/2005	168.24
CCWQP	309SAC	6/29/2005	27.21
CCWQP	309SAC	7/27/2005	79.95
CCWQP	309SAC	8/30/2005	0.00
CCWQP	309SAC	9/28/2005	0.00
CCWQP	309SAC	10/25/2005	0.00
CCWQP	309SAC	11/29/2005	7.94
CCWQP	309SAC	12/13/2005	44.51
CCWQP	309SAC	1/24/2006	331.51
CCWQP	309SAC	2/23/2006	102.98
CCWQP	309SAC	3/30/2006	978.49
CCWQP	309SAC	4/25/2006	757.35
CCWQP	309SAC	5/26/2006	306.73
CCWQP	309SAC	6/27/2006	35.79
CCWQP	309SAC	7/25/2006	181.62
CCWQP	309SAC	8/24/2006	81.20
CCWQP	309SAC	9/28/2006	0.00
CCWQP	309SAC	10/24/2006	0.00
CCWQP	309SAC	11/14/2006	203.30
CCWQP	309SAC	12/13/2006	55.82

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309SAC	1/30/2007	97.38
CCWQP	309SAC	2/15/2007	52.91
CCWQP	309SAC	3/22/2007	100.85
CCWQP	309SAC	4/16/2007	29.68
CCWQP	309SAC	5/29/2007	70.82
CCWQP	309SAC	6/27/2007	30.89
CCWQP	309SAC	7/24/2007	82.84
CCWQP	309SAC	8/29/2007	84.93
CCWQP	309SAC	9/26/2007	0.00
CCWQP	309SAC	10/23/2007	0.00
CCWQP	309SAC	11/27/2007	70.24
CCWQP	309SAC	12/17/2007	144.15
CCWQP	309SAC	1/24/2008	115.35
CCWQP	309SAC	2/23/2008	259.60
CCWQP	309SAC	3/25/2008	186.71
CCWQP	309SAC	4/15/2008	2.17
CCWQP	309SAC	5/27/2008	47.44
CCWQP	309SAC	6/24/2008	20.36
CCWQP	309SAC	7/29/2008	32.57
CCWQP	309SAC	8/26/2008	56.48
CCWQP	309SAC	9/30/2008	0.00
CCWQP	309SAC	10/29/2008	0.00
CCWQP	309SAC	11/19/2008	0.00
CCWQP	309SAC	12/17/2008	0.00
CCWQP	309SAC	1/26/2009	99.00
CCWQP	309SAC	2/7/2009	99.00
CCWQP	309SAC	3/24/2009	99.00
CCWQP	309SAC	4/28/2009	10.26
CCWQP	309SAC	5/26/2009	0.00
CCWQP	309SAC	6/23/2009	0.00
CCWQP	309SAC	7/28/2009	0.00
CCWQP	309SAC	8/25/2009	0.00
CCWQP	309SAC	9/29/2009	0.00
CCWQP	309SAC	10/27/2009	0.00
CCWQP	309SAC	11/9/2009	0.00
CCWQP	309SAC	12/7/2009	0.00
CCWQP	309SAC	1/18/2010	0.00
CCWQP	309SAC	2/22/2010	1279.24
CCWQP	309SAC	3/30/2010	272.69
CCWQP	309SAC	4/28/2010	79.14
CCWQP	309SAC	5/24/2010	16.09
CCWQP	309SAC	6/29/2010	41.70
CCWQP	309SAC	7/27/2010	32.76
CCWQP	309SAC	8/24/2010	27.58
CCWQP	309SAC	9/28/2010	32.20
CCWQP	309SAC	10/26/2010	21.83
CCWQP	309SAC	11/15/2010	0.00
CCWQP	309SAC	12/12/2010	0.00
CCWQP	309SAC	1/25/2011	52.25
CCWQP	309SAC	2/22/2011	477.53
CCWQP	309SAC	3/29/2011	1949.23
CCWQP	309SAC	4/26/2011	1775.17
CCWQP	309SAC	5/25/2011	548.94
CCWQP	309SAC	6/23/2011	280.07

Organization	Site Tag	Sample Date	Flow (cfs)
CCOWS	309SAG	6/28/2000	171.27
CCOWS	309SAG	2/14/2001	368.22
CCWQP	309SAG	1/25/2006	1162.28
CCWQP	309SAG	2/23/2006	352.58
CCWQP	309SAG	3/30/2006	768.84
CCWQP	309SAG	4/25/2006	1294.97
CCWQP	309SAG	5/26/2006	744.53
CCWQP	309SAG	6/28/2006	67.15
CCWQP	309SAG	7/25/2006	537.07
CCWQP	309SAG	8/24/2006	157.69
CCWQP	309SAG	9/28/2006	0.00
CCWQP	309SAG	10/24/2006	0.00
CCWQP	309SAG	11/14/2006	153.39
CCWQP	309SAG	12/13/2006	129.21
CCWQP	309SAG	1/30/2007	165.39
CCWQP	309SAG	2/15/2007	111.33
CCWQP	309SAG	3/22/2007	261.58
CCWQP	309SAG	4/6/2007	63.00
CCWQP	309SAG	4/16/2007	56.92
CCWQP	309SAG	5/30/2007	117.96
CCWQP	309SAG	6/26/2007	65.62
CCWQP	309SAG	7/24/2007	123.05
CCWQP	309SAG	8/29/2007	122.52
CCWQP	309SAG	9/26/2007	0.00
CCWQP	309SAG	10/23/2007	0.00
CCWQP	309SAG	11/28/2007	103.46
CCWQP	309SAG	12/17/2007	148.73
CCWQP	309SAG	1/24/2008	182.62
CCWQP	309SAG	2/23/2008	0.00
CCWQP	309SAG	3/25/2008	267.77
CCWQP	309SAG	4/14/2008	22.70
CCWQP	309SAG	5/27/2008	93.04
CCWQP	309SAG	6/24/2008	59.71
CCWQP	309SAG	7/29/2008	103.21
CCWQP	309SAG	8/26/2008	97.86
CCWQP	309SAG	9/30/2008	0.00
CCWQP	309SAG	10/29/2008	0.00
CCWQP	309SAG	11/19/2008	0.00
CCWQP	309SAG	12/17/2008	0.00
CCWQP	309SAG	1/26/2009	99.00
CCWQP	309SAG	2/7/2009	99.00
CCWQP	309SAG	3/24/2009	11.22
CCWQP	309SAG	4/28/2009	40.41
CCWQP	309SAG	5/26/2009	66.39
CCWQP	309SAG	6/23/2009	39.46
CCWQP	309SAG	7/28/2009	77.72
CCWQP	309SAG	8/25/2009	95.30
CCWQP	309SAG	9/29/2009	0.00
CCWQP	309SAG	10/27/2009	0.00
CCWQP	309SAG	11/9/2009	141.50
CCWQP	309SAG	12/7/2009	207.00
CCWQP	309SAG	1/18/2010	0.00
CCWQP	309SAG	2/22/2010	819.00
CCWQP	309SAG	3/30/2010	367.50

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309SAG	4/28/2010	326.84
CCWQP	309SAG	5/24/2010	107.81
CCWQP	309SAG	6/29/2010	116.50
CCWQP	309SAG	7/27/2010	142.98
CCWQP	309SAG	8/24/2010	107.25
CCWQP	309SAG	9/28/2010	112.88
CCWQP	309SAG	10/26/2010	61.59
CCWQP	309SAG	11/15/2010	5.10
CCWQP	309SAG	12/12/2010	10.69
CCWQP	309SAG	1/25/2011	236.36
CCWQP	309SAG	2/22/2011	973.40
CCWQP	309SAG	3/29/2011	3351.76
CCWQP	309SAG	4/26/2011	1157.39
CCWQP	309SAG	5/25/2011	152.07
CCWQP	309SAG	6/23/2011	139.39
CCOWS	309SBC	9/27/2001	1.06
CCOWS	309SBC	1/31/2002	0.77
CCWQP	309SBC	1/25/2008	0.57
CCWQP	309SBC	2/24/2008	1.87
CCWQP	309SBC	3/26/2008	0.04
CCWQP	309SBC	4/17/2008	1.17
CCWQP	309SBC	5/29/2008	1.95
CCWQP	309SBC	6/24/2008	1.12
CCWQP	309SBC	7/29/2008	0.18
CCWQP	309SBC	8/26/2008	0.08
CCWQP	309SBC	10/2/2008	0.04
CCWQP	309SBC	10/29/2008	0.00
CCWQP	309SBC	11/19/2008	0.00
CCWQP	309SBC	12/17/2008	0.00
CCOWS	309SLRLAG	10/22/2002	0.13
CCWQP	309SOS	1/25/2008	0.00
CCWQP	309SOS	2/24/2008	0.97
CCWQP	309SOS	3/26/2008	0.51
CCWQP	309SOS	4/17/2008	0.06
CCWQP	309SOS	5/29/2008	0.00
CCWQP	309SOS	6/24/2008	0.09
CCWQP	309SOS	7/29/2008	0.09
CCWQP	309SOS	8/26/2008	0.13
CCWQP	309SOS	10/2/2008	0.05
CCWQP	309SOS	10/29/2008	0.55
CCWQP	309SOS	11/19/2008	0.19
CCWQP	309SOS	12/17/2008	0.00
CCWQP	309SSP	1/27/2005	0.00
CCWQP	309SSP	2/17/2005	1035.00
CCWQP	309SSP	2/23/2005	909.00
CCWQP	309SSP	3/22/2005	936.00
CCWQP	309SSP	4/14/2005	531.45
CCWQP	309SSP	5/25/2005	97.71
CCWQP	309SSP	6/29/2005	0.09
CCWQP	309SSP	7/27/2005	20.24
CCWQP	309SSP	8/30/2005	0.01
CCWQP	309SSP	9/28/2005	0.00
CCWQP	309SSP	10/25/2005	0.00
CCWQP	309SSP	11/29/2005	36.45

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309SSP	12/13/2005	9.00
CCWQP	309SSP	1/24/2006	668.81
CCWQP	309SSP	2/23/2006	103.00
CCWQP	309SSP	3/30/2006	793.56
CCWQP	309SSP	4/25/2006	1490.22
CCWQP	309SSP	5/26/2006	620.28
CCWQP	309SSP	6/28/2006	6.42
CCWQP	309SSP	7/26/2006	1.00
CCWQP	309SSP	8/24/2006	2.54
CCWQP	309SSP	9/28/2006	1.06
CCWQP	309SSP	10/24/2006	0.31
CCWQP	309SSP	11/14/2006	0.37
CCWQP	309SSP	12/13/2006	1.92
CCWQP	309SSP	1/31/2007	64.08
CCWQP	309SSP	2/15/2007	22.20
CCWQP	309SSP	3/22/2007	28.50
CCWQP	309SSP	4/16/2007	9.83
CCWQP	309SSP	5/30/2007	5.98
CCWQP	309SSP	6/27/2007	0.04
CCWQP	309SSP	7/24/2007	0.00
CCWQP	309SSP	8/29/2007	0.14
CCWQP	309SSP	9/26/2007	0.00
CCWQP	309SSP	10/23/2007	0.00
CCWQP	309SSP	11/28/2007	0.00
CCWQP	309SSP	12/17/2007	24.77
CCWQP	309SSP	1/24/2008	76.35
CCWQP	309SSP	2/23/2008	210.49
CCWQP	309SSP	3/25/2008	179.89
CCWQP	309SSP	4/18/2008	0.96
CCWQP	309SSP	5/27/2008	0.00
CCWQP	309SSP	6/25/2008	0.00
CCWQP	309SSP	7/29/2008	0.00
CCWQP	309SSP	8/26/2008	0.00
CCWQP	309SSP	9/30/2008	0.00
CCWQP	309SSP	10/29/2008	0.00
CCWQP	309SSP	11/19/2008	0.00
CCWQP	309SSP	12/18/2008	0.00
CCWQP	309SSP	1/26/2009	99.00
CCWQP	309SSP	2/7/2009	99.00
CCWQP	309SSP	3/25/2009	0.00
CCWQP	309SSP	4/28/2009	0.00
CCWQP	309SSP	5/27/2009	0.00
CCWQP	309SSP	6/24/2009	0.00
CCWQP	309SSP	7/29/2009	0.00
CCWQP	309SSP	8/25/2009	0.00
CCWQP	309SSP	9/29/2009	0.00
CCWQP	309SSP	10/27/2009	0.00
CCWQP	309SSP	11/10/2009	0.00
CCWQP	309SSP	12/7/2009	7.20
CCWQP	309SSP	1/19/2010	0.00
CCWQP	309SSP	2/23/2010	708.75
CCWQP	309SSP	3/31/2010	651.33
CCWQP	309SSP	4/29/2010	169.92
CCWQP	309SSP	5/24/2010	17.62

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309SSP	6/29/2010	45.06
CCWQP	309SSP	7/27/2010	31.00
CCWQP	309SSP	8/25/2010	21.90
CCWQP	309SSP	9/29/2010	8.14
CCWQP	309SSP	10/26/2010	2.30
CCWQP	309SSP	11/15/2010	0.05
CCWQP	309SSP	12/12/2010	0.00
CCWQP	309SSP	1/25/2011	202.17
CCWQP	309SSP	2/23/2011	3170.78
CCWQP	309SSP	3/30/2011	26835.36
CCWQP	309SSP	4/27/2011	2284.00
CCWQP	309SSP	5/26/2011	159.71
CCWQP	309SSP	6/23/2011	82.66
CCOWS	309TDW	3/8/2000	258.15
CCOWS	309TDW	11/12/2001	0.00
CCWQP	309TEH	1/26/2005	41.13
CCWQP	309TEH	2/16/2005	350.37
CCWQP	309TEH	2/22/2005	86.37
CCWQP	309TEH	3/21/2005	42.19
CCWQP	309TEH	4/12/2005	27.74
CCWQP	309TEH	5/24/2005	16.34
CCWQP	309TEH	6/28/2005	16.22
CCWQP	309TEH	7/26/2005	20.40
CCWQP	309TEH	8/30/2005	6.51
CCWQP	309TEH	9/27/2005	3.97
CCWQP	309TEH	10/25/2005	57.34
CCWQP	309TEH	11/29/2005	30.38
CCWQP	309TEH	12/13/2005	0.00
CCWQP	309TEH	1/24/2006	4.19
CCWQP	309TEH	2/22/2006	4.79
CCWQP	309TEH	3/29/2006	72.48
CCWQP	309TEH	4/25/2006	43.31
CCWQP	309TEH	5/24/2006	18.55
CCWQP	309TEH	6/27/2006	20.66
CCWQP	309TEH	7/25/2006	14.17
CCWQP	309TEH	8/23/2006	13.71
CCWQP	309TEH	9/27/2006	17.91
CCWQP	309TEH	10/24/2006	15.48
CCWQP	309TEH	11/14/2006	151.20
CCWQP	309TEH	12/12/2006	19.65
CCWQP	309TEH	1/30/2007	33.44
CCWQP	309TEH	2/15/2007	18.06
CCWQP	309TEH	3/21/2007	17.25
CCWQP	309TEH	4/4/2007	6.03
CCWQP	309TEH	5/29/2007	1.67
CCWQP	309TEH	6/26/2007	9.27
CCWQP	309TEH	7/23/2007	9.06
CCWQP	309TEH	8/28/2007	7.55
CCWQP	309TEH	9/25/2007	6.74
CCWQP	309TEH	10/23/2007	0.00
CCWQP	309TEH	11/27/2007	0.00
CCWQP	309TEH	12/16/2007	0.00
CCWQP	309TEH	1/27/2008	107.46
CCWQP	309TEH	2/22/2008	23.29

Organization	Site Tag	Sample Date	Flow (cfs)
CCWQP	309TEH	3/26/2008	0.00
CCWQP	309TEH	4/16/2008	0.00
CCWQP	309TEH	5/28/2008	4.51
CCWQP	309TEH	6/25/2008	0.00
CCWQP	309TEH	7/30/2008	3.98
CCWQP	309TEH	8/28/2008	1.13
CCWQP	309TEH	10/1/2008	0.00
CCWQP	309TEH	10/28/2008	0.91
CCWQP	309TEH	11/19/2008	0.00
CCWQP	309TEH	12/17/2008	58.21
CCWQP	309TEH	1/27/2009	2.61
CCWQP	309TEH	2/6/2009	47.86
CCWQP	309TEH	3/25/2009	0.00
CCWQP	309TEH	4/29/2009	18.39
CCWQP	309TEH	5/27/2009	0.00
CCWQP	309TEH	6/24/2009	4.50
CCWQP	309TEH	7/29/2009	0.00
CCWQP	309TEH	8/26/2009	0.00
CCWQP	309TEH	9/30/2009	0.00
CCWQP	309TEH	10/28/2009	0.00
CCWQP	309TEH	11/10/2009	0.00
CCWQP	309TEH	12/8/2009	8.80
CCWQP	309TEH	1/19/2010	449.35
CCWQP	309TEH	2/23/2010	267.65
CCWQP	309TEH	3/31/2010	14.72
CCWQP	309TEH	4/29/2010	8.85
CCWQP	309TEH	5/25/2010	18.26
CCWQP	309TEH	6/30/2010	9.11
CCWQP	309TEH	7/28/2010	14.82
CCWQP	309TEH	8/25/2010	0.00
CCWQP	309TEH	9/29/2010	0.00
CCWQP	309TEH	10/27/2010	0.00
CCWQP	309TEH	11/16/2010	0.00
CCWQP	309TEH	12/13/2010	0.00
CCWQP	309TEH	1/26/2011	0.00
CCWQP	309TEH	2/23/2011	58.02
CCWQP	309TEH	3/30/2011	115.87
CCWQP	309TEH	4/27/2011	11.50
CCWQP	309TEH	5/26/2011	9.88
CCWQP	309TEH	6/22/2011	12.07
CCWQP	309UQA	1/25/2008	1.67
CCWQP	309UQA	2/24/2008	2.75
CCWQP	309UQA	3/26/2008	0.10
CCWQP	309UQA	4/17/2008	0.06
CCWQP	309UQA	5/28/2008	0.20
CCWQP	309UQA	6/25/2008	0.44
CCWQP	309UQA	7/29/2008	0.04
CCWQP	309UQA	8/27/2008	0.03
CCWQP	309UQA	10/2/2008	0.06
CCWQP	309UQA	10/30/2008	0.01
CCWQP	309UQA	11/20/2008	0.04
CCWQP	309UQA	12/18/2008	0.03
CCOWS	BLA-COO	11/12/2001	1.19
CCOWS	BLA-COO	7/8/2002	2.36

Organization	Site Tag	Sample Date	Flow (cfs)
CCOWS	BLA-COO	8/29/2002	1.90
CCOWS	BLA-COO	9/13/2002	2.72
CCOWS	BLA-COO	9/25/2002	1.69
CCOWS	BLA-COO	10/22/2002	2.16
CCOWS	BLA-COO	11/6/2002	0.71
CCOWS	BLA-COO	11/8/2002	1.23
CCOWS	BLA-COO	11/8/2002	1.86
CCOWS	BLA-COO	11/11/2002	0.71
CCOWS	BLA-COO	2/15/2003	4.75
CCOWS	BLA-COO	2/19/2003	3.17
CCOWS	BLA-COO	2/20/2003	2.68
CCOWS	BLA-COO	3/12/2003	2.19
CCOWS	BLA-COO	3/15/2003	5.56
CCOWS	BLA-COO	3/17/2003	3.18
CCOWS	BLA-COO	4/19/2003	2.30
CCOWS	BLA-COO	5/30/2003	2.65
CCOWS	BLA-COO	6/9/2003	3.09
CCOWS	BLA-COO	7/14/2003	2.16
CCOWS	BLA-COO	8/3/2003	2.89
CCOWS	BLA-PUM	10/22/2002	1.75
CCOWS	BLA-PUM	11/6/2002	1.33
CCOWS	BLA-PUM	11/11/2002	1.24
CCOWS	BLA-PUM	12/16/2002	2.29
CCOWS	BLA-PUM	2/15/2003	2.29
CCOWS	BLA-PUM	3/12/2003	2.43
CCOWS	BLA-PUM	3/17/2003	2.33
CCOWS	BLA-PUM	7/14/2003	9.23
CCOWS	BLA-PUM	8/3/2003	5.73
CCOWS	BOC-OSR	4/14/2000	0.14
CCOWS	BOC-OSR	4/16/2000	0.04
CCOWS	BOC-OSR	4/17/2000	0.04
CCOWS	BOC-OSR	4/17/2000	0.07
CCOWS	BOC-OSR	4/18/2000	0.04
CCOWS	BOC-OSR	7/12/2000	0.03
CCOWS	BOC-OSR	1/8/2001	0.01
CCOWS	BOC-OSR	1/8/2001	0.01
CCOWS	BOC-OSR	1/8/2001	0.02
CCOWS	BOC-OSR	1/8/2001	0.05
CCOWS	BOC-OSR	1/9/2001	0.02
CCOWS	BOC-OSR	1/10/2001	0.14
CCOWS	BOC-OSR	1/10/2001	0.21
CCOWS	BOC-OSR	1/11/2001	0.05
CCOWS	BOC-OSR	1/12/2001	0.01
CCOWS	BOC-OSR	1/23/2001	0.04
CCOWS	BOC-OSR	1/24/2001	0.14
CCOWS	BOC-OSR	1/25/2001	0.11
CCOWS	BOC-OSR	1/25/2001	2.37
CCOWS	BOC-OSR	1/26/2001	0.04
CCOWS	BOC-OSR	1/26/2001	0.14
CCOWS	BOC-OSR	2/9/2001	0.04
CCOWS	BOC-OSR	2/11/2001	0.28
CCOWS	BOC-OSR	2/18/2001	0.02
CCOWS	BOC-OSR	2/19/2001	0.18
CCOWS	CHU-CCR	3/14/2001	0.33

Organization	Site Tag	Sample Date	Flow (cfs)
CCOWS	CHU-CCR	6/28/2001	0.00
CCOWS	CHU-CCR	11/30/2001	0.00
CCOWS	CHU-CCR	12/16/2002	7.77
CCOWS	CHU-CCR	12/17/2002	2.75
CCOWS	CHU-CRR	3/17/2002	3.44
CCOWS	CHU-CRR	4/24/2002	1.38
CCOWS	CHU-CRR	5/23/2002	0.74
CCOWS	CHU-CRR	6/28/2002	1.70
CCOWS	CHU-CRR	7/31/2002	2.13
CCOWS	CHU-CRR	8/30/2002	1.34
CCOWS	CHU-CRR	9/25/2002	0.17
CCOWS	CHU-CRR	11/7/2002	0.11
CCOWS	CHU-CRR	11/8/2002	20.41
CCOWS	CHU-CRR	12/16/2002	54.67
CCOWS	CHU-CRR	12/17/2002	72.92
CCOWS	EP1-ROG	11/12/2001	15.17
CCOWS	EP1-ROG	7/8/2002	0.97
CCOWS	EP1-ROG	8/29/2002	0.67
CCOWS	EP1-ROG	9/13/2002	0.72
CCOWS	EP1-ROG	9/25/2002	0.40
CCOWS	EP1-ROG	10/22/2002	0.87
CCOWS	EP1-ROG	11/6/2002	0.43
CCOWS	EP1-ROG	11/8/2002	4.22
CCOWS	EP1-ROG	11/11/2002	0.53
CCOWS	EP1-ROG	2/15/2003	1.27
CCOWS	EP1-ROG	2/19/2003	2.07
CCOWS	EP1-ROG	2/20/2003	0.43
CCOWS	EP1-ROG	3/13/2003	0.33
CCOWS	EP1-ROG	3/15/2003	11.48
CCOWS	EP1-ROG	3/17/2003	0.35
CCOWS	EP1-ROG	4/19/2003	1.06
CCOWS	EP1-ROG	5/31/2003	0.99
CCOWS	EP1-ROG	6/10/2003	1.32
CCOWS	EP1-ROG	7/14/2003	1.73
CCOWS	EP1-ROG	8/3/2003	0.83
CCOWS	ESZ-HWY	10/30/2001	0.00
CCOWS	ESZ-HWY	11/30/2001	0.00
CCOWS	GAB-CRA	7/12/2000	4.61
CCOWS	GAB-CRA	10/25/2000	0.36
CCOWS	GAB-CRA	10/26/2000	7.22
CCOWS	GAB-CRA	10/28/2000	1.57
CCOWS	GAB-CRA	10/29/2000	3.48
CCOWS	GAB-CRA	10/29/2000	4.40
CCOWS	GAB-CRA	10/29/2000	21.35
CCOWS	GAB-CRA	1/7/2001	0.98
CCOWS	GAB-CRA	1/8/2001	1.43
CCOWS	GAB-CRA	1/8/2001	1.63
CCOWS	GAB-CRA	1/10/2001	1.31
CCOWS	GAB-CRA	1/10/2001	5.18
CCOWS	GAB-CRA	1/25/2001	14.51
CCOWS	GAB-CRA	1/26/2001	5.59
CCOWS	GAB-HER	4/13/2000	4.80
CCOWS	GAB-HER	7/3/2000	0.00
CCOWS	GAB-HER	10/29/2000	17.98

Organization	Site Tag	Sample Date	Flow (cfs)
CCOWS	GAB-HER	1/10/2001	0.13
CCOWS	GAB-HER	1/10/2001	0.29
CCOWS	GAB-HER	1/10/2001	0.45
CCOWS	GAB-HER	1/10/2001	2.46
CCOWS	GAB-HER	1/24/2001	0.00
CCOWS	GAB-HER	1/24/2001	0.00
CCOWS	GAB-HER	1/24/2001	0.00
CCOWS	GAB-HER	1/26/2001	0.00
CCOWS	GAB-HER	2/11/2001	11.97
CCOWS	GAB-NAT	4/14/2000	0.49
CCOWS	GAB-NAT	4/16/2000	0.00
CCOWS	GAB-NAT	4/17/2000	2.26
CCOWS	GAB-NAT	1/25/2001	11.51
CCOWS	GAB-NAT	1/26/2001	0.00
CCOWS	GAB-NAT	2/9/2001	0.00
CCOWS	GAB-NAT	2/11/2001	11.65
CCOWS	GAB-NAT	2/12/2001	6.43
CCOWS	GAB-NAT	2/13/2001	0.00
CCOWS	GAB-NAT	2/19/2001	0.00
CCOWS	GAB-OSR	3/8/2000	26.49
CCOWS	GAB-OSR	4/13/2000	4.87
CCOWS	GAB-OSR	4/17/2000	5.40
CCOWS	GAB-OSR	7/12/2000	1.87
CCOWS	GAB-OSR	10/25/2000	0.11
CCOWS	GAB-OSR	10/25/2000	0.28
CCOWS	GAB-OSR	10/26/2000	0.28
CCOWS	GAB-OSR	10/28/2000	0.57
CCOWS	GAB-OSR	10/29/2000	0.92
CCOWS	GAB-OSR	10/29/2000	7.13
CCOWS	GAB-OSR	1/7/2001	1.23
CCOWS	GAB-OSR	1/24/2001	3.00
CCOWS	GAB-VET	4/17/2000	1.45
CCOWS	GAB-VET	4/17/2000	2.51
CCOWS	GAB-VET	1/11/2001	0.83
CCOWS	GAB-VET	1/11/2001	5.60
CCOWS	GAB-VET	1/24/2001	4.24
CCOWS	GAB-VET	1/25/2001	6.82
CCOWS	GAB-VET	2/11/2001	23.98
CCOWS	MOS-SAN	11/12/2001	0.00
CCOWS	OLS-MON	11/12/2001	0.00
CCOWS	OLS-POT	11/12/2001	119.88
CCOWS	OLS-POT	2/14/2003	81.37
CCOWS	OLS-POT	2/20/2003	221.34
CCOWS	OLS-POT	3/12/2003	61.23
CCOWS	OLS-POT	3/17/2003	189.88
CCOWS	OLS-POT	4/19/2003	43.17
CCOWS	OLS-POT	6/9/2003	106.34
CCOWS	REC-183	1/8/2001	1.62
CCOWS	REC-183	1/8/2001	62.93
CCOWS	REC-183	1/8/2001	69.71
CCOWS	REC-183	1/8/2001	100.51
CCOWS	REC-183	1/9/2001	21.01
CCOWS	REC-183	1/10/2001	9.61
CCOWS	REC-183	1/10/2001	78.89

Organization	Site Tag	Sample Date	Flow (cfs)
CCOWS	REC-183	1/10/2001	119.89
CCOWS	REC-183	1/12/2001	67.24
CCOWS	REC-183	1/25/2001	146.27
CCOWS	SAL-MOU	12/17/2002	2.50
CCOWS	SAL-MOU	12/17/2002	30.00
CCOWS	SAL-MOU	12/23/2002	400.00
CCOWS	TOW-OSR	3/8/2000	2.47
CCOWS	TOW-OSR	4/14/2000	1.31
CCOWS	TOW-OSR	7/12/2000	0.56
CCOWS	TOW-OSR	1/25/2001	0.78

Appendix C − Assessment of Biostimulation

Tables

Figures

C.1 Water Quality Standards and Screening Criteria

Table 1. WQOs and Screening Criteria Used as Indicators of Biostimulation.

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 they can provide additional weight of evidence)		
Constituent – Parameter	**Source of Screening Criteria**	**Screening Criteria/Method**
Wide diel swings in DO - pH	Wide diel swings widely reported in scientific literature as indicating potential biostimulation	Observational – compare diel swings to reference sites (reference sites show diel DO variation of less than 1 mg/L).
Early morning DO crashes (pre-dawn sampling program)	Early morning DO crashes widely reported in scientific literature as indicating potential biostimulation	Early morning DO crashes, depressed below Basin Plan numeric objectives
Low dissolved oxygen and/or oxygen super saturation	Basin Plan Objectives and California Surface Water Ambient Monitoring Program Technical Report[A]	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.
Chlorophyll *a*	California Surface Water Ambient Monitoring Program Technical Report[A]	Exceeding 15 mg/L = 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[A]	NO3-N exceeding 1/mg/L = evidence of nutrient enrichment (Assessed using geomean of all samples at monitoring site > 1mg/L).
Evidence of phosphorus enrichment relative to reference conditions	USEPA 25th percentile reference approach for rivers and streams (USEPA, 2000)	Orthophosphate-P exceeding 25th percentile of inland streams for hydrologic unit 309 (Salinas Watershed) = 0.074 mg/L (evidence of enrichment assessed using geomean of all samples at HUC309 monitoring sites > 0.074mg/L).
Percent Floating Algal Cover	California Surface Water Ambient Monitoring Program Technical Report[A]	One or more observances of 50% cover or greater = 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.
Downstream Impacts	USEPA Scientific Advisory Board (2010) stressed the importance of recognizing downstream impacts[B]	Observational: assess whether stream reach showing 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).

[A] 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.
[B] U.S. EPA Science Advisory Board Review of "Empirical Approaches for Nutrient Criteria Derivation". U.S Environmental Protection Agency. April 27, 2010.

Table 2. Biostimulation Assessment Matrix.

Stream Reach	DO Problems			Nutrient Enrichment	Elevated Algal Biomass		Other indicators of Biostimulatory problems			Biostimulatory Impairment in Stream Reach?
	Wide Diel DO Swings	Pre-dawn DO crashes	Low DO and/or DO supersaturation	NO3-N exceeding reference conditions; or orthophosphate-P exceeding reference conditions	Chlorophyll a exceeding reference conditions	Excess floating algal cover (>50% cover)	Downstream nutrient impacts to waterbody exhibiting biostimulation	Reported fish kills likely or possibly linked to DO problems	Photo documentation of excessive algal biomass	
Old Salinas River @ Potrero Rd.	**No data**	**No data**	**Yes**	**Yes**	**Yes**	**No data**	**Yes (Elkhorn Slough)**	**Yes**	**No**	**Yes**
Old Salinas River @ Monterey Dunes	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes (Elkhorn Slough)**	**Yes**	**Yes**	**Yes**
Salinas River @ Hwy. 1	**No data**	**No data**	**Yes**	**Yes**	**Yes**	**No**	**Yes (Elkhorn Slough)**	**No**	**No**	**Yes**
Salinas River @ Davis Rd.	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**Yes (Elkhorn Slough)**	**No**	**Yes**	**Yes**
Salinas River @ Spreckels	**No data**	**No data**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No - based on DO and algal biomass problems not being expressed**
Salinas River @ Chualar	**No data**	**No data**	**No**	**Yes**	**No**	**No**	**No (no biostim observed at Salinas Riv. @ Spreckels)**	**No**	**No**	**No - based on DO and algal biomass problems not being expressed**
Salinas River @ Gonzalez	**No data**	**No data**	**No**	**Yes**	**No**	**No**	**No (no biostim observed at Salinas Riv. @ Spreckels)**	**No**	**No**	**No - based on DO and algal biomass problems not being expressed**
Tembadero Slough @ Molera	**No**	**No**	**No**	**Yes**	**Yes**	**No data**	**Yes**	**Yes**	**Yes**	**No – based on DO problems not being expressed; however, downstream nutrient impacts to Elkhorn Slough are present**
Tembadero Slough @ Preston Rd	**No**	**No**	**Yes**	**Yes**	**Yes**	**No data**	**Yes (Elkhorn Slough)**	**Yes**	**Yes**	**Yes**
Tembadero Slough @ Haro Rd	**No data**	**No data**	**Yes**	**Yes**	**No**	**No**	**Yes (Elkhorn Slough)**	**Yes**	**No**	**No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Elkhorn Slough are present**

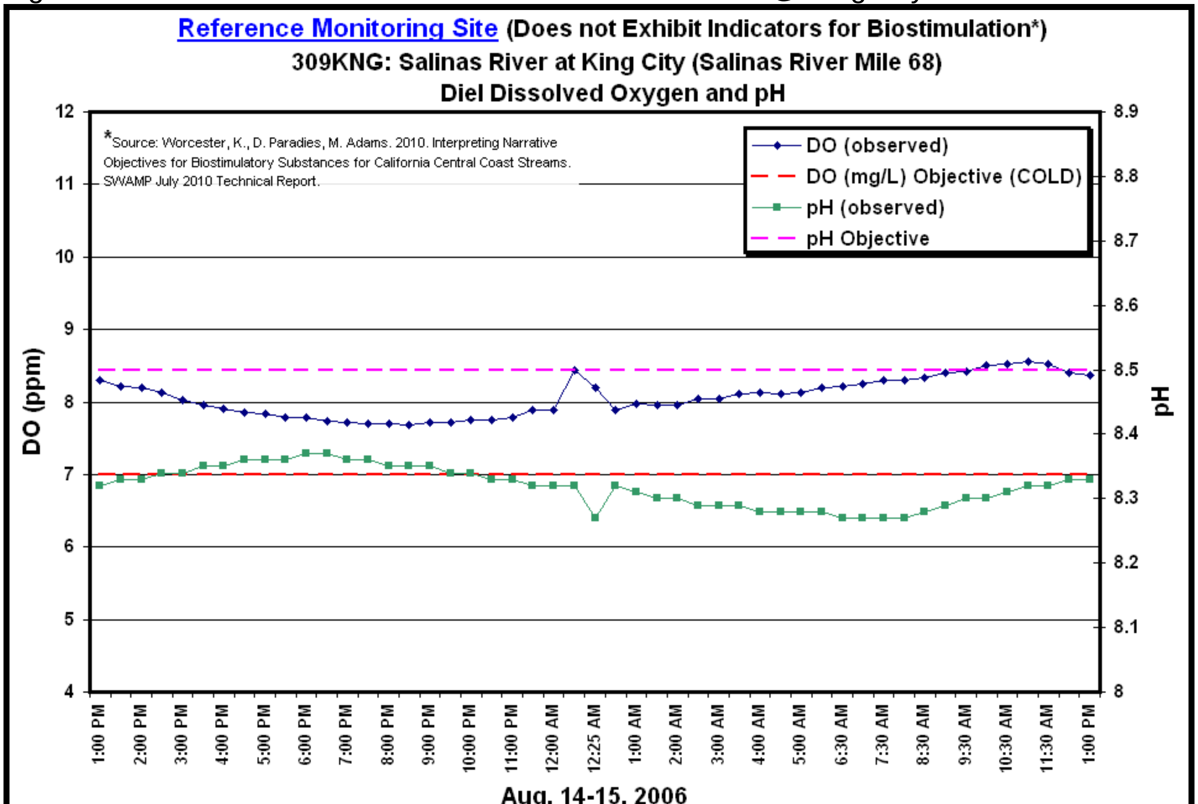
Stream Reach	DO Problems			Nutrient Enrichment	Elevated Algal Biomass		Other indicators of Biostimulatory problems			Biostimulatory Impairment in Stream Reach?
	Wide Diel DO Swings	Pre-dawn DO crashes	Low DO and/or DO supersaturation	NO3-N exceeding reference conditions; or orthophosphate-P exceeding reference conditions	Chlorophyll a exceeding reference conditions	Excess floating algal cover (>50% cover)	Downstream nutrient impacts to waterbody exhibiting biostimulation	Reported fish kills likely or possibly linked to DO problems	Photo documentation of excessive algal biomass	
Merritt Ditch upstream of Hwy 183	No data	No data	Yes	Yes	No	Yes	Yes (Tembladero Slough and Elkhorn Slough)	No	No	Yes
Lower Reclamation Canal San Jon Rd. to Victor Rd.	Yes	Yes	Yes	Yes	Yes	Yes	Yes (Tembladero Slough and Elkhorn Slough)	Yes	Yes	Yes
Upper Reclamation Canal Airport Rd. to La Guardia	No data	Yes	Yes	Yes	Yes	Yes	Yes (Tembladero Slough and Elkhorn Slough)	No	Yes	Yes
Quail Creek Hwy 101 to Potter Rd.	No data	No	No	Yes	No	Yes	No (biostimulation not present in Salinas Riv. above Sprekels)	No	Yes	No- based on DO problems not being expressed
Chualar Creek River Road to Old Stage Rd. and unnamed tributary	No data	No data	No	Yes	No	No	No (biostimulation not present in Salinas Riv. above Sprekels)	No	No	No- based on DO and algal biomass problems not being expressed
Blanco Drain @ pump	No data	No data	No	Yes	No	Yes	Yes (Salinas River below Spreckels)	No	Yes	No – based on DO problems not being expressed; however, downstream nutrient impacts to Salinas River below Spreckels are present
Espinosa Slough @ site 309ESP	No data	No data	Yes	Yes	No	No	Yes (lower Reclamation Canal)	No	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present

Stream Reach	DO Problems			Nutrient Enrichment	Elevated Algal Biomass		Other indicators of Biostimulatory problems			Biostimulatory Impairment in Stream Reach?
	Wide Diel DO Swings	Pre-dawn DO crashes	Low DO and/or DO supersaturation	NO3-N exceeding reference conditions; or orthophosphate-P exceeding reference conditions	Chlorophyll a exceeding reference conditions	Excess floating algal cover (≥50% cover)	Downstream nutrient impacts to waterbody exhibiting biostimulation	Reported fish kills likely or possibly linked to DO problems	Photo documentation of excessive algal biomass	
AlisalSlough @ White Barn	No data	No data	No	Yes	No	No	Yes (lower Reclamation Canal)	No	No	No – based on DO and algal biomass problems not being expressed; however, downstream nutrient impacts to Salinas River below Spreckels are present
Santa Rita Creek @ Santa Rita park	No data	No data	Yes	Yes	Yes	No	Yes (lower Reclamation Canal)	No	Yes	Yes
Gabilan Creek @ Boronda Rd.	No data	No data	Yes	Yes	No	No	Yes (lower Reclamation Canal)	No	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present
Natividad Creek - Las Casitas to Boronda Rd.	No data	No data	Yes (median DO saturation below Basin Plan objective)	Yes	No	No	Yes (lower Reclamation Canal)	No	No	No – based on algal biomass problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present
Alisal Creek - Hartnell and Boronda Rds.	No data	No data	No	Yes	Yes	No data	Yes (lower Reclamation Canal)	No	Yes	No – based on DO problems not being expressed; however, downstream nutrient impacts to Reclamation Canal are present
Moro Cojo Slough, sites 306MORMLN, 306MOR, 306-MOROC-32	No data	No data	Yes	Yes (orthophosphate exceeding reference conditions)	No	Yes	Yes (Elkhorn Slough)	No	Yes	Yes

C.2 Salinas River Reference Sites

C.2.1 Diel Data for Reference Sites

Figure 1. Diel Data Reference Site: 309KNG-Salinas River @ King City.



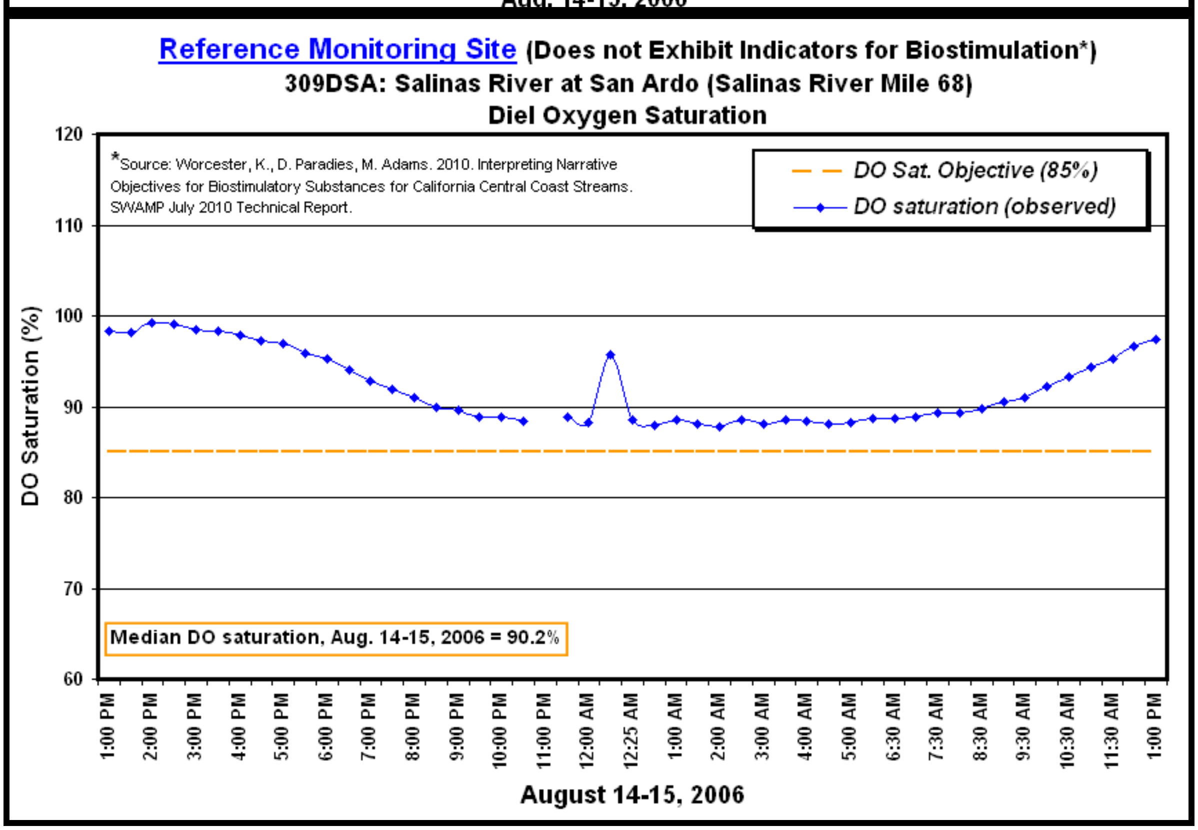
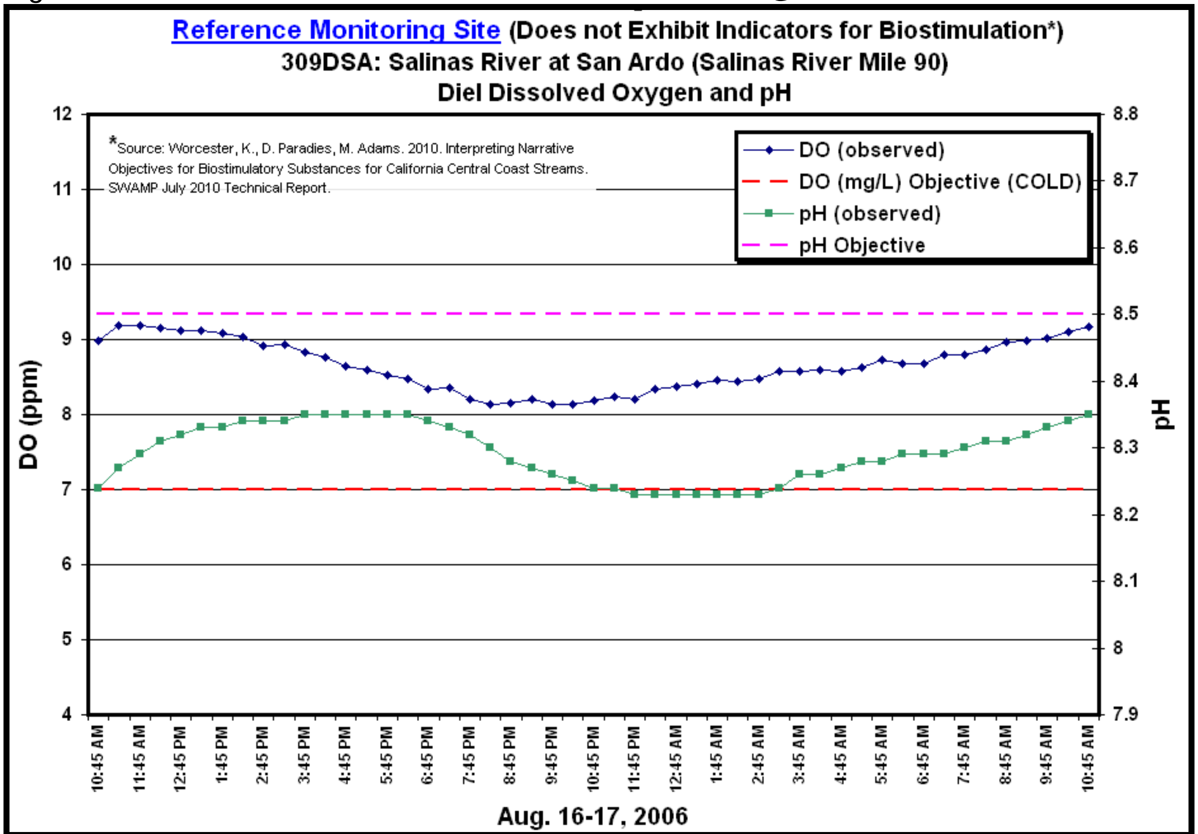
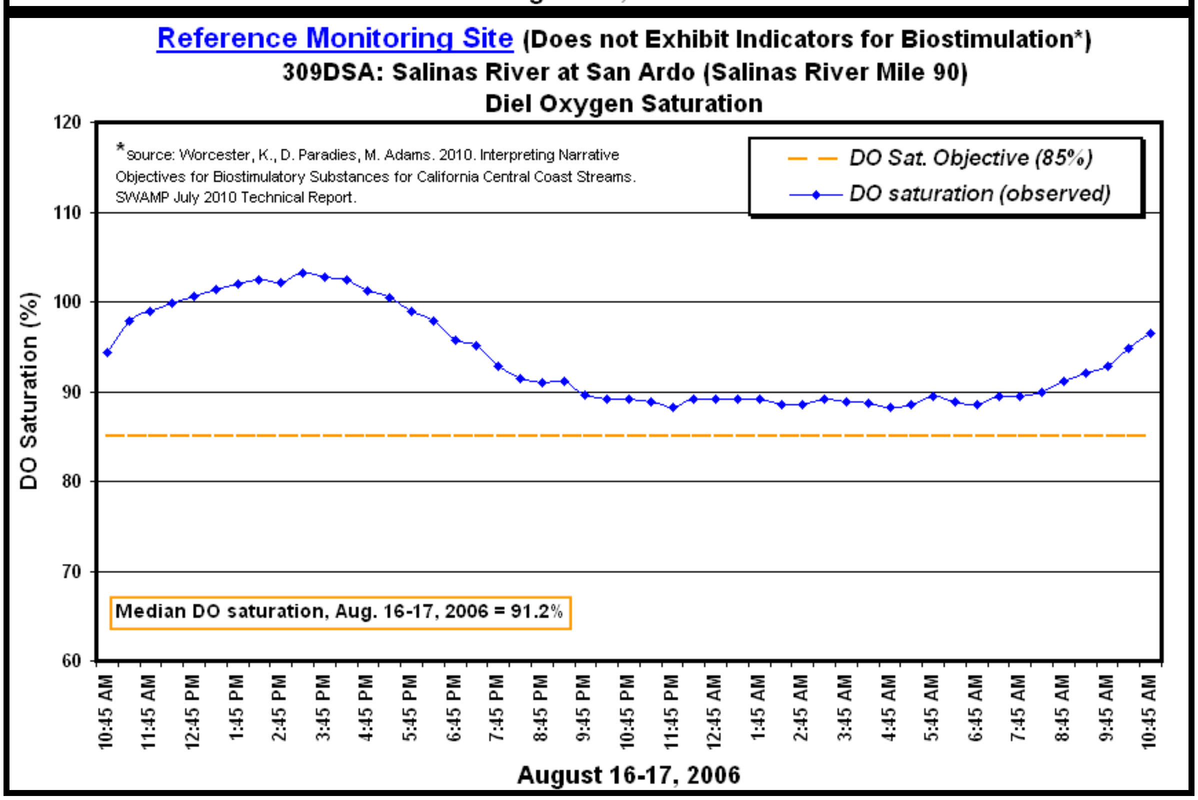


Figure 2. Diel Data Reference Site: 309DSA-Salinas River @ San Ardo.

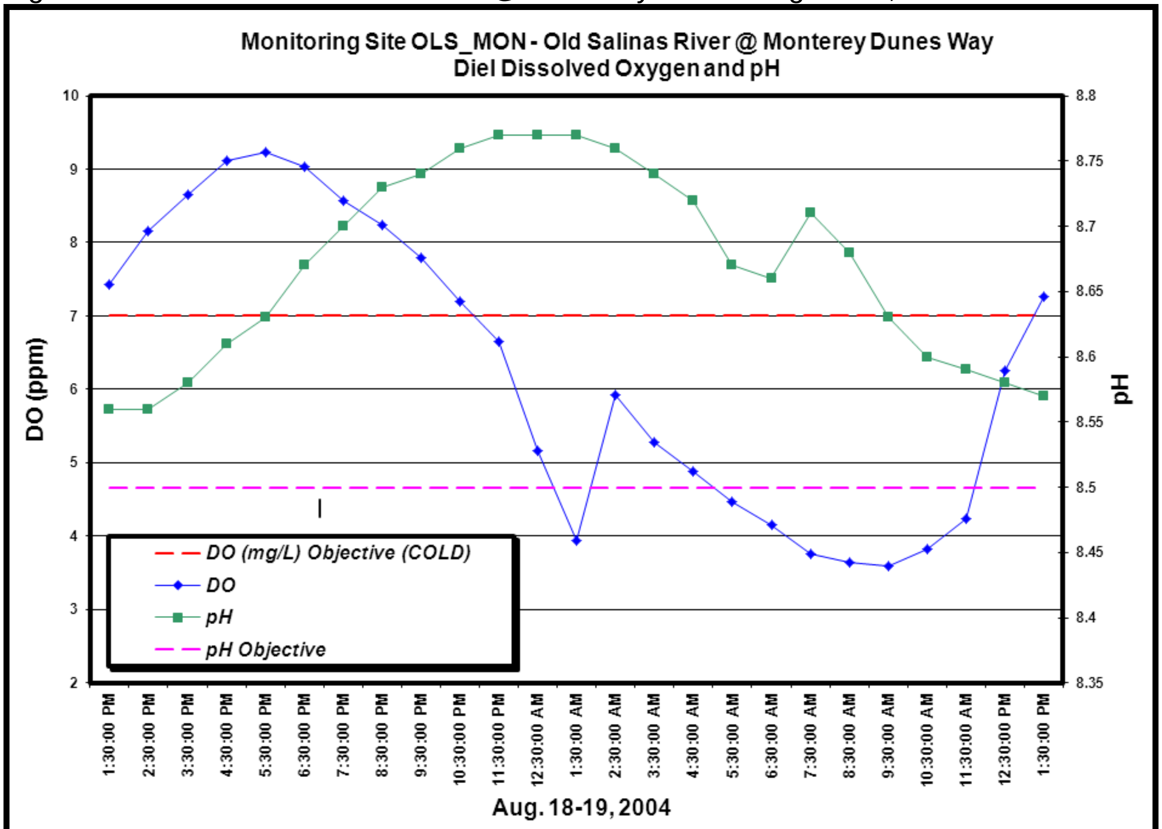




C.3 Lower Salinas River and Old Salinas River

C.3.1 Dissolved Oxygen: Diel Data, Pre-dawn Sampling, and Grab Samples

Figure 3. Diel Data Old Salinas River @ Monterey Dunes Aug 18-19, 2004.



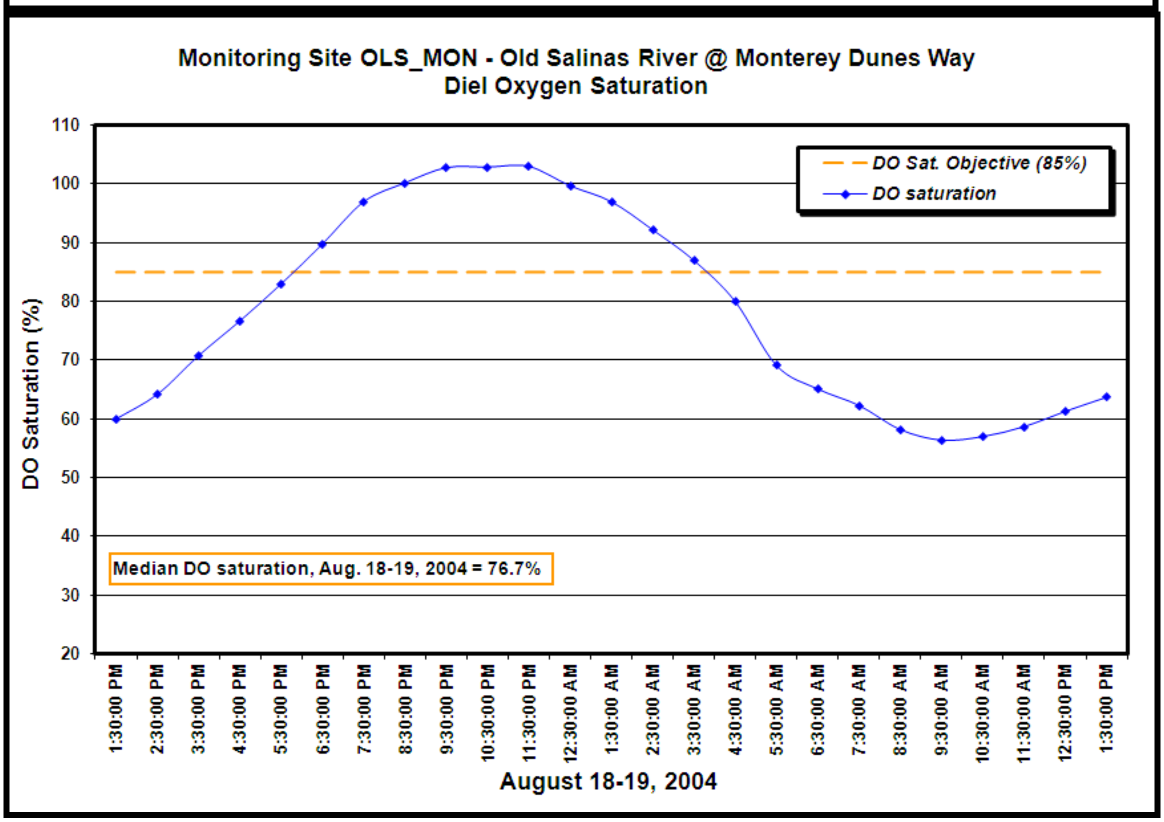


Figure 4. Diel Data Salinas River @ Davis Rd. Aug 18-19, 2004.

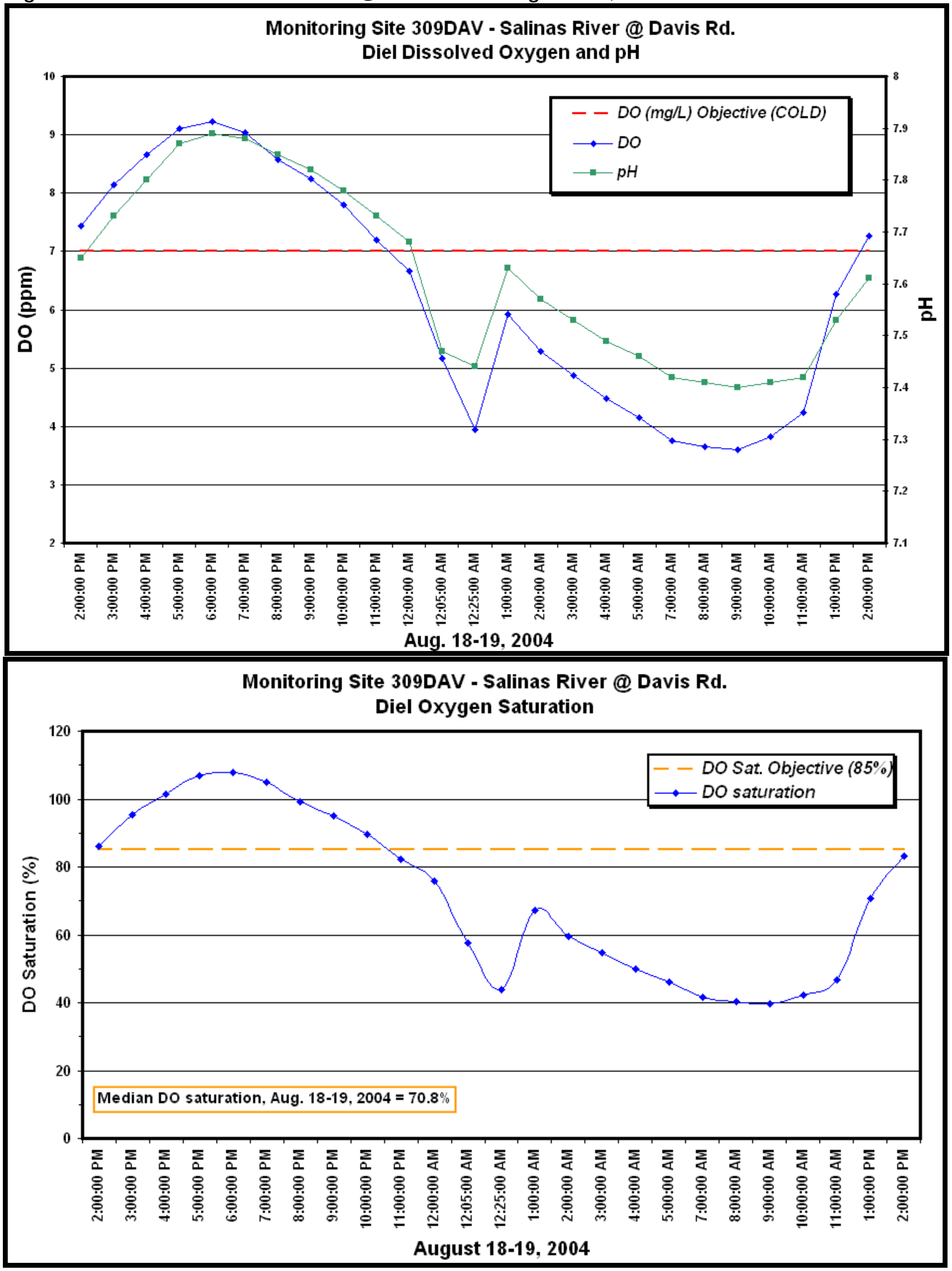
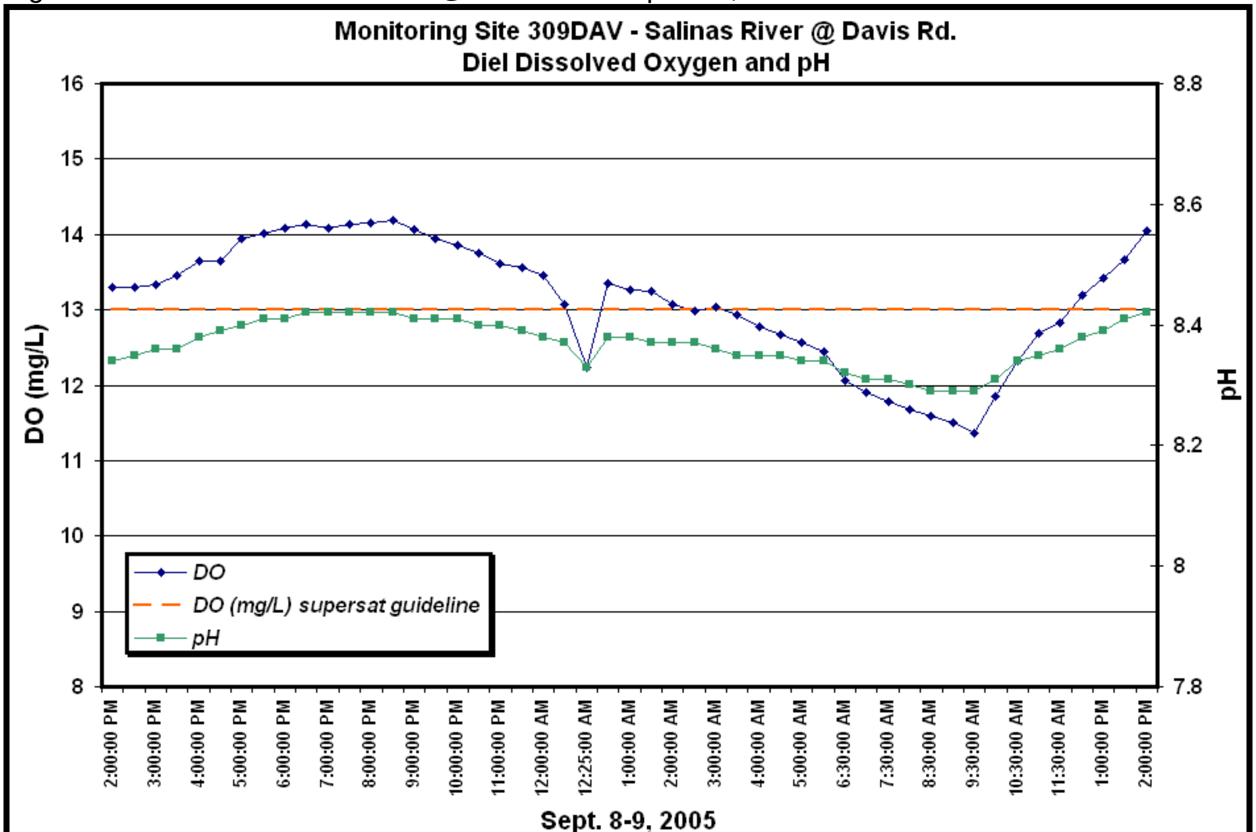


Figure 5. Diel Data Salinas River @ Davis Rd. Sept. 8-9, 2005.



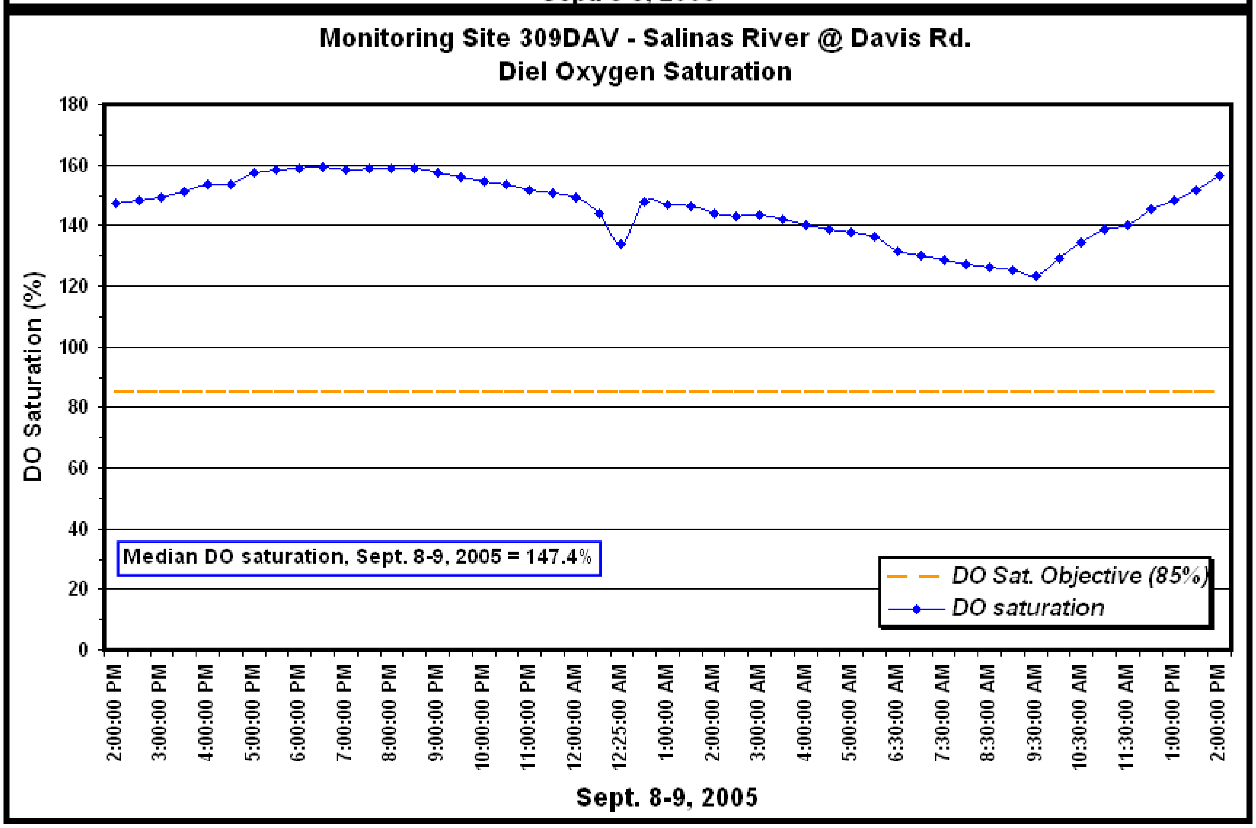
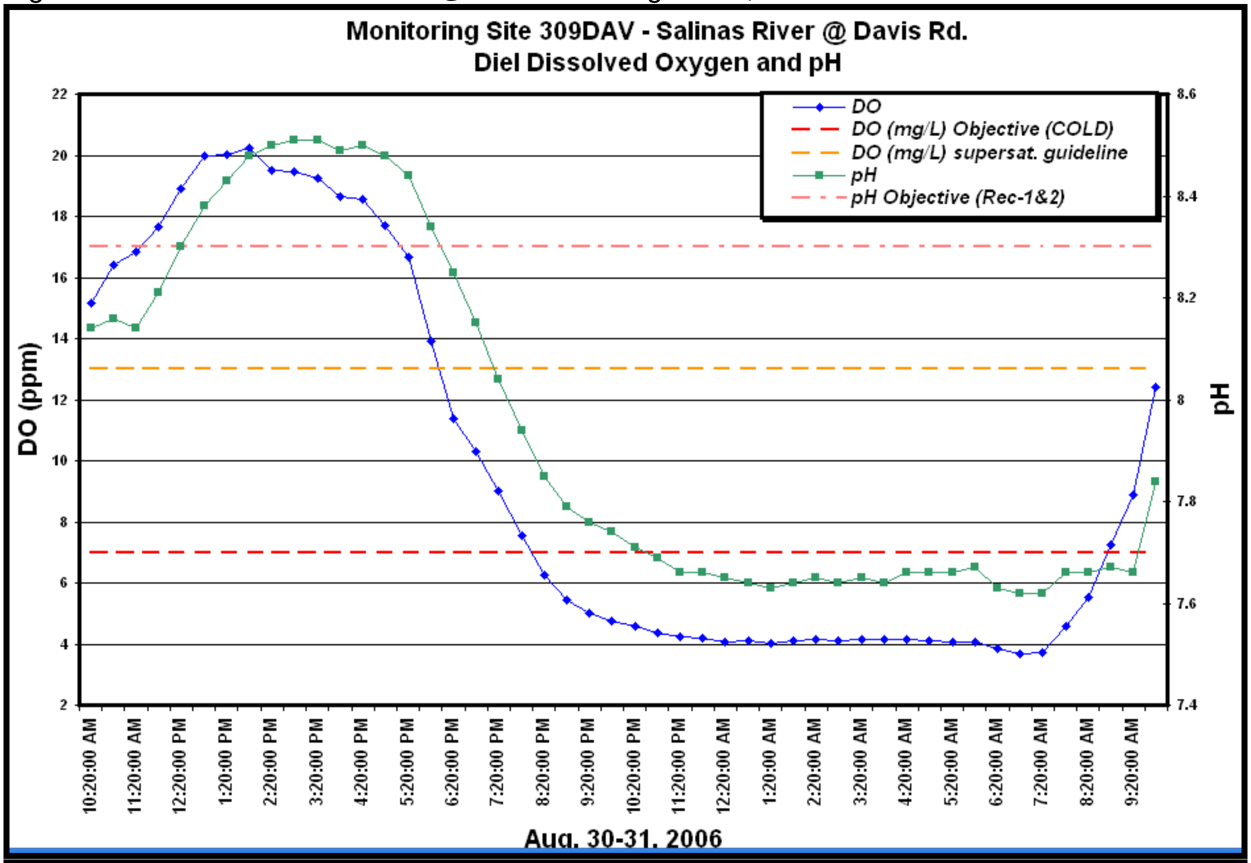


Figure 6. Diel Data Salinas River @ Davis Rd. Aug 30-31, 2006.



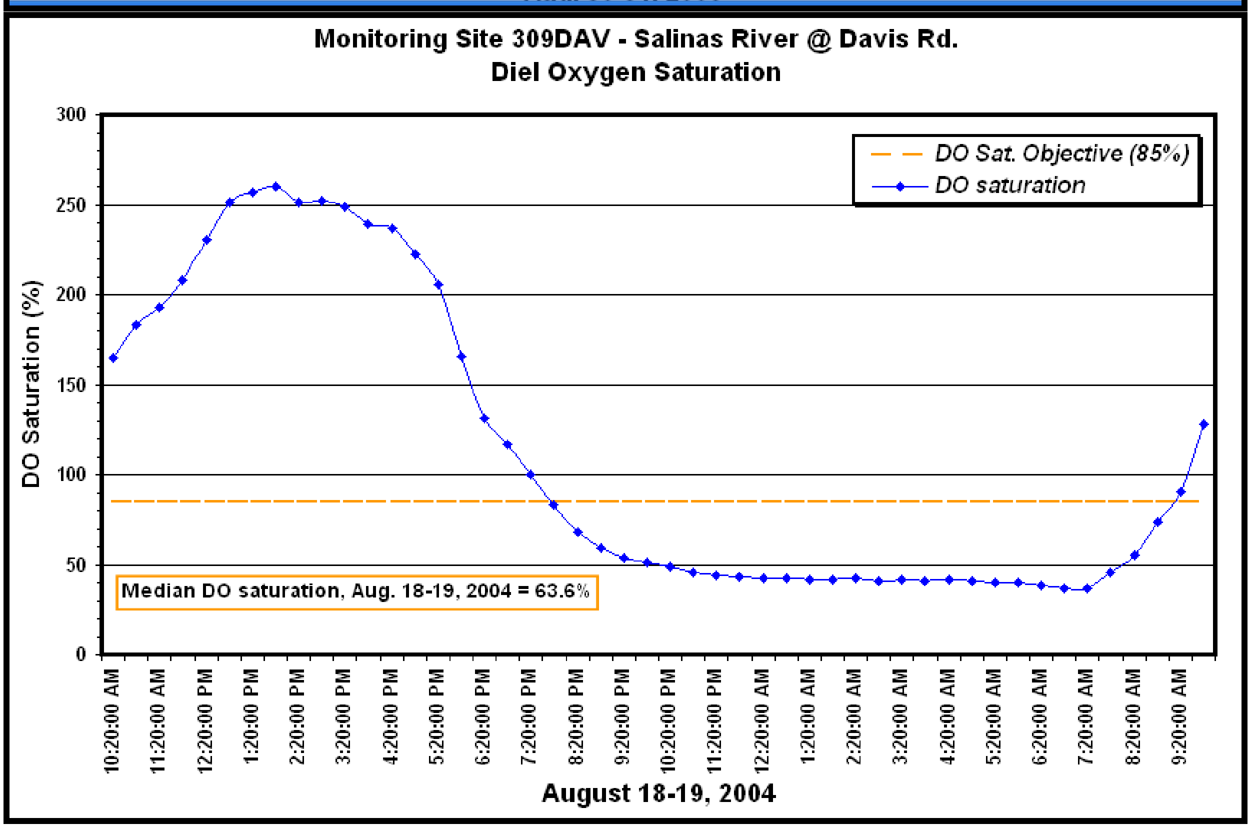
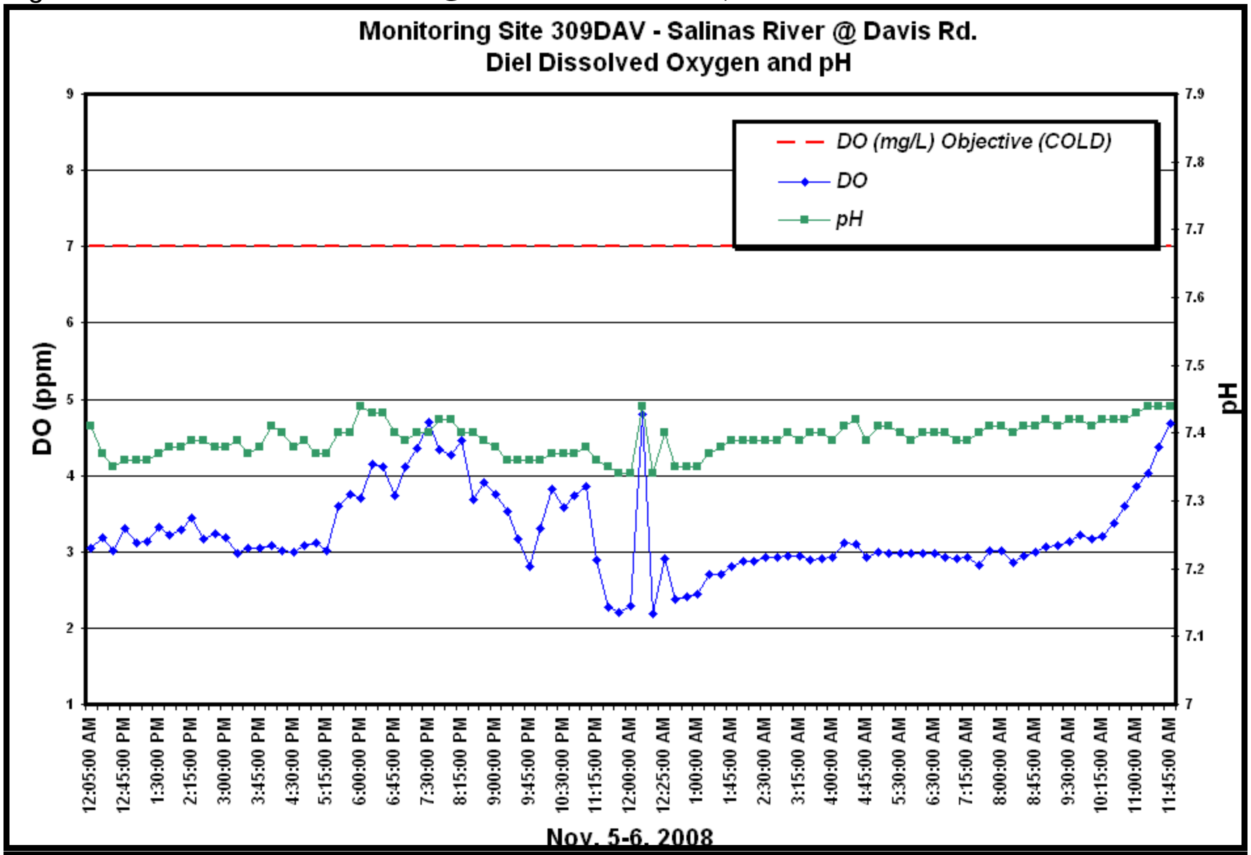


Figure 7. Diel Data Salinas River @ Davis Rd. Nov. 5-6, 2006



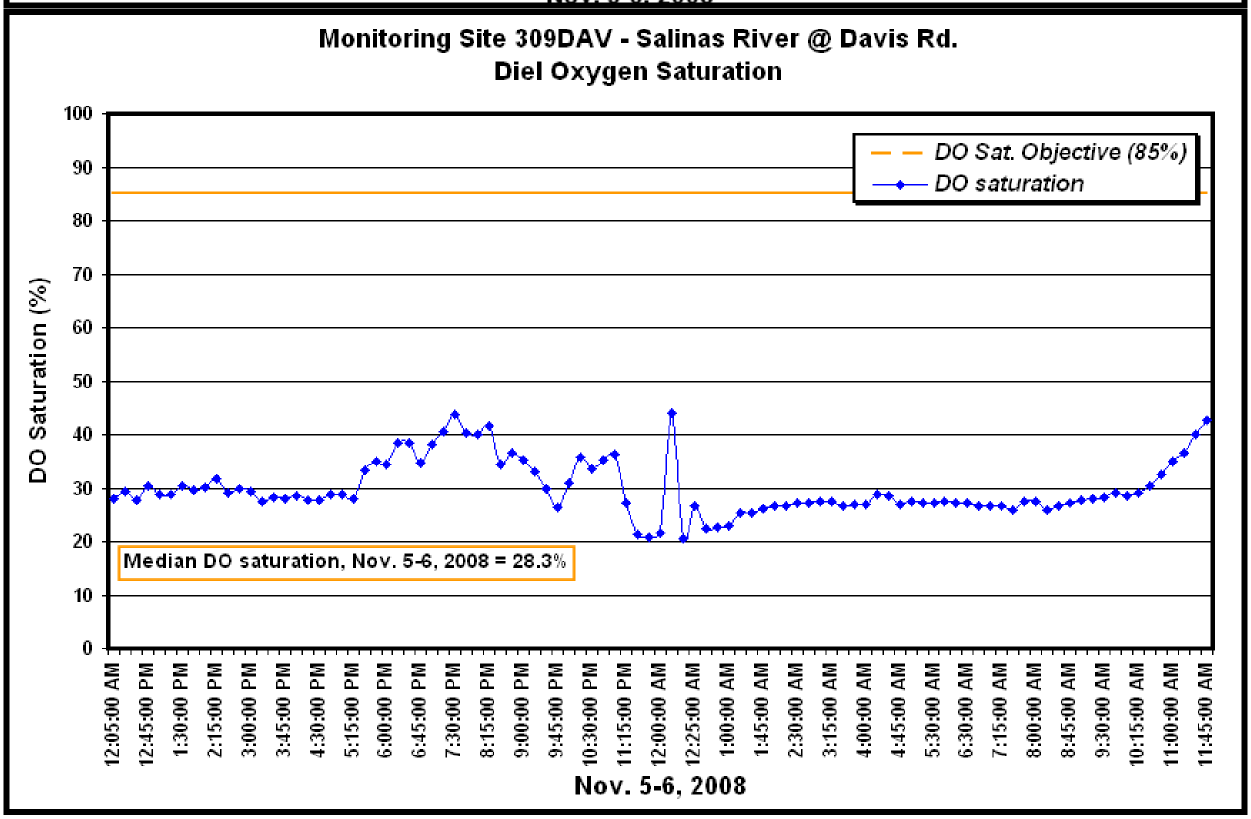


Figure 8. Monthly DO grab samples – Old Salinas River @ Potrero Rd.

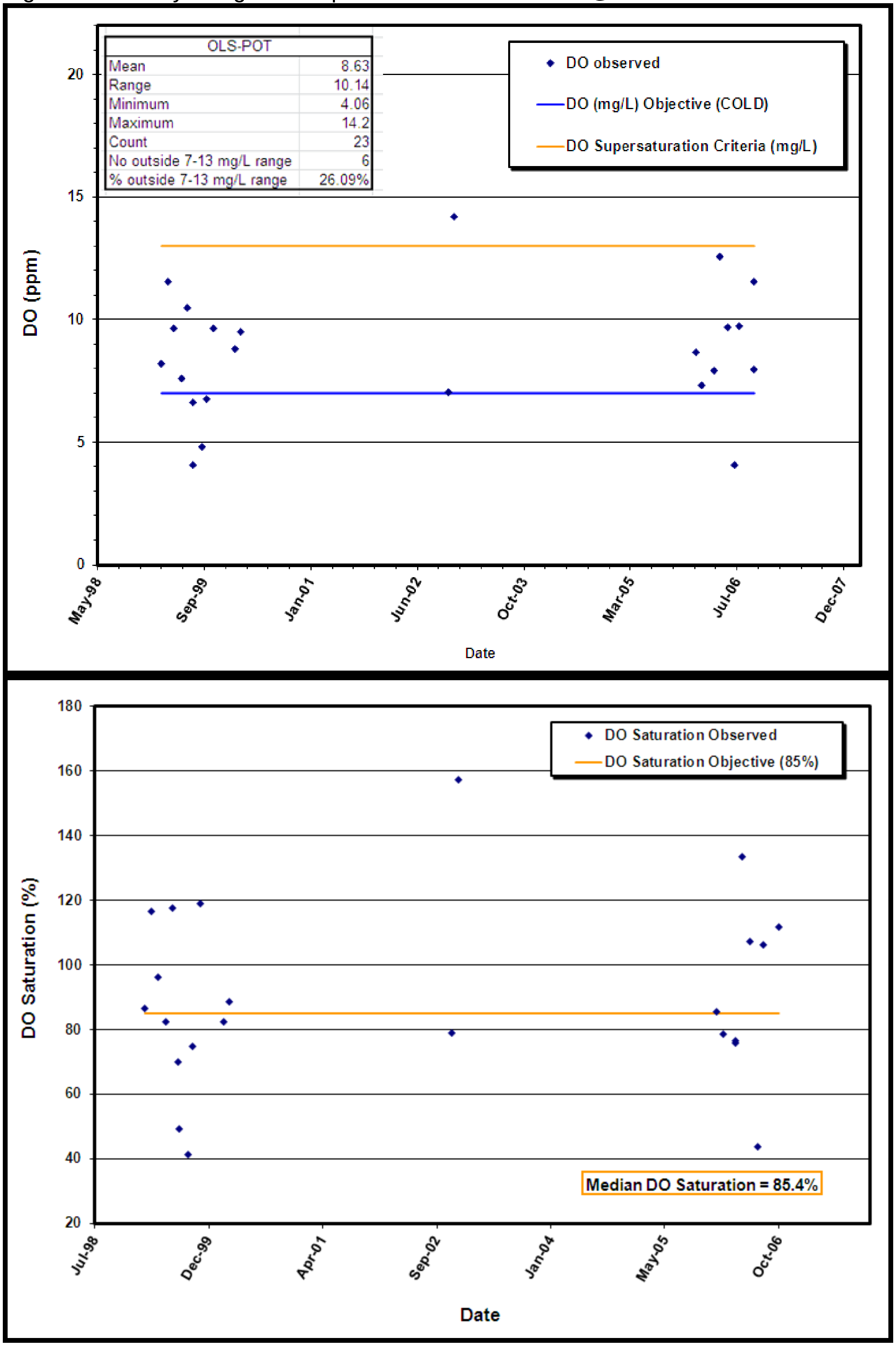


Figure 9. Monthly DO grab samples – Old Salinas River @ Monterey Dunes.

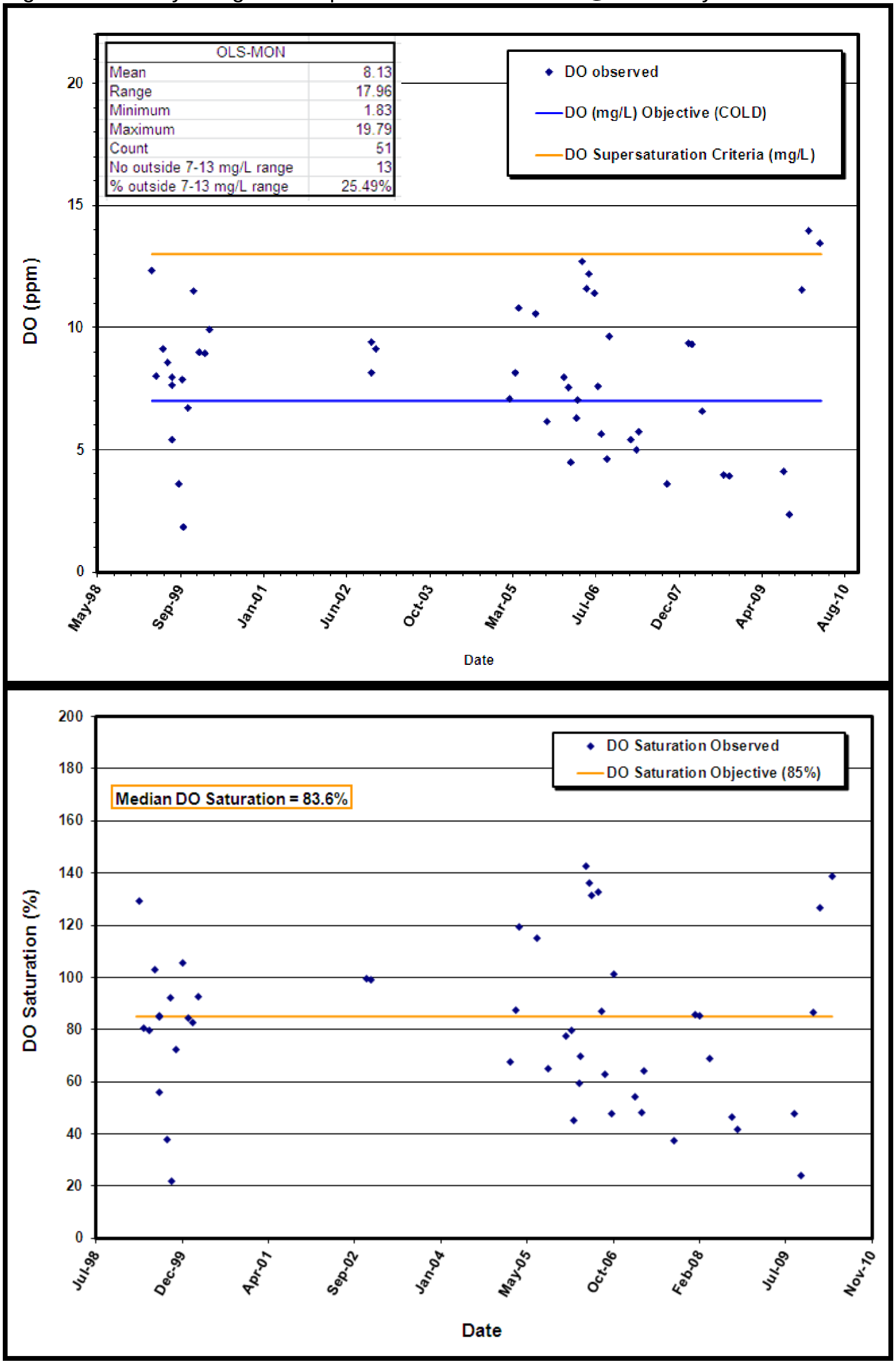
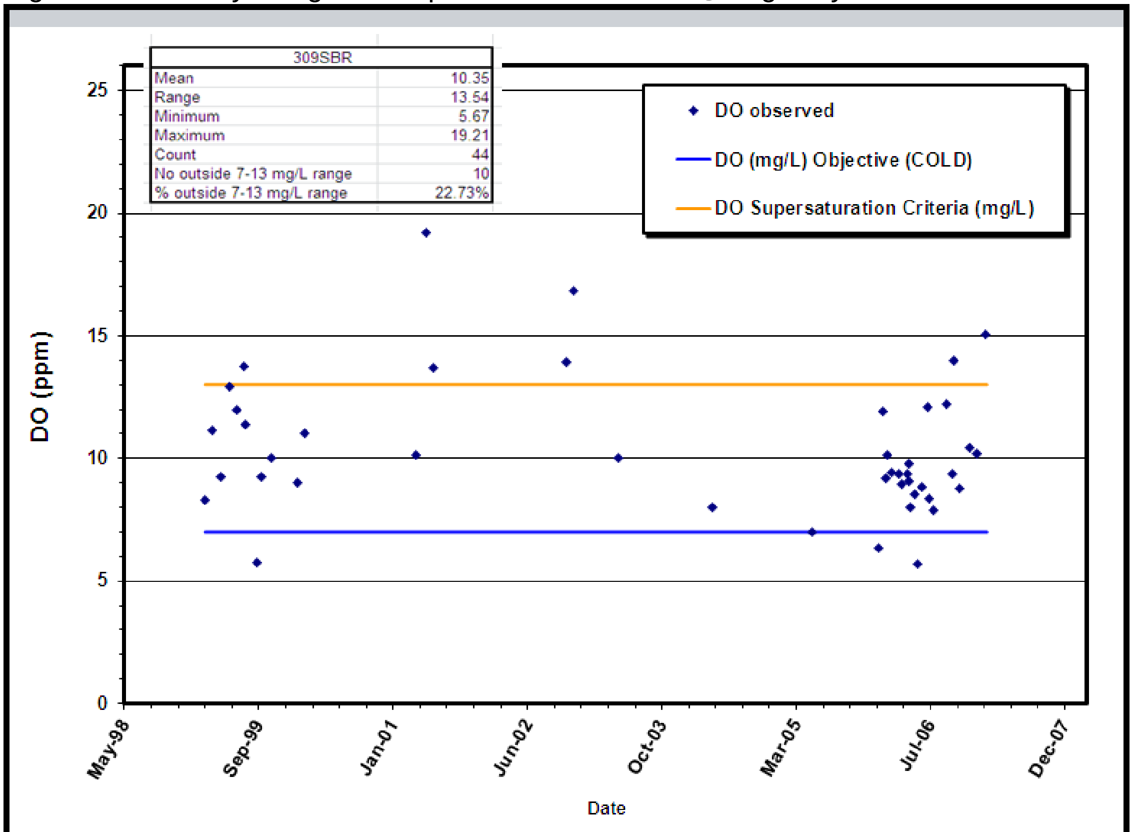


Figure 10. Monthly DO grab samples – Salinas River @ Highway 1.



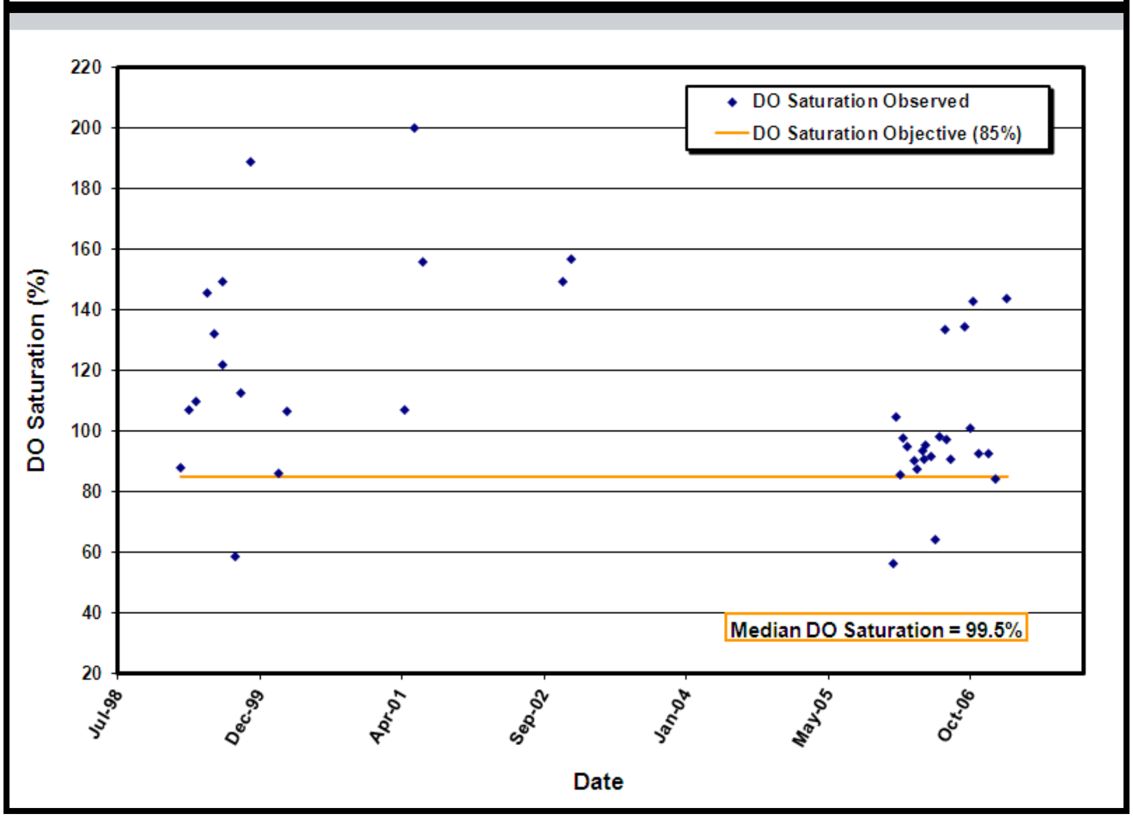


Figure 11. Monthly DO grab samples – Salinas River @ Spreckels.

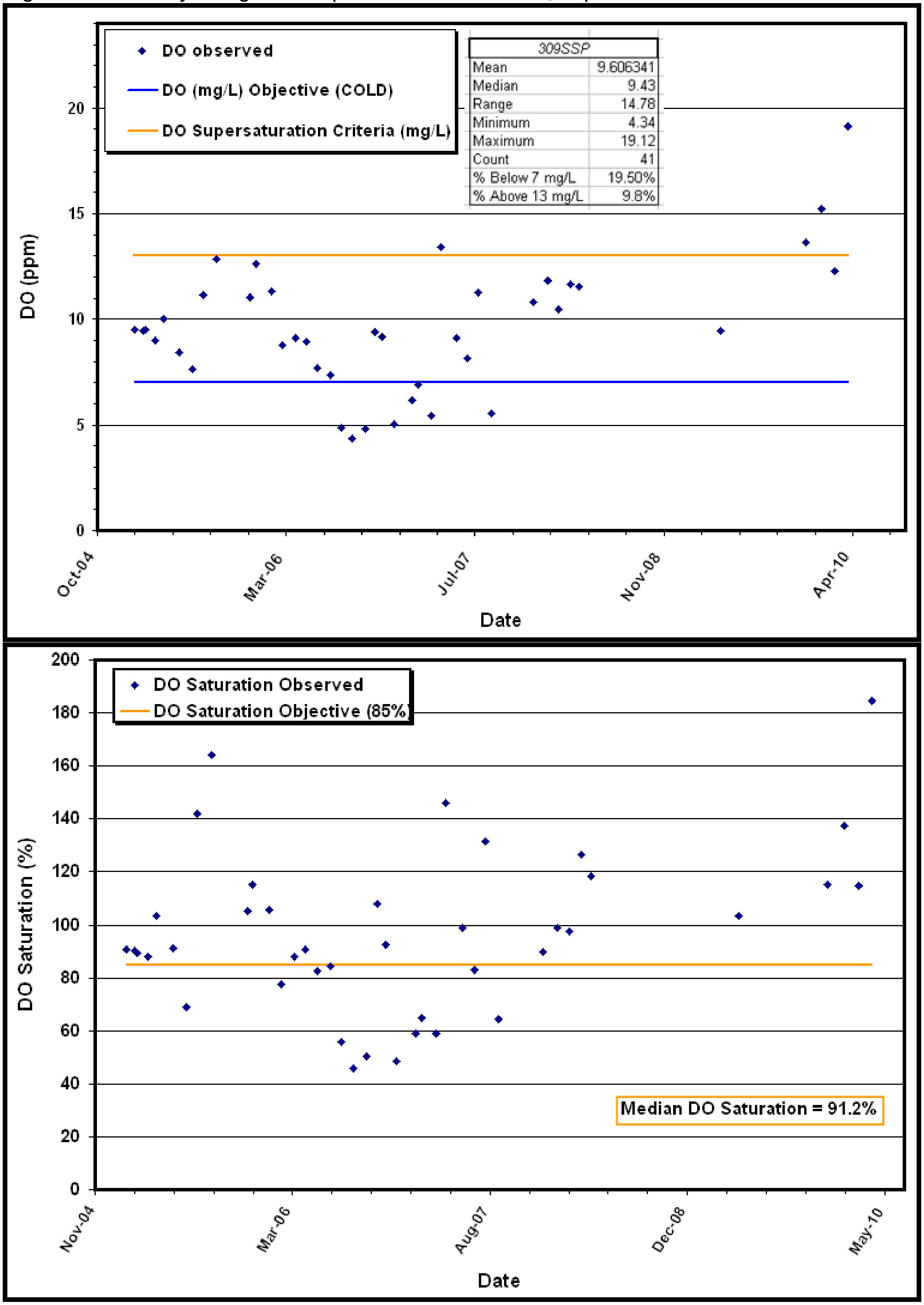


Figure 12. Monthly DO grab samples – Salinas River @ Chualar.

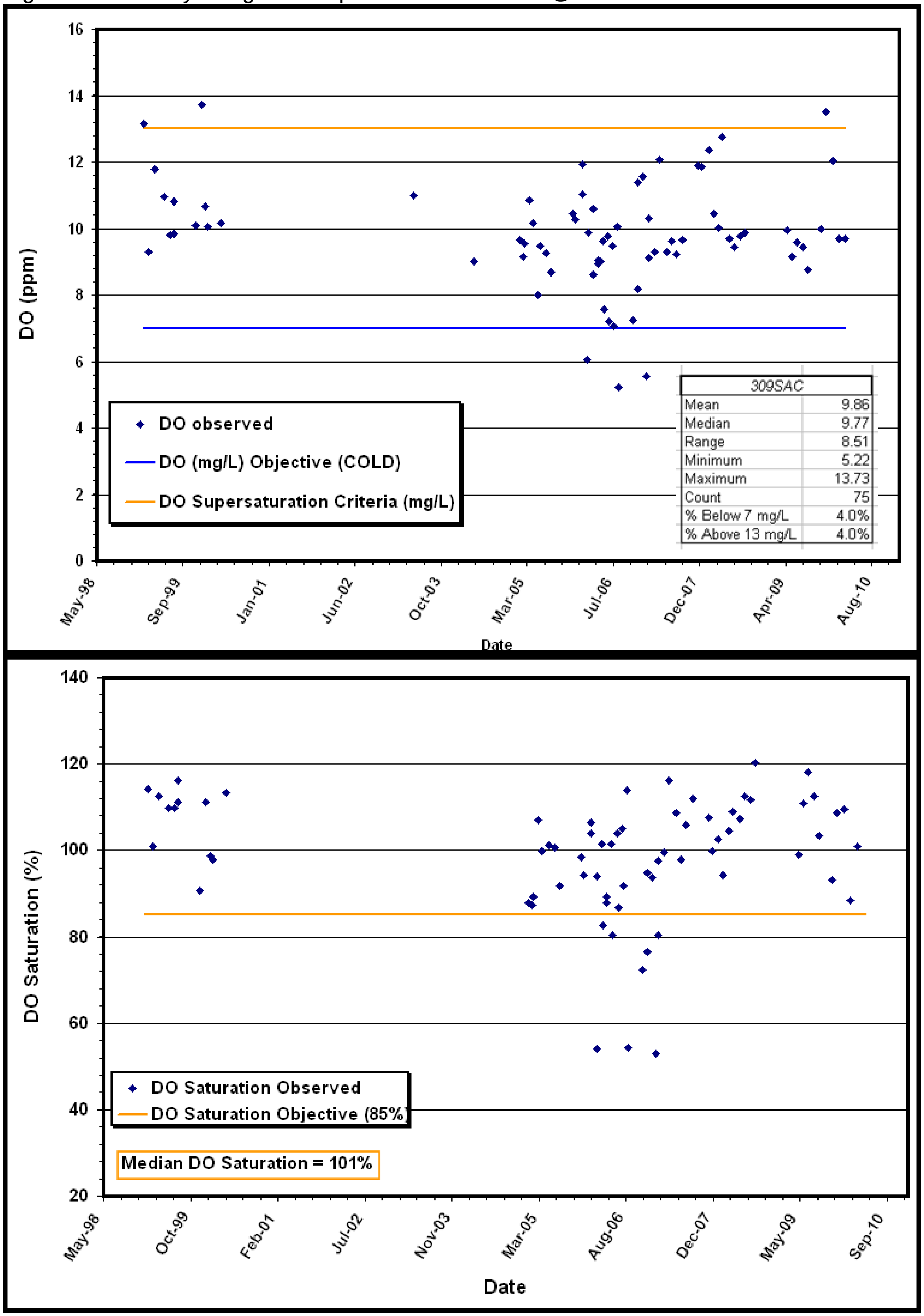
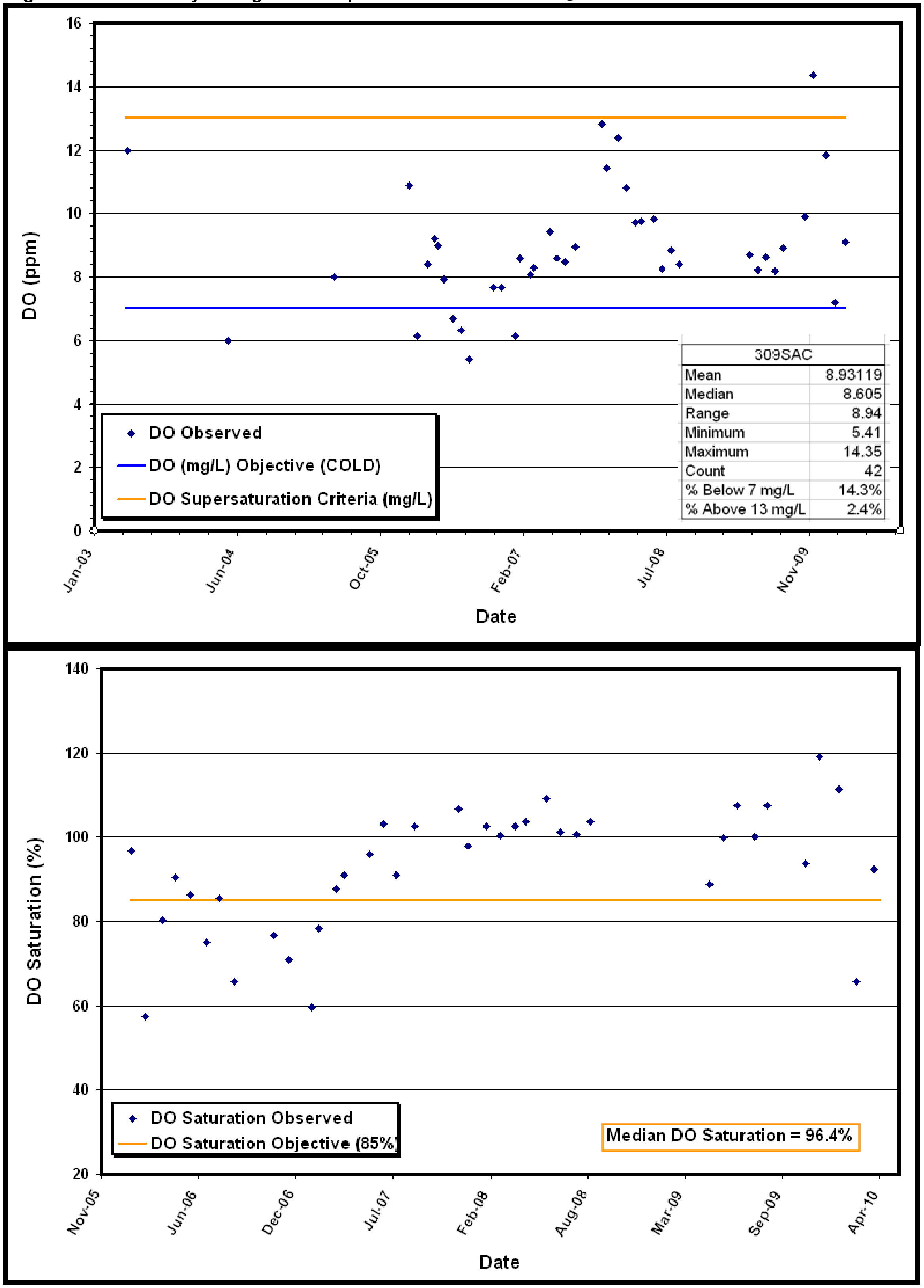


Figure -13. Monthly DO grab samples – Salinas River @ Gonzalez.



C.3.2 Old Salinas River and Lower Salinas River: Nutrients, Chlorophyll a and Algal Cover Data

Figure 14. Nitrate and Chlorophyll a average concentrations, lower Salinas River.

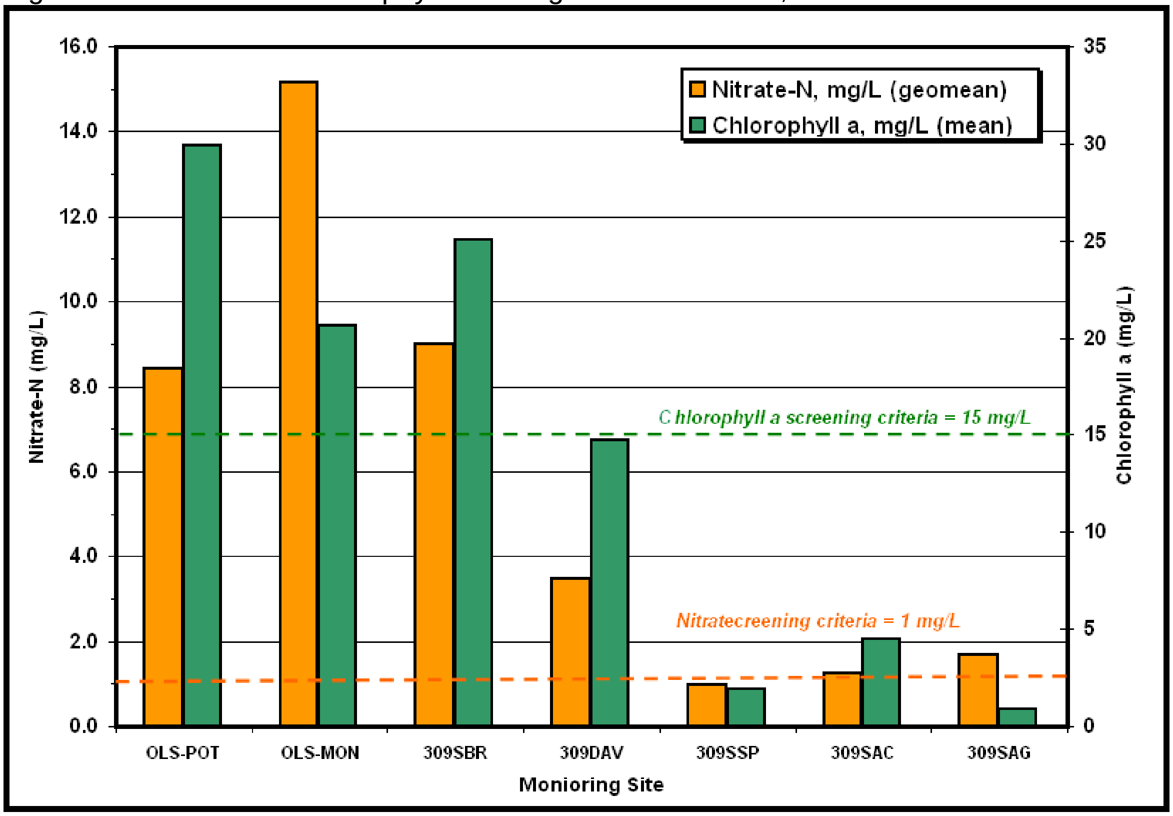


Table 3. % Algal Cover, Old Salinas River and lower Salinas River monitoring sites.

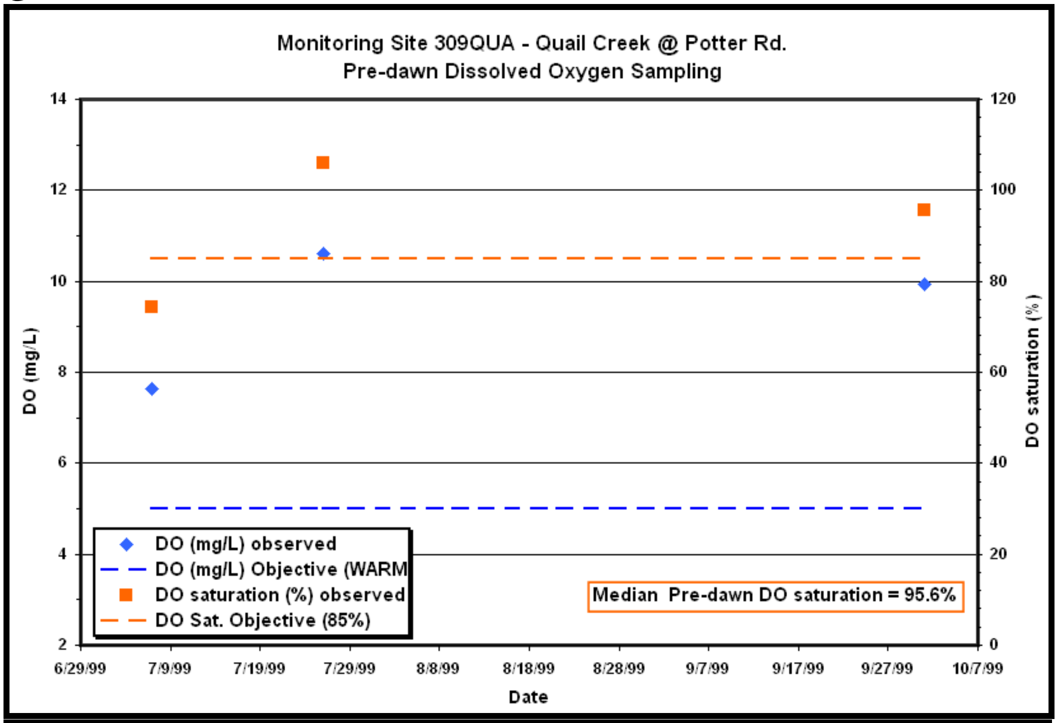
OLS-MON		***309SBR***		***309DAV***		***309SAC***	
Mean	3.93	Mean	0.56	Mean	3.33	Mean	0.75
Minimum	0	Minimum	0	Minimum	0	Minimum	0
Maximum	90	**Maximum**	5	**Maximum**	60	**Maximum**	5
Sum	110	Sum	5	Sum	867	Sum	12
Observations	28	Observations	9	Observations	40	Observations	16

Figure 15. Nitrate and Chlorophyll a average concentrations, Old Salinas River.

C.4 Lower Salinas River Tributaries – Quail Creek, Chualar Creek, Blanco Drain

C.4.1 Dissolved Oxygen, Nutrient, Chlorophyll *a*, and Algal Cover Data

Figure 16. Pre-dawn dissolved oxygen monitoring, and monthly DO grab samples – Quail Creek @ Potter Rd.



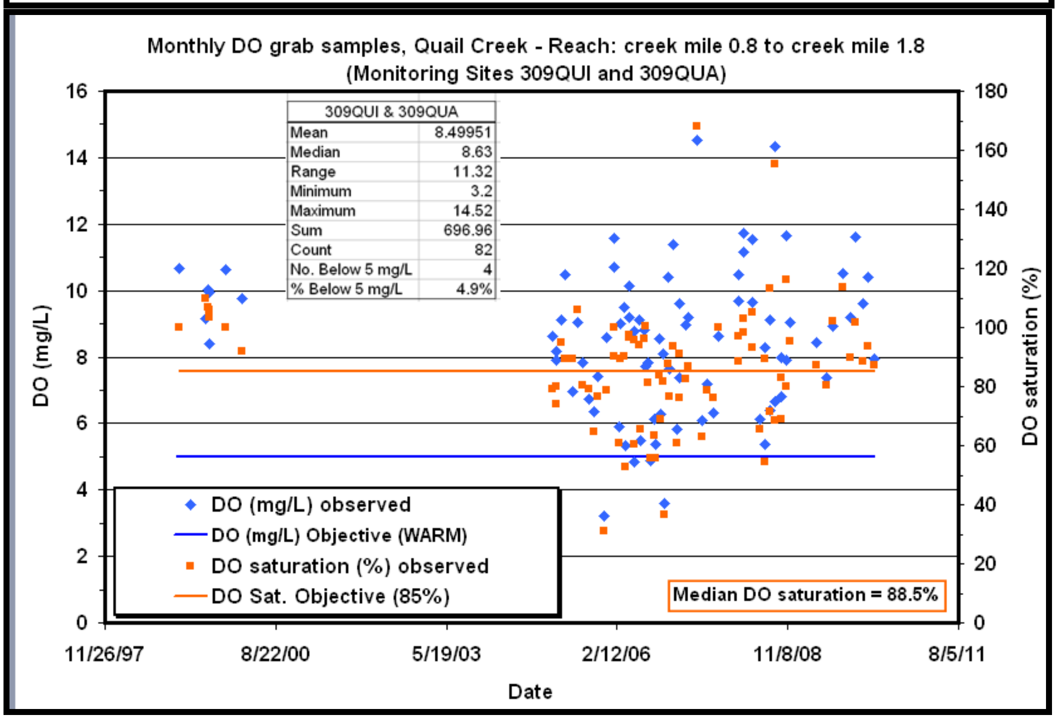
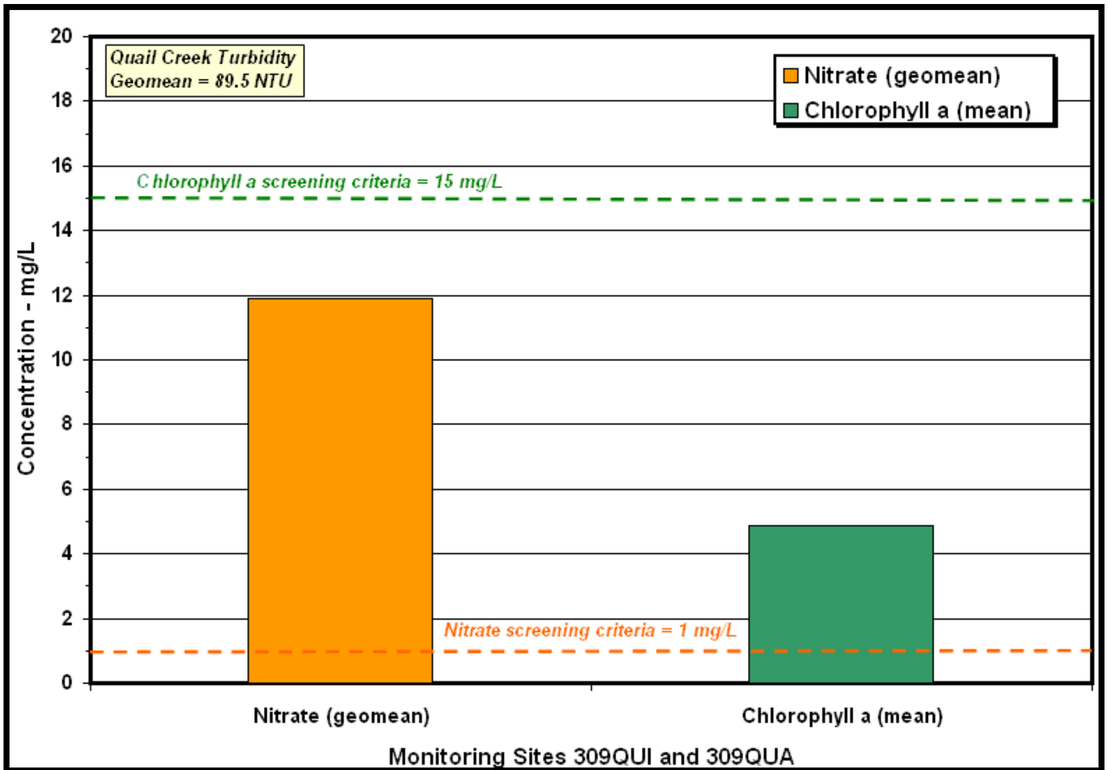


Figure 17. Nitrate and Chlorophyll *a* average concentrations, Quail Creek; and percent algal cover statistics.



309QUI and 309QUA % Algal Cover	
Mean	14.81
Median	0
Range	100
Minimum	0
Maximum	100
Observations	26

Figure 18. Monthly DO grab samples – Chualar Creek

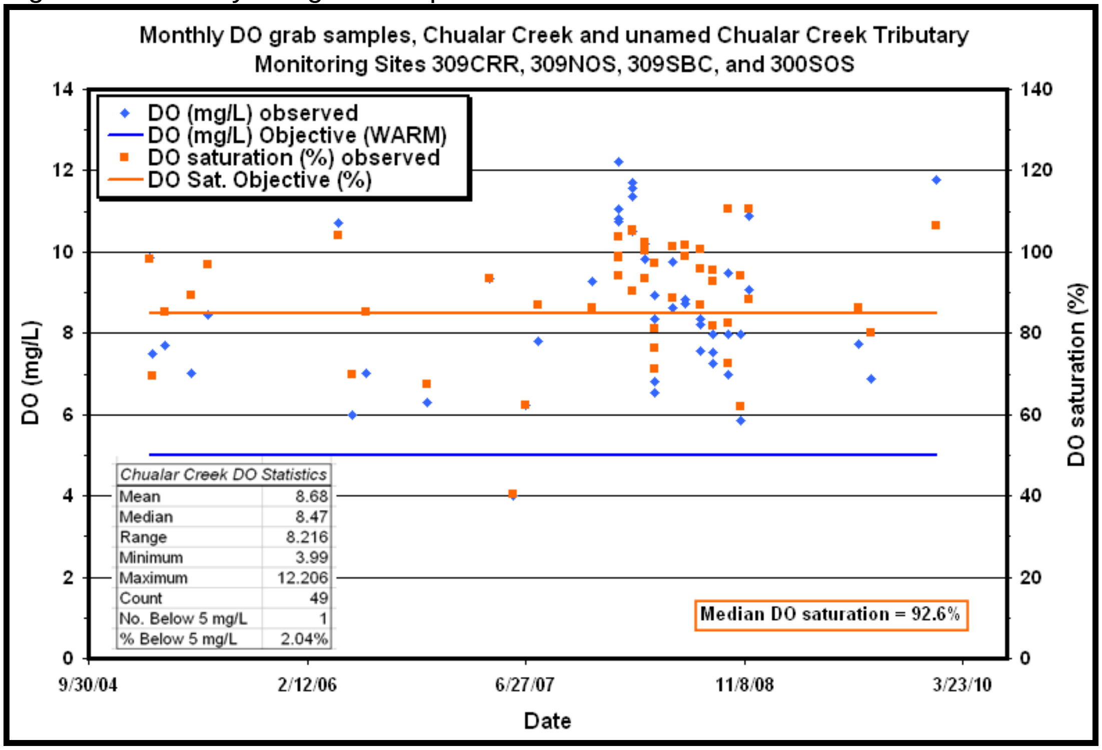
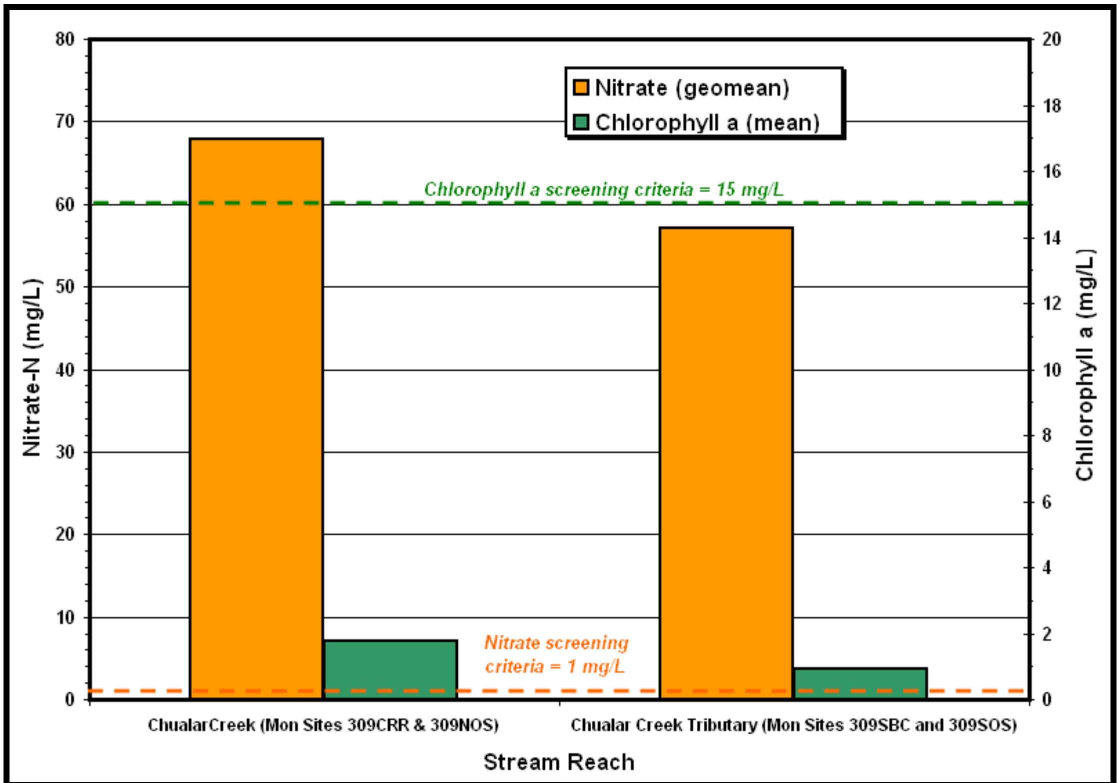


Figure 19. Nitrate and Chlorophyll *a* average concentrations, Chualar Creek; and percent algal cover statistics.



Site 309CRR % Algal Cover	
Mean	0
Median	0
Range	0
Minimum	0
Maximum	0
Observations	12

Figure 20. Monthly DO grab samples – Blanco Drain

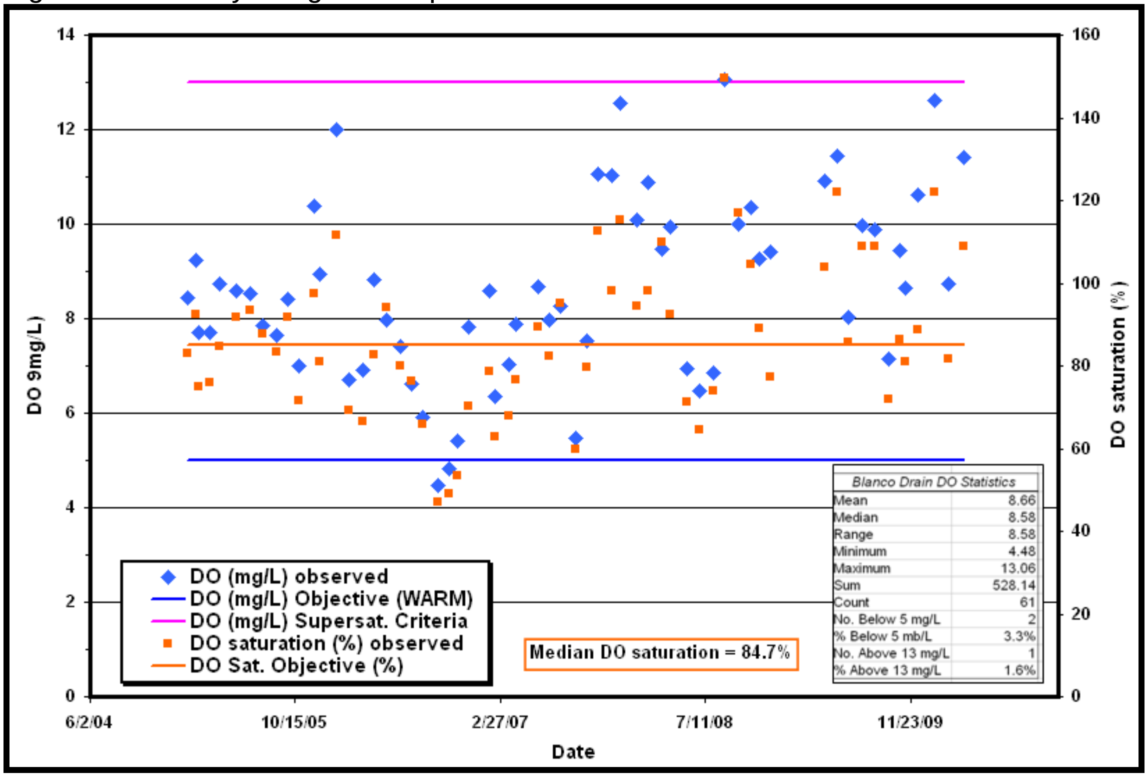
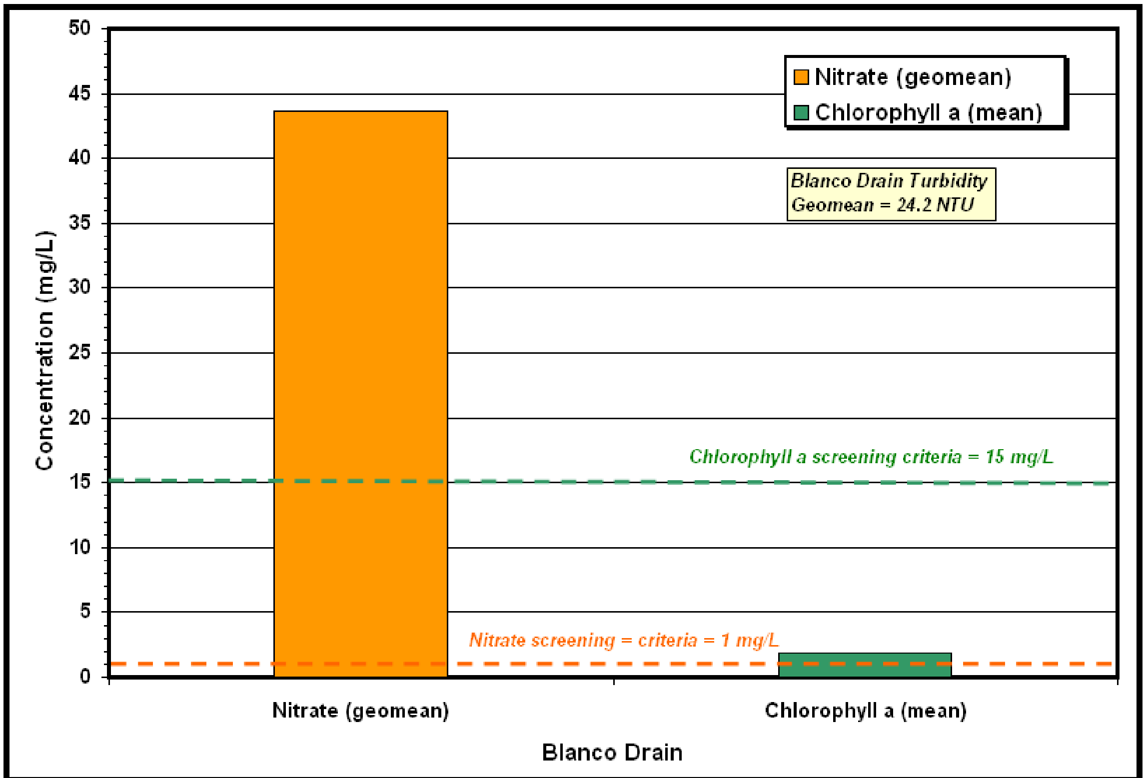


Figure 21. Nitrate and Chlorophyll *a* average concentrations, Blanco Drain; and percent algal cover statistics.



Site BLA-PUM % Algal Cover	
Mean	64.64
Median	90
Range	100
Minimum	0
Maximum	100
Observations	14

C.5 Reclamation Canal-Tembladero Slough

C.5.1 Dissolved Oxygen: Diel Data, Pre-dawn Sampling, and Grab Samples

Figure 22. Diel Data Tembladero Slough @ Molera Rd. Aug 18-19, 2004.

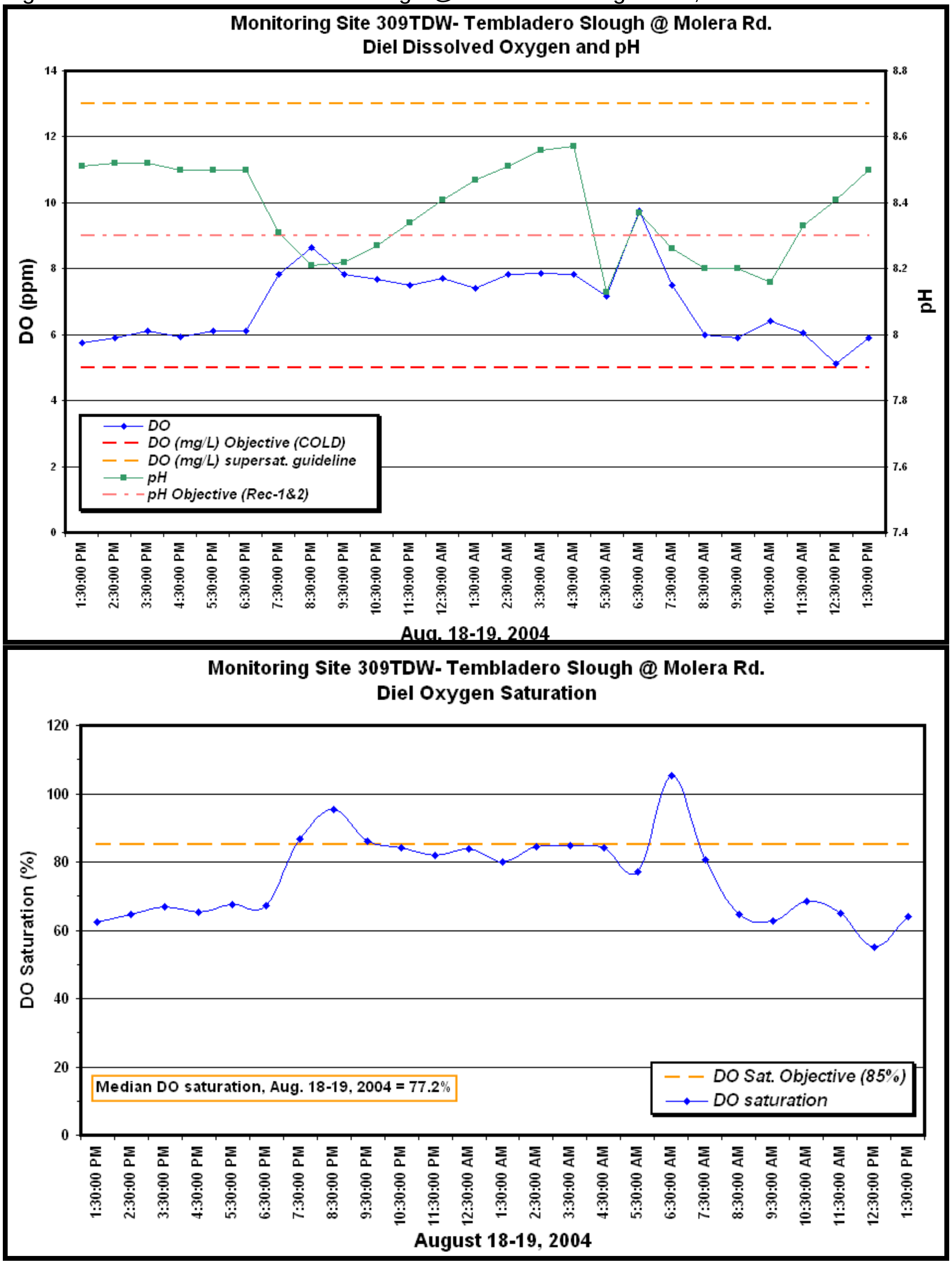
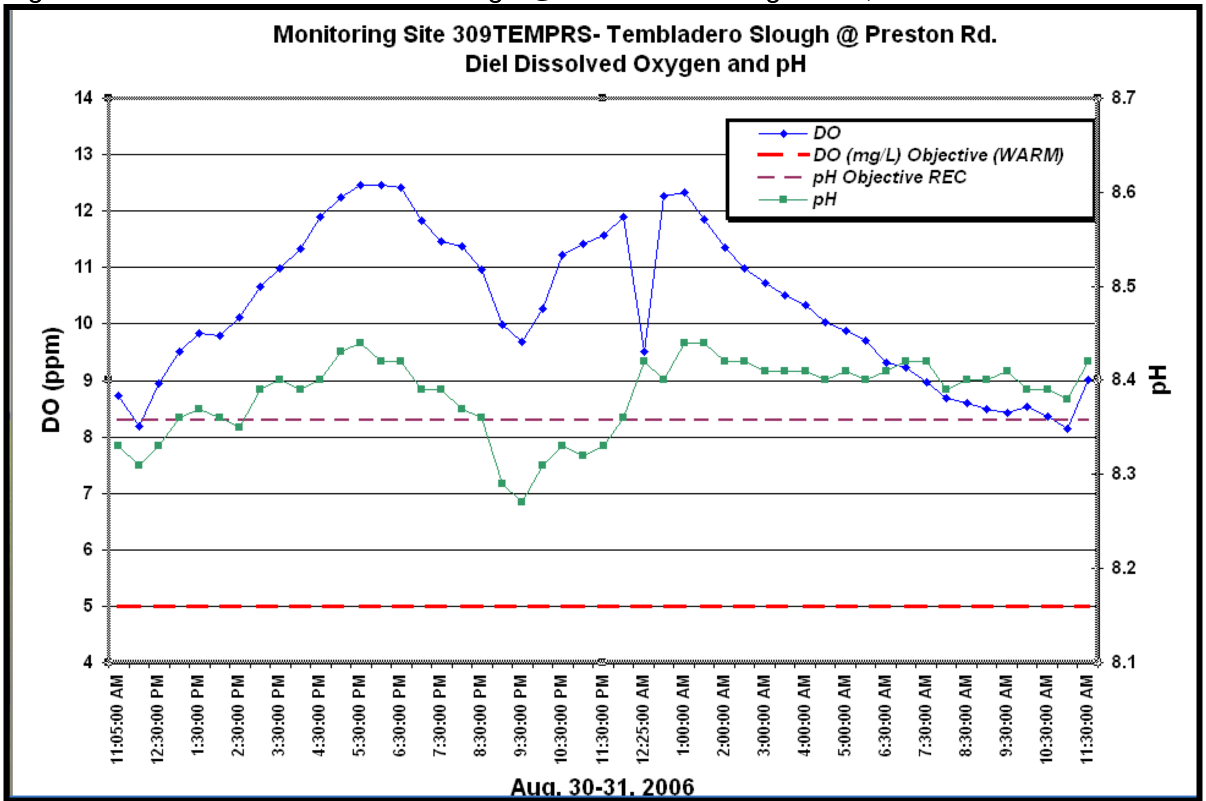


Figure23. Diel Data Tembladero Slough @ Preston Rd. Aug 30-31, 2006.



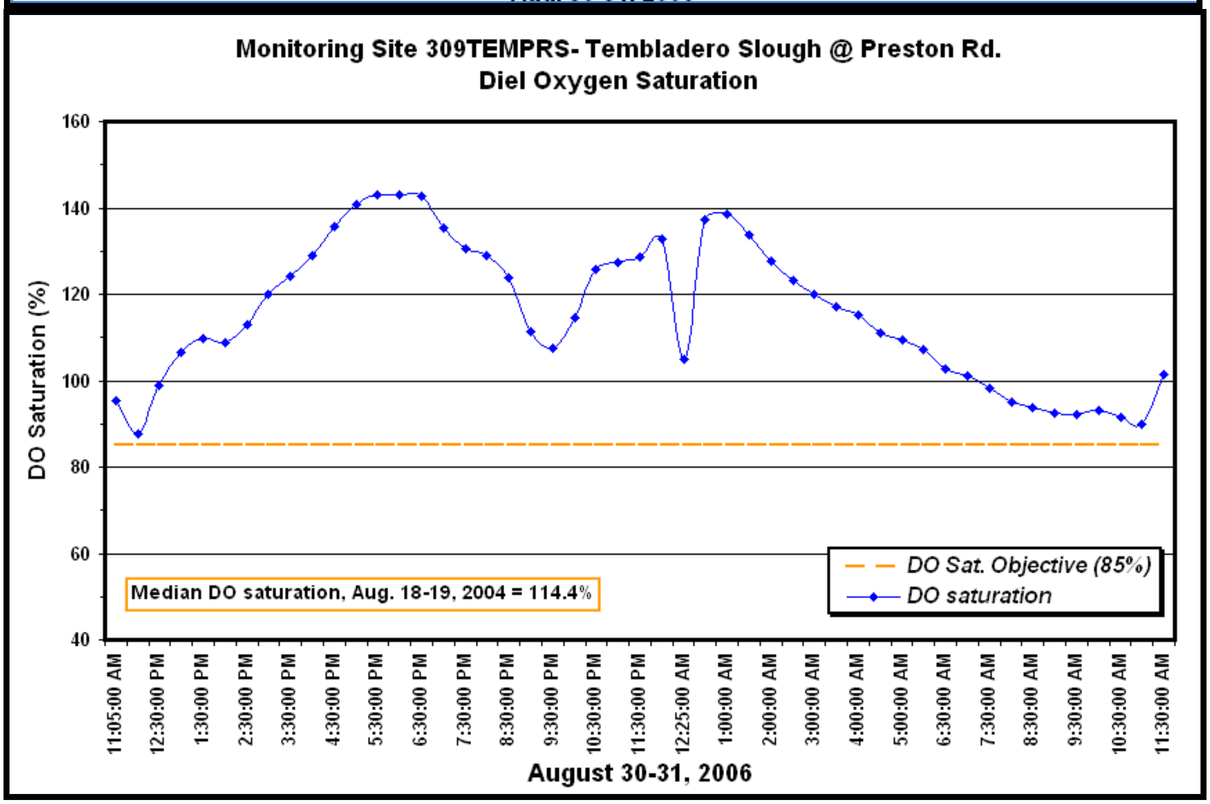


Figure 24. Monthly DO grab samples – Tembladero Slough @ 309TDW

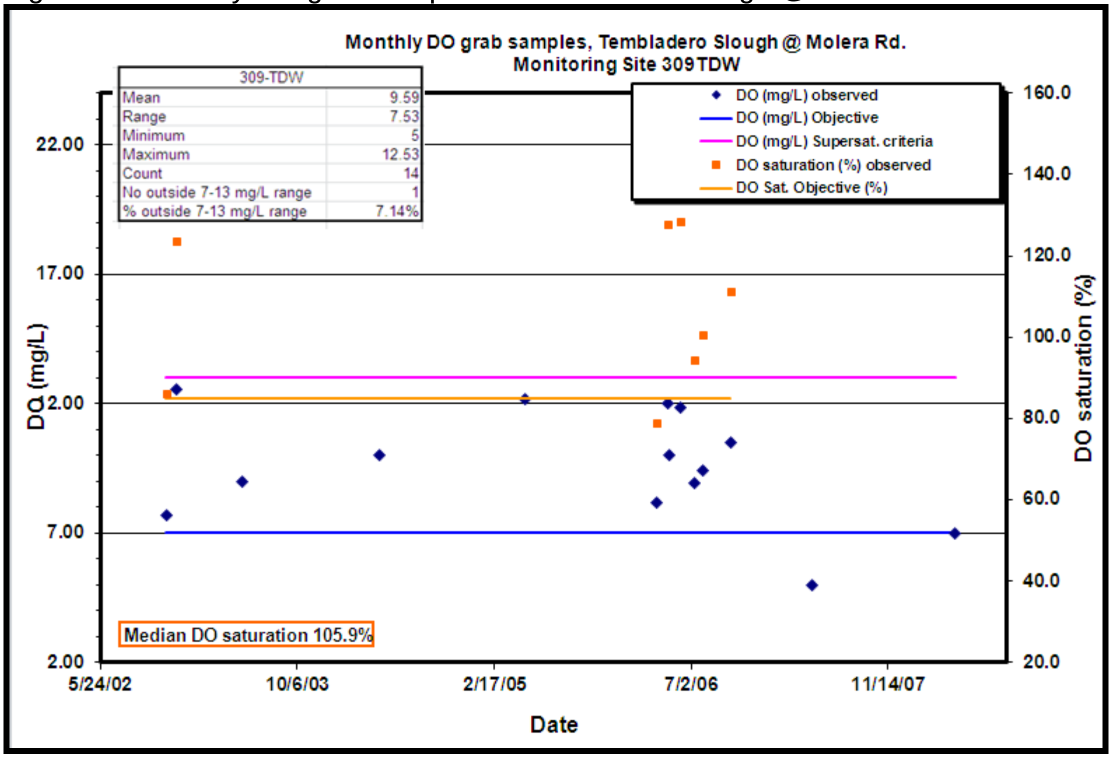


Figure 25. Monthly DO grab samples – Tembladero Slough @ 309TEMPRS.

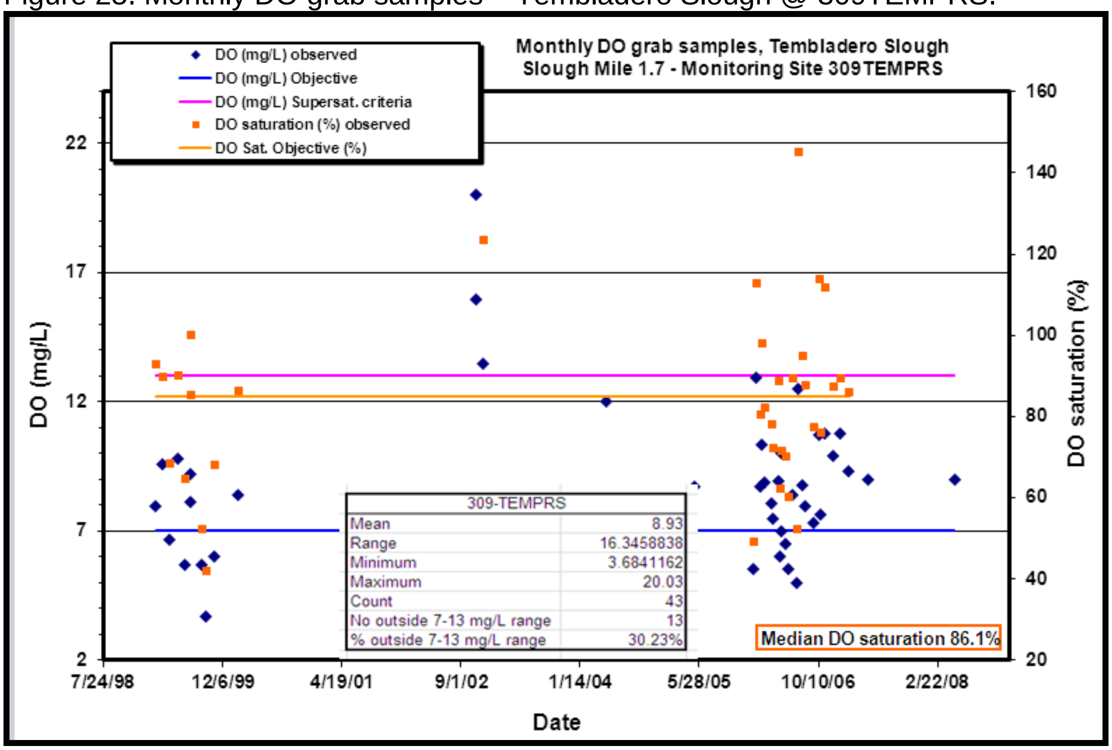


Figure 26. Monthly DO grab samples – Tembladero Slough @ 309TEH.

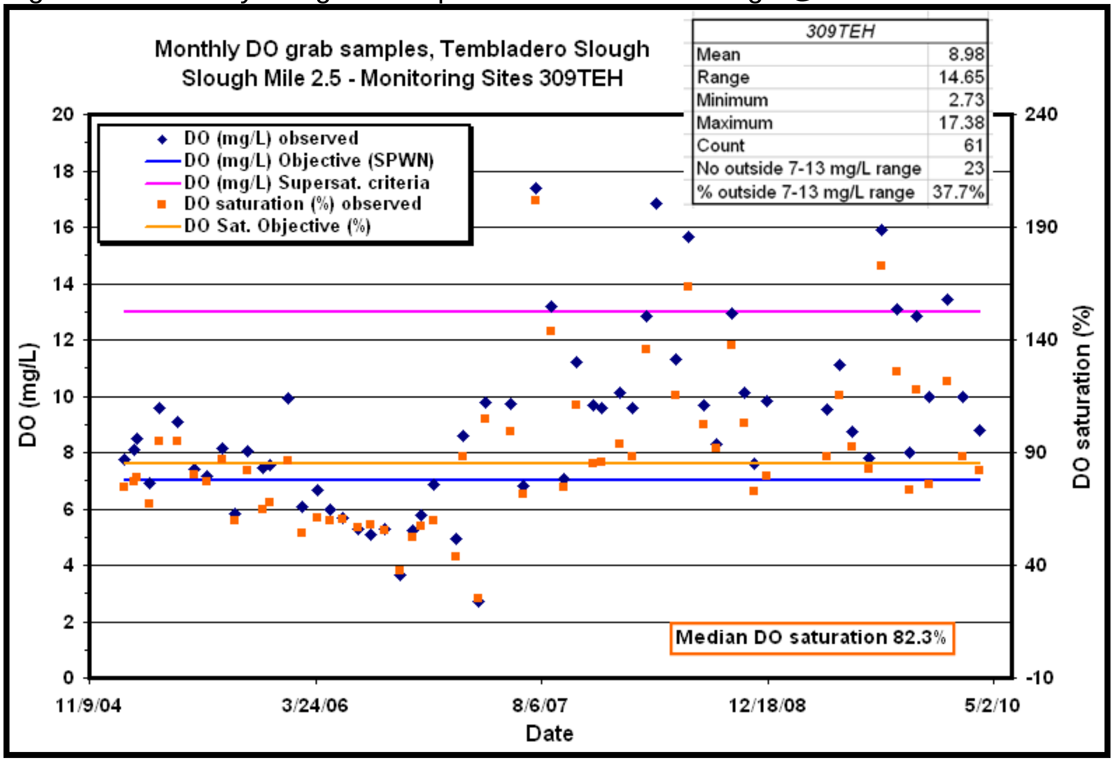


Figure 27. Monthly DO grab samples – Merritt Ditch @ 309MER.

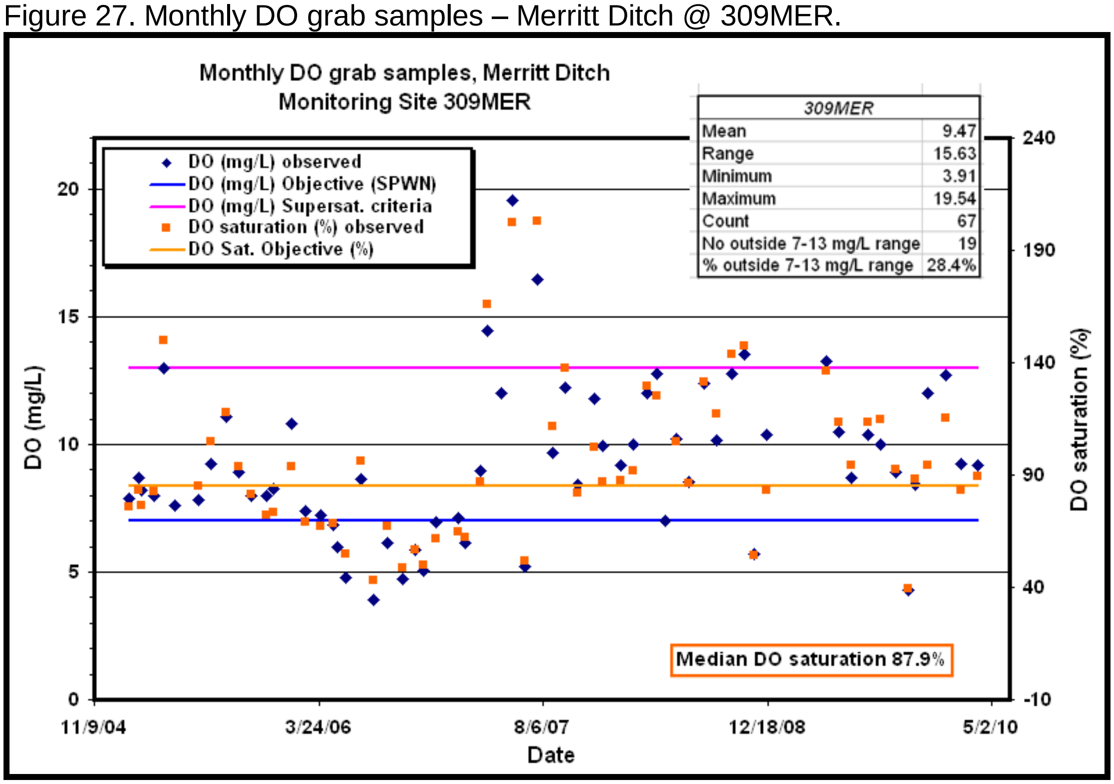


Figure 28 Diel Data Reclamation Canal @ Boronda Rd. Aug 30-31, 2006.

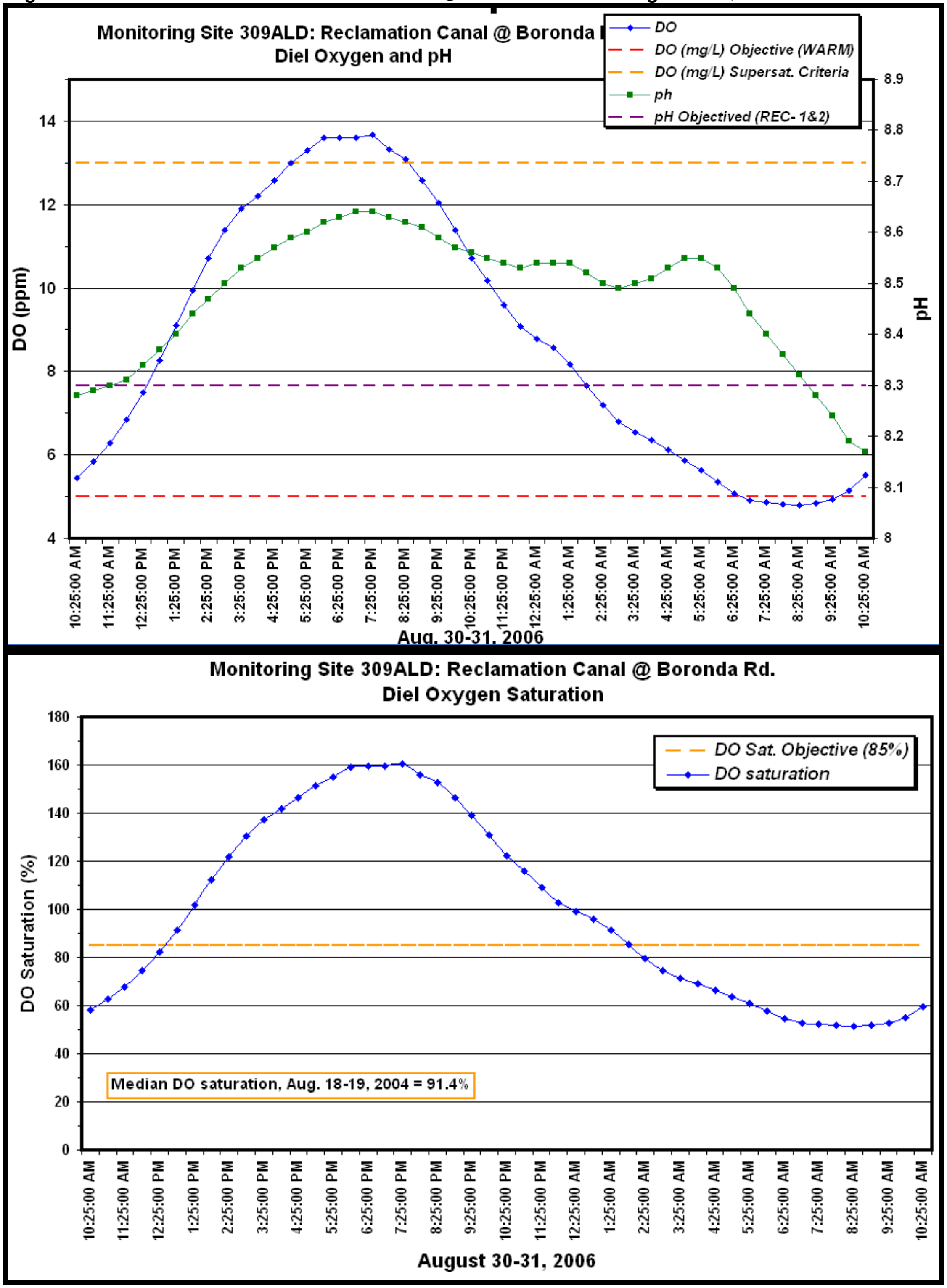


Figure 29. Pre-dawn dissolved oxygen monitoring – Reclamation Canal @ Airport Rd.

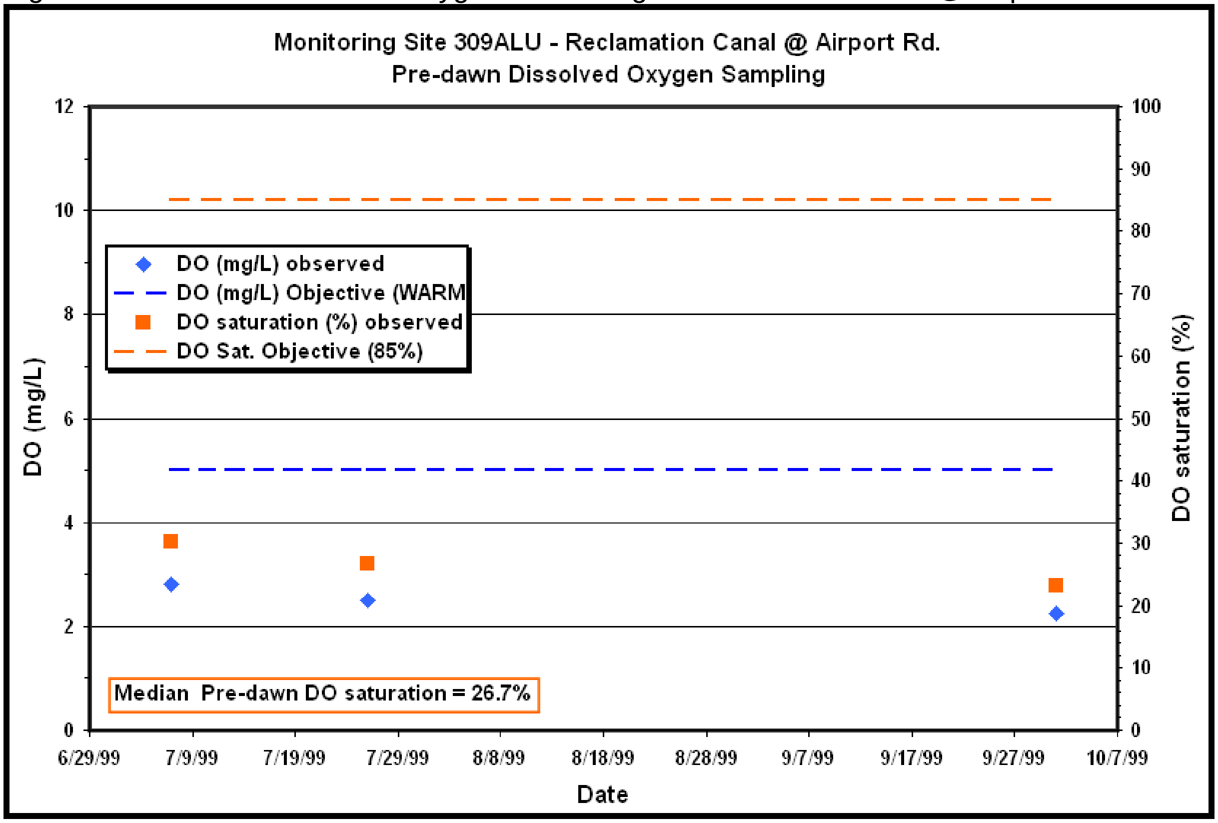
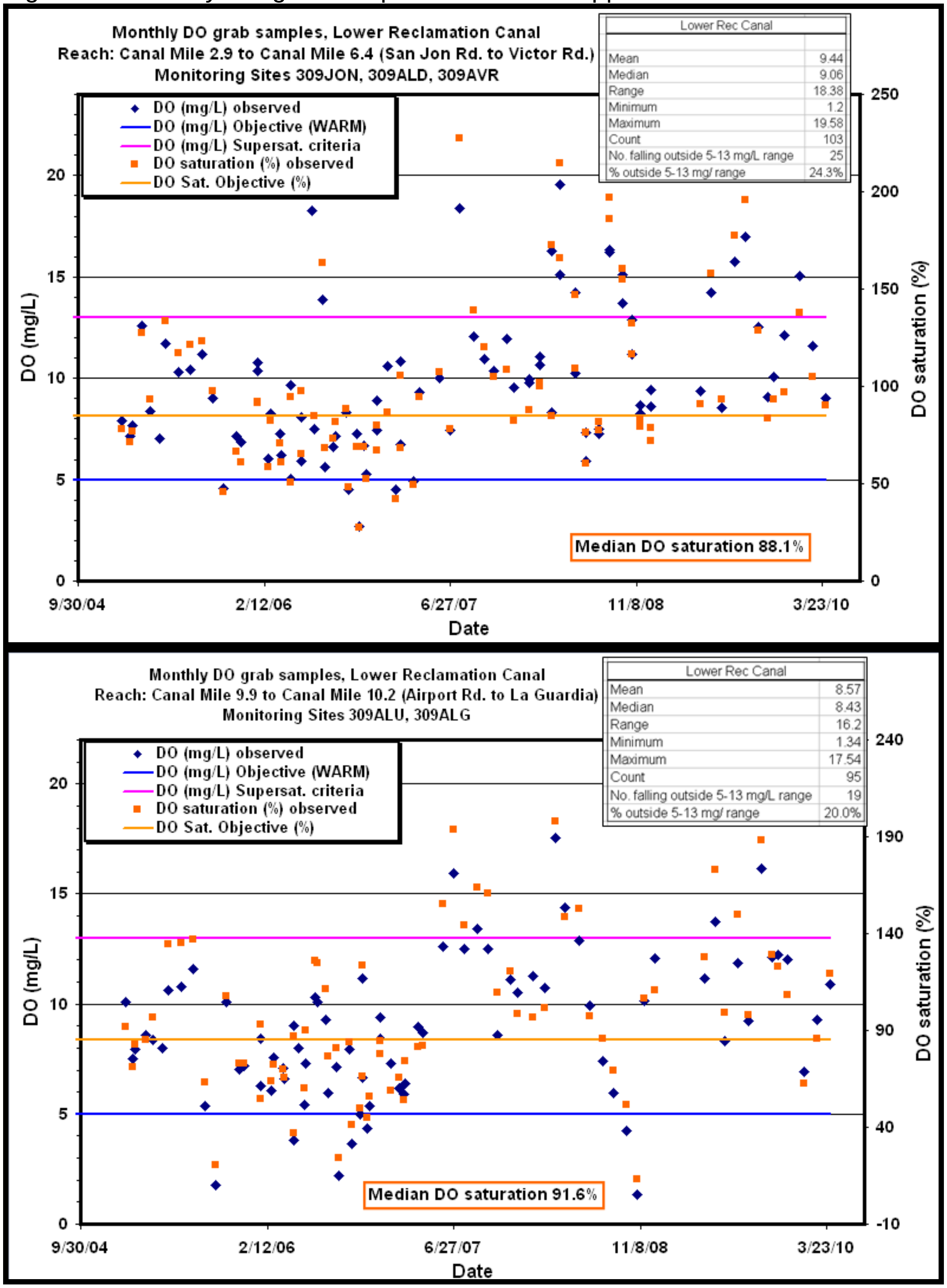
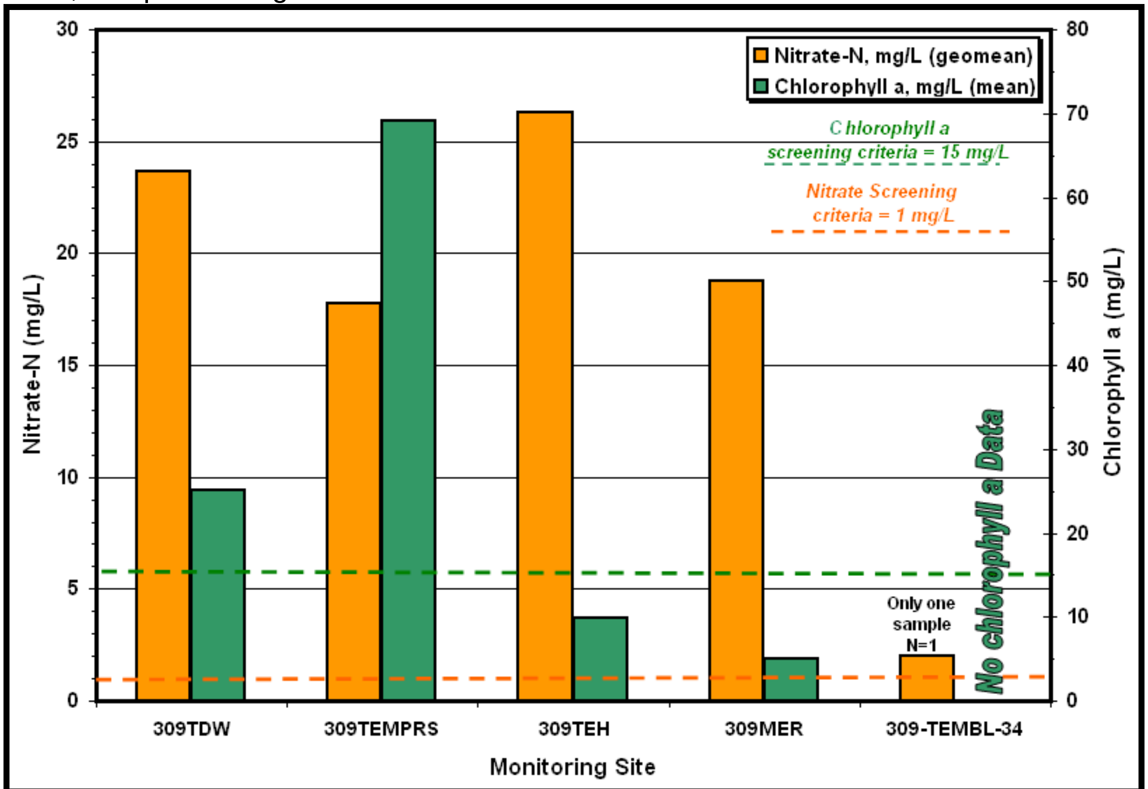


Figure 30. Monthly DO grab samples – lower and upper Reclamation Canal.



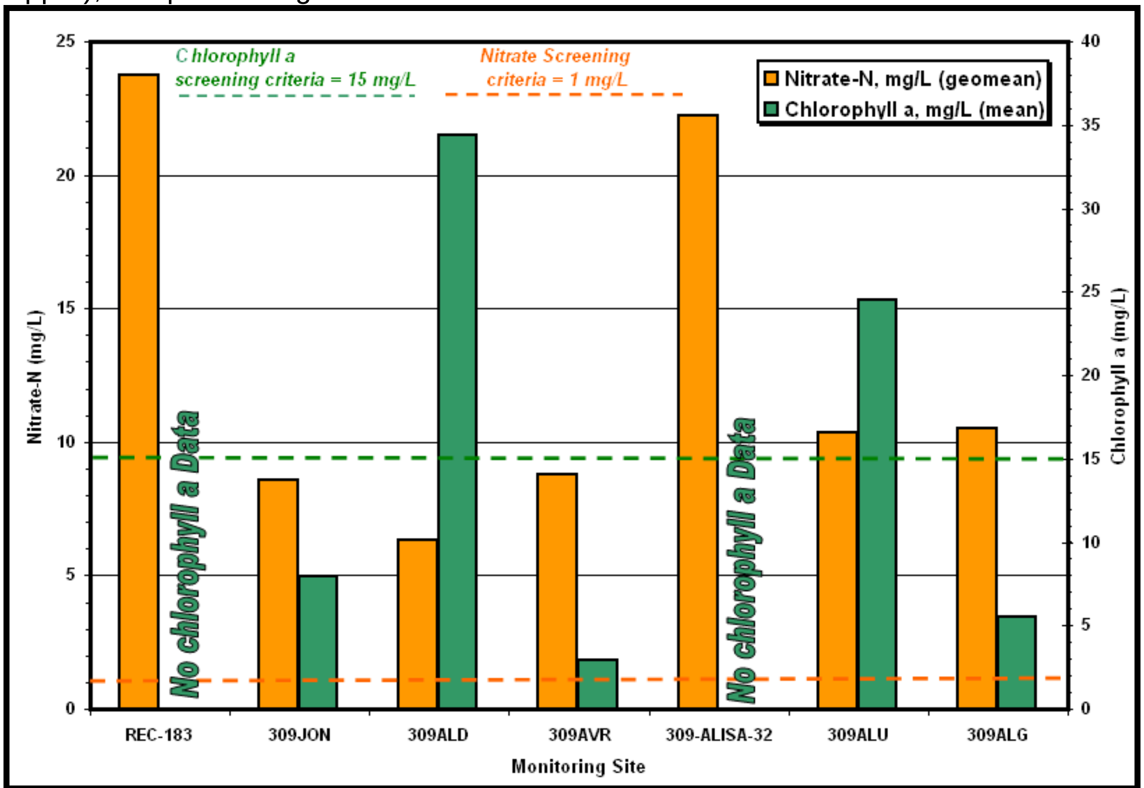
C.5.2 Nutrients, Chlorophyll *a* and Algal Cover Data

Figure 31. Nitrate and Chlorophyll *a* average concentrations, Tembladero Slough and Merritt Ditch; and percent algal cover statistics.



309TDW-Algal Cover	309TEM-Algal Cover		309TEH-Algal Cover		309MER-Algal Cover	
no data	Mean	0.00	Mean	0.00	Mean	35
	Range	0	Range	0	Range	100
	Minimum	0	Minimum	0	**Minimum**	0
	Maximum	0	**Maximum**	0	**Maximum**	100
	Observations	14	Observations	11	Observations	13

Figure 32. Nitrate and Chlorophyll *a* average concentrations, Reclamation Canal (Lower and Upper); and percent algal cover statistics.



309JON-Lower Rec Canal		***309ALD-Lower Rec Canal***		***309ALU-Upper Rec Canal***		***309ALG-Upper Rec Canal***	
Mean	23.75	Mean	0.92	Mean	0.14	Mean	13.57
Range	75	Range	10	Range	2	Range	50
Minimum	0	Minimum	0	Minimum	0	Minimum	**0**
Maximum	75	**Maximum**	10	**Maximum**	2	**Maximum**	50
Observations	12	Observations	13	Observations	14	Observations	14

C.6 Reclamation Canal Tributaries – Espinosa Slough, Santa Rita Creek, Gabilan Creek, Natividad Creek, Alisal Creek, Alisal Slough

C.6.1 Dissolved Oxygen: Pre-dawn Sampling, and Grab Samples

Figure 33. Monthly DO grab samples – Espinosa Slough.

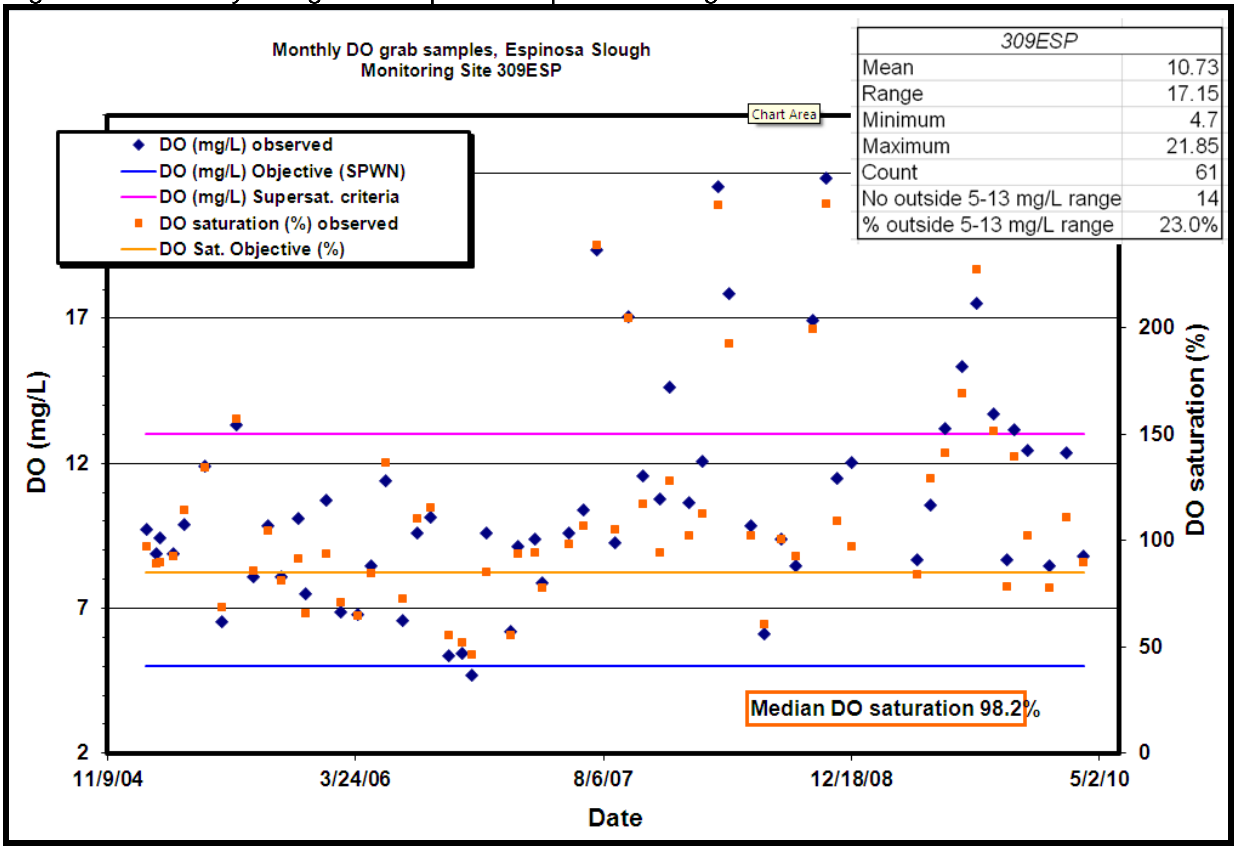


Figure 34. Monthly DO grab samples – Alisal Slough.

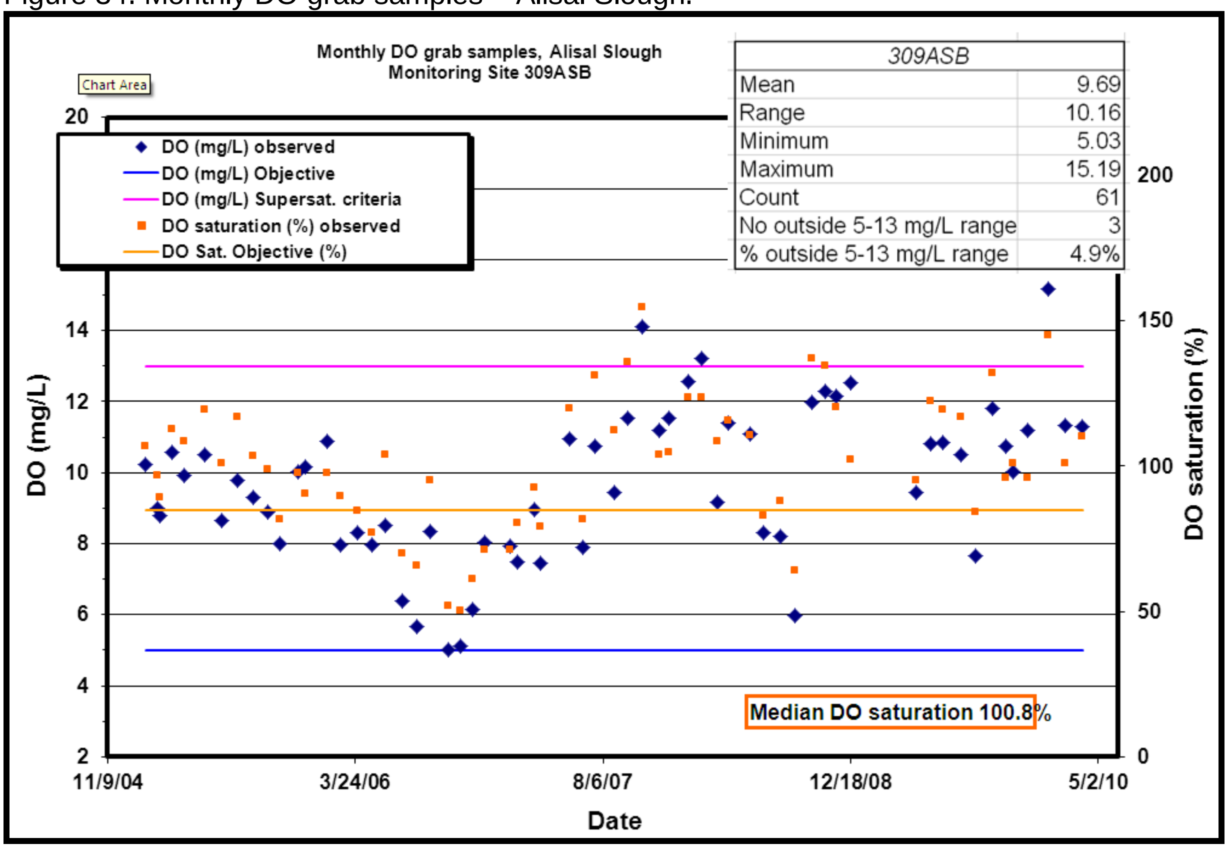


Figure 35. Monthly DO grab samples – Santa Rita Creek.

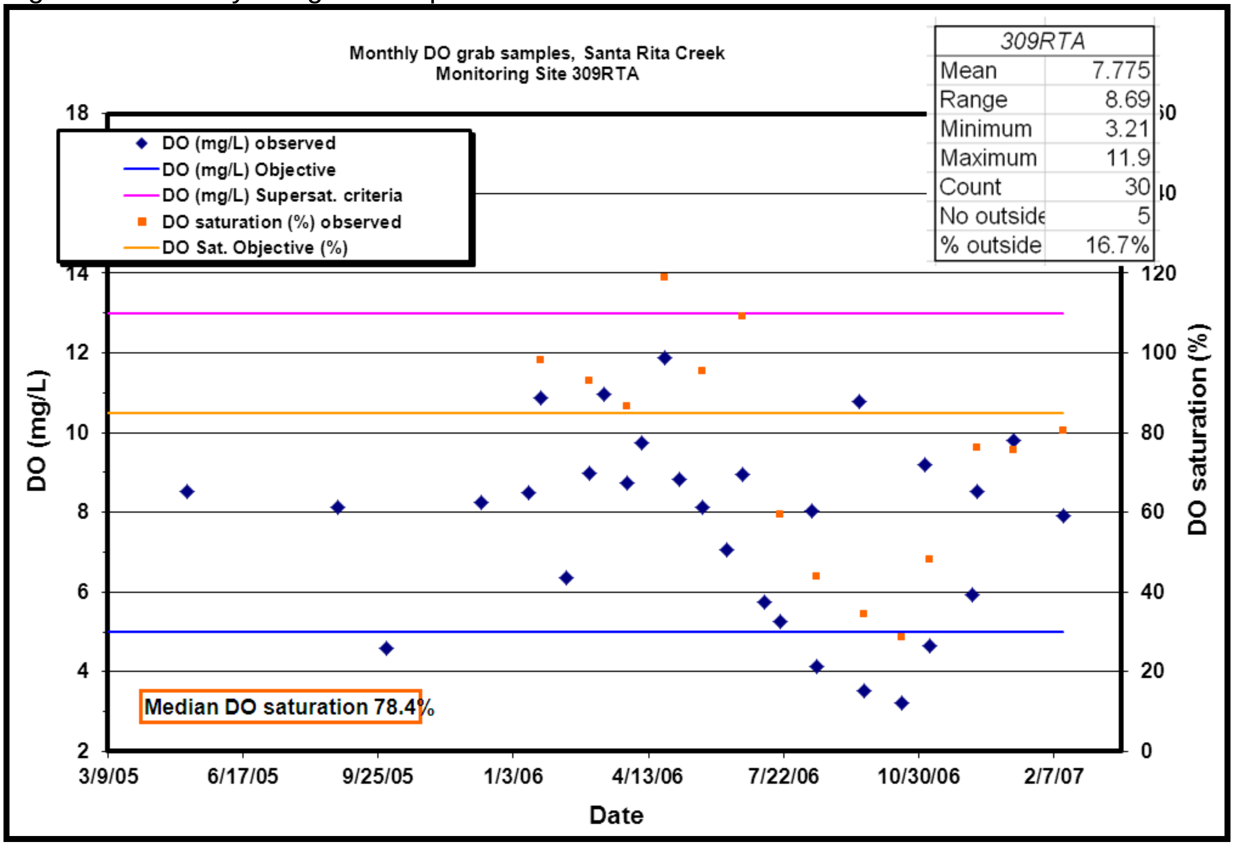


Figure 36. Monthly DO grab samples – Gabilan Creek.

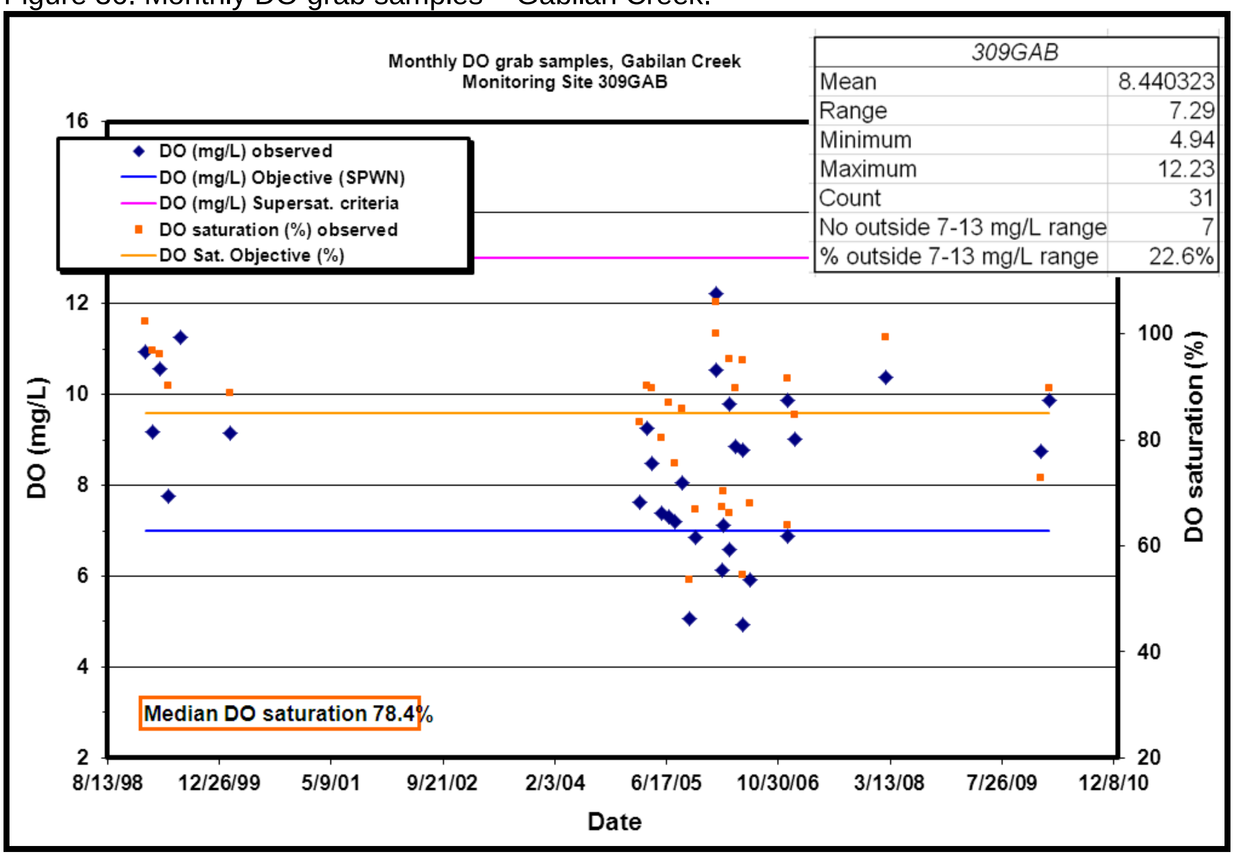


Figure 37. Monthly DO grab samples – Natividad Creek.

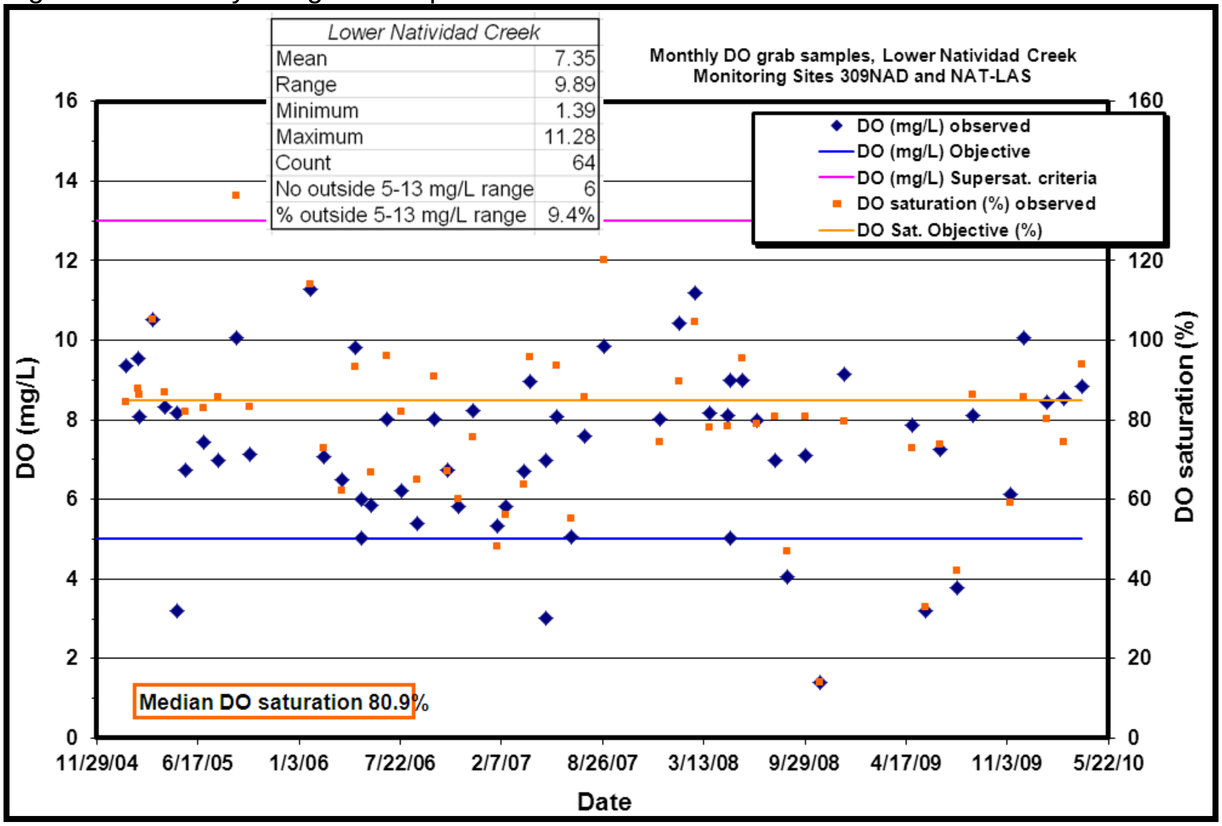
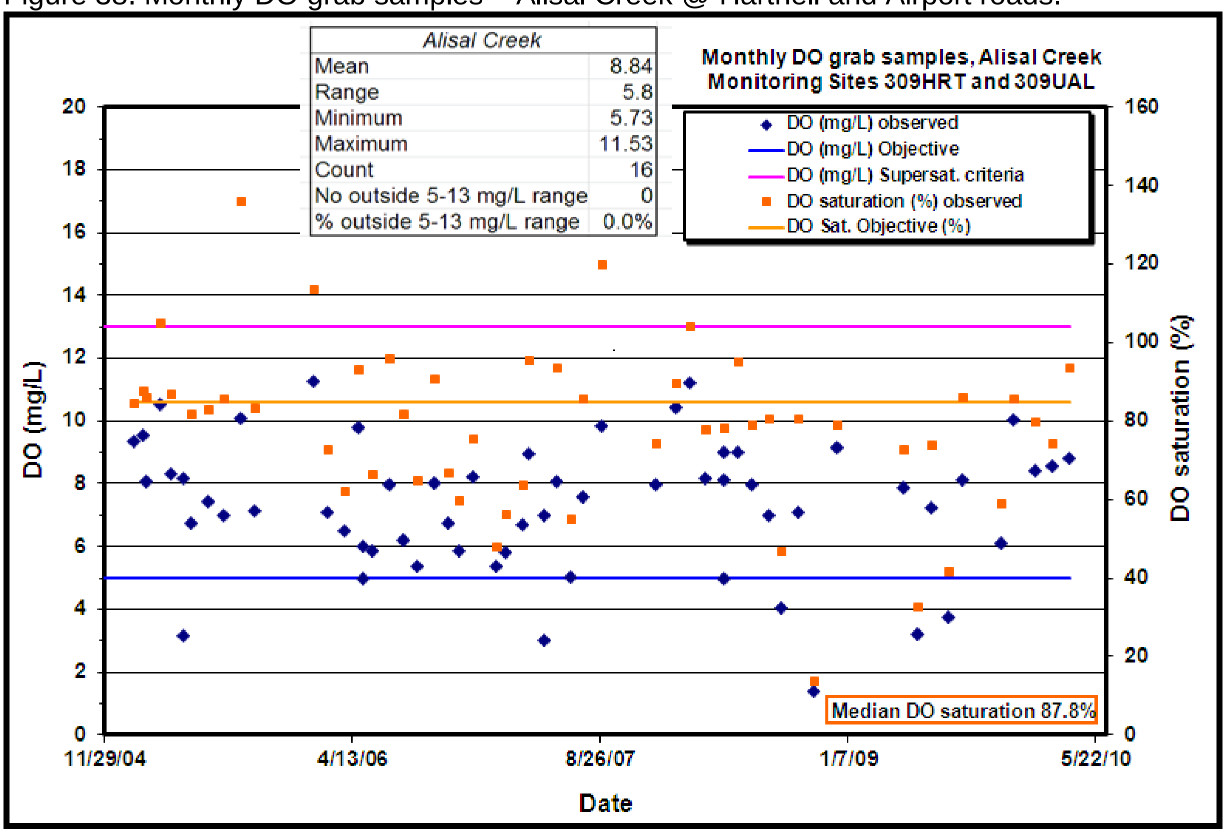
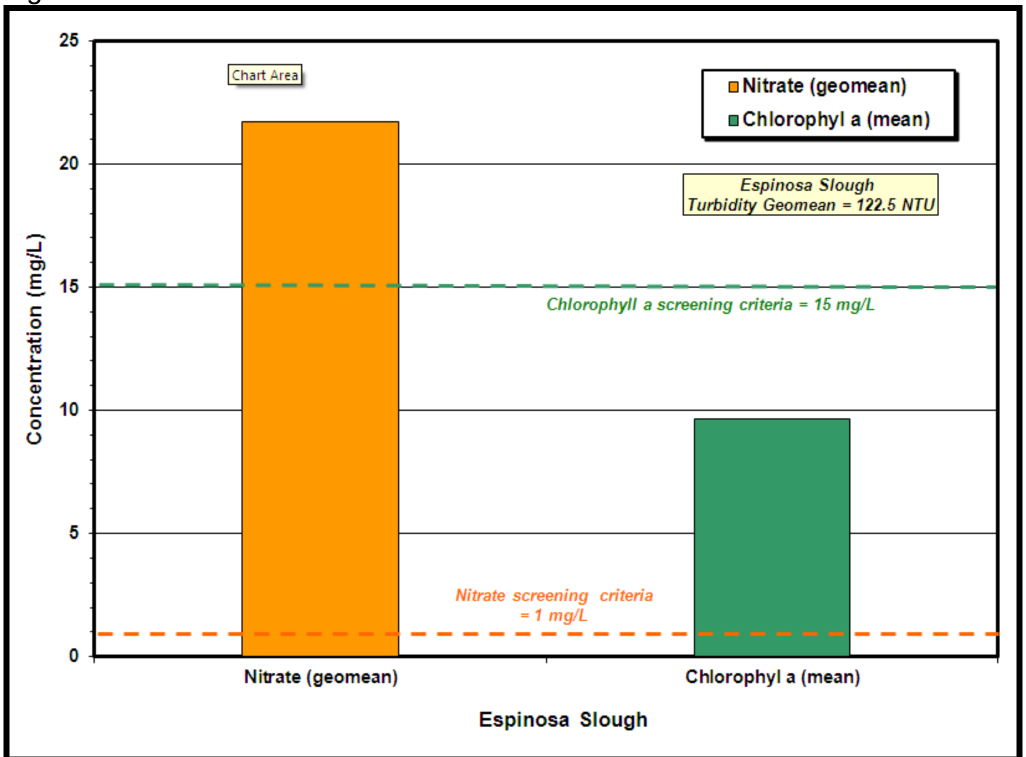


Figure 38. Monthly DO grab samples – Alisal Creek @ Hartnell and Airport roads.



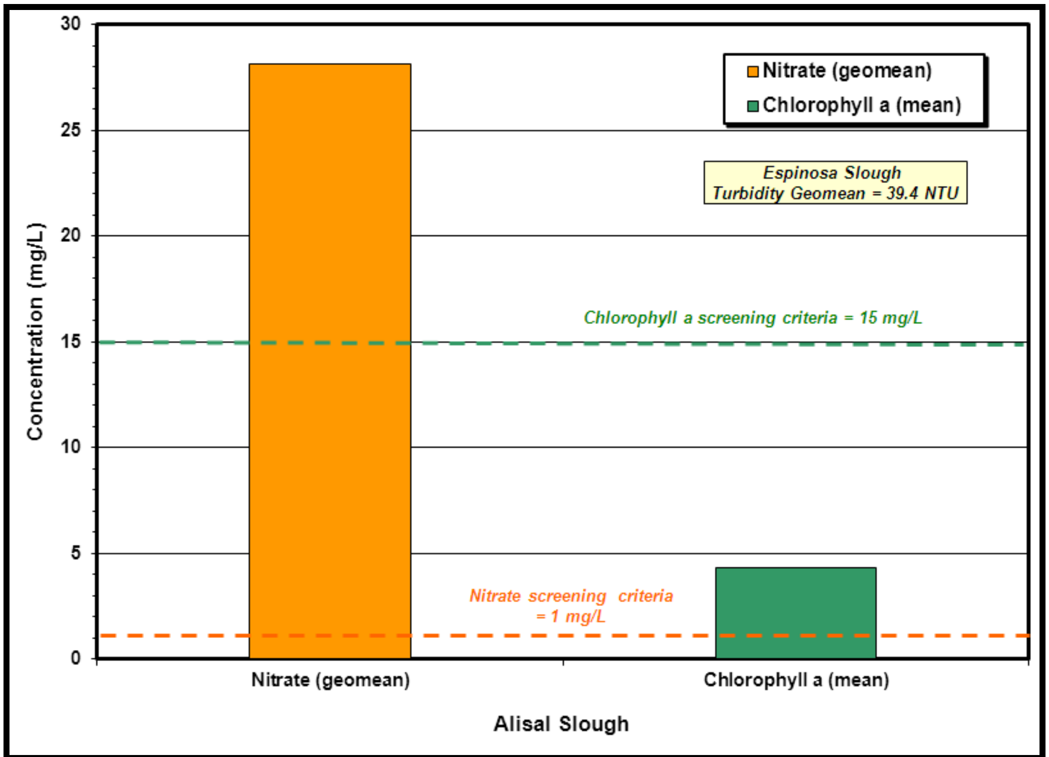
C.6.2 Nutrients, Chlorophyll *a* and Algal Cover Data

Figure 39. Nitrate and Chlorophyll *a* average concentrations, Espinosa Slough; and percent algal cover statistics.



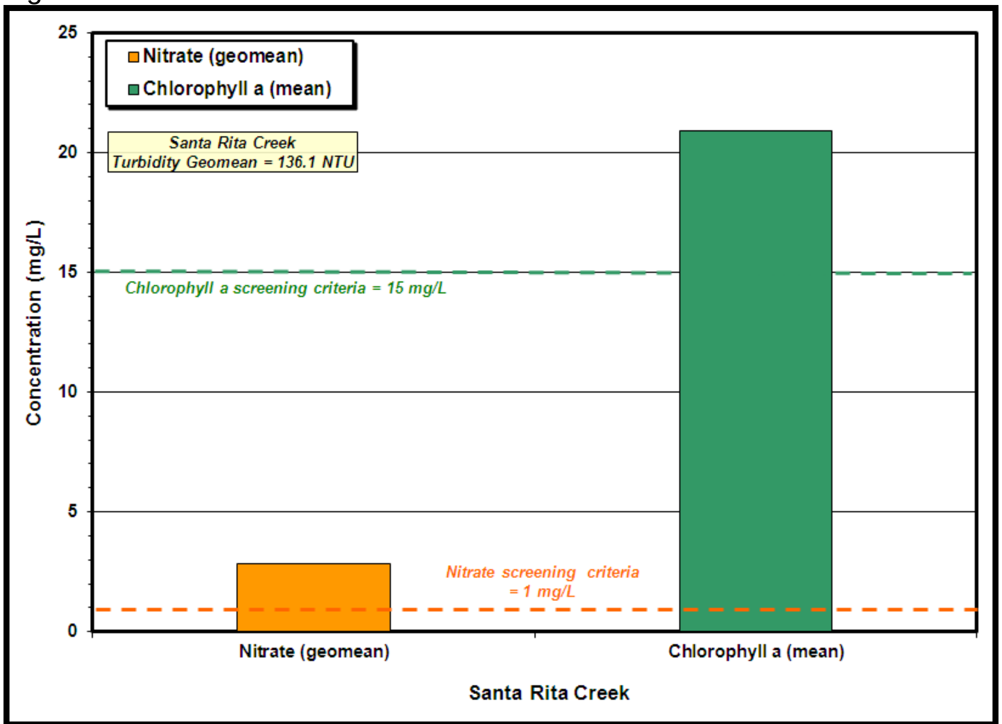
309ESP- % Algal Cover	
Mean	0.00
Range	0
Minimum	0
Maximum	0
Observations	12

Figure 40. Nitrate and Chlorophyll *a* average concentrations, Alisal Slough; and percent algal cover statistics.



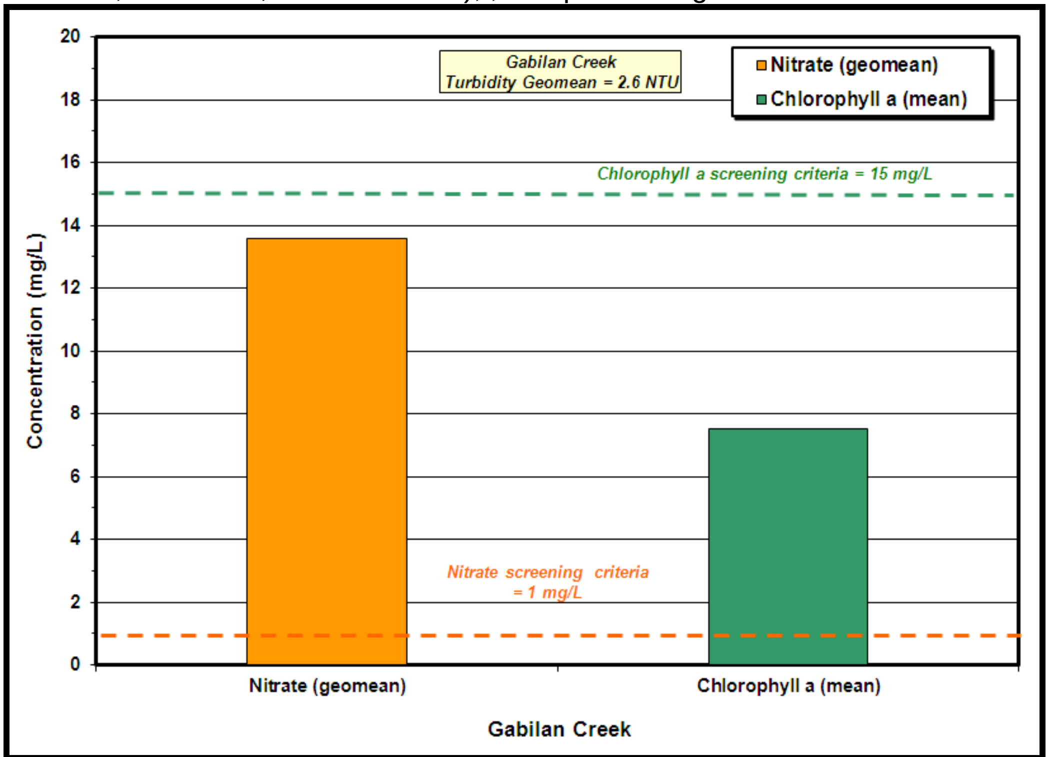
309ASB - % Algal Cover	
Mean	2.22
Range	25
Minimum	0
Maximum	25
Observations	27

Figure 41. Nitrate and Chlorophyll *a* average concentrations, Santa Rita Creek; and percent algal cover statistics.



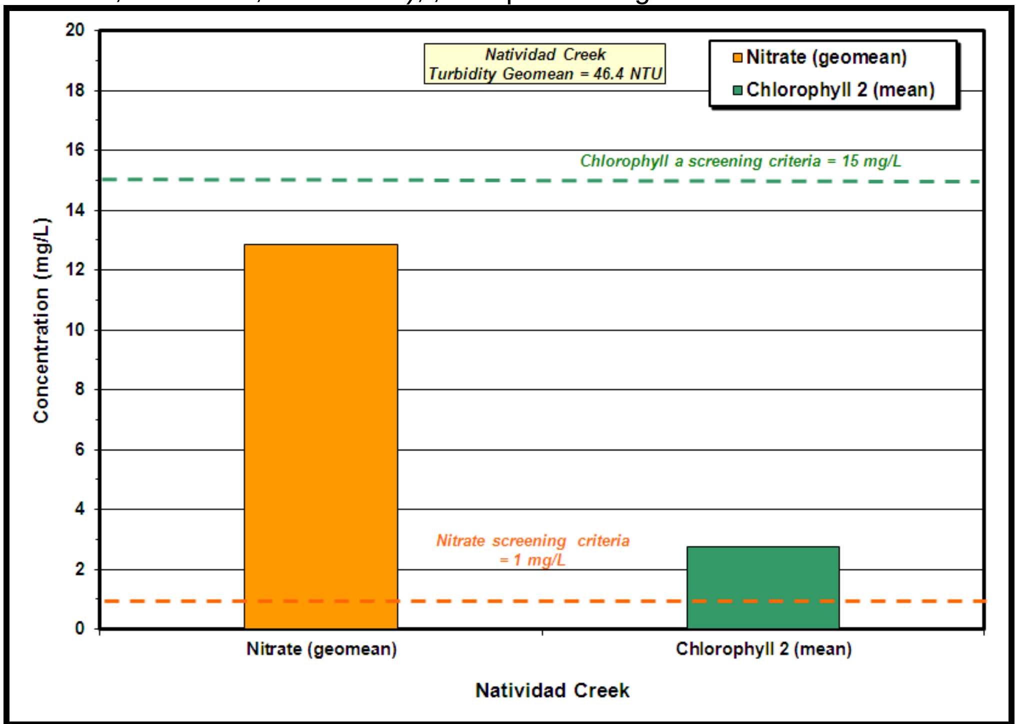
309RTA - % Algal Cover	
Mean	0.7
Range	10
Minimum	0
Maximum	10
Observations	14

Figure 42. Nitrate and Chlorophyll a average concentrations, lower Gabilan Creek (sites 309GAB, GAB-VET, 309-GABIL-31), ; and percent algal cover statistics.



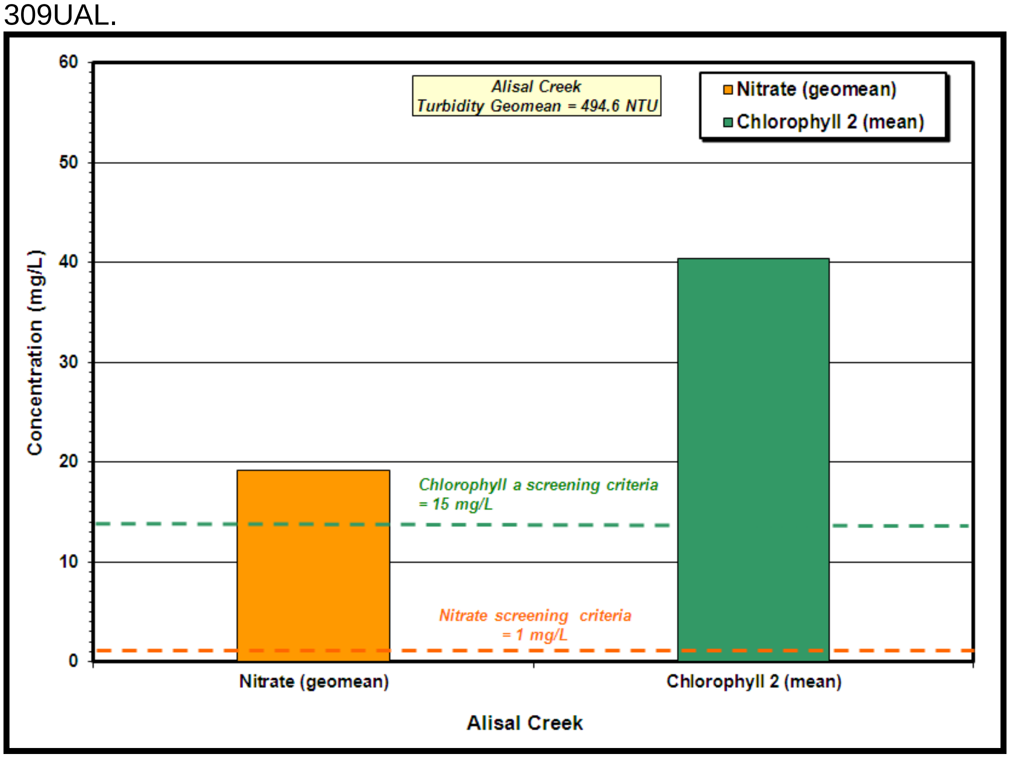
309GAB - % Algal Cover	
Mean	0
Range	0
Minimum	0
Maximum	0
Observations	16

Figure 43. Nitrate and Chlorophyll a average concentrations, lower Natividad Creek (sites 309NAD, NAT-LAS, NAT-FRE), ; and percent algal cover statistics.



309NAD - % Algal Cover	
Mean	0
Range	0
Minimum	0
Maximum	0
Observations	13

Figure 44. Nitrate and Chlorophyll a average concentrations, lower Alisal Creek (sites 309HRT, 309UAL.

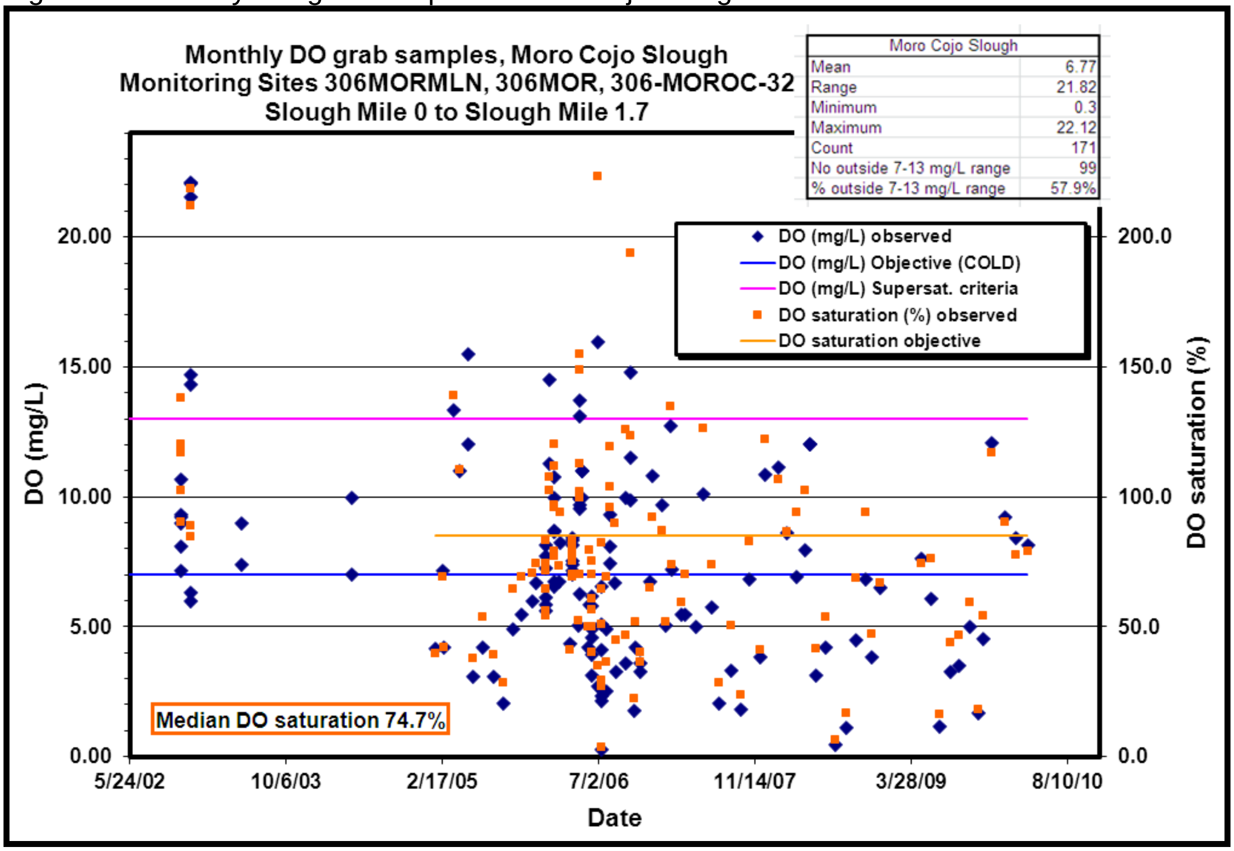


No algal % cover observations.

C.7 Moro Cojo Slough

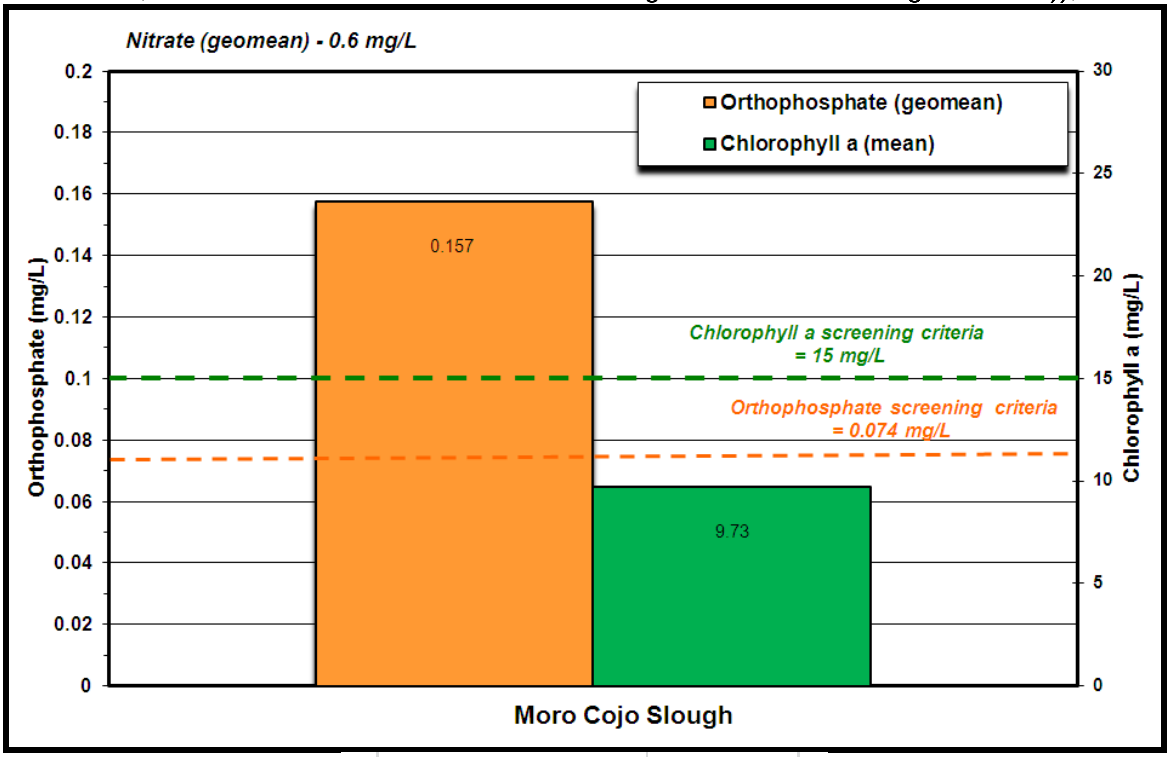
C.7.1 Dissolved Oxygen: Grab Samples

Figure 45. Monthly DO grab samples – Moro Cojo Slough.



C.7.2 Nutrients, Chlorophyll *a* and Algal Cover Data

Figure 46. Nitrate and Chlorophyll a average concentrations, Moro Cojo Slough (sites 306MORMLN, 306MOR and 306-MOROC-32 – Slough Mile Zero to Slough Mile 1.7)), .



Moro Cojo - % Algal Cover	
Mean	10.42
Range	80
Minimum	0
Maximum	80
Observations	24

C.8 Photo Documentation of Biostimulatory Conditions

CCAMP staff periodically photo-document evidence of biostimulation and excessive algal growth at water quality monitoring sites in the Project Area Figure 47. shows the location of photo monitored sites. The photographic documentation for these sites is presented in Figure 48

Figure 47. Location of photo monitoring sites.

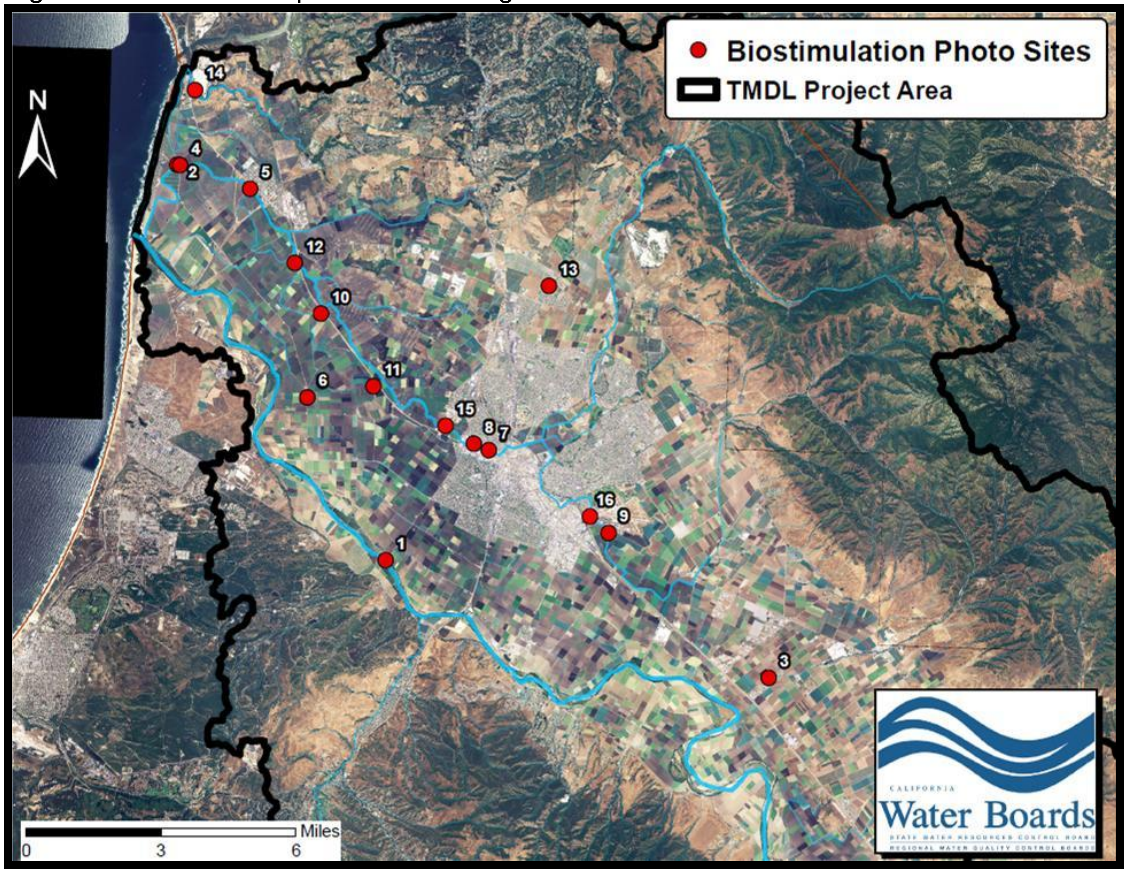


Figure 48. Photo documentation of biostimulation.

Photo documentation

Photo documentation

Old Salinas River @ Monterey Dunes Way (Sept. 2006)
Photo: Mary Adams

Old Salinas River @ Monterey Dunes Way
November 2011
Photo: Mary Adams

Quail Creek @ Highway 101 (July 2006)
Photo: Cooperative Monitoring Program

Tembladero Slough @ Molera Rd. (Sept. 2006)
Photo: Mary Adams

Tembladero Slough @ Preston Rd. (Sept. 2006)
Photo: Mary Adams

Blanco Drain @ Cooper Rd (2002)
Photo: Don Kozlowski - CCoWS

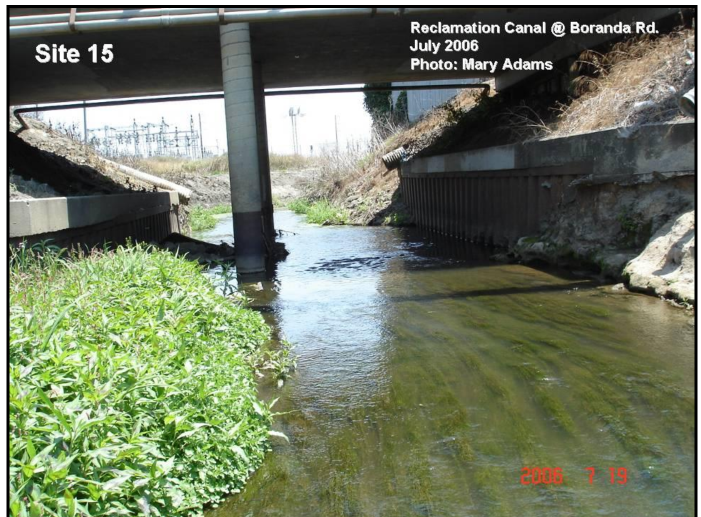
Photo documentation

Photo documentation

Santa Rita Creek @ Russell Rd.
June 2005
Photo: Joel Casagrande

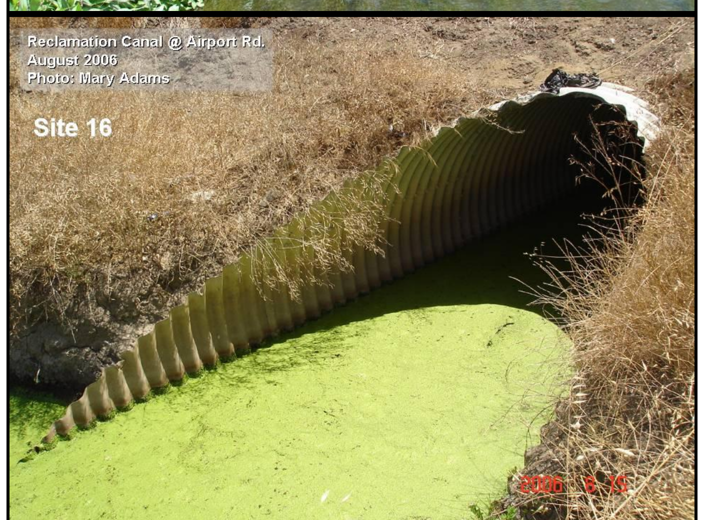
Moro Cojo Slough @ Moss Landing Rd.
Sept. 2011
Photo: Mary Adams

Moro Cojo Slough
Sept. 2006
Photo: Mary Adams



Reclamation Canal @ Boranda Rd.
July 2006
Photo: Mary Adams

Reclamation Canal @ Airport Rd.
August 2006
Photo: Mary Adams



Reclamation Canal @ Airport Rd.
August 2006
Photo: Mary Adams

Appendix D Nutrient Target Development

Contents

D.1 Introduction

The Central Coast Basin Plan has narrative criteria regarding biostimulatory substances, which states: "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses." They do not however specify what levels of algal growth constitute a nuisance.

The Water Board is required to develop technically defensible numeric water quality targets that are protective of the Basin Plan's narrative objective for biostimulatory substances. Targets should be based on established methodologies or peer-reviewed numeric criteria, 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. Eutrophication 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 biostimuation on inland surface waters from an agricultural watershed in the California central coast region indicates that existing nutrient numeric water quality objectives 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[1]. Therefore, the 10 mg/L nitrate-nitrogen objective is insufficiently protective against biostimlatory impairments. Consequently, staff concludes that it is necessary to set nutrient numeric targets more stringent than the existing numeric objectives found for nitrate in the Basin Plan (i.e., the 10 mg/L MUN objective).

In USEPA (2000) nutrient criteria guidance for streams, three general approaches for criteria setting are recommended:

(1) Statistical analysis of data: identification of reference reaches for each stream class based on best professional judgment or percentile selections of data plotted as frequency distributions;

(2) use of predictive relationships (e.g., trophic state classifications, models, biocriteria); and

(3) application and/or modification of established nutrient/algal thresholds (e.g., nutrient concentration thresholds or algal limits from published literature).

USEPA (2000) states that a weight of evidence approach combining any or all of the three approaches above will produce criteria of greater scientific validity.

[1] 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.

USEPA-recommended approaches for developing nutrient criteria.

USEPA-Recommended Approaches	Approach Assessed in this TMDL project?	Methodology	Notes
Use of **Predictive Relationships** (modeling; biocriteria)	☑	California NNE Approach	Staff used NNE benthic biomass model tool to supplement and corroborate targets based on USEPA-recognized statistical approaches
Statistical Analysis of Data	☑	USEPA-recommended statistical analysis: 25th percentile of nutrient data for stream population	Staff used USEPA recognized[h] statisitcal approach in development of nutrient numeric criteria.
Use of established concentration **thresholds from published literature**	☑	USEPA published nutrient criteria for Ecoregion III, Subecoregion 6	Staff evaluated USEPA ecoregional criteria. Staff finds subecoregion III-6 criteria are inappropriate, and over-protective for the TMDL project area . The ecoregional-scale 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.

Staff followed 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). Nutrient criteria need to be developed to account for natural variation existing at the regional and basin level. 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. Final Report: Long-Term, High Resolution Nutrient and Sediment Monitoring and Characterizing In-stream Primary Production. Proposition 40 Agricultural Water Quality Grant Program.*

Staff used USEPA's 25th percentile approach for developing nutrient targets. 25th percentile values are characterized by USEPA as criteria recommendations that could be used to protect waters against nutrient over-enrichment (USEPA, 2000)[2]. This is because the 25th percentile of the entire population has been shown by USEPA to represent a surrogate for an actual reference population.

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). Use of the USEPA 25th percentile approach in conjunction with the NNE spreadsheet provide an additional line of evidence, and also may help corroborate the reasonableness USEPA 25th percentile approach nutrient targets.

---

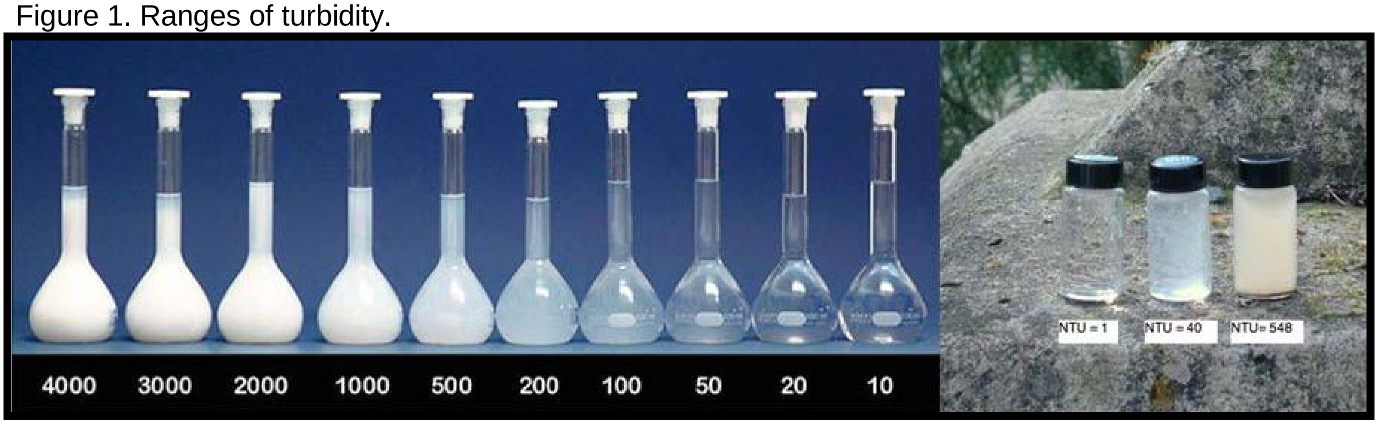
[2] U.S. Environmental Protection Agency. 2000. Nutrient Criteria Technical Guidance Manual, River and Streams. EPA-822-B-00-002.

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:

> *"...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 (University of West Florida), personal communication to Water Board staff, Sept. 12, 2011*

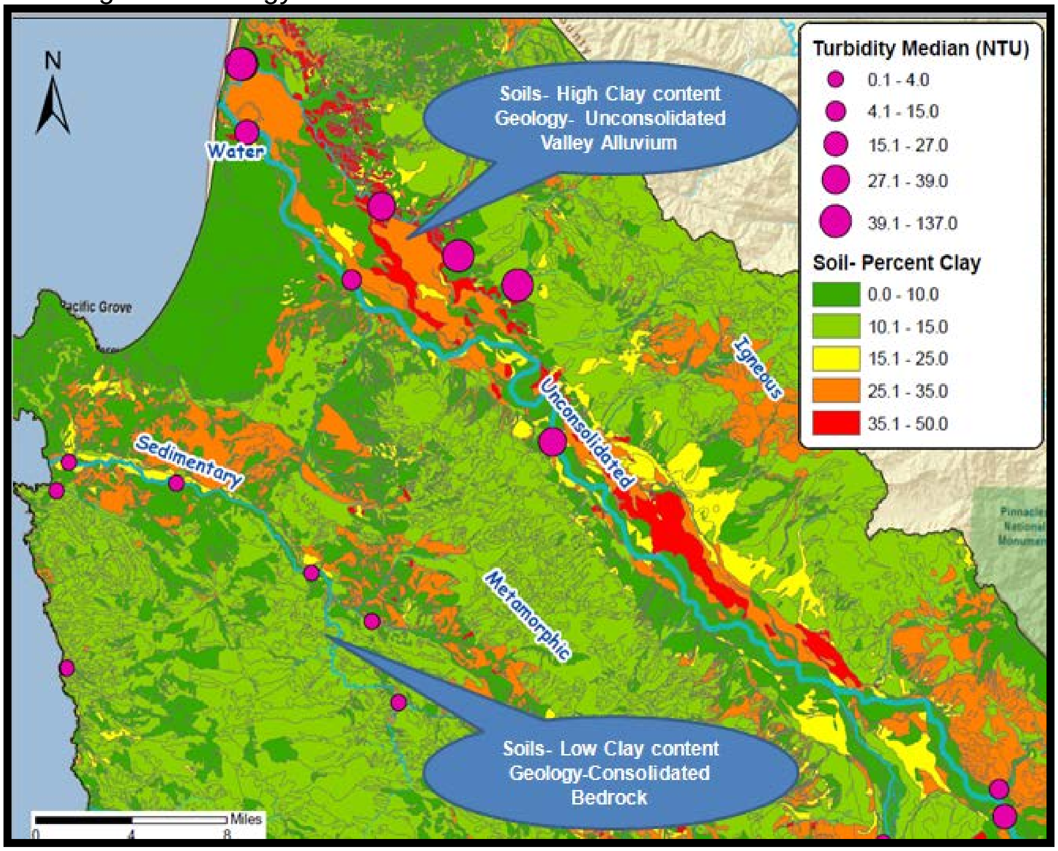
Nutrient target results provided by the NNE spreadsheet tool can vary substantially, based on even small changes in turbidity input. As such, it important it is to have plausible canopy and turbidity conditions that are reasonably representative of reach-scale conditions. The default value in the NNE spreadsheet tool is 0.6 NTU. The USEPA (2000) ecoregional criteria (Ecoregion III-6) for turbidity in reference conditions is 1.9 NTU. Both of these values (0.6 NTU and 1.9 NTU) represent ambient conditions in relatively undisturbed reference streams. It should be noted that relatively, undisturbed ambient turbidity conditions in some agricultural alluvial valley floor waterbodies may be closer to 20 or 30 NTU. For illustrative purposes, Figure 1 illustrates the appearance of water with various ranges of turbidity.

Figure 1. Ranges of turbidity.



Further, a cursory evaluation of water column turbidity, soil conditions, and regional geology illustrate the substantial variability in ambient conditions even at reach-scale or watershed-scale. Figure 2 illustrates that in northern Monterey County, turbidity conditions in an agricultural alluvial valley, with clay-rich soils and substrates will likely have substantially different ambient or relatively undisturbed turbidity conditions relative to stream reaches in upland areas, or areas underlain by consolidated bedrock and sandy soil and substrate conditions. A difference in five or ten NTU turbidity input into the NNE spreadsheet tool will provide significantly different results. It is noteworthy that in areas with clay-rich soil conditions and substrates, ambient turbidity is likely to be much higher (see figure below). 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 2. Northern Monterey County, Water Column Turbidity (Median NTU), Soil Texture (% Clay), and Regional Geology.



The basis for staff's previous comment about the expectation of higher ambient turbidity levels in agricultural drainages (up to 20 or 30 NTU) are summarized below:

1) Peer-reviewed literature: It is recognized in the peer-reviewed literature that the hydraulics and substrates of agricultural water conveyance structures, such as canals and ditches, are often substantially different than natural streams, and can result in higher levels of turbidity under relatively undisturbed conditions.

> ***"The turbidity of irrigation water increases as it travels through delivery ditches, which are bare earth and add suspended solids via erosion"***
>
> *From: Research Article - "Monitoring helps reduce water-quality impacts in flood-irrigation pasture". Ken Tate, Donald Lancaster, Julie Morrison, David Lile, Yukako Sado, and Betsy Huang, in California Agriculture 59(3):168-175.*

2) Agricultural drain monitoring data: A large body of monitoring data from agricultural drains in the Central Valley and Salinas Valley of California indicate that an average expected 25th percentile of turbidity data is 21 NTU (representing a relatively unimpacted condition) – see the figure below. This is consistent with staff's comment in the project report about the expectation of relatively higher levels and valley floor agricultural drainages.

Further, as shown in Figure 3 below, expected relatively undisturbed conditions in agricultural drainages could be around 20 NTU, which is far higher than natural streams. The USEPA ecoregional criteria for subecoregion 1.9 NTU (see Figure 4), which is unreasonably low for many agricultural valley floor drainages.

Figure 3. Turbidity data from agricultural dainages in California.

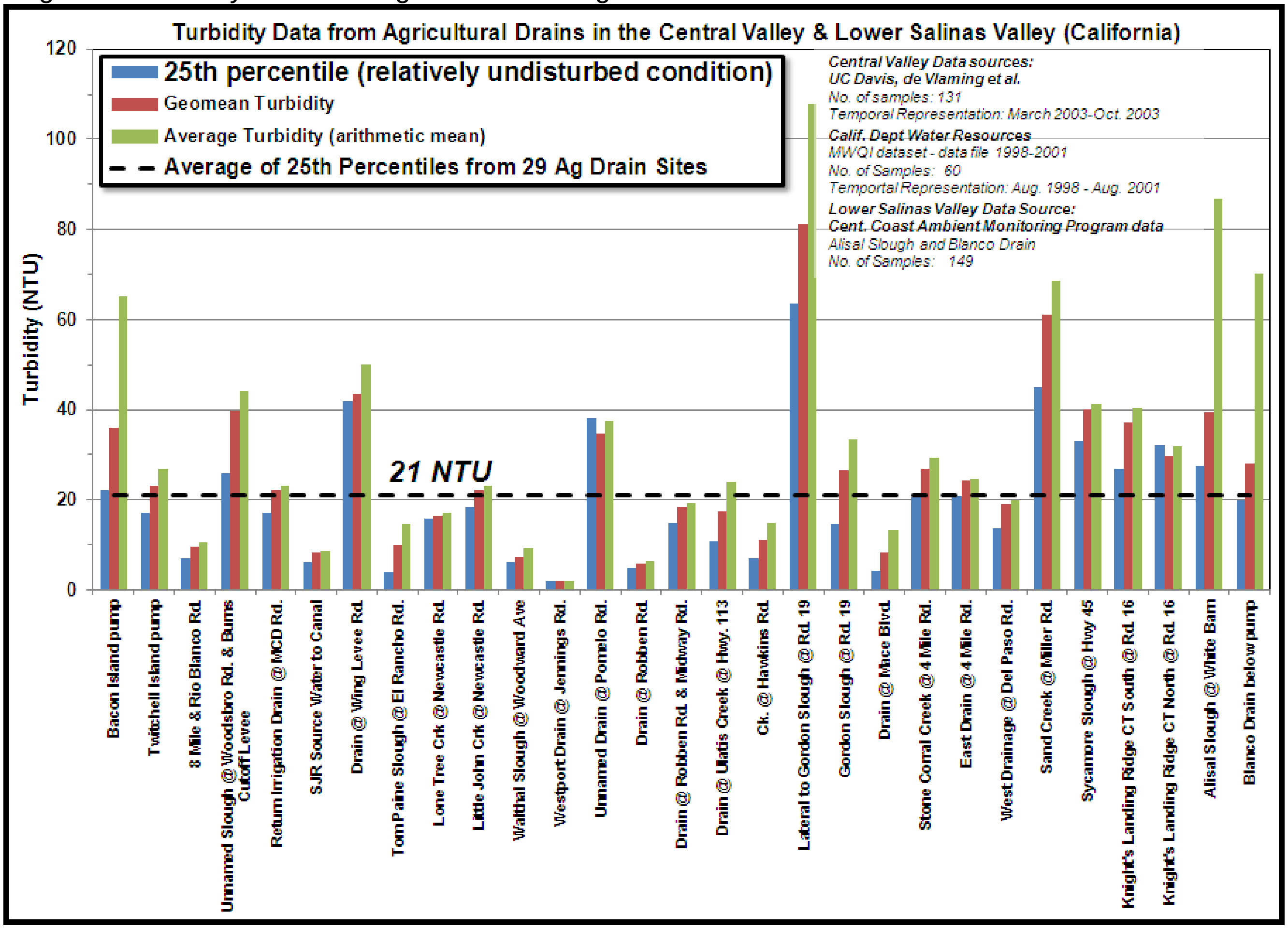
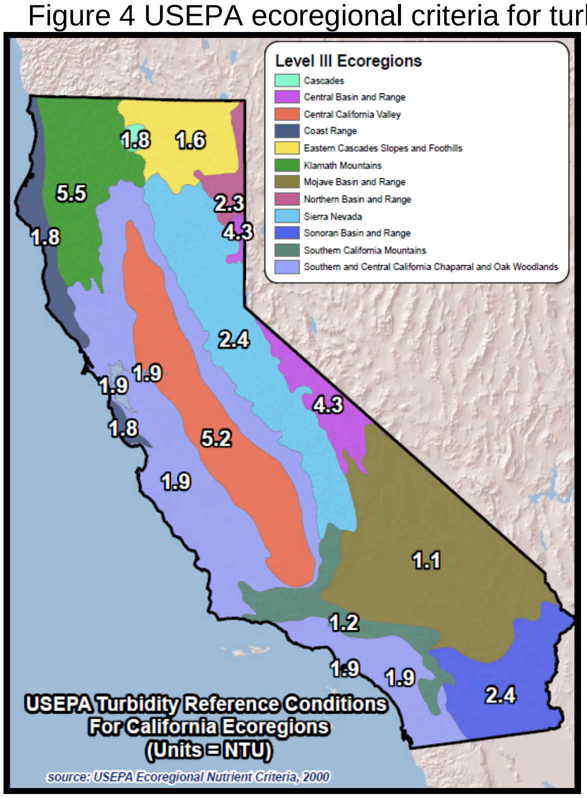


Figure 4 USEPA ecoregional criteria for turbidity.



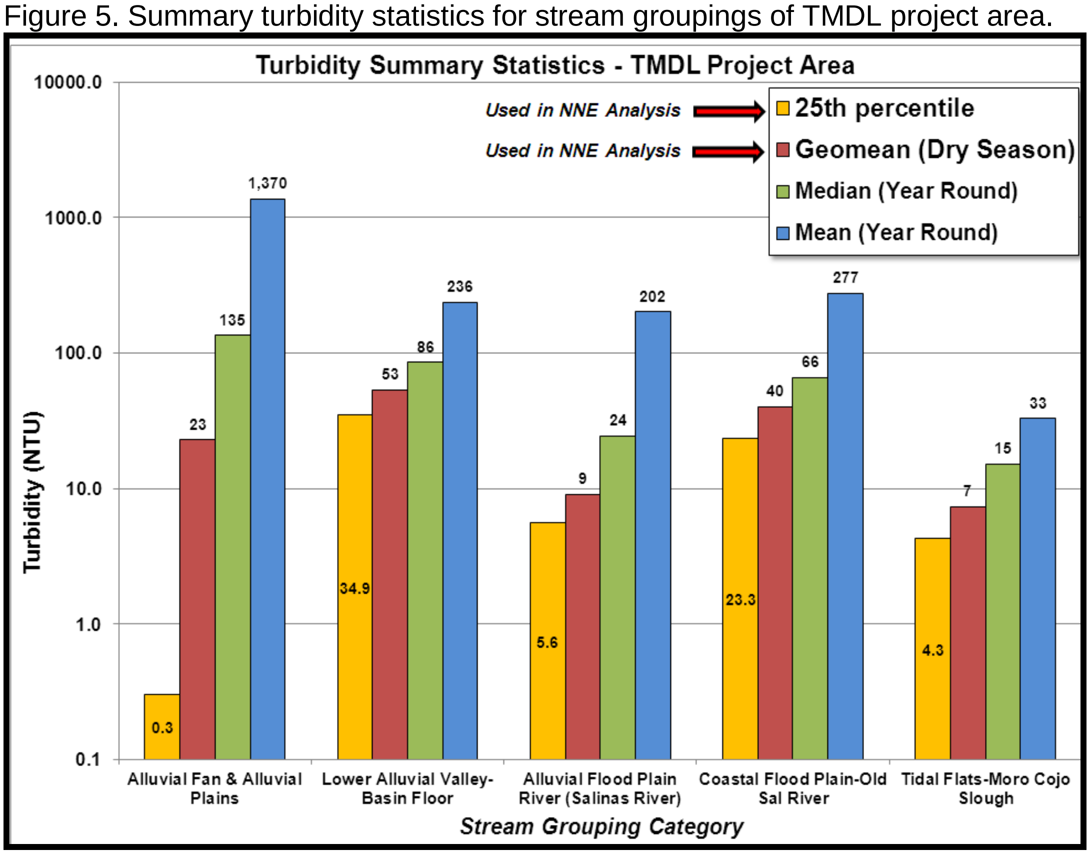
As turbidity is a senstitive input value into the Calif. NNE spreadsheet tool, staff concluded that plausible reach-scale turbidity inputs should represent a range from relatively undisturbed (ambient-25th percentile of data population) conditions to lightly-to-moderately disturbed conditions at the high end. Higher turbidity conditions that may reflect substantial anthropogenic activities and impacts were not included in the NNE spreadsheet inputs.

This approach conceptually is also consistent with the recommendations received from a scientific peer reviewer for this TMDL project:

> *"I would argue that the turbidity conditions that drive NNE modeling should be indicative of the **ambient or moderately disturbed conditions***."*
>
> - Dr. Marc Beutel, Washington State University, peer reviewer for this TMDL project (see Appendix 5 to the Staff Report)
>
> ***** emphasis added by Water Board staff

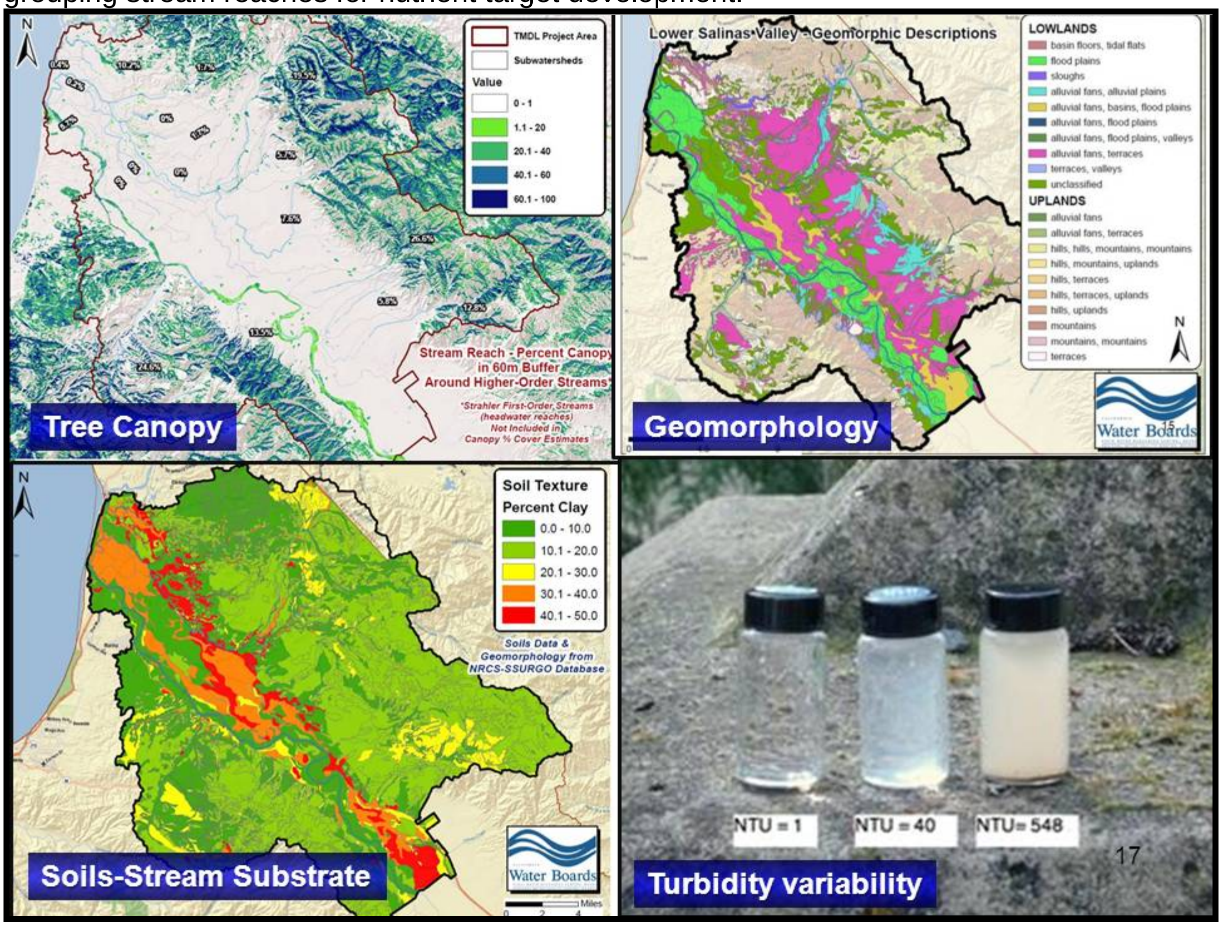
In fact, the upper, high-end NNE spreadsheet turbidity values staff used (dry season geomean – see sections D.4 through D.8) can plausibly be characterized as a lightly-to-moderately disturbed conditions. As our peer review referee Dr. Buetel, suggests above, it would be reasonable to use a range of ambient to *moderately disturbed turbidity* inputs in the NNE spreadsheet runs to represent reach conditions under which there are not substantial anthropogenic inputs. Figure 5 illustrates that for each stream grouping in the TMDL project area, the NNE turbidity dry-season geomean input values staff used are generally an order of magnitude lower than year-round averages (arithmetic mean) turbidity for each respective stream grouping. Further, the dry-season geomean turbidity input values also range 39% to 83% lower than the median turbidity value for each stream grouping (the median value represent the 50th percentile of the data population). Therefore, staff maintains that the dry-season geomean turbidity value of each stream grouping can fairly be characterized as a lightly-to-moderately disturbed condition; e.g. they are substantially lower than the average or median measures of turbidity in each respective stream grouping.

Figure 5. Summary turbidity statistics for stream groupings of TMDL project area.



Staff used field observations and digital datasets for tree canopy cover (source: National Land Cover Dataset, 2001) as presented in the Project Report, to estimate plausible canopy shading for stream categories. Additionally, as noted previously, stream geomorphology and stream physiography is important to consider with respect to establishing linkages between nutrient concentrations and algal growth (UC Santa Cruz, 2010)[3]. Consequently, staff used geomorphic classifications and soil properties data from the NRCS-SSURGO database (presented in the Project Report) to assist in classifying and grouping streams with comparable characteristics. Figure 6 conceptually illustrates some of the stream-reach and water column properties staff evaluated in grouping and classifying stream reaches with comparable characteristics, consistent with USEPA guidance.

Figure 6. Conceptual illustration of stream reach and water column characteristics used by staff in grouping stream reaches for nutrient target development.



D.2 California Nutrient Numeric Endpoints Approach

As noted previously, 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). The California NNE approach is to use nutrient response indicators to develop potential nutrient water quality criteria. The California NNE approach also includes a set of relatively simple spreadsheet scoping tools for application in lake/reservoir or

[3] 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.

river systems to assist in evaluating the translation between response indicators (e.g. algal biomass) and nutrient concentrations. Accordingly, staff used the California NNE benthic biomass spreadsheet tool to develop potential water quality targets for the response indicator (e.g., benthic chlorophyll a density and corresponding estimated algal biomass density). These targets determine how much algae can be present without impairing designated beneficial uses. Numeric models (e.g., QUAL2K) are then used to convert the initial water quality targets for the response variables into numeric targets for nutrients.

The California NNE Approach Defines three risk categories for indicators (measures of algal growth and oxygen deficit): 1) Presumably unimpaired; 2) Potentially impaired; 3) Likely impaired. Additional detail on the three risk categories is provided by TetraTech, 2007, as reproduced below:

> The California NNE approach recognizes that there is no clear scientific consensus on precise levels of nutrient concentrations or response variables that result in impairment of a designated use. To address this problem, waterbodies are classified in three categories, termed Beneficial Use Risk Categories (BURCs). BURC I waterbodies are not expected to exhibit impairment due to nutrients, while BURC III waterbodies have a high probability of impairment due to nutrients. BURC II waterbodies are in an intermediate range, where additional information and analysis may be needed to determine if a use is supported, threatened, or impaired. Tetra Tech (2006) lists consensus targets for response indicators defining the boundaries between BURC I/II and BURC II/III.

The table below synthesizes the consensus BURC boundaries for various secondary indicators developed by TetraTech for the California NNE approach. The BURC II/III boundary provides an initial scoping point to establish minimum requirements for a TMDL.

Nutrient Numeric Endpoints for Secondary Indicators – Risk Classification Category Boundaries: I & II and II & III

Beneficial Use Risk-Category I. Presumptive unimpaired (use is supported).
Beneficial Use Risk Category II. Potentially impaired (may require an impairment assessment)
Beneficial Use Risk Category III. Presumptive impaired (use is not supported or highly threatened)

RESPONSE VARIABLE	RISK – CATEGORY BOUNDARY	BENEFICIAL USE						
		COLD	WARM	REC-1	REC-2	MUN[1]	SPWN	MIGR
Benthic Algal Biomass in streams (mg chl-*a*/m^2) Maximum	I / II	100	150	C	C	100	100	B
	II / III	150	200	C	C	150	150	B
Planktonic Algal Biomass in Lakes and Reservoirs (as µg/L Chl-*a*)[2] – summer mean	I / II	5	10	10	10	5	A	B
	II / III	10	25	20	25	10	A	B
Clarity (Secchi depth, meters.)[3] – lakes summer mean	I / II	A	A	2	2	A	A	B
	II / III	A	A	1	1	A	A	B
Dissolved Oxygen (mg/l) Streams – the mean of the 7 daily minimums	I / II	9.5	6.0	A	A	A	8.0	C
	II / III	5.0	4.0	A	A	A	5.0	C
pH maximum – photosynthesis driven	I / II	9.0	9.0	A	A	A	C	C
	II / III	9.5	9.5	A	A	A	C	C
DOC (mg/l)	I / II	A	A	A	A	2	A	A
	II / III	A	A	A	A	5	A	A

A = No direct linkage
B = More research needed to quantify linkage
C = Addressed by Aquatic Life Criteria

[1] For application to zones within water bodies that include drinking water intakes.
[2] Reservoirs may be composed of zones or sections that will be assessed as individual water bodies
[3] Assumes that lake clarity is a function of algal concentrations, does not apply in waters of high non-algal turbidity

Staff developed nitrogen and phosphorus NNE nutrient targets in this appendix using existing NNE predictor run spreadsheet templates developed by the Water Board's Central Coast Ambient Monitoring Program staff available at http://www.ccamp.us/nne/nne_runs/

D.3 Nutrient Target Selection

In developing nutrient targets, it is important to recognize that

1) ambient nutrient concentrations in and of themselves, are not sufficient to predict the risk of biostimulation. because algal productivity depends on several additional factors such as stream morphology, hydraulics, light availability, etc., and
2) An important tenet of the California NNE approach (Tetra Tech 2006) is that targets should not be set lower than the value expected under natural conditions.

Staff developed targets by using a combination of recognized methods to bracket and calibrate nutrient targets appropriate to local conditions, and that are credibly neither over-protective nor under-protective. The USEPA nutrient criteria technical guidance manual for rivers prescribes a combination of several approaches when developing water quality criteria for nutrients, including

1) the application of reference conditions;
2) predictive stressor-response relationships; and
3) values from existing literature.

Both USEPA and researchers (UC Santa Cruz, 2010-refer back to footnote 1) have recognized that combining these approaches help in the development of scientifically valid numeric objectives for nutrients. Staff used a range recognized nutrient target development methodologies, the USEPA recognized statistical-approaches, and the CA NNE approach. Additionally, staff identified a plausible range of ambient reach-scale stream conditions to account for local variation. This is consistent with USEPA guidance to group streams by type or comparable characteristics, thereby allowing nutrient criteria to be applied such that they account for spatial variations in stream characteristics.

The aforementioned approaches have different strengths. The CA NNE is a predictive modeling approach that helps establish concentrations at which nutrients can have detrimental effects on the biological health of a stream. The 25th percentile approach is a statistical approach, which can provide a plausible approximation of nutrient concentrations one might expect during a relatively undisturbed state and given local conditions. An important tenet of the California NNE approach (Tetra Tech 2006)[4] is that targets should not be set lower than the value expected under background or relatively undisturbed conditions. Therefore, the 25th percentile USEPA approach can help satisfy the caveat those targets should not be set lower than expected under local background, or relatively undisturbed conditions.

Further, staff received guidance from a researcher with expertise in central coast biostimulation problems that nutrient targets should not be more stringent than nutrient concentrations found in natural systems in the Salinas River basin. Therefore, staff applied the USEPA reference stream methodology (75th percentile approach) which ensures that biostimulation nutrient targets are no more stringent than nutrient concentrations found in natural or lightly-disturbed headwater and tributary reaches in the Salinas River basin.

In summary, staff was able to evaluate a range of plausible nutrient targets for identified stream reaches using the strengths of various approaches. After establishing plausible ranges of potential

[4] TetraTech. 2006. Technical approach to develop nutrient numeric endpoints for California. Prepared for USEPA Region IX (Contract No. 68-C-02-108 to 111)

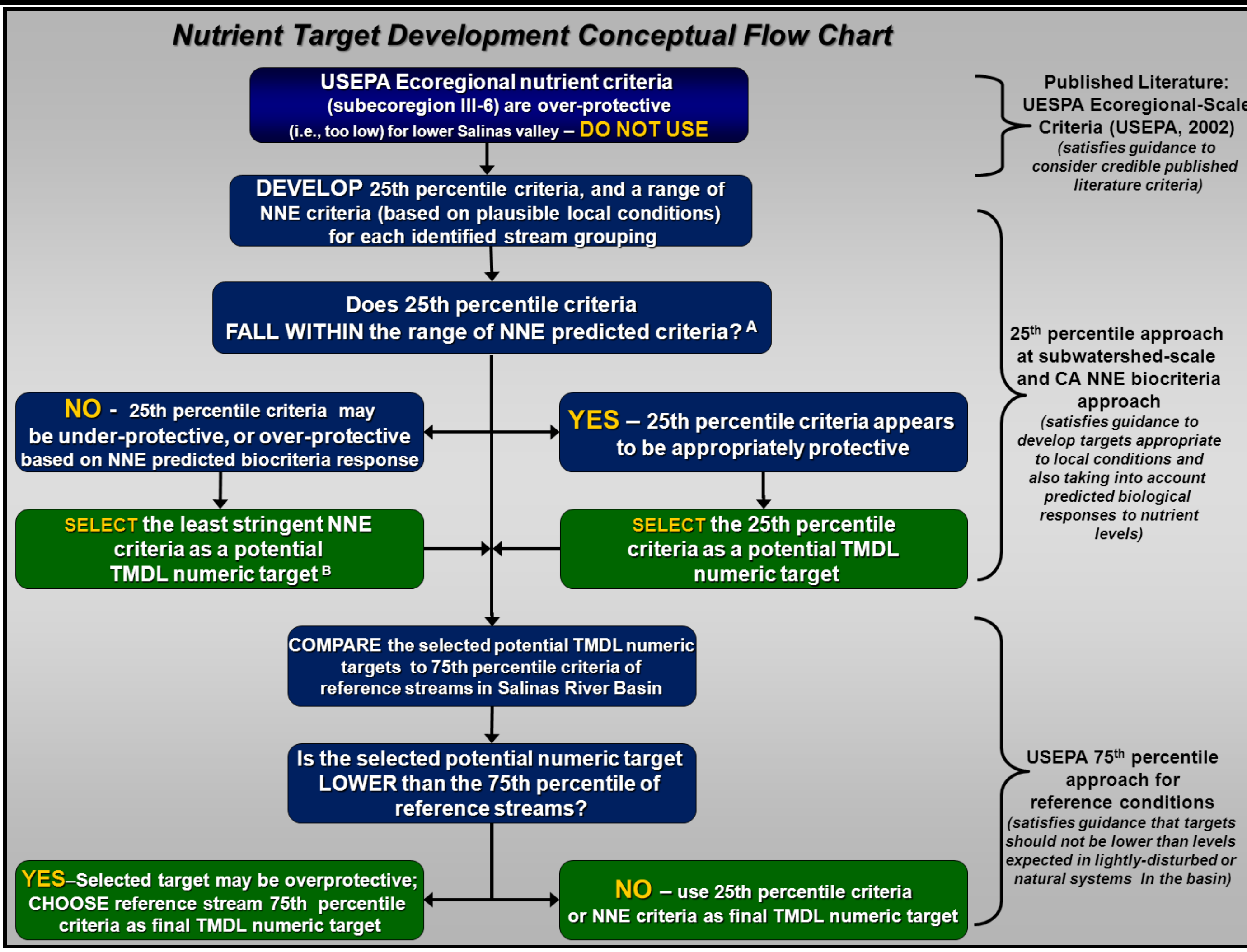
nutrient targets using the aforementioned methodologies, the development and selection of final nutrient TMDL targets were determined using the following hierarchical approach, as illustrated below:

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 (source: USEPA, 2000. Nutrient Criteria Manual).
- ✓ Classify and group streams needing nutrient targets, based on similar characteristics (source: USEPA, 2000. Nutrient Criteria Manual).
- ✓ Targets should not be lower than expected concentrations found in background/natural conditions (source: Calif. NNE guidance – TetraTech, 2006).

See Figure 7 for a conceptual flow chart of the nutrient target development approach used in this TMDL project.

Figure 7. Nutrient target selection conceptual flow chart.

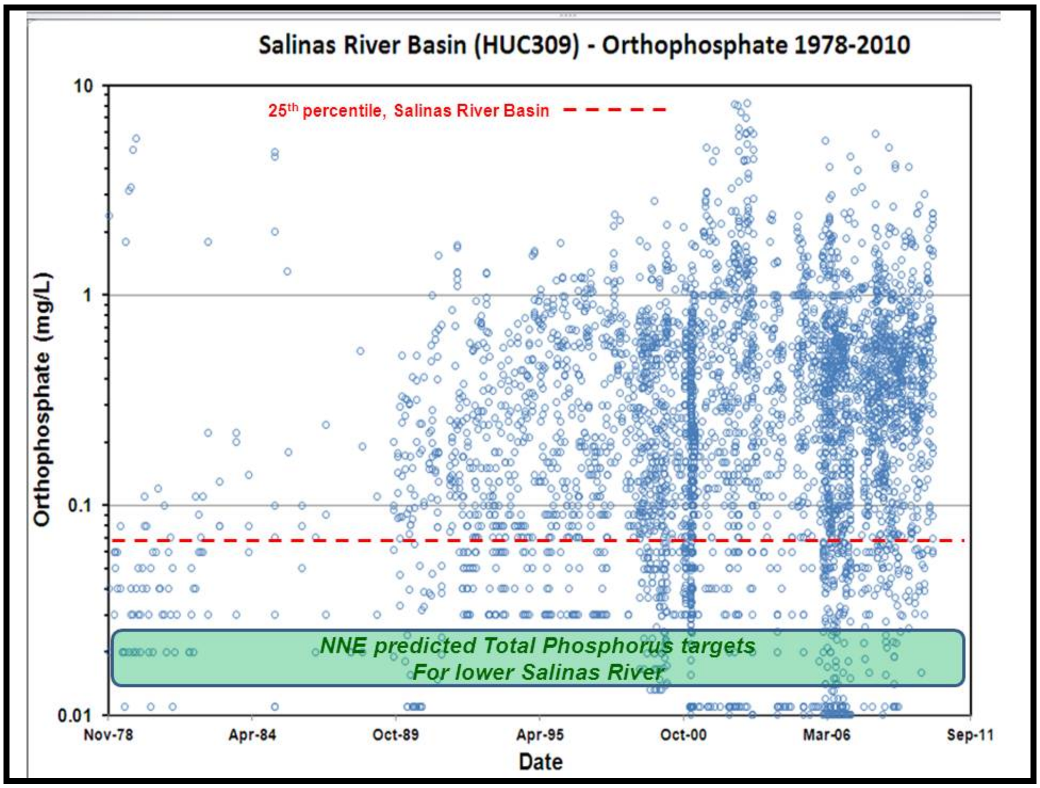


Notes:

[A] Orthophosphate targets developed with percentile-based approaches were not calibrated to NNE results. NNE only provides results for total phosphorus which may not be a good measure of orthophosphate. In contract, nitrate typically comprises over 95% of water column total Nitrogen (TN) in project area streams; therefore, nitrate is a plausible surrogate for total nitrogen and can be compared to NNE TN target predictions.

[B] The marginally less stringent NNE numeric target is selected because central coast researchers have suggested that while it is reasonable to set lower nutrient numeric targets on stream reaches with limited anthropogenic sources, it may be prudent in areas with significant human disturbances to have less stringent targets until more information is available (source: Prop. 40 Nutrient Study–Pajaro River Watershed, 2011 – Project Lead: Dr. Marc Los Huertos.)

Note that orthophosphate numeric targets were based on USEPA 25th percentile methods. The CA NNE spreadsheet tool only calculates total phosphorus targets. In general, total phosphorus is not an adequate measurement of water column orthophosphate. Orthophosphate is only a fraction to total water column phosphorus. In addition, CA NNE calculations of total phosphorus generally appear to estimate targets that are lower than values expected under natural conditions in the Salinas River Basin. The total phosphorus targets predicted by NNE for project area waterbodies are even below USEPA's subecoregion III-6 total phosphorus criteria (0.03 mg/L). As such, these NNE values could be reasonably be considered over-protective. In addition, when NNE predicted targets for total phosphorus are plotted on a graph of orthophosphate data from throughout the Salinas River basin, the NNE predicted targets for phosphorus appear to be unreasonably low (see figure below). As such, staff followed guidance to develop targets that are not below (i.e., more stringent) than concentrations expected under natural conditions; therefore, staff used the 25th percentiles for orthophosphate as TMDL numeric targets.



The following sections of this Appendix present information pertaining to development of nutrient targets for project area waterbodies.

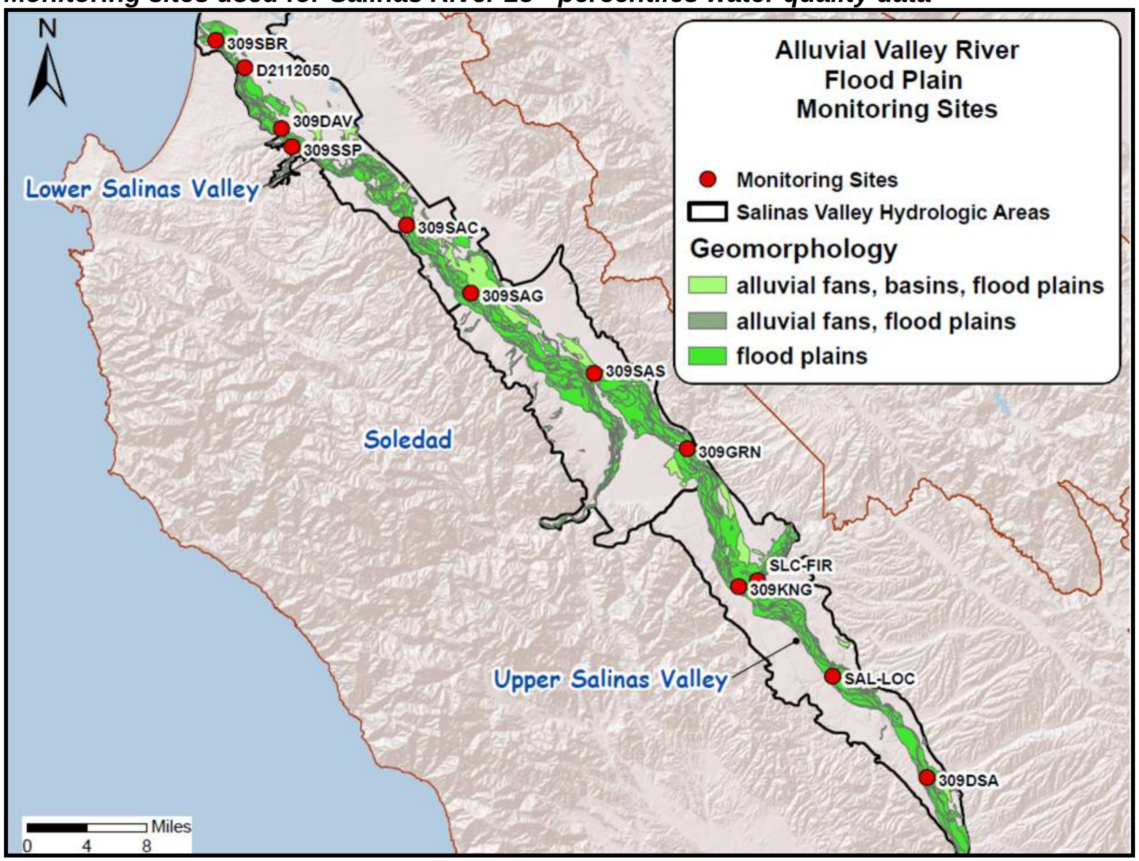
D.4 Lower Salinas River – Alluvial Valley Floodplain River

D.4.1 Lower Salinas River 25th Percentile Targets

Stream Conditions

- Geomorphic description: Alluvial valley river; alluvial floodplain (source: NRCS-SSURGO)
- Estimated average riparian tree canopy: 13.5% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Dominantly sandy; <10% clay (source: NRCS-SSURGO)
- Turbidity conditions: 6 NTU (25th percentile-year round); 9 NTU (geomean-dry season, May-Oct.); 20.5 NTU (median-dry season, May-Oct)

Monitoring sites used for Salinas River 25th percentiles water quality data



Alluvial Valley River - flood plain: Statistical Summary

Salinas River - Soledad to Lagoon @ Monterey Bay
Stream geomorphic description: Alluvial valley - floodplain
Statistical Summary of Nitrate-N

Temporal Representation	July 1965 to Dec. 2010
Mean	7.467873042
Standard Error	0.362364006
Median	2.938
Mode	2
Standard Deviation	10.71887185
Range	77.9976
Minimum	0.0024
Maximum	78
No| of samples	875
25th percentile	**1.0**

Salinas River - Soledad to Lagoon @ Monterey Bay
Stream geomorphic description: Alluvial valley - floodplain
Statistical Summary of Orthophosphate-P

Temporal Representation	July 1965 to March 2010
Mean	1.237583006
Standard Error	0.178862758
Median	0.084
Mode	0.03
Standard Deviation	5.684347372
Range	60.996
Minimum	0.004
Maximum	61
No| of samples	1010
25th percentile	**0.04**

D.4.2 Lower Salinas River Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

The lower Salinas River is specifically designated for cold freshwater aquatic habitat (COLD) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for COLD beneficial use.

Site:	Salinas Riv - Alluvial Valley Flood Plain
Analyst:	PAO
Date:	10/4/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

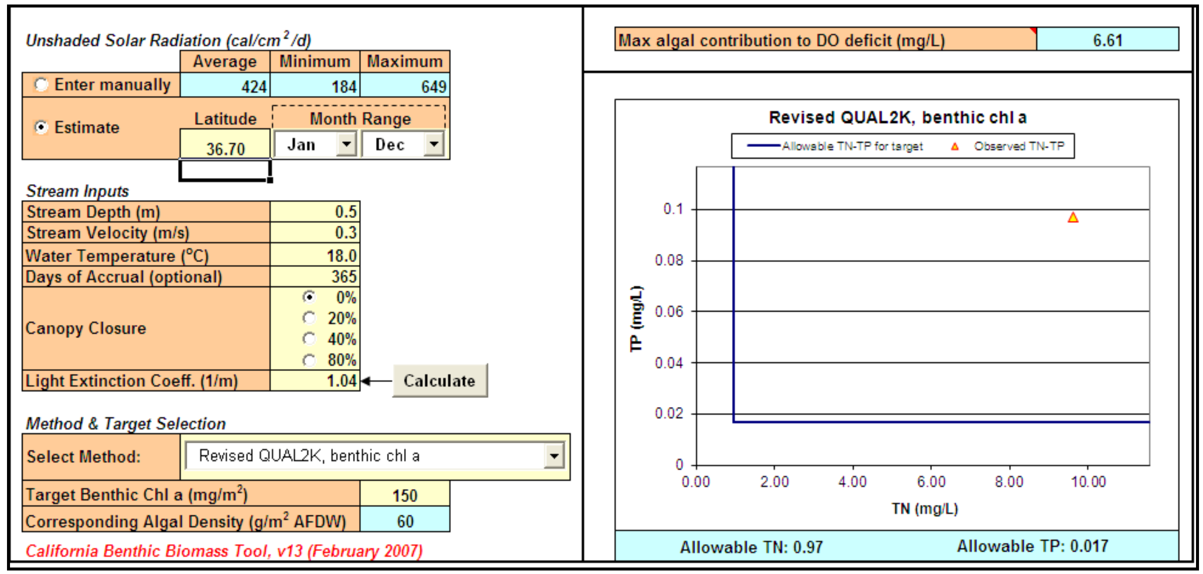
Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity (6 NTU):

6 NTU turbidity = 25th percentile of Salinas River monitoring sites used in 25th percentile analysis



Site:	Salinas Riv - Alluvial Valley Flood Plain
Analyst:	PAO
Date:	10/4/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

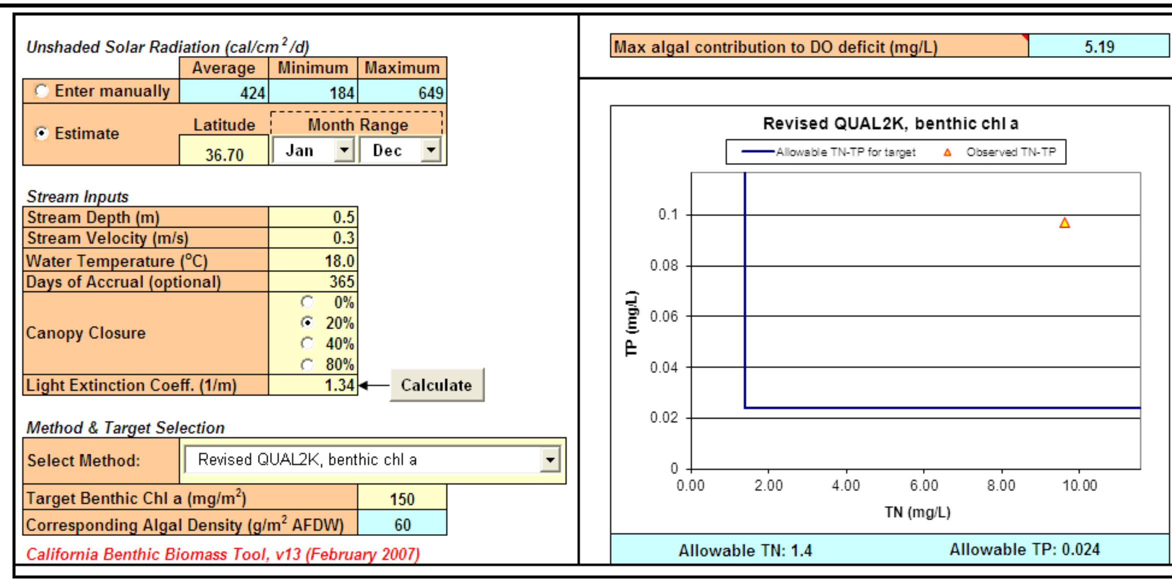
Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 20% Tree Canopy Closure

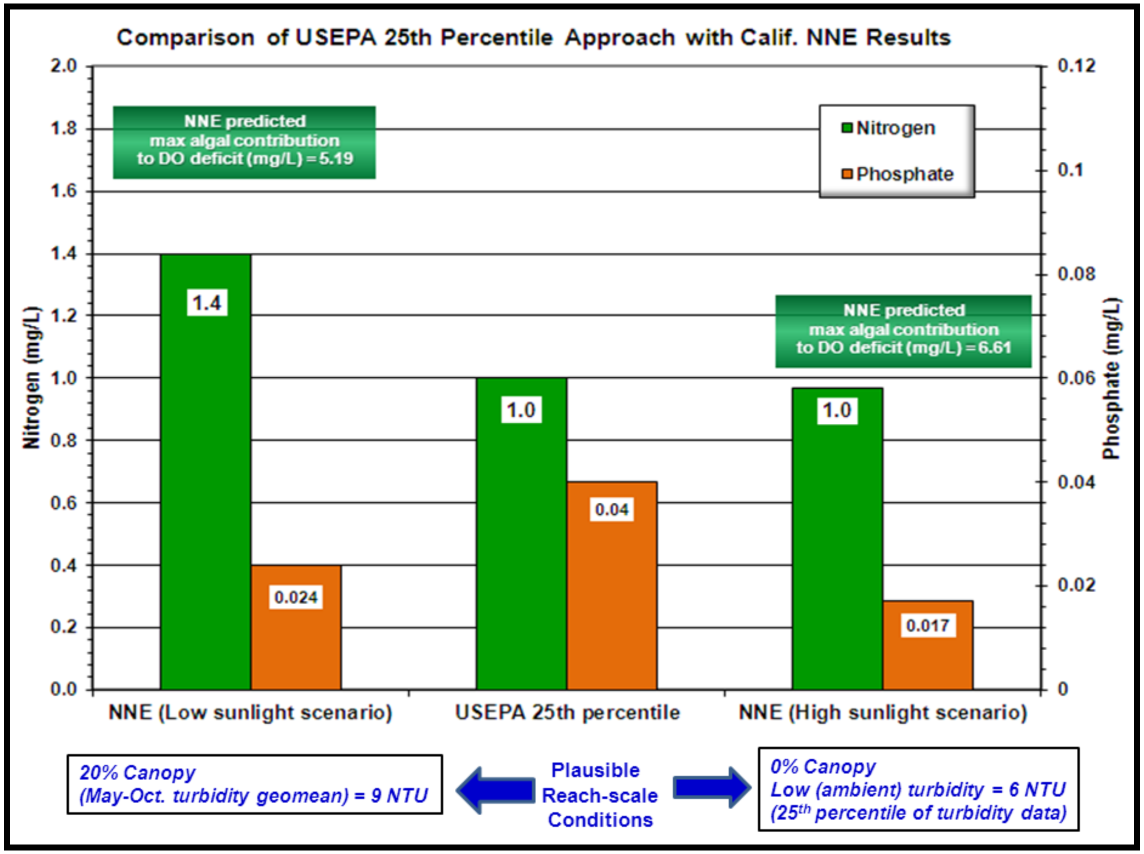
- Geomean Dry Season Turbidity (9 NTU):

9 NTU turbidity = turbidity geomean of May-Oct sample of Salinas River monitoring sites used in 25th percentile analysis



D.4.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Lower Salinas River)

The USEPA 25th percentile targets shown previously are show relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. This suggests the 25th percentile targets are in reasonably good agreement with NNE predicted nutrient targets that are based on plausible ranges of observed local conditions It is important to note that the 25th percentiles are calculated on nitrate-N and orthophosphate-P. These constituents are not directly comparable to the total N and total P results that the Calif. NNE spreadsheet tool provides, nevertheless nitrate is typically over 95% of total water column nitrogen in project area inland streams, Orthophosphate is estimated to generally (but not always) be the largest fraction of water column phosphorus in project area inland streams. For purposes of comparing the 25th percentile methodology and the NNE approach, nitrate and orthophosphate are plausible surrogates for total N and P in project area streams. The USEPA 25th percentile targets are shown relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. In this case, the 25th percentile criteria is exactly equal to the marginally more stringent NNE criteria (1.0 mg/L). Consistent with the nutrient target development approach outlined in Section D.3, the marginally less stringent NNE criteria is identified here as a potential numeric target. Therefore, marginally less stringent NNE criteria (1.4 mg/L) and the 25th percentile for orthophosphate (0.04 mg/L) are selected as potential numeric targets for this stream reach.



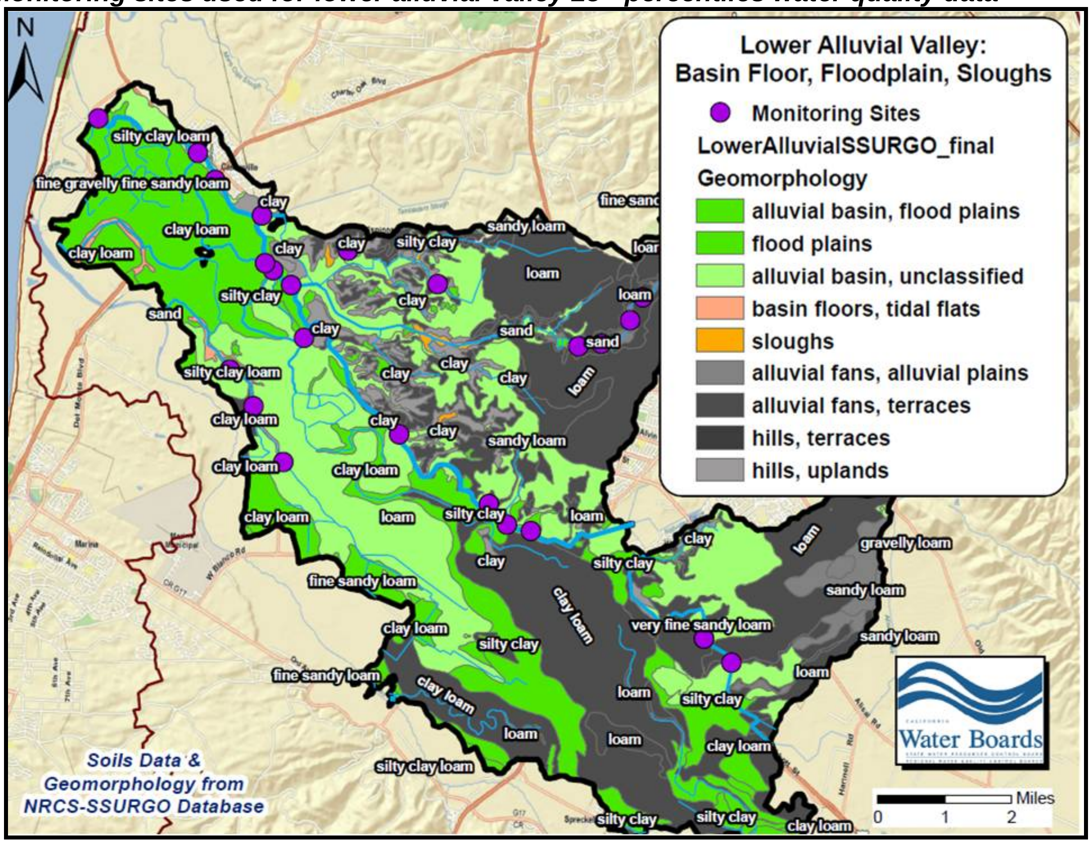
D.5 Lower Alluvial Valley - Basin Floor Stream Reaches

D.5.1 Lower Alluvial Valley Basin Floor Streams and Sloughs 25th Percentile Targets

Stream Conditions

- Geomorphic description: Alluvial basin floor; floodplain, sloughs. Low gradient, slopes less than 1 degree (source: NRCS-SSURGO)
- Waterbodies: Alisal Slough, Blanco Drain, Espinosa Slough, Merritt Ditch, Reclamation Canal, Santa Rita Creek, Tembladero Slough
- Estimated riparian tree canopy: close to 0% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Dominantly fine-grained: clays, clay loams, silty clays (source: NRCS-SSURGO)
- Turbidity conditions: 35 NTU (25th percentile-year round); 53 NTU (geomean-dry season, May-Oct.); 56 NTU (median-dry season, May-Oct)

Monitoring sites used for lower alluvial valley 25th percentiles water quality data



Agricultural Alluvial Valley Inland Streams:
Basin floor, sloughs, and flood plain: Statistical Summary.

Reclamation Canal, Tembladero Slough, Alisal Slough, Santa Rita Creek, Blanco Drain
Stream Geomorphic Description: Agricultural Valley Inland Streams - Basin Floor, Slough, and Floodplains
Statistical Summary of Nitrate-N

Temporal Representation	**Nov. 1971 – Dec. 2009**
Mean	22.70226313
Standard Error	0.939154872
Median	15.417
Mode	0.036
Standard Deviation	26.62963663
Range	439.975
Minimum	0.025
Maximum	440
No. of Samples	804
25th percentile	6.4

Reclamation Canal, Tembladero Slough, Alisal Slough, Santa Rita Creek, Blanco Drain
Stream Geomorphic Description: Agricultural Valley Inland Streams - Basin Floor, Slough, and Floodplains
Statistical Summary of Orthophosphate-P

Temporal Representation	**Nov. 1971 – Mar. 2010**
Mean	0.593975919
Standard Error	0.031233157
Median	0.34625
Mode	0.0075
Standard Deviation	1.330986993
Range	29.7925
Minimum	0.0075
Maximum	29.8
No. of Samples	1816
25th percentile	0.125

D.5.2 Alluvial Basin Floor Streams and Sloughs Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

Site:	Lower Alluvial Valley - Basin Floor Sites
Analyst:	PAO
Date:	10/8/2011 16:32

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity (35 NTU)

35 NTU turbidity = 25th percentile of lower alluvial valley monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm^2/d)

	Average	Minimum	Maximum
○ Enter manually	424	184	649
⦿ Estimate	Latitude 36.70	Month Range Jan	Dec

Stream Inputs

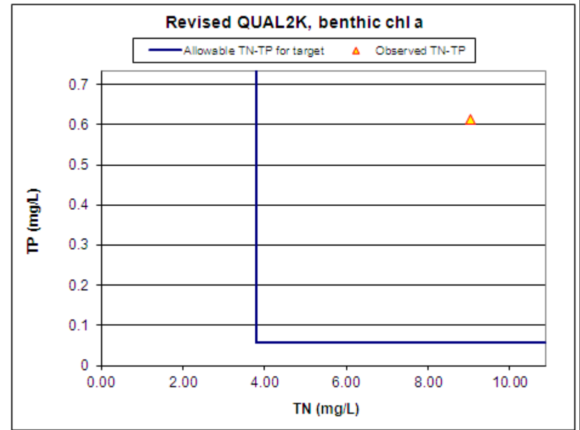
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	18.1
Days of Accrual (optional)	365
Canopy Closure	⦿ 0% ○ 20% ○ 40% ○ 80%
Light Extinction Coeff. (1/m)	3.94 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m^2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v13 (February 2007)

Max algal contribution to DO deficit (mg/L)	4.97



Allowable TN: 3.8 Allowable TP: 0.058

Site:	Lower Alluvial Valley - Basin Floor Sites
Analyst:	PAO
Date:	10/8/2011 16:32

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^{2}rclark@mlml.calstate.edu
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Geomean Dry Season Turbidity (53 NTU)

53 NTU turbidity = turbidity geomean of May-Oct. samples of lower alluvial valley monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm^2/d)

	Average	Minimum	Maximum
○ Enter manually	424	184	649
⦿ Estimate	Latitude 36.70	Month Range Jan	Dec

Stream Inputs

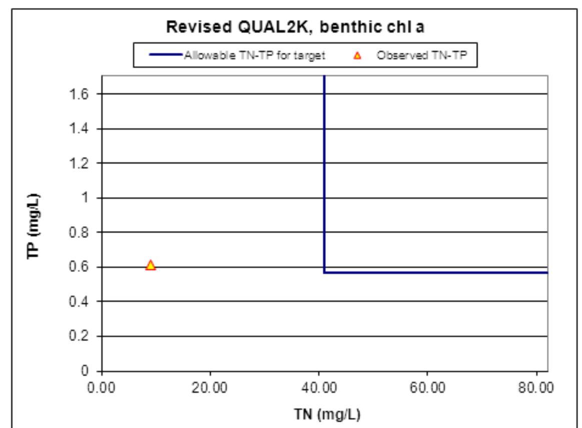
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	18.1
Days of Accrual (optional)	365
Canopy Closure	⦿ 0% ○ 20% ○ 40% ○ 80%
Light Extinction Coeff. (1/m)	5.74 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m^2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v13 (February 2007)

Max algal contribution to DO deficit (mg/L)	2.93



Allowable TN: 41 Allowable TP: 0.57

Site:	Lower Alluvial Valley - Basin Floor Sites
Analyst:	PAO
Date:	10/8/2011 16:32

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity (35 NTU)

35 NTU turbidity = 25^{th} percentile of lower alluvial valley monitoring sites used in 25^{th} percentile analysis

Unshaded Solar Radiation (cal/cm²/d)

		Average	Minimum	Maximum
○ Enter manually		424	184	649
◉ Estimate	Latitude	36.70	Month Range: Jan	Dec

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	18.1
Days of Accrual (optional)	365
Canopy Closure	◉ 0% ○ 20% ○ 40% ○ 80%
Light Extinction Coeff. (1/m)	3.94

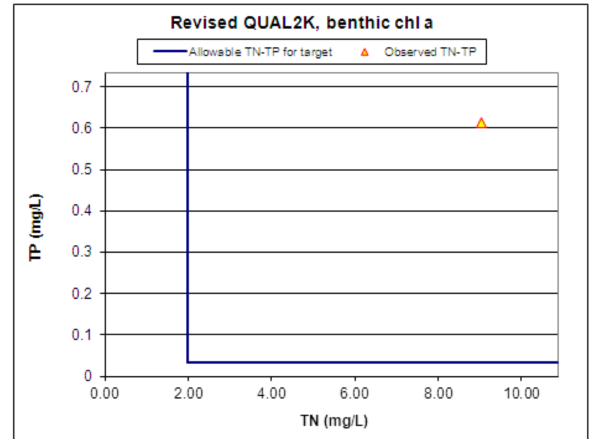
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v13 (February 2007)

Max algal contribution to DO deficit (mg/L)	4.97



Allowable TN: 2 Allowable TP: 0.033

Site:	Lower Alluvial Valley - Basin Floor Sites
Analyst:	PAO
Date:	10/8/2011 16:32

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Geomean Dry Season Turbidity (53 NTU)

53 NTU turbidity = turbidity geomean of May-Oct. samples of lower alluvial valley monitoring sites used in 25^{th} percentile analysis

Unshaded Solar Radiation (cal/cm²/d)

		Average	Minimum	Maximum
○ Enter manually		424	184	649
◉ Estimate	Latitude	36.70	Month Range: Jan	Dec

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	18.1
Days of Accrual (optional)	365
Canopy Closure	◉ 0% ○ 20% ○ 40% ○ 80%
Light Extinction Coeff. (1/m)	5.74

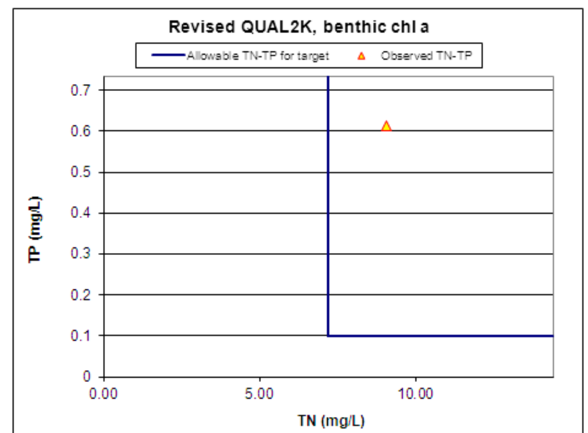
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v13 (February 2007)

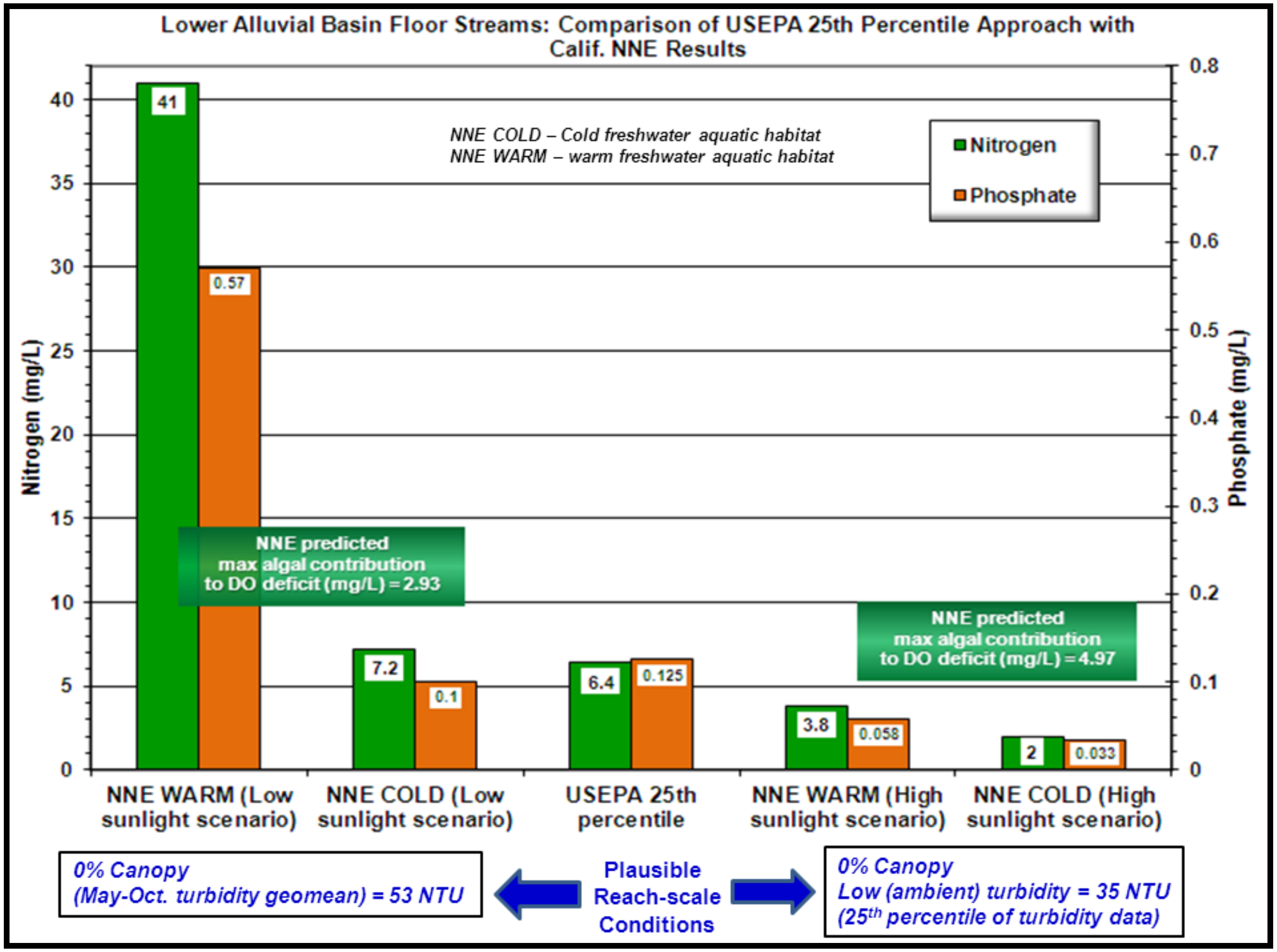
Max algal contribution to DO deficit (mg/L)	2.93



Allowable TN: 7.2 Allowable TP: 0.1

D.5.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Alluvial Basin Floor Streams and Sloughs)

The USEPA 25th percentile targets shown previously are shown relative to the NNE Higher Sunlight Availability and NNE low sunlight Availability scenarios, as shown in the figure below. This suggests the 25th percentile targets are in reasonably good agreement with NNE predicted nutrient targets that are based on plausible ranges of observed local conditions. Therefore, USEPA 25th percentile for nitrate (6.4 mg/L) and the 25th percentile for orthophosphate (0.125 mg/L) are selected as potential numeric targets for this stream reach



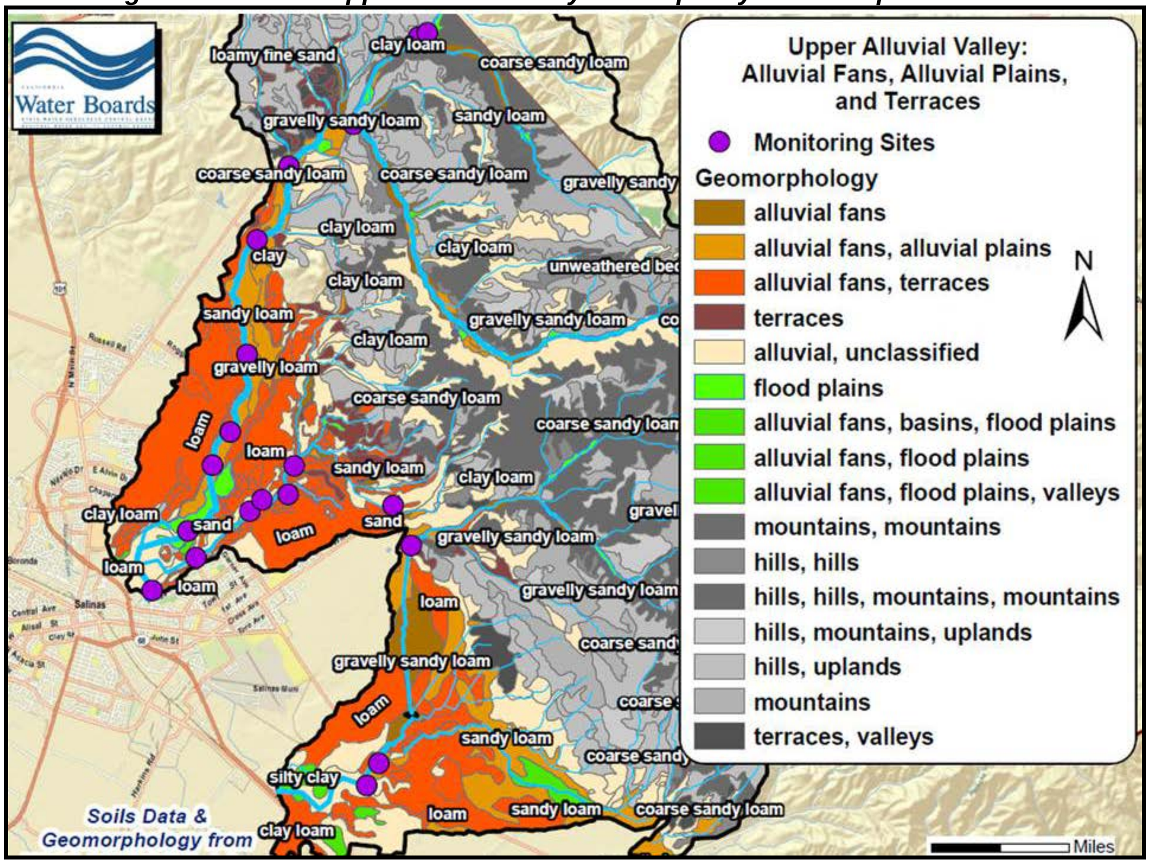
D.6 Upper Alluvial Valley - Alluvial Fan and Alluvial Plain Stream Reaches

D.6.1 Upper Alluvial Valley – Alluvial Fan and Plains 25th Percentile Targets

Stream Conditions

- Geomorphic description: Alluvial fans; alluvial plains, alluvial terraces, moderately-low gradient - slopes generally 1 to 3 degrees (source: NRCS-SSURGO)
- Waterbodies: Alisal Creek (upstream of Hartnell Rd), Gabilan Creek, Natividad Creek.
- Estimated riparian tree canopy: Varies, but generally 0% to 20% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Sand-rich - generally loams, sandy loams, and gravelly loams (source: NRCS-SSURGO)
- Turbidity conditions: <1 NTU (25th percentile-year round); 23 NTU (geomean-dry season, May-Oct.); 67 NTU (median-dry season, May-Oct)

Monitoring sites used for upper alluvial valley water quality data 25th percentiles



Upper Alluvial Valley Streams: Alluvial Fans, Alluvial Plain and Terraces: Statistical Summary

Alisal Creek, Gabilan Creek, Natividad Creek Stream Geomorphic Description: Upper alluvial valley, alluvial fan, plains and terraces **Statistical Summary of Nitrate-N**	
Temporal Representation	May 1974 - December 2008
Mean	13.2340784
Standard Error	1.534558199
Median	4
Mode	2
Standard Deviation	20.47355997
Sample Variance	419.166658
Kurtosis	8.448836613
Skewness	2.769385739
Range	110.986
Minimum	0.014
Maximum	111
No. of Samples	178
25th percentile	**2**

Alisal Creek, Gabilan Creek, Natividad Creek Stream Geomorphic Description: Upper alluvial valley, alluvial fan, plains and terraces **Statistical Summary of Orthophosphate-P**	
Temporal Representation	June 1999 - March 2010
Mean	0.411987756
Standard Error	0.031945399
Median	0.27065
Mode	0.0075
Standard Deviation	0.486577822
Sample Variance	0.236757977
Kurtosis	13.49157755
Skewness	2.782657889
Range	3.9545
Minimum	0.0075
Maximum	3.962
No. of Samples	232
25th percentile	**0.05**

D.6.2 Upper Alluvial Valley – Alluvial Fan and Plains Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

Site:	Upper Alluvial Valley- Alluvial Fan&Plain
Analyst:	PAO
Date:	10/11/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity (1 NTU)

<1 NTU turbidity = 25th percentile of lower alluvial valley monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm^2/d)

	Average	Minimum	Maximum
Enter manually	424	184	649

	Latitude	Month Range	
● Estimate	36.70	Jan	Dec

Stream Inputs

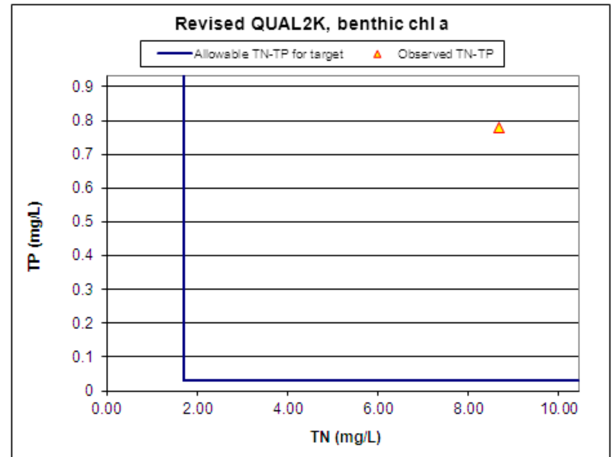
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.5
Days of Accrual (optional)	365
Canopy Closure	● 0% / 20% / 40% / 80%
Light Extinction Coeff. (1/m)	0.54 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m^2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v13 (February 2007)

Max algal contribution to DO deficit (mg/L)	6.95



Allowable TN: 1.7 Allowable TP: 0.029

Site:	Upper Alluvial Valley- Alluvial Fan&Plain
Analyst:	PAO
Date:	10/11/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **WARM**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 200 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 20% Tree Canopy Closure

- Geomean Dry Season Turbidity (23 NTU)

23 NTU turbidity = turbidity geomean of May-Oct. samples of lower alluvial valley monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm^2/d)

	Average	Minimum	Maximum
Enter manually	424	184	649

	Latitude	Month Range	
● Estimate	36.70	Jan	Dec

Stream Inputs

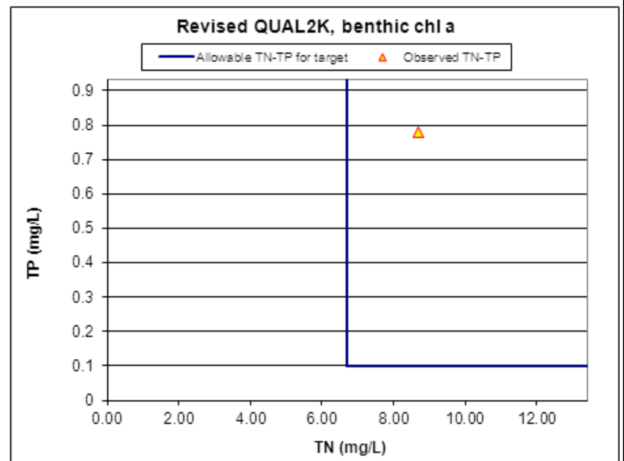
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.5
Days of Accrual (optional)	365
Canopy Closure	0% / ● 20% / 40% / 80%
Light Extinction Coeff. (1/m)	2.74 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m^2)	200
Corresponding Algal Density (g/m^2 AFDW)	80

California Benthic Biomass Tool, v13 (February 2007)

Max algal contribution to DO deficit (mg/L)	3.85



Allowable TN: 6.7 Allowable TP: 0.098

Site:	Upper Alluvial Valley- Alluvial Fan&Plain
Analyst:	PAO
Date:	10/11/2011 0:00

NNE Input:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity (1 NTU)

<1 NTU turbidity = 25th percentile of lower alluvial valley monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	424	184	649
◉ Estimate	Latitude: 36.70	Month Range: Jan	Dec

Stream Inputs

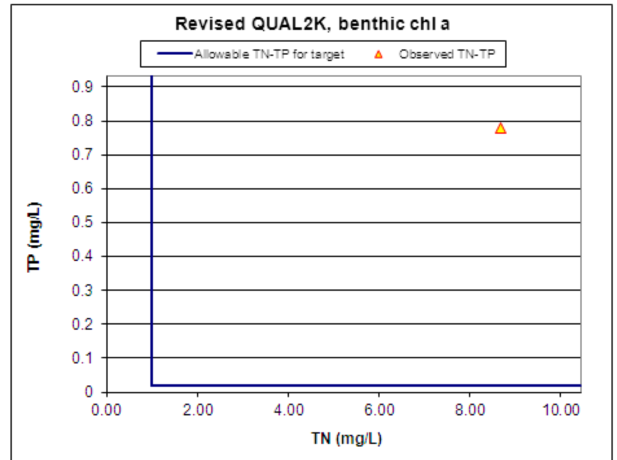
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.5
Days of Accrual (optional)	365
Canopy Closure	◉ 0% ○ 20% ○ 40% ○ 80%
Light Extinction Coeff. (1/m)	0.54 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v13 (February 2007)

Max algal contribution to DO deficit (mg/L)	6.95



Allowable TN: 1 Allowable TP: 0.0185

Site:	Upper Alluvial Valley- Alluvial Fan&Plain
Analyst:	PAO
Date:	10/11/2011 0:00

NNE Input:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 20% Tree Canopy Closure

- Geomean Dry Season Turbidity (23 NTU)

23 NTU turbidity = turbidity geomean of May-Oct. samples of lower alluvial valley monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm²/d)

	Average	Minimum	Maximum
Enter manually	424	184	649
◉ Estimate	Latitude: 36.70	Month Range: Jan	Dec

Stream Inputs

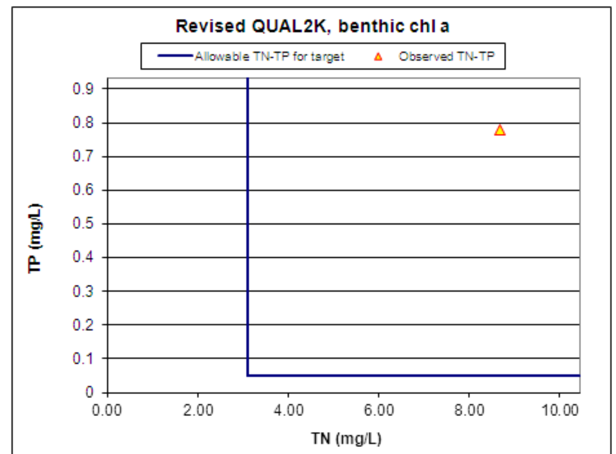
Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	16.5
Days of Accrual (optional)	365
Canopy Closure	○ 0% ◉ 20% ○ 40% ○ 80%
Light Extinction Coeff. (1/m)	2.74 ← Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m²)	150
Corresponding Algal Density (g/m² AFDW)	60

California Benthic Biomass Tool, v13 (February 2007)

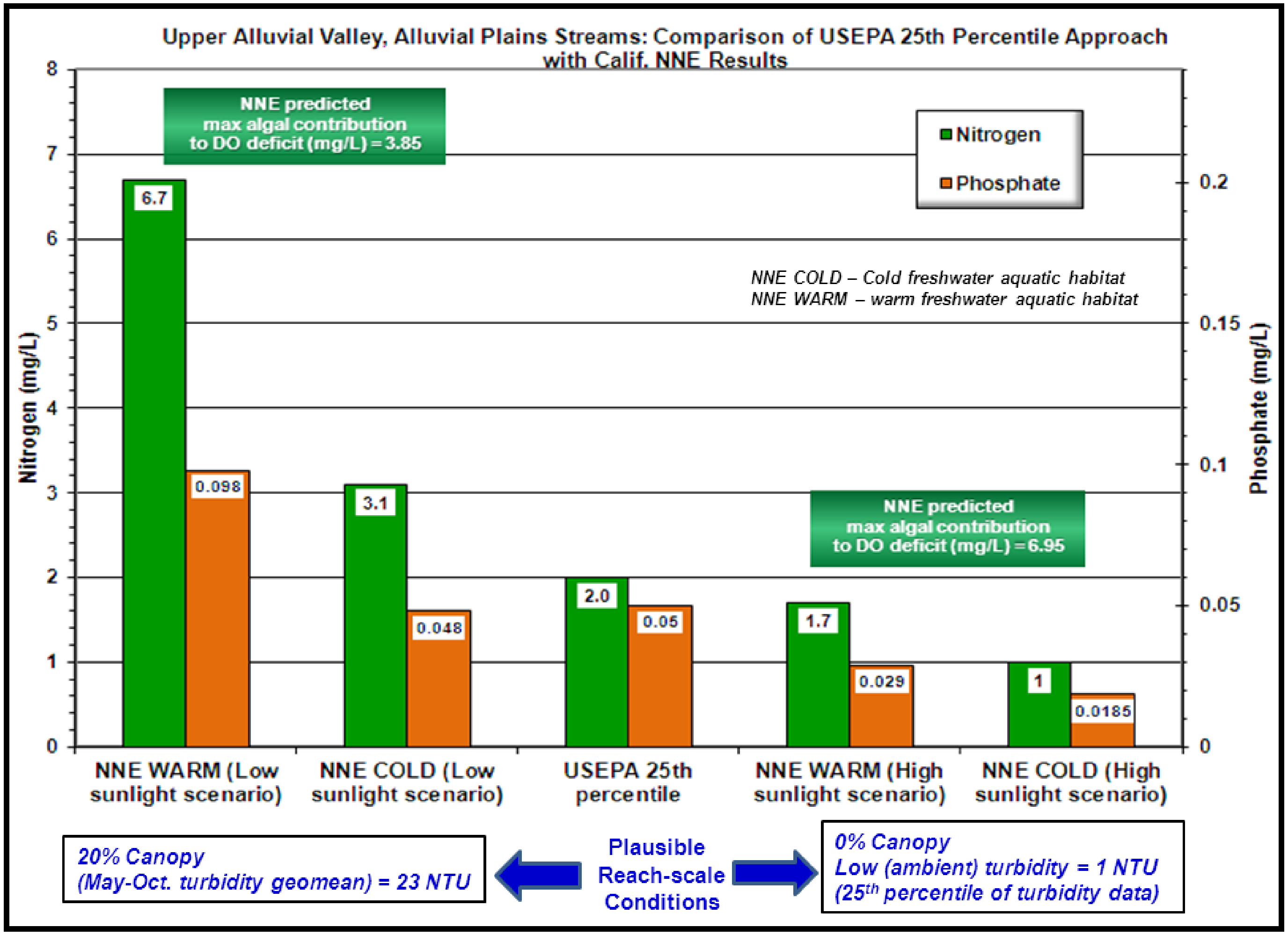
Max algal contribution to DO deficit (mg/L)	3.85



Allowable TN: 3.1 Allowable TP: 0.048

D.6.3 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Alluvial Fan and Plain Streams)

The USEPA 25th percentile targets shown previously are intermediate between the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. This suggests the 25th percentile targets are in reasonably good agreement with NNE predicted nutrient targets that are based on plausible ranges of observed local conditions. Therefore, USEPA 25th percentile for nitrate (2.0 mg/L) and the 25th percentile for orthophosphate (0.05 mg/L) are selected as potential numeric targets for this stream reach



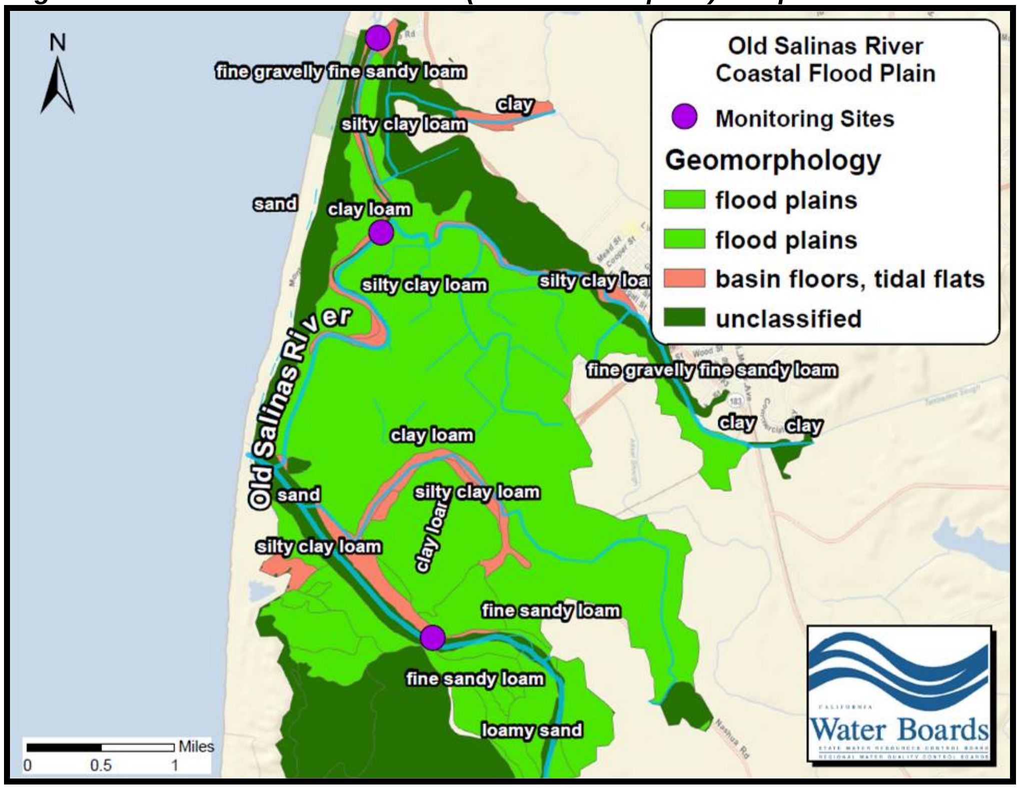
D.7 Old Salinas River – Coastal Flood Plain

Monitoring sites used to develop 25th percentile targets include 309SBR, OLS-MON, and OLS-POT. 309SBR is located at the Highway 1 and is the only reasonable approximation of nutrient concentrations in the Salinas River lagoon currently available. Note that the Old Salinas River receives it's inflow from the lagoon via a slide gate at Mulligan Hill; therefore 309SBR represents plausible nutrient concentrations in the uppermost reach of the Old Salinas River.

Stream Conditions

- Geomorphic description: Coastal flood plain, tidal flats. Low gradient - slopes generally less than 1 degree (source: NRCS-SSURGO)
- Waterbodies: Old Salinas River, from Salinas River lagoon slide gate to outlet to Old Salinas River estuary at Potrero Rd.
- Estimated average riparian tree canopy: 0% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Dominantly fine-grained: clay loams, silty clay loams (source: NRCS-SSURGO)
- Turbidity conditions: 23 NTU (25th percentile-year round); 40 NTU (geomean-dry season, May-Oct.); 53 NTU (median-dry season, May-Oct)

Monitoring sites used for Old Salinas River (coastal flood plain) 25th percentiles



Old Salinas River – Statistical Summary

Old Salinas River - Outflow from Lagoon to Potrero Rd. *Stream geomorphic description: Coast flood plain and tidal flat* **Statistical Summary of Nitrate-N**	
Temporal Representation	Nov. 1971 to July 2009
Mean	13.8614247
Standard Error	0.359693207
Median	11.3
Mode	1.582
Standard Deviation	11.88621429
Range	66.98822992
Minimum	0.01177008
Maximum	67
No. of samples	1092
25th percentile	**4.3**

Old Salinas River - Outflow from Lagoon to Potrero Rd. *Stream geomorphic description: Coast flood plain and tidal flat* **Statistical Summary of Orthophosphate-P**	
Temporal Representation	Nov. 1971 to July 2009
Mean	0.508657174
Standard Error	0.026075332
Median	0.29
Mode	0.03
Standard Deviation	0.820026705
Range	6.396
Minimum	0.004
Maximum	6.4
No. of samples	989
25th percentile	**0.13**

D.7.1 Old Salinas River Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

The Old Salinas River estuary is specifically designated for cold freshwater aquatic habitat (COLD) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for COLD beneficial use.

Site:	Old Salinas River- Coastal Flood Plain
Analyst:	PAO
Date:	10/12/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity (23 NTU):

23 NTU turbidity = 25th percentile of Old Salinas River monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm^2/d)

	Average	Minimum	Maximum
Enter manually	424	185	649

	Latitude	Month Range	
Estimate (selected)	36.80	Jan	Dec

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	17.0
Days of Accrual (optional)	365
Canopy Closure	0% (selected) / 20% / 40% / 80%
Light Extinction Coeff. (1/m)	2.74

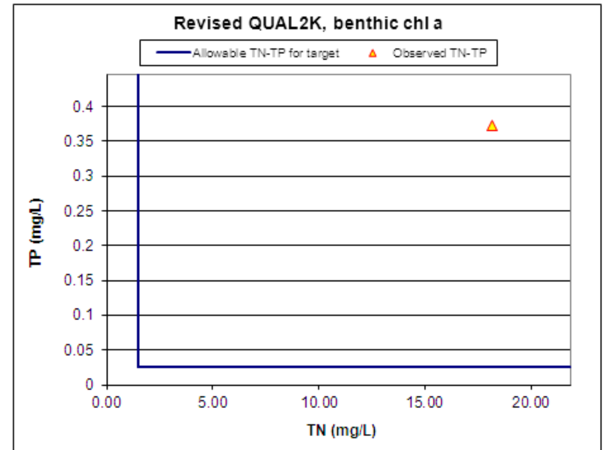
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m^2)	150
Corresponding Algal Density (g/m^2 AFDW)	60

California Benthic Biomass Tool, v13 (February 2007)

Max algal contribution to DO deficit (mg/L)	6.33



Allowable TN: 1.5	Allowable TP: 0.0255

Site:	Old Salinas River- Coastal Flood Plain
Analyst:	PAO
Date:	10/12/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Geomean Dry Season Turbidity (40 NTU):

40 NTU turbidity = turbidity geomean of May-Oct sample of Old Salinas River monitoring sites used in 25th percentile analysis

Unshaded Solar Radiation (cal/cm^2/d)

	Average	Minimum	Maximum
Enter manually	424	185	649

	Latitude	Month Range	
Estimate (selected)	36.80	Jan	Dec

Stream Inputs

Stream Depth (m)	0.5
Stream Velocity (m/s)	0.3
Water Temperature (°C)	17.0
Days of Accrual (optional)	365
Canopy Closure	0% (selected) / 20% / 40% / 80%
Light Extinction Coeff. (1/m)	4.44

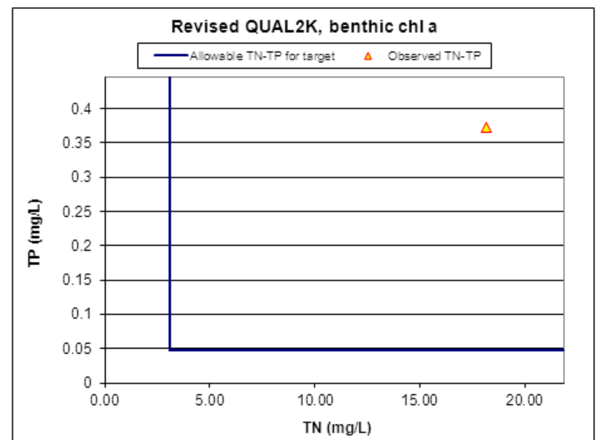
Calculate

Method & Target Selection

Select Method:	Revised QUAL2K, benthic chl a
Target Benthic Chl a (mg/m^2)	150
Corresponding Algal Density (g/m^2 AFDW)	60

California Benthic Biomass Tool, v13 (February 2007)

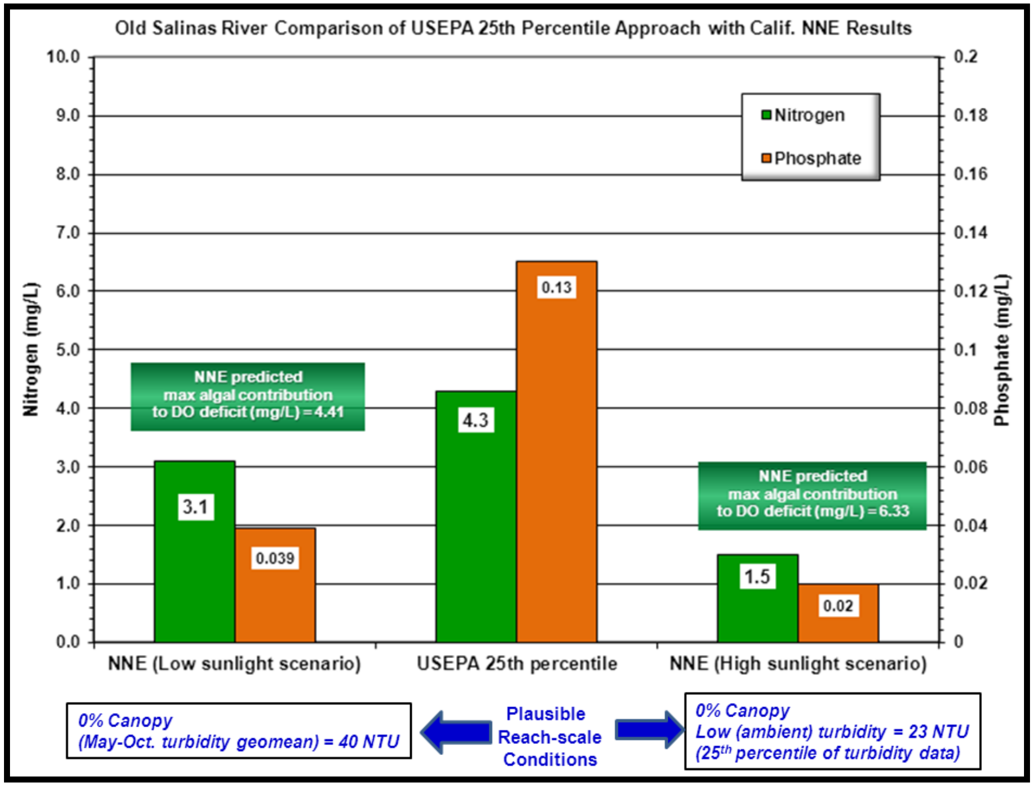
Max algal contribution to DO deficit (mg/L)	4.41



Allowable TN: 3.1	Allowable TP: 0.047

D.7.2 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Old Salinas River-Coastal Flood Plain)

The USEPA 25th percentile targets shown previously are show relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. For this stream reach, the USEPA 25th percentile for nitrogen is marginally higher than both the NNE scenarios; as such, in this case the USEPA 25th percentile appears to be marginally under-protective. As such, the 25th-percentile criteria for this stream appears to be underprotective. Consequently, the NNE nutrient targets under geomean dry season turbidity conditions (3.1 mg/L Nitrate-N) and 0.039 mg/L orthophosphate[5] are selected as potential numeric targets for this stream reach.



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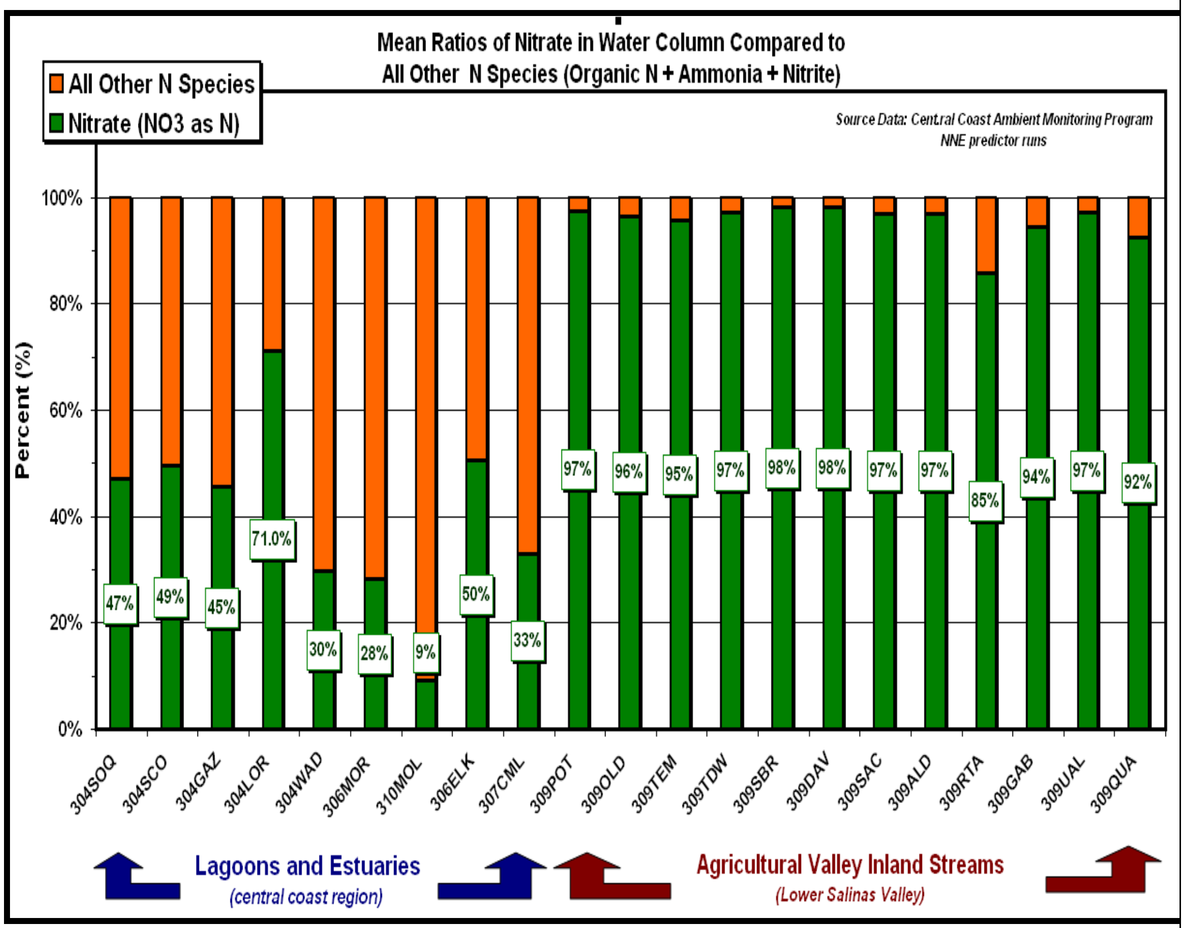
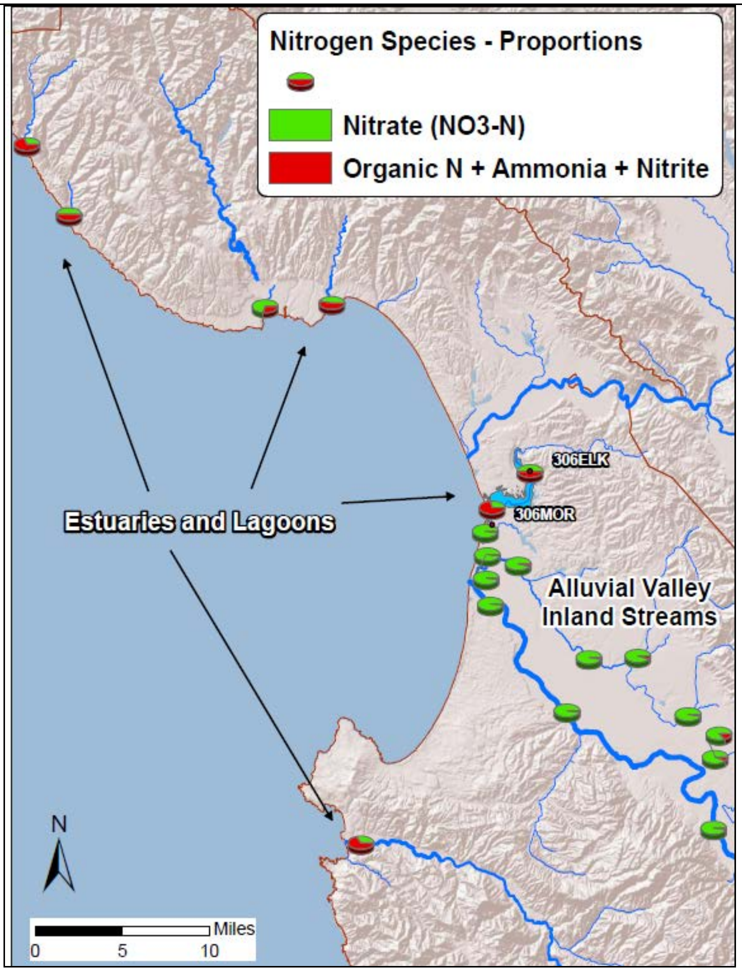
[5] A scientific peer review referee for this project noted that for the river ecotypes, the 25th percentile values for nitrate and orthophosphate covary; systems with > 4 mg-N/L nitrate have > 0.1 mg/L orthophosphate while systems with < 2 mg-N/L nitrate have < 0.05 mg/L orthophosphate. Consequently, the peer reviewer noted that it appears that the 25th percentile value for both nitrate and orthophosphate for the Old Salinas River are not representative of moderately disturbed conditions, as they are both higher than NNE model results under "low" and "typical" turbidity levels. As such, the orthophosphate targets should be down-scaled. The peer review referee recommended in the current scheme (refer back to Figure 7), it would more appropriate to lower the orthophosphate target to 0.039 mg/L (NEE low light scenario), then subsequently default to 0.07 mg/L (lightly disturbed orthophosphate 75th percentile level – see Section C.9.1 of this Appendix).

D.8 Moro Cojo Slough – Tidal Flats

Nitrate targets are not appropriate for Morro Cojo slough. Nitrate concentrations in Moro Cojo slough only measure a fraction of total nitrogen in the water column as shown in the figures below. In contrast, nitrate in the Salinas Valley agricultural valley inland streams constitute generally over 95% of total nitrogen in the water column, and thus nitrate is a plausible surrogate measuring total water column nitrogen in these waterbodies. Accordingly, a nitrate concentration from Moro Cojo slough may not be directly comparable to a nitrate concentration from, say, the Reclamation Canal. Presumably, nitrate comprises a lower ratio of total nitrogen in the water columns of coastal estuaries and lagoons in the central coast region because these are typically areas of high primary productivity, and nitrogen cycling and biological uptake are likely more pronounced relative to Salinas valley agricultural inland streams. As shown graphically below, nitrate-N is likely only a small fraction of total N in the water column at Moro Cojo Slough site 306MOR, likely due to elevated biological uptake of NO3 in tidal flat-estuarine environments and sequestration of N in organic phases. As such, total nitrogen targets (rather than nitrate targets) are more appropriate for Moro Cojo slough.

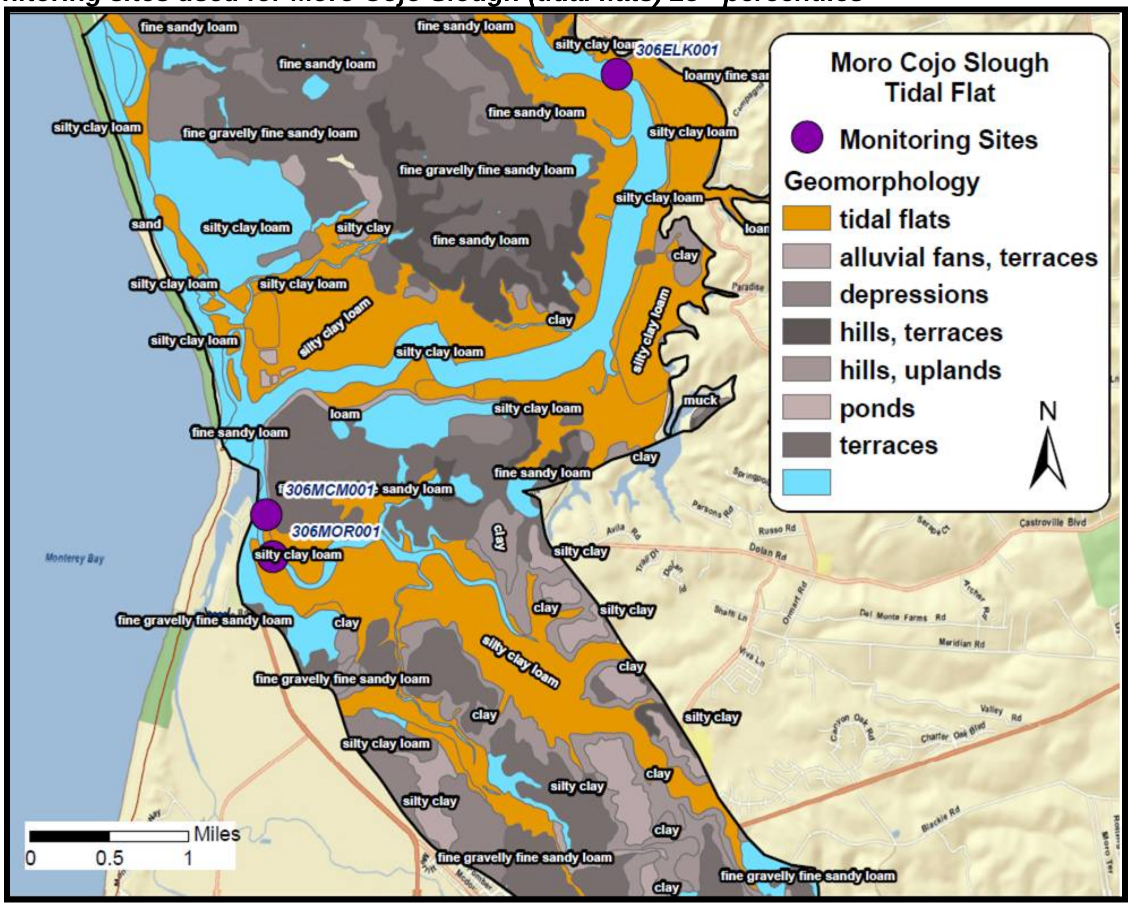




Stream Conditions

- Geomorphic description: Tidal flats. Low gradient - slopes generally less than 1 degree (source: NRCS-SSURGO)
- Waterbodies: Moro Cojo Slough
- Estimated average riparian tree canopy: 10% (source: NLCD, 2001 canopy raster, field observation)
- Substrate-soils: Mostly moderately fine-grained: silty clay loams, and clay (source: NRCS-SSURGO)
- Turbidity conditions: 4 NTU (25th percentile-year round); 7 NTU (geomean-dry season, May-Oct.); 9 NTU (median-dry season, May-Oct)

Monitoring sites used for Moro Cojo Slough (tidal flats) 25th percentiles



Tidal Flat: Statistical Summary.

Moro Cojo Slough *Stream geomorphic description: Tidal flats* **Statistical Summary of Total Nitrogen**	
Temporal Representation	Mar. 1999 - Feb. 2007
Mean	4.85
Standard Error	0.52
Median	5.00
Mode	5.00
Standard Deviation	3.28
Range	13.25
Minimum	1
Maximum	14.254826
No. of samples	40
25th percentile	**2.0**

Moro Cojo Slough *Stream geomorphic description: Tidal flats* **Statistical Summary of Total Nitrogen**	
Temporal Representation	Jan. 2006 - Feb. 2007
Mean	0.54
Standard Error	0.14
Median	0.23
Mode	0.15
Standard Deviation	0.77
Range	2.88
Minimum	0.02
Maximum	2.9
No. of samples	28
25th percentile	**0.13**

D.8.1 Moro Cojo Slough Nutrient Numeric Endpoint Analysis (Calif. NNE Approach)

The Old Salinas River estuary is specifically designated for cold freshwater aquatic habitat (COLD) in Table II-1 of the Basin Plan; therefore NNE analysis was limited to the BURC II /III category for COLD beneficial use.

Site:	Moro Cojo Slough-Tidal Flats
Analyst:	PAO
Date:	10/13/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

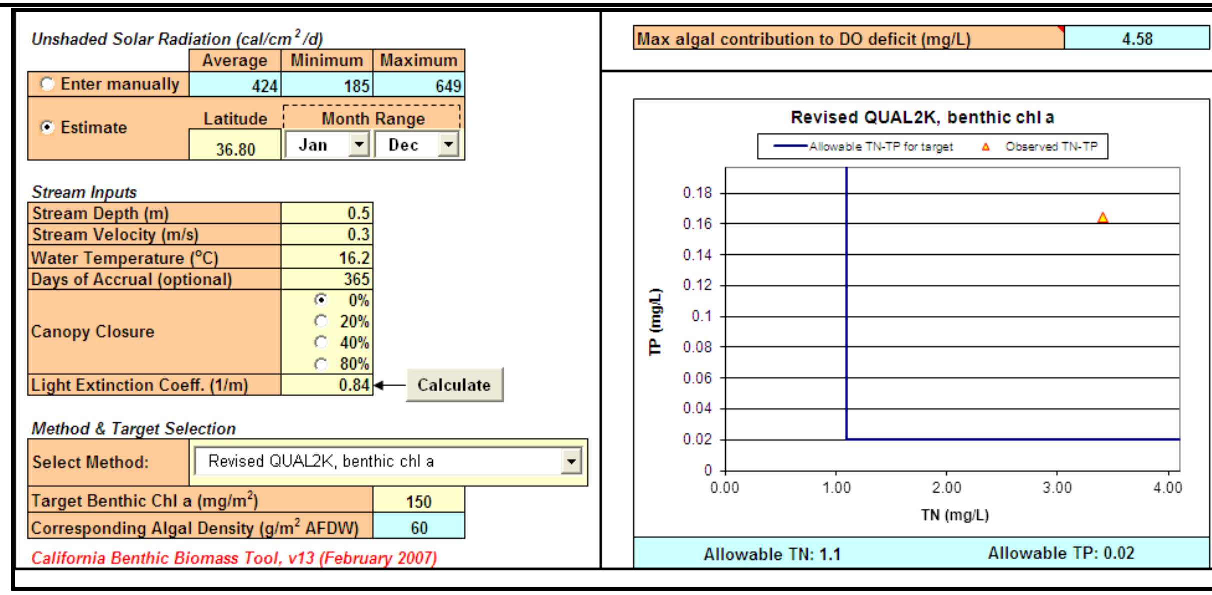
Higher Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 0% Tree Canopy Closure

- Ambient (low) Turbidity (4 NTU):

4 NTU turbidity = 25^{th} percentile of observed turbidity at site 306MOR.



Site:	Moro Cojo Slough-Tidal Flats
Analyst:	PAO
Date:	10/13/2011 0:00

NNE Parameters:

- Beneficial Use Risk-Classification: (BURC): II / III
- Beneficial Use: **COLD**
- Response Variable: Benthic Algal biomass in streams
- Numeric Target: 150 mg chl-a/m^2
- Method: Revised QUAL2k, benthic chl a

Stream Condition Input:

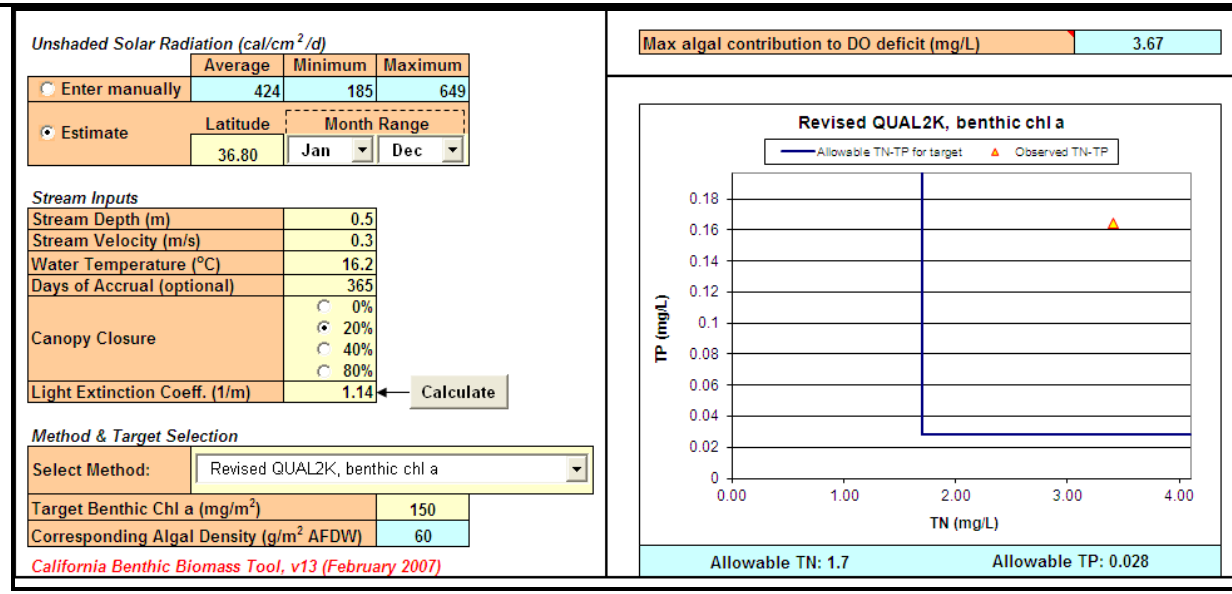
Lower Sunlight Availability Scenario

(based on plausible ranges of local conditions)

- 20% Tree Canopy Closure

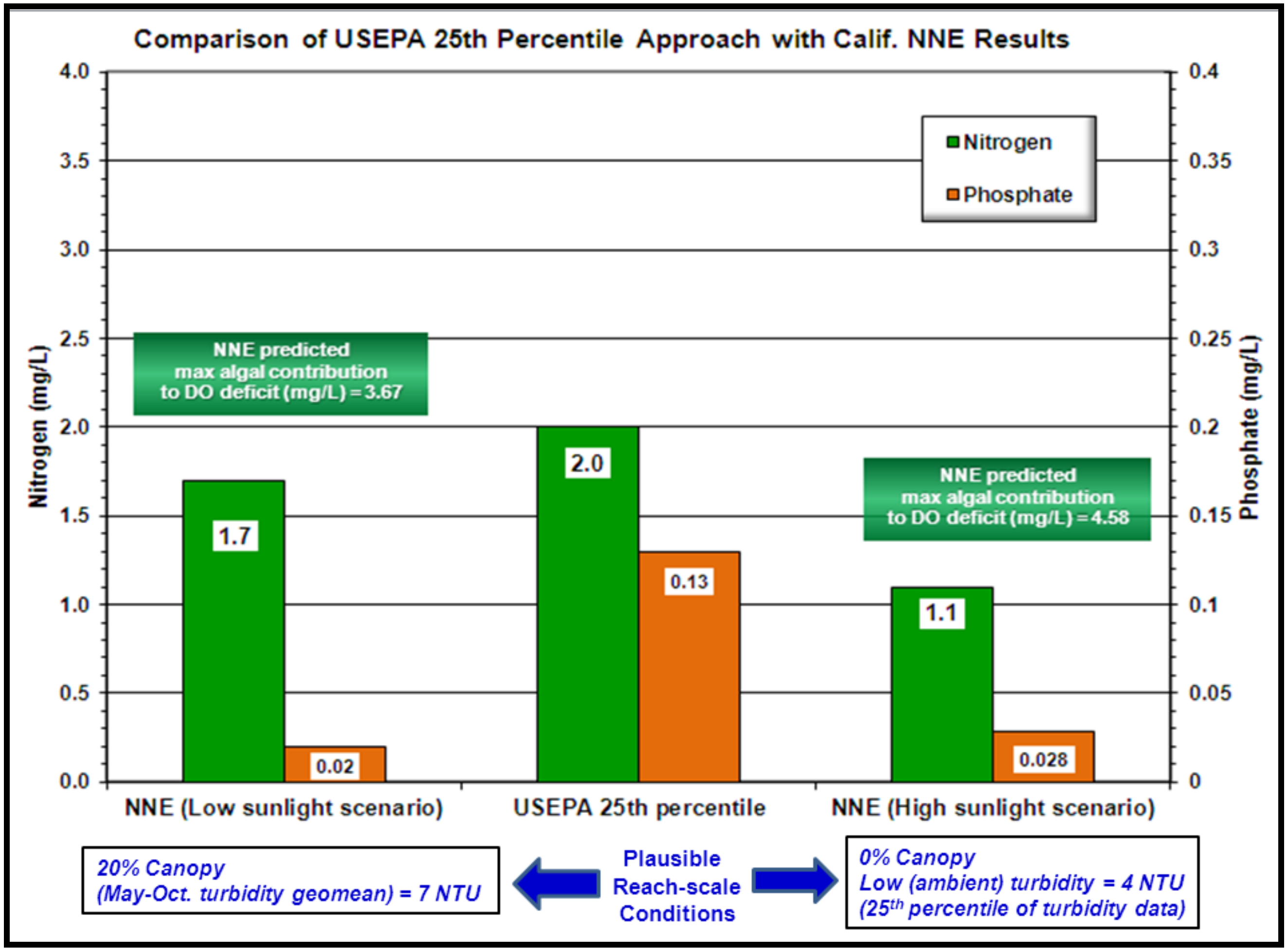
- Geomean Dry Season Turbidity (7 NTU):

7NTU turbidity = turbidity geomean of May-Oct. samples from site 306MOR.



D.8.2 Comparison of USEPA 25th Percentile Approach and Calif. NNE Approach (Moro Cojo Slough – Tidal Flats)

The USEPA 25th percentile targets shown previously are show relative to the NNE Higher Sunlight Availability and NNE Lower Sunlight Availability scenarios, as shown in the figure below. For this stream reach, the USEPA 25th percentile for nitrogen is marginally higher than both the NNE scenarios; as such in this case the USEPA 25th percentile appears to be marginally under-protective. Therefore, the 25th percentile target for this stream reach will not be based on the USEPA 25th percentile target. The NNE nitrate target under "typical" dry season turbidity conditions (1.7 mg/L total nitrogen) and the 25th percentile for orthophosphate (0.13 mg/L) are selected as potential numeric targets for this stream reach.



D.9 Nutrient Concentrations in Headwater Reaches and Lightly-Disturbed Tributaries of the Salinas River Basin

An important tenet of the California NNE approach (Tetra Tech, 2006 - refer back to footnote 4) 2Fis that targets should not be set lower than the concentrations expected under background or relatively undisturbed conditions. Further, guidance from researchers with expertise in central coast biostimulation issues indicates regulatory nutrient targets should not be more stringent (i.e., lower) than nutrient concentrations found in natural systems in the Salinas River basin (Dr. Marc Los Huertos[6], California State University, Monterey Bay, personal communication Oct. 14, 2011).

Therefore, staff applied the USEPA reference stream methodology, to ensure that biostimulation nutrient targets are no more stringent than expected nutrient concentrations found in natural or lightly-disturbed headwater and tributary reaches in the Salinas River basin. USEPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams (USEPA, 2000 - refer back to footnote 2) describes an approach to establish a nutrient reference condition. The approach is to establish the upper 75th percentile of a reference population of streams. The 75th percentile was chosen by USEPA since it is likely associated with minimally impacted conditions, and will be protective of designated uses. 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."

The following figures illustrate the range and statistics of nitrate (as N) and orthophosphate (as P) concentrations in headwater reaches and lightly disturbed tributaries of the Salinas River basin. Note that the 75th percentiles for this population of stream data are 0.15 mg/L nitrate-N, and 0.07 mg/L orthophosphate-P. For comparative purposes, note that USEPA's reference condition for total phosphorus in subecoregion III-6 (Calif. Chaparral and Oak Woodlands) is 0.03 mg/L for total phosphorus[7]. Also noteworthy is that the 90th percentile of nitrate-N in Salinas River basin reference streams is 0.98 mg/L. This suggests that nitrate-N in reference stream conditions typically never exceeds about 1 mg/L except in outlier or anomalous conditions.

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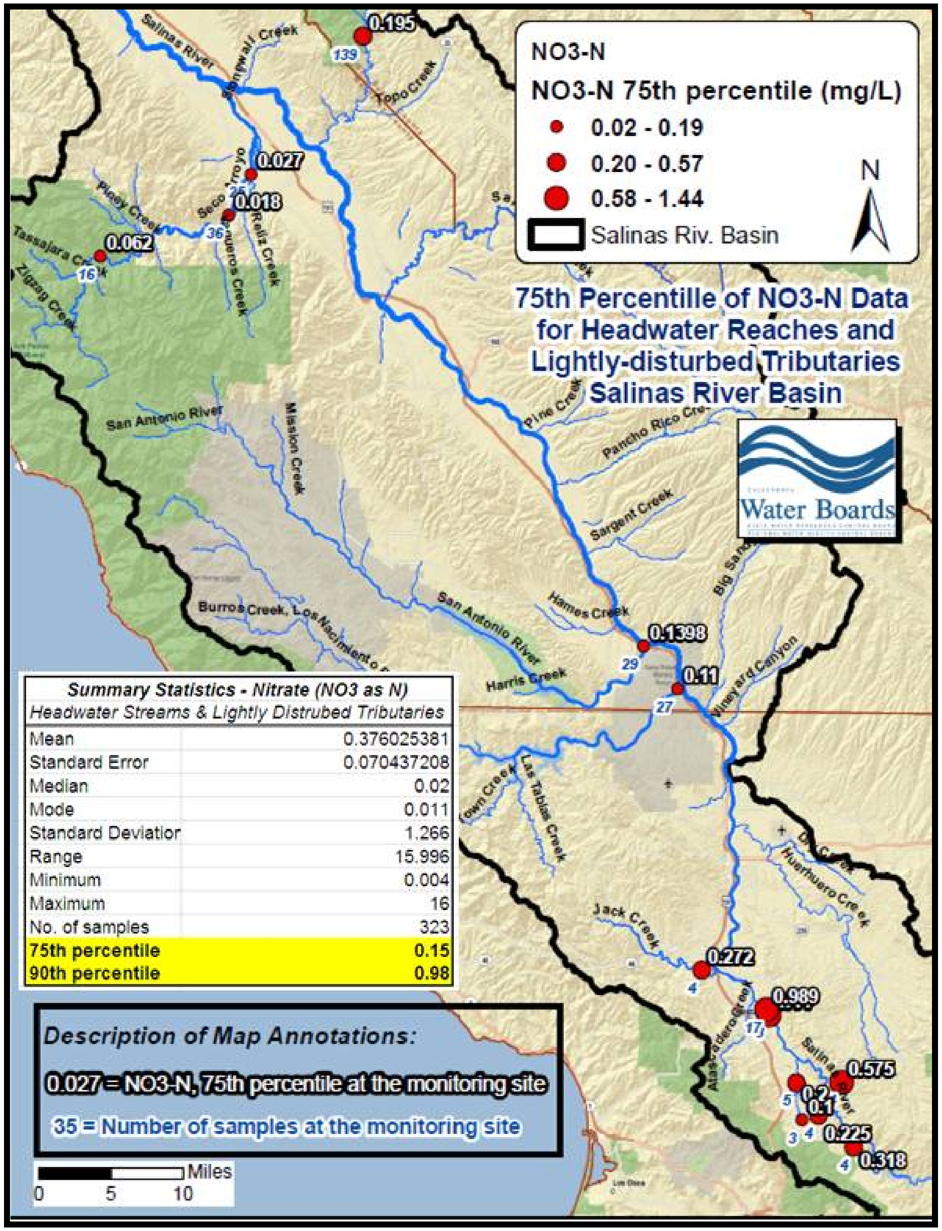
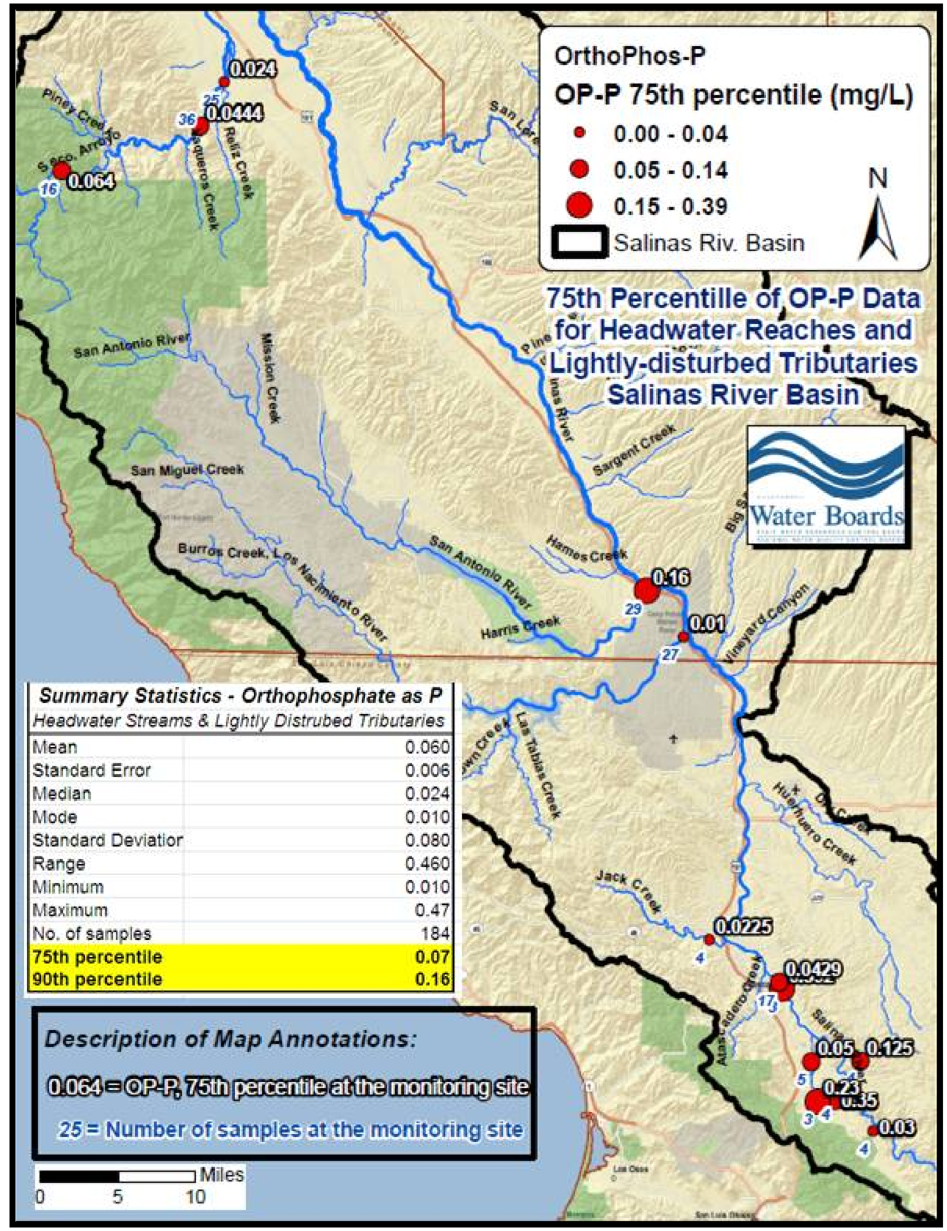
[6] Dr. Marc Los Huertos in an Assistant Professor of Science and Environmental Policy at California State University, Monterey Bay. Dr. Los Huertos has substantial research experience with agricultural water quality, aquatic ecology, and biostimulation in the California central coast region.

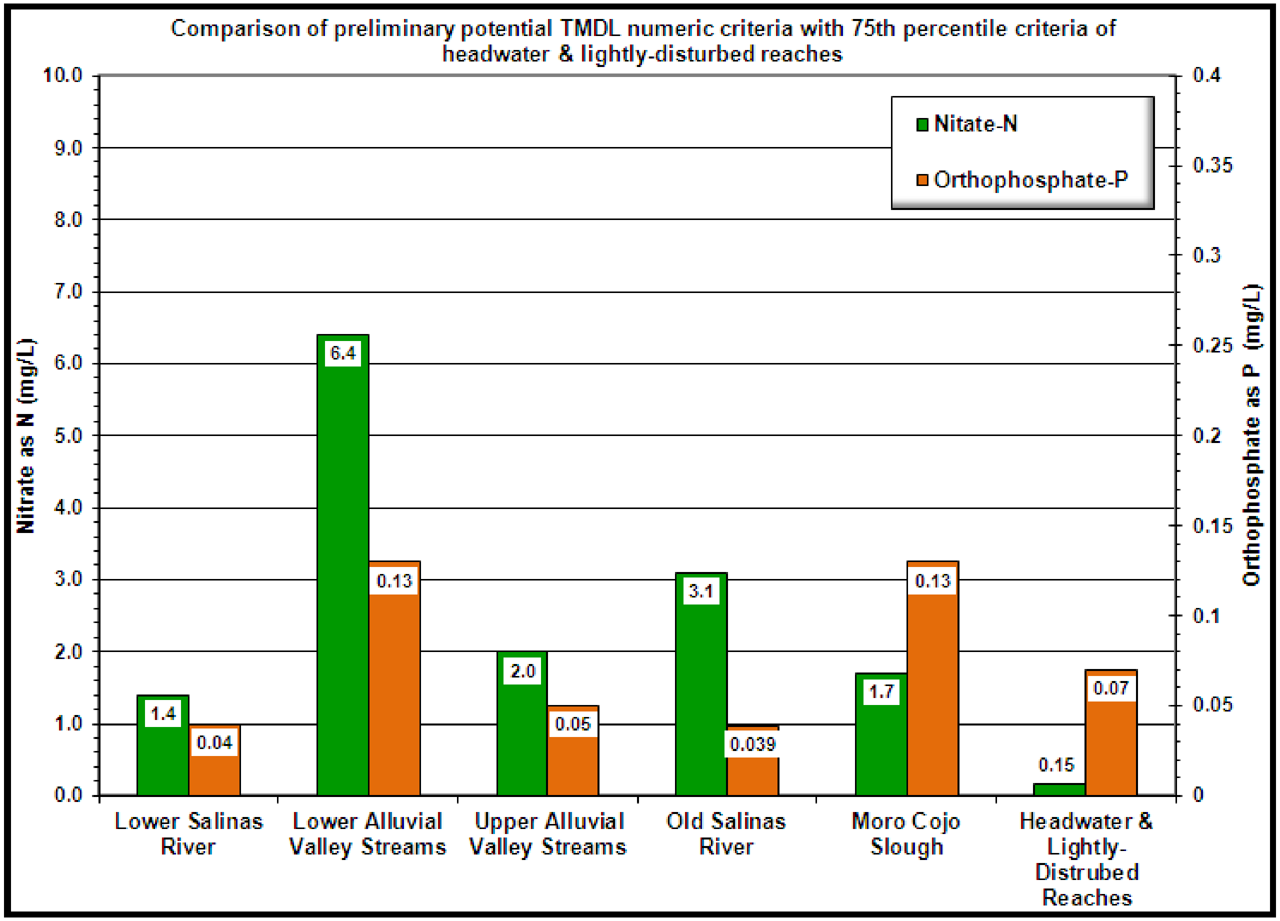
[7] USEPA. 2000. Ambient Water Quality Criteria Recommentations. Information Supporting the Development of State and Tribal Nutrient Criteria for River and Streams in Nutrient Ecoregion III – Xeric West. EPA-822-B-00-016.


NO3-N
NO3-N 75th percentile (mg/L)
0.02 - 0.19
0.20 - 0.57
0.58 - 1.44
Salinas Riv. Basin
N
75th Percentille of NO3-N Data
for Headwater Reaches and
Lightly-disturbed Tributaries
Salinas River Basin
Water Boards
Summary Statistics - Nitrate (NO3 as N)
Headwater Streams & Lightly Distrubed Tributaries
Mean 0.376025381
Standard Error 0.070437208
Median 0.02
Mode 0.011
Standard Deviatior 1.266
Range 15.996
Minimum 0.004
Maximum 16
No. of samples 323
75th percentile 0.15
90th percentile 0.98
Description of Map Annotations:
0.027 = NO3-N, 75th percentile at the monitoring site
35 = Number of samples at the monitoring site
Miles
0 5 10
0.195
139
0.027
0.018
0.062
0.1398
29
0.11
27
0.272
4
0.989
17
0.575
0.225
0.318
Salinas River
Topo Creek
San Antonio River
Mission Creek
Pine Creek
Pancho Rico Creek
Sargent Creek
Hames Creek
Harris Creek
Vineyard Canyon
Jack Creek
Burros Creek, Los Nacimiento


OrthoPhos-P
OP-P 75th percentile (mg/L)
0.00 - 0.04
0.05 - 0.14
0.15 - 0.39
Salinas Riv. Basin
N
75th Percentille of OP-P Data
for Headwater Reaches and
Lightly-disturbed Tributaries
Salinas River Basin
Water Boards
Summary Statistics - Orthophosphate as P
Headwater Streams & Lightly Distrubed Tributaries
Mean 0.060
Standard Error 0.006
Median 0.024
Mode 0.010
Standard Deviatior 0.080
Range 0.460
Minimum 0.010
Maximum 0.47
No. of samples 184
75th percentile 0.07
90th percentile 0.16
Description of Map Annotations:
0.064 = OP-P, 75th percentile at the monitoring site
25 = Number of samples at the monitoring site
Miles
0 5 10
0.024
0.0444
0.064
0.16
29
0.01
27
0.0225
0.0429
0.05
0.125
0.23
0.35
0.03
San Antonio River
Mission Creek
San Miguel Creek
Sargent Creek
Hames Creek
Harris Creek
Vineyard Canyon
Jack Creek

D.9.1 Comparison of Preliminary Numeric Criteria with 75th Percentile Numeric Criteria of Headwater Reaches

The preliminary and potential TMDL numeric criterion developed previously in this appendix with the 25th percentile approach and the Calif. NNE approach are show below relative to the 75th percentile criterion for headwater and lightly-disturbed reaches in the Salinas River basin. Generally, most of the previously developed potential criterion are not less than the 75th percentile reference stream criterion, and therefore conform to technical guidance that nutrient targets should not be lower than nutrient concentrations found in natural systems. However, note that the preliminary orthophosphate criteria for the lower Salinas River, the alluvial fan and plain stream reaches (Gabilan Creek, Natividad Creek, Alisal Creek), and the Old Salinas River are lower than the 75th percentile of orthophosphate at reference site conditions. As such, these preliminary nutrient criteria may be over-protective for these stream reaches. Accordingly, the orthophosphate target for the lower Salinas River, for the alluvial fan and plain stream reaches, and the Old Salinas River will be set at the less stringent 75th percentile criteria in reference streams (i.e., 0.07 mg/L orthophosphate as P)



D.10 Seasonal Biostimulatory Numeric Targets

D.10.1 Basis for Dry-Season and Wet-Season Numeric Targets

Photo documentation, field observations, and input provided by researchers[8] with expertise in eutrophication issues in Elkhorn Slough and the lower Salinas Valley indicate clear evidence of algae problems and biostimulation in the summer months, and that eutrophication is primarily a summer-time water quality problem in coastal confluence waterbodies and streams of northern Monterey County (for example, see following figure).

There is also some evidence of periodic and episodic excessive chlorophyll levels in winter months, based on available water quality data. Staff concludes that it would be unwarranted at this time to apply the nutrient numeric targets developed in this appendix to implement the Basin Plan's biostimulatory objective on a year-round basis. Additionally, 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

[8] Personal communications: Ken Johnson, Ph,D. (Senior Scientist, Monterey Bay Aquarium Research Institute); Brent Hughes (estuarine ecologist, Elkhorn Slough National Estuarine Research Reserve); Mary Hamilton (environmental scientist, Central Coast Ambient Monitoring Program)

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. In short, evidence of algal impairment is less conclusive for winter time than for summer conditions.

Therefore, the nutrient numeric criteria develop in preceding sections of this appendix are proposed to apply during the dry season (May 1 to October 31) when excessive algal growth and biostimulation problems appear to be unequivocal.

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 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[9]. 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 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[10] have similarly incorporated seasonal targets for nutrients for the same reasons.

At this time, staff proposes a TMDL nitrate target for the wet-season (Nov. 1 to April 30) that is less stringent than the dry-season targets developed previously in this appendix, but more stringent that the Basin Plan numeric objective for nitrate (i.e., the 10 mg/L MUN objective). Staff proposes incorporating a 20% explicit margin of safety to the Basin Plan nitrate MUN numeric objective for the wet-season numeric target to help account for uncertainty concerning biostimulatory problems in the wet season. As such, the proposed wet-season biostimulatory target for nitrate is 8 mg/L. The basis for identifying the 8 mg/L wet-season nitrate-N target is as follows:

1) Photo documentation, field observations, water quality data, and input provided by researchers (refer back to footnote 8) with expertise in eutrophication issues in the central coast region indicate clear evidence of algae problems and biostimulation in the summer months, and that eutrophication is primarily manifested as a summer-time water quality problem in project area waterbodies, and in Elkhorn Slough. In the winter higher flows, cooler temperatures, lower light availability, and scouring evidently limit algal production. There are substantial uncertainties regarding the extent to which winter-time algal biomass problems manifest themselves, and about the extent to which winter time loads of nitrogen ultimately contribute to biostimulation problems in the summer.
2) The USEPA similarly established a nutrient TMDL for inland stream in southern California which contained a winter time nitrogen target of 8 mg/L, based on the application of a 20% margin of safety to the Basin Plan's numeric objective of nitrate and to account for uncertainty regarding winter time algae problems[11].

[9] State of Connecticut Dept. of Environmental Protection. 2005. A Total Maximum Daily Load Analysis for Linsley Pond in North Branford and Branford, Connecticut

[11] USEPA. Total Maximum Daily Loads for Nutrients, Malibu Creek Watershed.

3) Recent research on biostimulation on inland surface waters from agricultural watersheds in the California central coast region indicates that 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[12,13]. Therefore, the 10 mg/L nitrate-nitrogen objective is insufficiently protective against biostimulatory impairments. Consequently, staff concludes that it is necessary to set nutrient wet-season numeric targets more stringent than the existing numeric objectives found for nitrate in the Basin Plan (i.e., the 10 mg/L MUN objective).

Similarly, staff proposes to establish a wet season orthophosphate target that is less stringent than the dry-season orthophosphate targets developed previously in this appendix. Staff is proposing a wet season target to help account for uncertainty regarding biostimulatory problems associated with wet season loads of orthophosphate. Unfortunately, there are currently no established numeric water quality objectives for phosphates in the Basin Plan on which to base a less stringent wet-season target. However, phosphate targets for streams have been adopted in some other states. The State of Nevada adopted a total phosphate target of 0.3 mg/L for Class B streams, and for most reaches of Class A streams. As such, the proposed wet-season biostimulatory target for orthophosphate is 0.3 mg/L. The basis for identifying the 0.3 mg/L wet-season orthophosphate-P target is as follows:

The basis for this proposal is as follows:

1) Photo documentation, field observations, water quality data, and input provided by researchers (refer back to footnote 8) with expertise in eutrophication issues in the central coast region indicate clear evidence of algae problems and biostimulation in the summer months, and that eutrophication is primarily manifested as a summer-time water quality problem in project area waterbodies, and in Elkhorn Slough. In the winter higher flows, cooler temperatures, lower light availability, and scouring evidently limit algal production. There are substantial uncertainties regarding the extent to which winter time algal biomass problems manifest themselves, and about the extent to which winter time loads of phosphorus ultimately contribute to biostimulation problems in the summer.

2) The State of Nevada adopted a total phosphate numeric criteria of 0.3 mg/L for Class B streams, and for most reaches of Class A streams[14]

3) USEPA nutrient target development guidance recognizes the use of established concentration thresholds from published literature (refer back to footnote 2)

4) A wet season value of 0.3 mg/L comports well with the high end of orthophosphate concentrations found in reference conditions in the Salinas River basin (i.e., lightly-disturbed and natural stream systems). As shown in Section D.9, the 90th percentile, and the maximum concentrations of reference conditions in the Salinas River basin range from 0.16 mg/L to 0.47 mg/L orthophosphate, respectively. Therefore, the proposed wet-season of 0.3 mg/L satisfies the conditions that a wet season target at this time should be less stringent than a dry season target, and the proposed target itself falls well within the range of high-end concentrations (i.e., 0.16 to 0.47 mg/L) that

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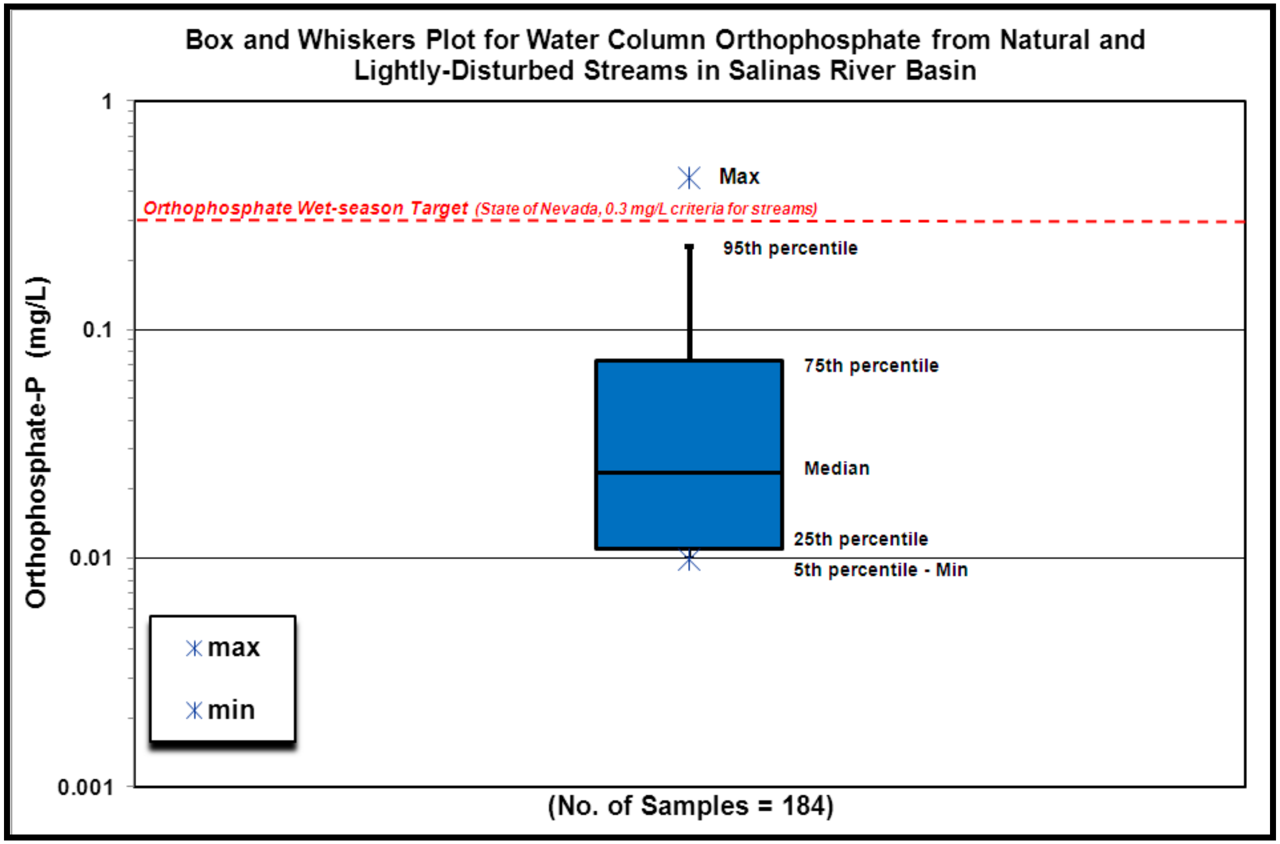
[12] University of California, Santa Cruz. 2010. Final Report: Long-term, high resolution nutrient and sediment monitoring and characterizing in-stream primary production. Proposition 40 Agricultural Water Quality Grant Program. Dr. Marc Los Huuertos, Ph.D., project director.

[13] 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

[14] USEPA, 1988. Phosphorus – Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria. (Sept. 1988)

can plausibly be expected under relatively undisturbed or reference conditions (see following figure). In other words, 0.3 mg/L is consistent with high-end orthophosphate concentrations found in natural and lightly-disturbed stream systems in the Salinas River basin, and consequently does not plausibly appear to be under-protective for use as a less-stringent wet season target.



However, it should be noted that research into eutrophication in inland surface streams and estuaries are an active and ongoing area of research. Should future research and studies indicate systematic biostimulatory impairments in the winter months, or contributions to summertime biostimulation ultimately resulting from winter time loading, the Water Board may consider extending the more stringent dry season numeric targets to the wet season.

Finally, nutrient TMDLs often embed a statistical threshold in targets developed for biostimulatory substances. This is because the application and use of the USEPA-recognized statistical approaches must consider that the published ecoregional approaches that underlies these statistical approaches inherently accounts for natural variability. Therefore, it would be inappropriate to expect project area streams to not exhibit some natural variability , including concentrations that will ultimately be marginally higher than the proposed biostimulatory targets, as well as lower. Therefore, dry-season targets, which are based on USEPA statistical methodologies are established as the geomean values of dry-season samples.

D.11 Final TMDL Numeric Targets for Biostimulatory Substances

Waterbody Type	Geomorphology & Stream Characteristics	Project Area Stream Reaches	Allowable Nitrate-N (mg/L)	Allowable Orthophosphate-P (mg/L)	Methodology for Developing Numeric Target	Notes Pertaining to Development of Targets
Alluvial Valley Flood Plain River	Alluvial valley river. Alluvial flood plain. Low ambient turbidity 13% average canopy cover; sandy substrate	Lower Salinas River – Gonzalez to Salinas River Lagoon	**1.4** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.07** **Dry Season Samples (May 1-Oct. 31)** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	Generally low ambient turbidity (5 NTU-25th percentile), sandy substrate, good sunlight penetration, low to moderate canopy cover indicates risk of biostimulation at relatively low concentrations of nutrients.
Lower Alluvial Valley streams and sloughs	Alluvial basin floor and alluvial floodplains; Moderate ambient turbidity; Muddy to earthen substrates and fine-grained soil conditions; almost no canopy cover	Tembladero Slough all reaches Merritt Ditch dwnstrm of Merritt Lake Reclamation Canal downstream of Hartnell Rd. to confluence w/Tembladero Slough Alisal Slough all reaches Espinosa Slough from Espinosa lake to confluence with Reclamation Canal Santa Rita Creek all reaches	**6.4** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.13** **Dry Season Samples (May 1-Oct. 31)** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	muddy and fine-grained substrates and local soil conditions result in relatively high ambient turbidity (30 NTU – 25th percentile) which precludes good sunlight penetration of water column; risk of biostimulation occurs at relatively higher nutrient concentrations.
Upper Alluvial Valley tributaries	Alluvial fans, alluvial plains and alluvial terraces, low to moderate ambient turbidity; generally silty or sandy substrates and soil conditions, canopy cover generally 20% or lower.	Gabilan Creek all reaches Natividad Creek all reaches Alisal Creek upstream of Hartnell Rd.	**2.0** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.07** **Dry Season Samples (May 1-Oct31)** **0.3** **Single Sample Max. 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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	Relatively low ambient turbidity (<1 NTU-25th percentile), silty or sandy substrates and local soil conditions. Canopy cover generally 40% or less Sunlight penetration likely moderate. These stream reaches are currently not expressing a full range of biostimulatory indicators. They are however, discharging elevated nutrient loads to impaired downstream waterbodies. Nutrient targets are toprotect against downstream impacts and against the risk of biostimulation in these stream reaches.

Waterbody Type	Geomorphology & Stream Characteristics	Project Area Stream Reaches	Allowable Nitrate-N (mg/L)	Allowable Orthophosphate-P (mg/L)	Methodology for Developing Numeric Target	Notes Pertaining to Development of Targets
Moro Cojo Slough	Tidal Flats. Low ambient turbidity, minimal canopy cover	Moro Cojo Slough, all reaches	**1.7 (TOTAL NITROGEN)** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.13** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	Generally low ambient turbidity (4 NTU), good sunlight penetration, low canopy cover indicates risk of biostimulation at low concentrations of nutrients. Note that **Nitrate-N is likely only a small fraction of total N** in the water column at site 306MOR, likely due to elevated biological uptake of NO3 in tidal flat environment and sequestration of N in other phases
Old Salinas River	Coastal flood plain and tidal flats Moderately high ambient turbidity, minimal canopy cover.	Old Salinas River from outflow @ Salinas River Lagoon to Old Salinas River at Potrero Rd.	**3.1** **Dry Season Samples (May 1-Oct31)** **8.0** **Wet Season Samples (Nov. 1-Apr. 30)**	**0.07** **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 Coast Basin Plan nitrate objectives and State of Nevada phosphate criteria for streams	muddy and fine-grained substrates and local soil conditions result in relatively high ambient turbidity (30 NTU – 25th percentile) which precludes good sunlight penetration of water column; risk of biostimulation occurs at relatively higher nutrient concentrations.

Appendix E STEPL Spreadsheet Results

STEPL Spreadsheets for TMDL project area major drainage basins

STEPL Input Sheet: Values in RED are required input. Change worksheets by clicking on tabs at the bottom You entered 3 subwatershed(s).

This sheet is composed of eight input tables. The first four tables require users to change initial values. The next four tables (initially hidden) contain default values users may choose to change.
Step 1: Select the state and county where your watersheds are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4.
Step 2: (a) Enter land use areas in acres in Table 1; (b) enter total number of agricultural animals by type and number of months per year that manure is applied to croplands in Table 2;
(c) enter values for septic system parameters in Table 3; and (d) if desired, modify USLE parameters associated with the selected county in Table 4.
Step 3: You may stop here and proceed to the BMPs sheet. If you have more detailed information on your watersheds, click the Yes button in row 10 to display optional input tables.
Step 4: (a) Specify the representative Soil Hydrologic Group (SHG) and soil nutrient concentrations in Table 5; (b) modify the curve number table by landuse and SHG in Table 6;
(c) modify the nutrient concentrations (mg/L) in runoff in Table 7; and (d) specify the detailed land use distribution in the urban area in Table 8.
Step 5: Select BMPs in BMPs sheet. **Step 6**: View the estimates of loads and load reductions in Total Load and Graphs sheets.

Show optional input table: Yes No ☑ Treat all the subwatersheds as parts of a single watershed ☑ Groundwater load calculation

State	County	Weather Station (for rain correction factors)
California	Monterey	CA SANTA MARIA WSO ARPT

1. Input watershed land use area (ac) and precipitation (in)

Rain correction factors: 0.865, 0.418

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total	Annual Rainfall	Rain Days	Avg. Rain/Eve
Salinas	6244	51411	48218	42938	0	0	0-24%	148811	17.8	47	0.784
Rec Canal	13734	33534	33612	19810	0	0	0-24%	100690	17.8	47	0.784
Moro Cojo	1478	3185	487	4585	0	0	0-24%	9735	16.3	47	0.718

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	months manure applied
W1	3250	0	81	110	1285	479	0	0	0
W2	3250	0	81	110	1285	479	0	0	0
W3	333	0	8	11	132	49	0	0	0
Total	6833	0	170	232	2702	1007	0	0	

3. Input septic system and illegal direct wastewater discharge data

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	er Direct Discharge, # of People	Discharge Reduction, %
W1	0	3.14	1	0	0
W2	63	3.14	1	0	0
W3	0	3.14	1	0	0

Input / General Input Data / Land&Rain / Animal / BMPs / Urban / Feedlots / Septic / Sediment / Gully&Streambank / Total Load

4. Modify the Universal Soil Loss Equation (USLE) parameters

Watershed	Cropland					Pastureland					Forest				
	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P
W1	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
W2	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
W3	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000

Optional Data Input:

5. Select average soil hydrologic group (SHG), SHG A = highest infiltration and SHG D = lowest infiltration

Watershed	SHG A	SHG B	SHG C	SHG D	SHG Selected	Soil N conc.%	Soil P conc.%	Soil BOD conc.%
W1		⦿			B	0.100	0.031	0.200
W2		⦿			B	0.100	0.031	0.200
W3			⦿		C	0.100	0.031	0.200

6. Reference runoff curve number (may be modified)

SHG	A	B	C	D
Urban	83	89	92	93
Cropland	67	78	85	89
Pastureland	49	69	79	84
Forest	39	60	73	79
User Defined	50	70	80	85

6a. Detailed urban reference runoff curve number (may be modified)

Urban\SHG	A	B	C	D
Commercial	89	92	94	95
Industrial	81	88	91	93
Institutional	81	88	91	93
Transportati	98	98	98	98
Multi-Family	77	85	90	92
Single-Famil	57	72	81	86
Urban-Cultiv	67	78	85	89
Vacant-Deve	77	85	90	92
Open Space	49	69	79	84

7. Nutrient concentration in runoff (mg/l)

Land use	N	P	BOD
1. L-Cropl	**11.4**	**0.64**	**4**
1a. w/ manure	0	0	12.3
2. M-Crop	**11.4**	**0.64**	**6.1**
2a. w/ manur	0	0	18.5
3. H-Crop	**11.4**	**0.64**	**9.2**
3a. w/ manur	0	0	24.6
4. Pasture	**0.25**	**0.27**	**13**
5. Forest	**0.2**	**0.1**	**0.5**
6. User D	**0**	**0**	**0**

7a. Nutrient concentration in shallow groundwater (mg/l) (may be modified)

Landuse	N	P	BOD
Urban	1.8	0.03	0
Cropland	10.3	0.03	0
Pastureland	0.47	0.03	0
Forest	0.47	0.03	0
Feedlot	6	0.03	0
User-Defined	0	0	0

8. Input or modify urban land use distribution

Watershed	Urban Area	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivate	Vacant (develop	Open Space %	Total % Area
W1	6244	15	10	10	10	10	30	5	5	5	100
W2	13734	15	10	10	10	10	30	5	5	5	100
W3	1478	15	10	10	10	10	30	5	5	5	100

Input / General Input Data / Land&Rain / Animal / BMPs / Urban / Feedlots / Septic / Sediment / Gully&Streambank / Total Lo

Ready

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	114698.36	15197.53	250185.32	1486.67
Cropland	1608557.32	266408.05	1717491.16	174802.79
Pastureland	143733.75	54201.94	930727.79	32717.14
Forest	14205.22	5561.14	31498.80	2007.13
Feedlots	0.00	0.00	0.00	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	25.31	9.91	103.34	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	1017165.01	7556.67	0.00	0.00
Total	2,898,384.97	348,935.24	2,930,006.41	211,013.73

STEPL Spreadsheets for TMDL project area subwatersheds

STEPL Input Sheet: Values in RED are required input. Change worksheets by clicking on tabs at the bottom. You entered 19 subwatershed(s).

This sheet is composed of eight input tables. The first four tables require users to change initial values. The next four tables (initially hidden) contain default values users may choose to change.

Step 1: Select the state and county where your watersheds are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4.

Step 2: (a) Enter land use areas in acres in Table 1; (b) enter total number of agricultural animals by type and number of months per year that manure is applied to croplands in Table 2;
(c) enter values for septic system parameters in Table 3; and (d) if desired, modify USLE parameters associated with the selected county in Table 4.

Step 3: You may stop here and proceed to the BMPs sheet. If you have more detailed information on your watersheds, click the Yes button in row 10 to display optional input tables.

Step 4: (a) Specify the representative Soil Hydrologic Group (SHG) and soil nutrient concentrations in Table 5; (b) modify the curve number table by landuse and SHG in Table 6;
(c) modify the nutrient concentrations (mg/L) in runoff in Table 7; and (d) specify the detailed land use distribution in the urban area in Table 8.

Step 5: Select BMPs in BMPs sheet. **Step 6:** View the estimates of loads and load reductions in Total Load and Graphs sheets.

Show optional input tables? Yes No ☑ Treat all the subwatersheds as parts of a single watershed ☑ Groundwater load calculation

State: California **County:** Monterey **Weather Station (for rain correction factors):** CA SANTA MARIA WSO ARPT

Rain correction factors: 0.865 0.418

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Grazing Lands	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total	Annual Rainfall	Rain Days	Rain/Event
Alisal Creek/Upper Rec Canal	3,796	10,135	12,724	3,000	0	0	0-24%	29655	17.8	47	0.784
Alisal Slough	705	3,884	0	32	0	0	0-24%	4621	17.8	47	0.784
Blanco Drain	64	4,374	0	1	0	0	0-24%	4439	17.8	47	0.784
Chualar Creek	123	7,737	13,511	4,051	0	0	0-24%	25422	17.8	47	0.784
El Toro Creek	1,333	26	15,566	10,137	0	0	0-24%	27062	17.8	47	0.784
Esperanza Creek	0	2,922	2,252	513	0	0	0-24%	5687	17.8	47	0.784
Espinosa Slough	37	2,158	0	460	0	0	0-24%	2655	17.8	47	0.784
Gabilan Creek	1,705	2,497	14,638	9,117	0	0	0-24%	27957	17.8	47	0.784
Merritt Lake	2,457	3,707	1,461	6,611	0	0	0-24%	14236	17.8	47	0.784
Moro Cojo Slough	1,478	3,185	487	4,585	0	0	0-24%	9735	16.3	47	0.718
Natividad Creek	1,002	1,476	4,494	364	0	0	0-24%	7336	17.8	47	0.784
Old Salinas River	44	1,058	37	353	0	0	0-24%	1492	17.8	47	0.784
Quail Creek	114	2,705	3,709	4,570	0	0	0-24%	11098	17.8	47	0.784
Reclamation Canal Lower	2,544	3,124	13	48	0	0	0-24%	5729	17.8	47	0.784
Sal River u/s of Spreckels	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0-24%	50423	17.8	47	0.784
Sal River d/s of Spreckels	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0-24%	19352	17.8	47	0.784
Salinas River Lagoon	34	2,485	508	810	0	0	0-24%	3837	17.8	47	0.784
Santa Rita Creek	1,143	4,769	281	154	0	0	0-24%	6347	17.8	47	0.784
Tembladero Slough	345	1,784	1	24	0	0	0-24%	2154	17.8	47	0.784

Input | General Input Data | Land&Rain | Animal | BMPs | Urban | Feedlots | Septic | Sediment | Gully&Streambank | Total Load

4. Modify the Universal Soil Loss Equation (USLE) parameters

Watershed	Cropland					Pastureland					Forest				
	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P
Alisal Creek/Upper Rec Canal	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Alisal Slough	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Blanco Drain	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Chualar Creek	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
El Toro Creek	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Esperanza Creek	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Espinosa Slough	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Gabilan Creek	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Merritt Lake	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Moro Cojo Slough	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Natividad Creek	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Old Salinas River	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Quail Creek	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Reclamation Canal Lower	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Sal River u/s of Spreckels	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Sal River d/s of Spreckels	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Salinas River Lagoon	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Santa Rita Creek	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000
Tembladero Slough	44.290	0.276	13.861	0.200	0.998	44.290	0.276	13.861	0.040	1.000	44.290	0.276	13.861	0.003	1.000

Optional Data Input:

5. Select average soil hydrologic group (SHG), SHG A = highest infiltration and SHG D = lowest infiltration

Watershed	SHG A	SHG B	SHG C	SHG D	SHG Selected	Soil N conc.%	Soil P conc.%	Soil BOD
Alisal Creek/Upper Rec Canal	○	●	○	○	B	0.100	0.031	0.200
Alisal Slough	○	●	○	○	B	0.100	0.031	0.200
Blanco Drain	○	●	○	○	B	0.100	0.031	0.200
Chualar Creek	○	●	○	○	B	0.100	0.031	0.200
El Toro Creek	○	●	○	○	B	0.100	0.031	0.200
Esperanza Creek	○	●	○	○	B	0.100	0.031	0.200
Espinosa Slough	○	●	○	○	B	0.100	0.031	0.200
Gabilan Creek	○	●	○	○	B	0.100	0.031	0.200
Merritt Lake	○	●	○	○	B	0.100	0.031	0.200
Moro Cojo Slough	○	○	●	○	C	0.100	0.031	0.200
Natividad Creek	○	●	○	○	B	0.100	0.031	0.200
Old Salinas River	○	●	○	○	B	0.100	0.031	0.200
Quail Creek	○	●	○	○	B	0.100	0.031	0.200
Reclamation Canal Lower	○	●	○	○	B	0.100	0.031	0.200
Sal River u/s of Spreckels	○	●	○	○	B	0.100	0.031	0.200
Sal River d/s of Spreckels	○	●	○	○	B	0.100	0.031	0.200
Salinas River Lagoon	○	●	○	○	B	0.100	0.031	0.200
Santa Rita Creek	○	●	○	○	B	0.100	0.031	0.200
Tembladero Slough	○	●	○	○	B	0.100	0.031	0.200

Input | General Input Data | Land&Rain | Animal | BMPs | Urban | Feedlots | Septic | Sediment | Gully&Streambank | Total Load

6. Reference runoff curve number (may be modified)

SHG	A	B	C	D
Urban	83	89	92	93
Cropland	67	78	85	89
Pastureland	49	69	79	84
Forest	39	60	73	79
User Defined	50	70	80	85

6a. Detailed urban reference runoff curve number (may be modified)

Urban\S	A	B	C	D
Commercial	89	92	94	95
Industrial	81	88	91	93
Institutional	81	88	91	93
Transportat	98	98	98	98
Multi-Family	77	85	90	92
Single-Famil	57	72	81	86
Urban-Culti	67	78	85	89
Vacant-Dev	77	85	90	92
Open Space	49	69	79	84

7. Nutrient concentration in runoff (mg/l)

Land use	N	P	BOD
1. L-Cropland	**11.4**	**0.64**	**4**
1a. w/ manure	0	0	12.3
2. M-Cropland	**11.4**	**0.64**	**6.1**
2a. w/ manure	0	0	18.5
3. H-Cropland	**11.4**	**0.64**	**9.2**
3a. w/ manure	0	0	24.6
4. Pastureland	**0.25**	**0.27**	**13**
5. Forest	**0.2**	**0.1**	**0.5**
6. User Defined	**0**	**0**	**0**

7a. Nutrient concentration in shallow groundwater (mg/l) (may be modified)

Landuse	N	P	BOD
Urban	1.8	0.03	0
Cropland	10.3	0.03	0
Pastureland	0.47	0.03	0
Forest	0.47	0.03	0
Feedlot	6	0.03	0
User-Define	0	0	0

8. Input or modify urban land use distribution

Watershed	Urban Area	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivate	Vacant (develop	Open Space %	Total % Area
W1	3736	15	10	10	10	10	30	5	5	5	100
W2	705	15	10	10	10	10	30	5	5	5	100
W3	64	15	10	10	10	10	30	5	5	5	100
W4	123	15	10	10	10	10	30	5	5	5	100
W5	1333	15	10	10	10	10	30	5	5	5	100
W6	0	15	10	10	10	10	30	5	5	5	100
W7	37	15	10	10	10	10	30	5	5	5	100
W8	1705	15	10	10	10	10	30	5	5	5	100
W9	2457	15	10	10	10	10	30	5	5	5	100
W10	1478	15	10	10	10	10	30	5	5	5	100
W11	1002	15	10	10	10	10	30	5	5	5	100
W12	44	15	10	10	10	10	30	5	5	5	100
W13	114	15	10	10	10	10	30	5	5	5	100
W14	2544	15	10	10	10	10	30	5	5	5	100
W15	2114	15	10	10	10	10	30	5	5	5	100
W16	2418	15	10	10	10	10	30	5	5	5	100
W17	34	15	10	10	10	10	30	5	5	5	100
W18	1143	15	10	10	10	10	30	5	5	5	100
W19	345	15	10	10	10	10	30	5	5	5	100

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
Aliral Creek/U	346810.3	42748.9	386438.9	25511.1	0.0	0.0	0.0	0.0	346810.3	42748.9	386438.9	25511.1	0.0	0.0	0.0	0.0
Aliral Slough	116706.0	12355.7	83793.8	7753.4	0.0	0.0	0.0	0.0	116706.0	12355.7	83793.8	7753.4	0.0	0.0	0.0	0.0
Blanco Drain	127018.3	13387.4	85872.7	8680.1	0.0	0.0	0.0	0.0	127018.3	13387.4	85872.7	8680.1	0.0	0.0	0.0	0.0
Chualar Creek	257800.8	33460.5	306455.8	20845.3	0.0	0.0	0.0	0.0	257800.8	33460.5	306455.8	20845.3	0.0	0.0	0.0	0.0
El Toro Creek	50687.5	12911.0	196448.1	6632.5	0.0	0.0	0.0	0.0	50687.5	12911.0	196448.1	6632.5	0.0	0.0	0.0	0.0
Esperanza Cre	89993.4	10523.3	82537.5	6706.0	0.0	0.0	0.0	0.0	89993.4	10523.3	82537.5	6706.0	0.0	0.0	0.0	0.0
Espinosa Slou	63029.4	6663.8	42675.0	4296.6	0.0	0.0	0.0	0.0	63029.4	6663.8	42675.0	4296.6	0.0	0.0	0.0	0.0
Gabilan Creek	121671.3	19959.7	237909.1	11160.1	0.0	0.0	0.0	0.0	121671.3	19959.7	237909.1	11160.1	0.0	0.0	0.0	0.0
Merritt Lake	129985.1	14820.6	120230.4	8300.1	0.0	0.0	0.0	0.0	129985.1	14820.6	120230.4	8300.1	0.0	0.0	0.0	0.0
Moro Cojo Slou	92016.6	12010.7	91611.1	6754.8	0.0	0.0	0.0	0.0	92016.6	12010.7	91611.1	6754.8	0.0	0.0	0.0	0.0
Natividad Cree	59063.3	8359.9	91279.5	4793.8	0.0	0.0	0.0	0.0	59063.3	8359.9	91279.5	4793.8	0.0	0.0	0.0	0.0
Old Salinas Riv	31232.9	3327.1	21715.9	2126.8	0.0	0.0	0.0	0.0	31232.9	3327.1	21715.9	2126.8	0.0	0.0	0.0	0.0
Quail Creek	90496.3	11405.2	97964.8	6983.5	0.0	0.0	0.0	0.0	90496.3	11405.2	97964.8	6983.5	0.0	0.0	0.0	0.0
Reclamation C	105794.7	11366.2	90511.5	6378.6	0.0	0.0	0.0	0.0	105794.7	11366.2	90511.5	6378.6	0.0	0.0	0.0	0.0
Sal River u/s	725959.8	81129.1	586594.2	50778.9	0.0	0.0	0.0	0.0	725959.8	81129.1	586594.2	50778.9	0.0	0.0	0.0	0.0
Sal River d/s	216848.4	25190.4	204996.4	14936.4	0.0	0.0	0.0	0.0	216848.4	25190.4	204996.4	14936.4	0.0	0.0	0.0	0.0
Salinas River L	73852.4	8045.8	54871.5	5157.3	0.0	0.0	0.0	0.0	73852.4	8045.8	54871.5	5157.3	0.0	0.0	0.0	0.0
Santa Rita Cre	145754.5	15608.0	109662.0	9654.3	0.0	0.0	0.0	0.0	145754.5	15608.0	109662.0	9654.3	0.0	0.0	0.0	0.0
Tembladera Sl	53847.1	5733.5	39181.1	3563.4	0.0	0.0	0.0	0.0	53847.1	5733.5	39181.1	3563.4	0.0	0.0	0.0	0.0
Total	2898567.9	349006.9	2930749.5	211013.0	0.0	0.0	0.0	0.0	2898567.9	349006.9	2930749.5	211013.0	0.0	0.0	0.0	0.0

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	114698.36	15197.53	250185.32	1486.67
Cropland	1608556.17	266407.70	1717488.86	174802.50
Pastureland	143731.79	54201.21	930716.07	32716.69
Forest	14205.62	5561.29	31499.69	2007.18
Feedlots	0.00	0.00	0.00	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	210.50	82.45	859.54	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	1017165.50	7556.70	0.00	0.00
Total	2898567.94	349006.88	2930749.47	211013.04

General Input Data | Land&Rain | Animal | BMPs | Urban | Feedlots | Septic | Sediment | Gully&Streambank | Total Load | Graphs

Appendix F Export Coefficient Model

Nutrient Export Coefficients

The Export Coefficient Model (ECM) (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 ECM requires the use of nutrient export coefficients. Nutrient export coefficients are the amounts of nitrogen or phosphorus exported from an area over a specific time period and are generally applied to a specific land use. They are typically expressed as kilograms of phosphorus per hectare per year, or pounds of nitrogen per acre per year, or some other mass-area-time unit.

The general form of the ECM is:

$$L_N = \sum_{i=1}^{n} [Ei * Ai] + S + W + P$$

L_N is the catchment nutrient load (kg/year);
E_i is the export coefficient (kg/ha/yr) for a land class i;
A_i is the area of the catchment occupied by land class i;
W is the waste water load from point sources (kg/yr);
S is the septic load (kg/yr);
P is the precipitation/atmospheric load (kg/yr)

In the absence of significant loads from point sources or septic, the nonpoint source land use load is the watershed summation of the *Ei* and *Ai* product alone, plus the atmospheric load.

Pollutant loads from various land uses can be calculated by applying appropriate export coefficients from published literature to the corresponding land use areas. Unfortunately, peer-reviewed nutrient export coefficients have not been reported for the Project Area or in Monterey County. However, numerous studies have derived land use based export coefficients characteristic of various watershed conditions for estimating nonpoint source pollutant yields.

Despite the existence of scientifically peer-reviewed literature values, it is important to recognize that selection of nutrient export coefficients remains, to a degree, an unavoidably subjective task. Nutrient loading to streams is dependent on climate, catchment geology, vegetation, soil type, human activities and land use practices (Sharpley et al., 1994; Mulholland and Hill, 1997; Coulter et al., 2004). As a result, there is a wide range of reported nutrient export coefficients for various land uses. Therefore, it is important to apply best professional judgment and knowledge of local watershed conditions in choosing appropriate export coefficients.

Some researchers (Shaver et al., 2007; Joubert et al, 2003) indicated that the export coefficient model can be improved by establishing a range of areal loading rates (in contrast to a single export coefficient per land use category) from published literature sources to account for uncertainty or error. It is important to note that although there are a substantial amount of studies on the linkage between land use and nutrient export coefficients, comparable studies conducted in Mediterranean-like climates are rare. Mediterranean-like climates are characterized by high variability in precipitation and extended dry periods for which few nutrient export studies have been conducted. Consequently, staff identified a range of reasonable land use export coefficients from regions that have similar watershed characteristics to the Project Area of northern Monterey County; or alternatively by identifying "averaged" median national export coefficient values.

Accordingly, staff used a hierarchical approach to obtain a reasonable range of values for nutrient export coefficients by taking the following steps:

i. First, coefficients from a variety of studies and publications were obtained.
ii. From these literature-reported values, nutrient export coefficients from Level III Nutrient Ecoregion, Zone 6 (i.e., Southern and Central California Chaparral and Oak Woodlands ecogregion) were selected. Note that nutrient ecoregions are USEPA designations for subregions of the United States that denote areas with ecosystems that are generally similar (e.g., physiography, climate, geology, soils, land use, hydrology).
iii. Next, export coefficients from other nutrient ecoregions located in the State of California were selected.
iv. In the absence of Level III Zone 6 ecoregion data, or California-specific export coefficients, median national values, or regional values applicable to the western United States were selected.
v. Finally, local watershed conditions were considered in screening and culling the literature export coefficients. For example, reported national median export coefficient values for agricultural land uses that are not representative of the Project Area (e.g., corn, soybean, cotton) were not selected for consideration. Where possible, export coefficients were selected that could reasonably be associated with Project Area-specific land uses.

Figure 1 illustrates the nutrient ecoregions of California and the locations of nutrient export coefficients used in this report.

Figure 1. Map of Nutrient Ecoregions of California and Locations of Literature Nutrient Coefficients Selected for Use in the TMDL Project.

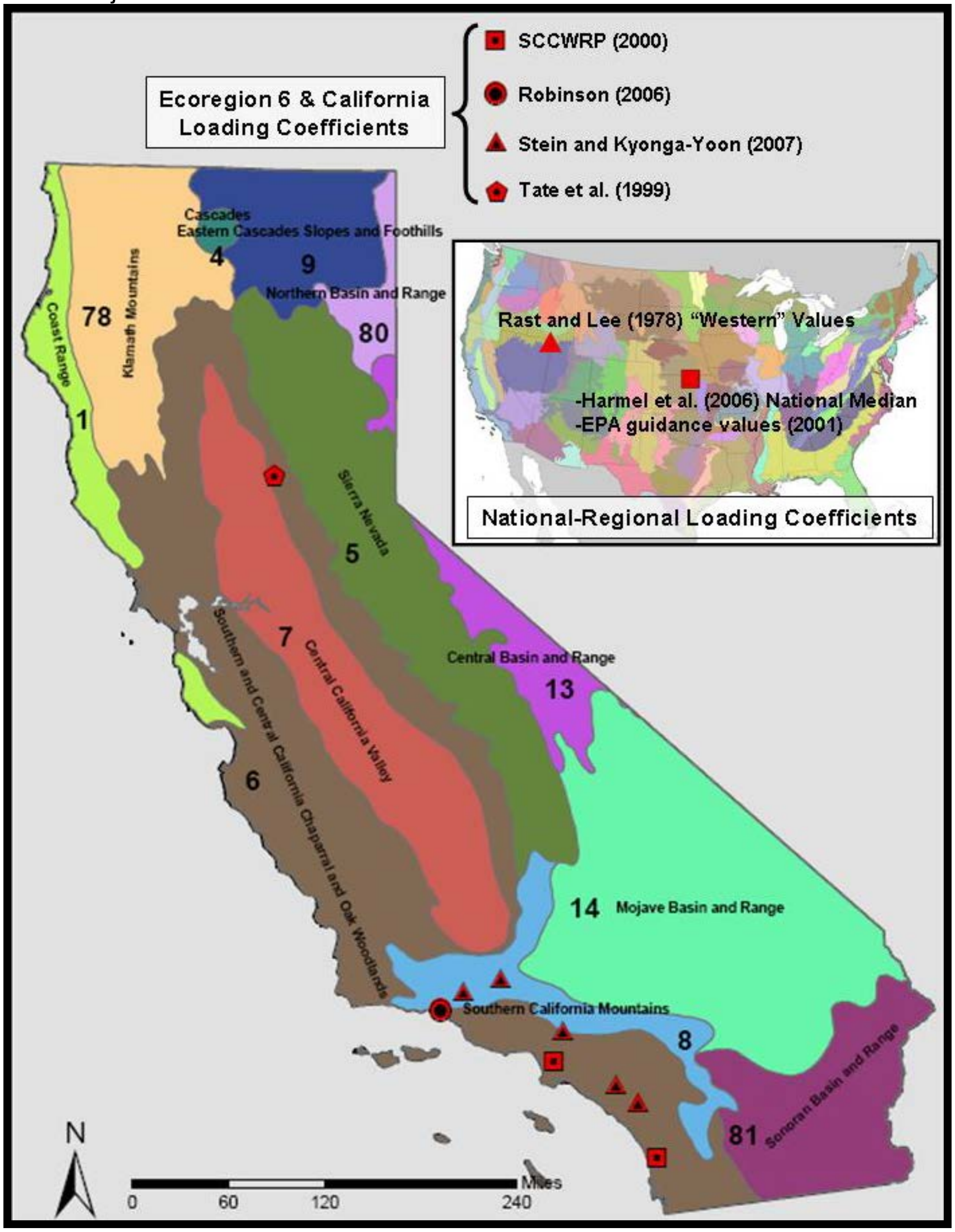


Table 1 compiles the values and ranges of nitrogen export coefficients used in this report.

Table 1. Selected Literature Nitrogen Export Coefficients (Units = kg/ha/year).

		Literature Source Study Area							
Land Use	***Land Treatment or Subcategory***	**Rast and Lee (1983)**	**SCCWRP et al. (2000)**	**Harmel et al. (2006)**	**Robinson (2006)**	**USDA MANAGE Database**	**Stein and Kyonga-Yoon (2007)**	**Tate et al. (1999)**	**USEPA Nutrient TMDL Guidance (from Table 5-3, 2001)**
		"Western" Regional U.S. value	Coastal Southern California	Median National Values	Santa Barbara County Calif. (mean of dry and wet years)	Median National Values	Coastal Southern Calif. (Median Value for Four Watersheds)	Yuba County, Calif.-mean Value	Median Values
Agriculture -Cropland	Various Rotations	2.0 for all "ag"	4.4 for all "ag"	3.68	-	-	-	-	-
	Fallow Cultivated			3.0	-				
	Oats-wheat			6.61	-				
	Avocado			-	5.18				
Urban	Commercial-High Density	2.5 for all "urban"	4.7	-	12.93	-	-	-	5.8
	Residential		3.1		3.19	-			4
Pasture	Dryland alfalfa, barley, oats, etc.; No grazing to rotational grazing	-	-	0.97	-	0.8		-	4.2
	Pasture (grazed)					2.4			
Range/ Grassland	Native grass; No grazing to light grazing to moderate grazing	-	-	0.97	-	1.3	-	1.6	4.2
Forest/ Shrubland	Forest, Undeveloped Shrub Land	1	-	-	0.68		2.3	-	2
	"Open", undeveloped		0.9						
Wetland[A]		0	-	-	-	-	-	-	-

[A] Wetlands or marshes can act as sinks or sources of nutrients, depending upon the specific season of the year. It has been found, however, that the quantities of phosphorus that enter and leave wetlands over an annual cycle are essentially equal (as reported in Rast and Lee, 1983). On this basis, the net contribution of nutrients from wetlands is zero over the annual cycle

The Manage Method of Estimating Export Coefficients

Modifying Export Coefficients to Account for Variations in Runoff Potential: The MANAGE Method of Estimate Export Coefficients

In its traditional form the ECM assumes that export coefficient values are uniform for each land cover type or nutrient source within a catchment, regardless of proximity to water or hydrologic pathways. It is important to recognize that over large watershed areas, nutrient export may not be proportional to watershed area and some attenuation of nutrients occur due to variations in runoff rates, plant cover and retention, and travel distance to streams (Heathwaite and Burt, 1991; Minnesota Pollution Control Agency, 2003; Endreny and Wood, 2003; Theodore Endreny, personal communication, Nov. 2009). While the ECM is capable of generating reasonable estimates of nutrient loads simply from a watershed land cover data and associated homogeneous export coefficient values, research findings and professional literature suggest that the export coefficients approach can be slightly modified to account for field characteristics such as soil drainage, attenuation along hill slope runoff flow paths, and distance to streams from the contributing source area (Johnes and Heathwaite, 1997; McMahon and Roessler. 2002; Endreny and Wood, 2003; Mitsova-Boneva and Wang, 2008). Consequently, staff evaluated whether uniform land use export coefficients were appropriate, or whether modified export coefficients – taking into account watershed physical/spatial field characteristics – should be developed, as outlined below.

The Project Area is over 1,009 square kilometers, and has substantial variation in land cover, soils, and elevation. In addition, it is important to consider a watershed's drainage density, and how it qualitatively relates to the probability of material (e.g., nutrients) entering along a stream reach. Drainage density is simply a measure of how well or poorly a watershed is drained by stream channels, as is mathematically expressed as:

$$\text{Drainage Density} = \text{Stream Length} / \text{Basin Area}$$

Drainage density is dependent on climate, topography, vegetative cover, geology, and other conditions. The measurement of drainage density can provide a useful measure of runoff potential. On a highly permeable landscape, with low potential for runoff discharging directly to streams, drainage densities are sometimes less than 1 kilometer per square kilometer. Highly dissected watershed surface drainage densities can be tens or even hundreds of kilometers per square kilometer.

Staff calculated a drainage density of 1.01 kilometers per square kilometer for the Project Area, using a digital clipped river reach file, and a digital Project Area polygon.

Cumulative Stream Reach Length in Project Area	Project Area Size	**Drainage Density** (stream length / basin area)
1023 kilometers	**1010 km^2**	**1.01**

This drainage density qualitatively suggests that the Project Area, broadly speaking, has a relatively low potential for runoff discharging directly to a stream, compared to basins that are highly dissected by streams and have higher drainage densities. It is important to recognize however, that digital river reach files may not include field scale ditches, canals, and other unmapped water conveyance structures in the Project Area. Therefore the Project Area drainage density could be higher than the one calculated by Staff.

Based on the aforementioned information, Staff did not choose to apply uniform nutrient export coefficients for each land classification throughout the Project Area, as is often the case with the traditional Export Coefficient Model. Staff took into consideration in ruling out the use of uniform land use export coefficients:

- the large geographic scale of the project area;
- the heterogeneity of land cover and soils; and
- the relatively low drainage density of the project area.

Instead, Staff employed recognized-approaches that allow for modification of the Export Coefficient Model, accounting for field characteristics such as soil drainage, and distance-decay factors related to the physical proximity (distance) of source areas to surface waterbodies.

One such method for employing a GIS-based pollution risk assessment to derive modified export coefficients is the "Method for Assessment, Nutrient-loading, And Geographic Evaluation of Nonpoint Pollution" (MANAGE). In the MANAGE method a mass balance approach is used to estimate nutrient (nitrogen and phosphorus) loading to surface water (Adamus and Bergman, 1993). Upper and lower limits are assigned for nitrogen and phosphorus delivery to surface water from each land use category in lb/acre/yr or kg/ha/yr. Then the hydrologic soil group (HSG) is used to determine a "most likely" nitrogen or phosphorus export coefficient for a particular land use is calculated for each SOIL / LAND USE combination as:

$$PC = LPC + (HPC - LPC) \times X$$
$$NC = LNC + (HNC - LNC) \times X$$

where
PC or NC = Most likely export coefficient for phosphorus (P) or nitrogen (N)
LPC or LNC = Lower limit export coefficient for P or N
HPC or HNC = Upper limit export coefficient for P or N
X = Value associated with each HSG (see Table 2)

Table 2. Weighting Factors (X) Used for Different Hydrologic Soil Groups in Equation X.

Hydrologic Soil Group (HSG)	Value of X
A	0
B	1/3 (0.33)
C	2/3 (0.67)
D	1

Essentially this formula divides the range of export coefficients evenly into quarters, with the high end assigned to hydrologic soil group A (high infiltration/low runoff rate) and the low end assigned to hydrologic soil group D (very slow infiltration/high runoff rate). The MANAGE model indicates that this based on the approach developed by Adamus and Bergman (1993).

Using the range of literature nitrogen export coefficients from Table 1 and the MANAGE Model equation, Table 3 shows the calculated most likely nitrogen export coefficients for each Land Use/Soil combination.

Table 3. Total Nitrogen Export Coefficients (kg/ha/year) for Each Soil/Land Use Combination in Project Area.

Land Use Category	**Export Coefficient Reference Values**		**Calculated Most Likely Export Coefficient Based on Hydrologic Soil Group**			
	LNC	**HNC**	**A**	**B**	**C**	**D**
Agriculture/Cropland	2	6.61	2	3.52	5.09	6.61
Urban Commercial	2.5	12.93	2.5	5.94	9.49	12.93
Urban Residential	2.5	4	2.5	3.0	3.5	4
Pasture	0.8	4.2	0.8	1.92	3.08	4.2
Range/Grazing Land	0.97	4.2	0.97	2.04	3.13	4.2
Forest	0.68	2.3	0.68	1.21	1.77	2.3
Wetland	0	0	0	0	0	0

A compilation of literature-reported nutrient export coefficients was compiled in an Excel spreadsheet.

Distance Attenuation of Export Coefficients

Modifying Export Coefficients to Account for Distance Attenuation of Export Coefficients:

As noted earlier, in addition to using soil data to account for spatial variations in runoff potential (as in the MANAGE method above), researchers have also identified that there is some attenuation of nutrients occur due to travel distance to streams. Clearly, pollutants generated at a certain location are subject to degradation and transformation processes. One such process is the travel distance or travel time to the nearest stream discharge point.

Over large watershed areas, some researchers have noted that nutrient export is not proportional to watershed area and some attenuation of nutrients occurs, especially in natural vegetation that have low runoff rates. Recently, researchers who have examined the nutrient export issue on landscape level scales (large watersheds and higher order streams) have raised concerns over the applicability of uniform export coefficients across large watershed areas (Birr and Mulla, 2001; Cammermeyer, et al, 1999; Johnson and gage, 1997; Jones, et al, 2001; Mattson and Isaac, 1999; McFarland and Hauck, 1998; Richards, et al, 2001;Sharpley, et al, 1993; Soranno, et al, 1996; Worrall and Burt, 1999). The underlying issue related to this concern is that not all areas in a large watershed contribute nutrients equally. In its traditional form the ECM assumes that nutrient export coefficients are homogeneous within each land cover type, yet basic nutrient runoff and hydrological theory suggests that runoff rates have spatial patterns controlled by filtering and attenuation along the flow paths from the upslope contributing area to the downslope stream discharge point (Endreny and Woods, 2003).

Johnes and Heathwaite (1997) suggested that greater rates of nutrient export occur for sources located within the riparian zones than for those at distance from the stream. Accordingly, Johnes and Heathwaite (1997) used a distance decay function to model the impact of land use change on nitrogen and phosphorus concentrations in streams. They argued that nutrient-contributing areas greater than 50 meters from the drainage network were less important than near-stream zones due to attenuation and uptake of nutrients during downslope transit and that export coefficients for each land use can be adjusted for each field in a catchment with respect to their proximity to surface waterbodies. In other words, areas within the 50 m wide riparian zone, were defined as high risk areas, with a higher index of nutrient export than similar land use types outside this zone. Jones and Heathwaite concluded that nutrient contributing areas outside the 50 meter riparian zone is subject to at least a 50% attenuation rate.

Based on the aforementioned research, distance-decay weighting of export coefficients has been utilized in nutrient TMDL development. For example, in the USEPA-approved State of New Mexico Rio Hondo TMDL (2005), the Export Coefficient Model (Reckhow, et al., 1980) was modified by weighting the nitrogen export based on distance from the stream with 50 meter, 500 meter, and 5000 meter buffer zones. The largest unit load was assigned to the 50 meter zone and the smallest unit-area load was assigned to the 5000 meter zone. In other words, the approach assumed that the export coefficient values undergo a step-wise decay when originating beyond the 50 meter distance cutoff and that nutrient loading is buffered beyond this distance.

Table 4 tabulates the distance decay attenuation coefficients derived from the aforementioned research and TMDL studies, and presents provisional distance decay attenuation coefficients for use in the Lower Salinas River watershed nutrient TMDL. As shown in the table, export coefficients associated with a particular land use category are attenuated by 50 % outside the 50 meter riparian buffer, and by 90% outside a 500 meter buffer. It is important to note that for the lower Salinas River nutrient project it may be prudent to use a 60 meter riparian buffer, rather than a 50 meter buffer. This is due to the fact that land use raster grid data available for use in GIS have a grid increment of 30 m. A 60 meter spatial buffer would be an increment of measurement exactly 2 times the raster grid sampling density.

Table 4. Weighting Coefficients for Modified Nutrient Export Coefficients based on Distance Attenuation.

	Relative Nutrient Loading Risk		
	Higher	***Moderate***	***Lower***
Source/Study	**50 m Buffer**	**> 50 m to < 500 m Buffer**	**> 500 m Buffer**
Johnes and Heathwaite (1997)	1.0	0.5	N.A.
New Mexico Rio Hondo Nutrient TMDL	1.0	0.5	0.1
Lower Salinas Nutrient TMDL (provisional)	1.0	0.5	0.1

Conceptually, the modification of land use-based export coefficients using the MANAGE method and distance-to-stream attenuation as detailed above, can be illustrated as shown in Figure 2:

Figure 2. Modifying Export Coefficients.

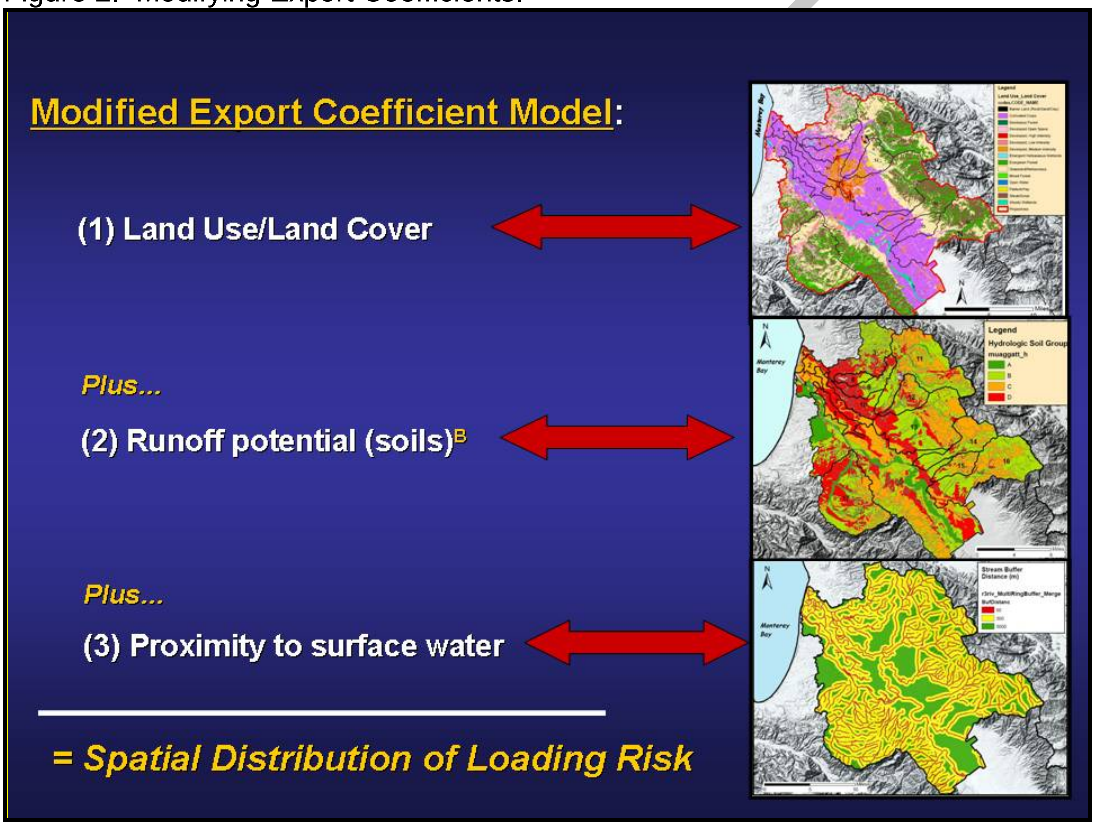
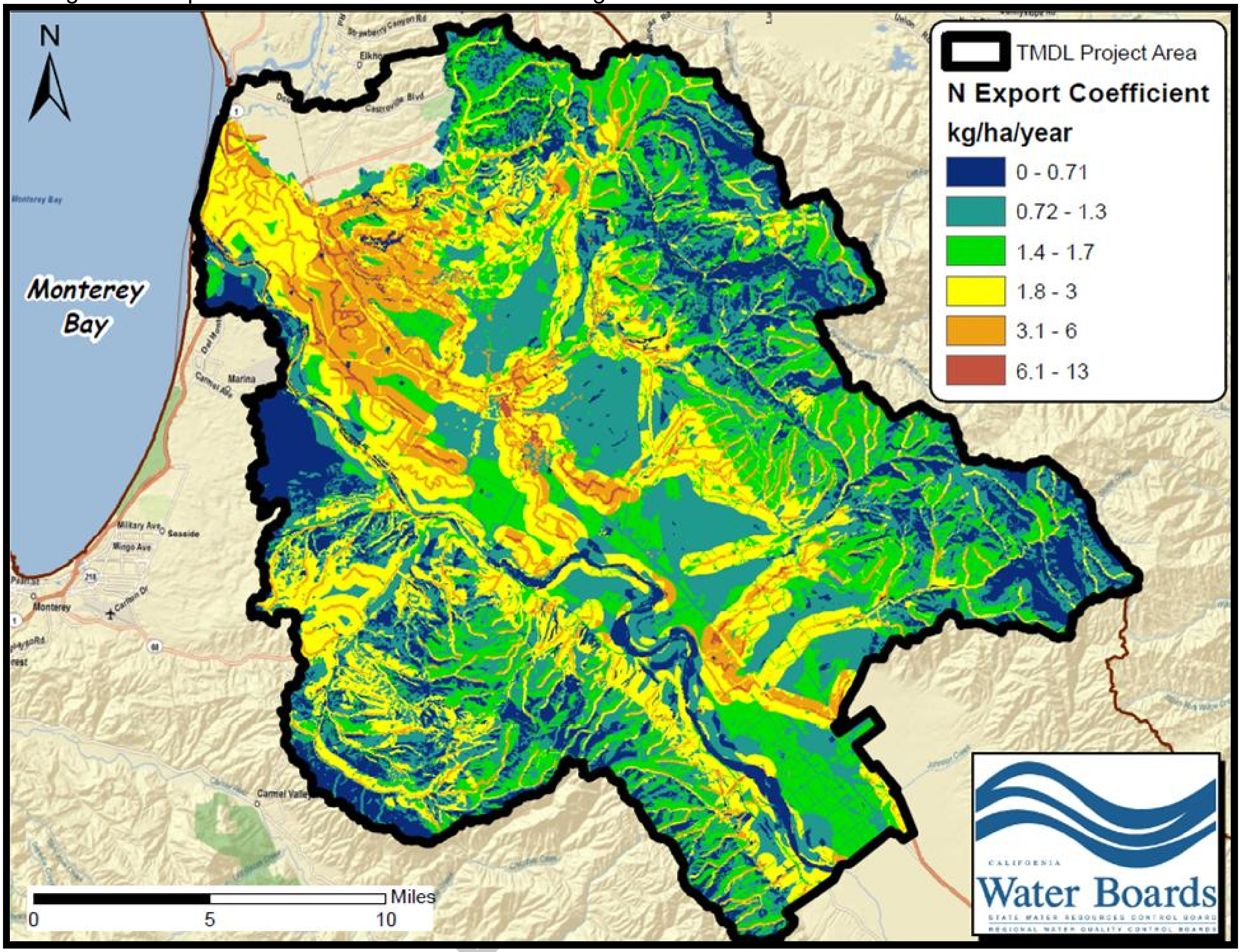


Figure 3 illustrates a preliminary and provisional export coefficient model for total nitrogen which incorporates weighting factors to standard export coefficients based on the land use / hydrologic soil group/ and distance to stream combinations, as outlined above.

Figure 3. Export Coefficient Model for Total Nitrogen in Lower Salinas River Watershed.



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Appendix G − Alternative Pollutant Load Expressions to Facilitate Implementation of Concentration-based Allocations

The purpose of this appendix is to provide alternative, non-daily pollutant load expressions to facilitate implementation of the daily allocations. Daily allocations, as expressed in this TMDL, are on the basis of daily time-step concentrations (e.g., instantaneous receiving water concentrations represented in grab and field samples). Relevant guidance published by the U.S. Environmental Protection Agency (USEPA) pertaining to alternative load expressions is presented below:

> *Facilitating Implementation of Wasteload 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 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.

Table 1 and Table 2 present alternative, non-daily mass load expressions and estimated load reductions for nitrate to facilitate implementation of the TMDLs on an annual (Table 1) and seasonal (Table 2) basis. These alternative load expressions shall be considered implementation-related assumptions of the daily time-step concentration-based allocations.

Figure 1 and Figure 2 provide graphical, map-view context regarding the spatial distribution of existing nitrate-N annual and seasonal loads in TMDL project area stream reaches.

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., USGS gages or hydrologic modeling), there could be a high degree of error associated with estimated daily flows from limited amounts of instantaneous flows[1]. According to USEPA, the potential for error is particularly pronounced in arid areas, areas with few USGS gages, and areas where flows are highly modified by human activities (e.g., impoundments, regulated flows, and irrigation return flows)[2]. Therefore, as noted previously, this TMDL and associated load allocation are based on instantaneous concentration-based loads – this satisfies the USEPA guidance to incorporate a daily time-step load. In addition, concentration is generally a more direct linkage to the protection of aquatic habitat, than annual or seasonal mass loads.

As more flow data, or better flow estimates become available in the future, these alternative, non-daily load expressions may be revised during reconsideration of the TMDL, scheduled for ten years after adoption.

Table 1. Alternative, non-daily (annual) load expressions and estimated annual load reductions to facilitate implementation of allocations.

Waterbody-Site	Estimated Mean Annual Flow (cfs)	Mean Annual Conc. (mg/L)	Mean Annual Existing Load (lbs.)	Mean Annual Loading Capacity (lbs.)	Estimated Load Reduction Necessary (lbs.)	% Reduction Goal[A]	NO3-N Numeric Target Used for Loading Capacity (mg/L)
Salinas River @ Spreckels-309 SSP	420	1.85	1,529,907	8,269,769	0	0%	MUN (10)
Salinas River @ Hwy 1 - 309SBR	350	13.29	9,158,769	5,513,179	3,645,590	40%	Wet Season Biostim (8.0)
Old Salinas Riv-OLS-MON	36.2	18.68	1,331,464	570,220	761,244	57%	Wet Season Biostim (8.0)
Tembladero Slough-309TDW	36	27.2	1,928,037	567,070	1,360,967	71%	Wet Season Biostim (8.0)
Moro Cojo Slough-306MOR	6	5.3	62,614	94,512	0	0%	Wet Season Biostim (8.0)
Chualar Creek-309CRR	1.79	90.5	318,967	35,245	283,722	89%	MUN (10)
Quail Creek-309QUI	0.7	30.62	42,203	13,783	28,420	67%	MUN (10)
Esperanza Creek-ESZ-HWY	0.38	65.43	48,956	7,482	41,474	85%	MUN (10)
Blanco Drain-BLA-PUM	5.75	61.76	699,229	90,574	608,655	87%	Wet Season Biostim (8.0)
Lower Reclamation Canal-309JON	16.66	13.28	435,629	262,427	173,202	40%	Wet Season Biostim (8.0)
Upper Reclamation Canal-309ALG	10.47	16.48	339,741	164,923	174,818	51%	Wet Season Biostim (8.0)
Natividad Creek-309NAD	0.99	21.3	41,520	15,594	25,926	62%	Wet Season Biostim (8.0)
Gabilan Creek-309GAB	8.22	10.49	169,782	129,481	40,301	24%	Wet Season Biostim (8.0)
Alisal Creek – 309HRT & 309UAL	2.3	23.9	106,825	35,757	71,068	67%	Wet Season Biostim (8.0)
Alisal Slough – 309ASB	1.64	47.5	153,385	20,667	132,718	87%	Wet Season Biostim (8.0)

[1] U.S. Environmental Protection Agency, 2007. Options for Expression Daily Loads in TMDLs. June 22, 2007.

[2] *Ibid.*

Waterbody-Site	Estimated Mean Annual Flow (cfs)	Mean Annual Conc. (mg/L)	Mean Annual Existing Load (lbs.)	Mean Annual Loading Capacity (lbs.)	Estimated Load Reduction Necessary (lbs.)	% Reduction Goal[A]	NO3-N Numeric Target Used for Loading Capacity (mg/L)
Santa Rita Creek-309SRTA-36	4.9	12.16	105,110	69,151	35,959	34%	Wet Season Biostim (8.0)
Merrit Ditch-309MER	3.7	20.98	111,122	58,282	52,840	48%	Wet Season Biostim (8.0)
Gabilan Creek-GAB-OSR	5.16	1.48	15.037	101,600	0	0%	MUN (10)

[A] Percent reduction goals are for informational purposes only, and should not be viewed as the TMDL.

Table 2. Alternative, non-daily (dry season – May. 1 to Oct. 30) load expressions and estimated dry season load reductions to facilitate implementation of allocations.

Waterbody-Site	Estimated Mean Dry Flow (cfs)	Mean Dry Season Conc. (mg/L)	Mean Dry Existing Load (lbs.)	Mean Dry Loading Capacity (lbs.)	Estimated Load Reduction Necessary (lbs.)	% Reduction Goal [A]	NO3-N Numeric Target Used for Loading Capacity (mg/L)
Salinas River-309 DAV	5.98	17.24	101,497	8,242	93,255	92%	dry Season Biostim (1.4)
Salinas River-309SBR	26.3	19.02	492,471	36,249	456,222	93%	dry Season Biostim (1.4)
Salinas River-309SAC	57.33	1.59	88,664	564,412	0	0%	MUN
Old Salinas River-OLS-MON	7.08	19.47	135,711	21,608	114,103	84%	dry Season Biostim (3.1)
Tembladero Slough-309TEH	14.2	28.72	401,501	89,471	312,030	78%	dry Season Biostim (6.4)
Moro Cojo Slough-306MOR	4.15	4.5	18,386	6,946	11,440	62%	dry Season Biostim (1.7-TN)
Chualar Creek-309CRR	0.95	106.42	99,139	9,353	89,786	91%	MUN (10)
Quail Creek-309QUI	1.99	28.32	55,444	19,592	35,852	65%	MUN (10)
Blanco Drain-BLA-PUM	5.6	57.67	317,945	35,285	282,660	89%	dry Season Biostim (6.4)
Lower Reclamation Canal-309JON	3.73	7.72	28,349	23,502	4,847	17%	dry Season Biostim (6.4)
Upper Reclamation Canal-309ALG	2.4	18.06	42,667	15,122	27,545	65%	dry Season Biostim (6.4)
Natividad Creek-309NAD	0.33	25.91	8,418	650	7,768	92%	dry Season Biostim (2.0)
Gabilan Creek-309GAB	0.69	7.27	4,939	1,359	3,580	72%	dry Season Biostim (2.0)
Alisal Creek – 309HRT & 309UAL	0.5	23.1	11,371	984	10,387	91%	dry Season Biostim (2.0)
Alisal Slough-209ASB	1.29	42.13	53,505	16,256	37,249	70%	dry Season Biostim (6.4)
Espinosa Slough-309ESP	1.71	36.82	61,986	10,775	51,211	83%	dry Season Biostim (6.4)
Merrit Ditch-309MER	3.7	30.98	47,604	12,350	35,254	74%	dry Season Biostim (6.4)

[A] Percent reduction goals are for informational purposes only, and should not be viewed as the TMDL

Figure 1. Spatial distribution of estimated mean annual existing nitrate-N loading in TMDL project area.

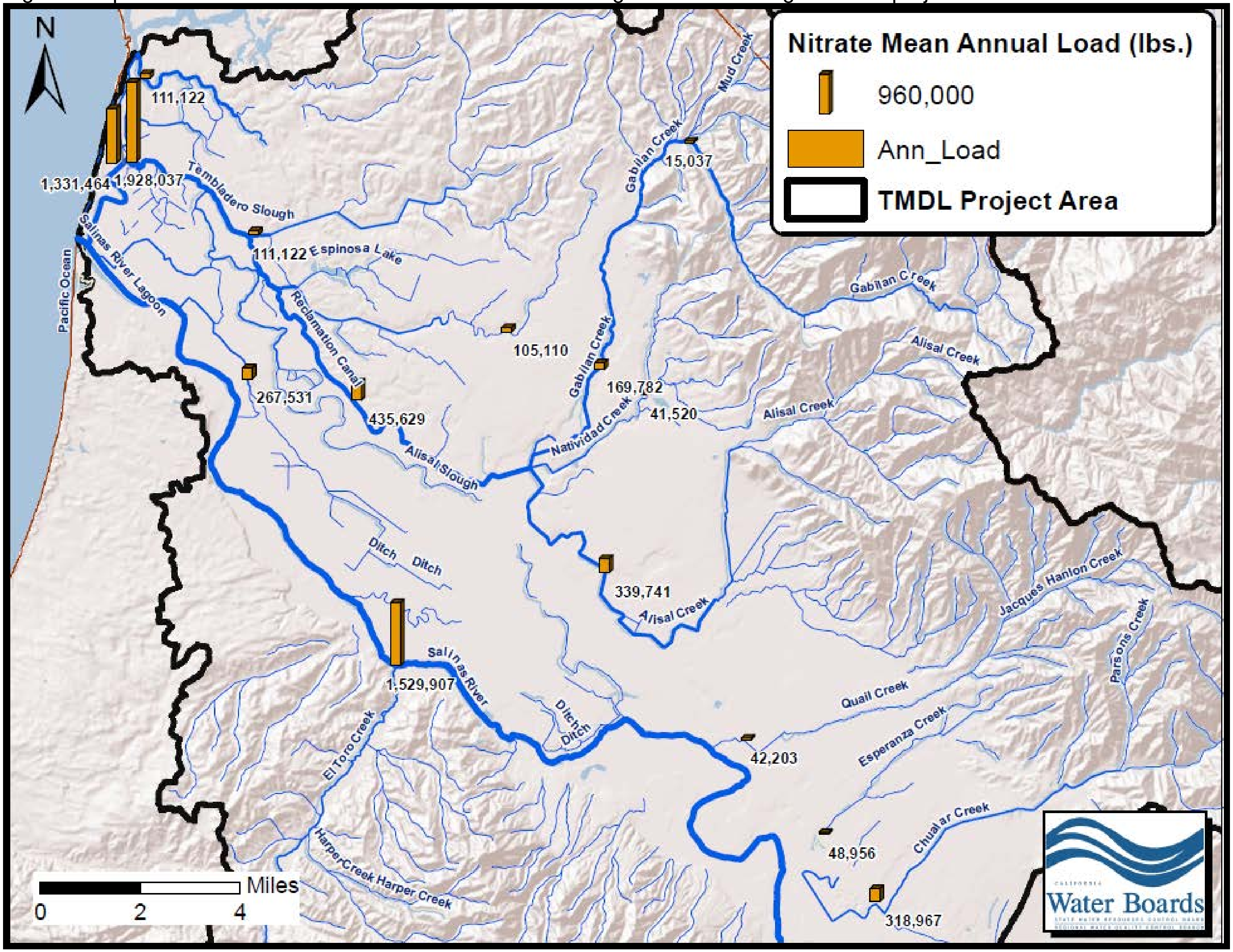

Figure 2. Spatial distribution of estimated dry season (May 1 – Oct 31) existing nitrate-N loading in TMDL project area.

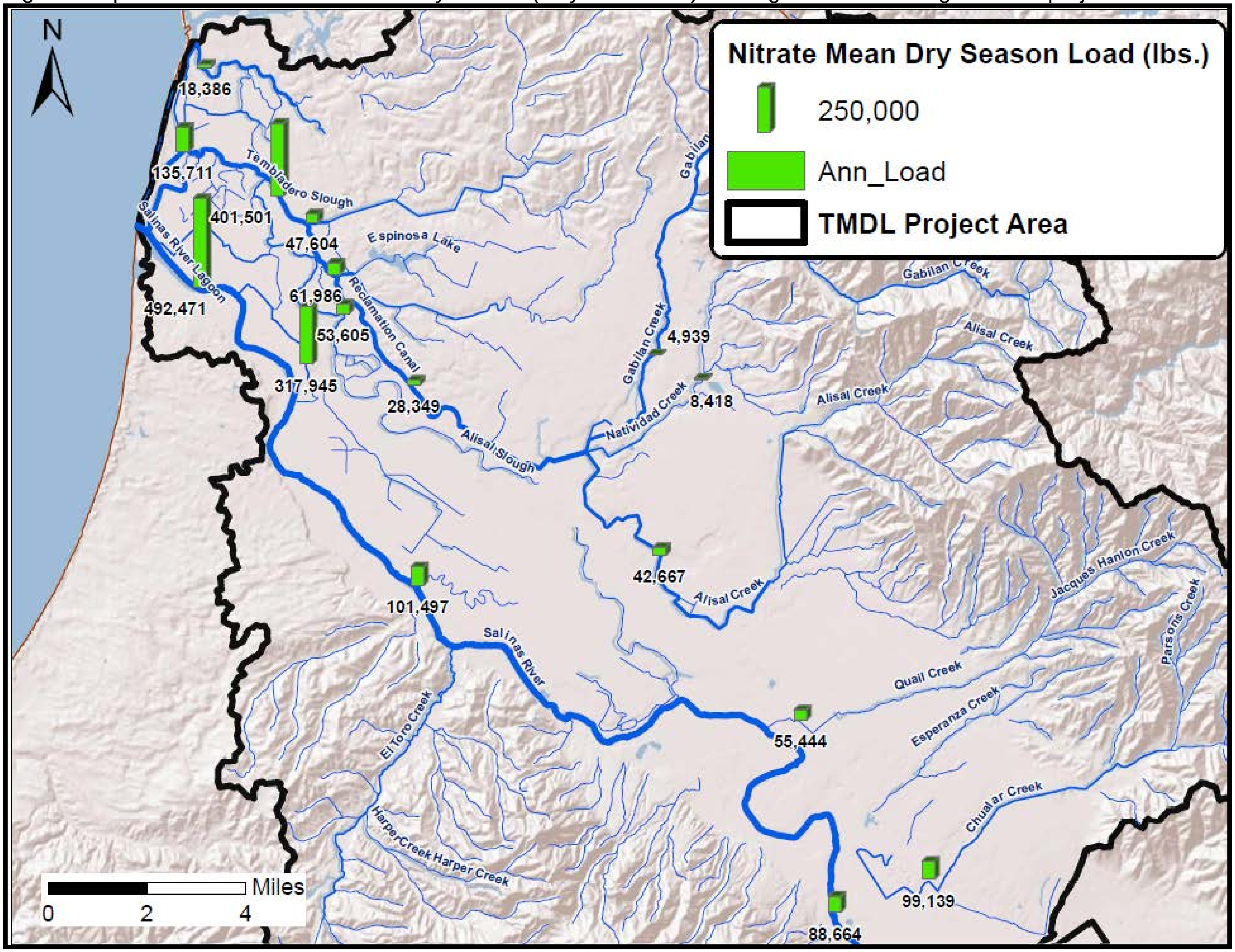

Figure 3. Monitoring sites and subwatersheds.

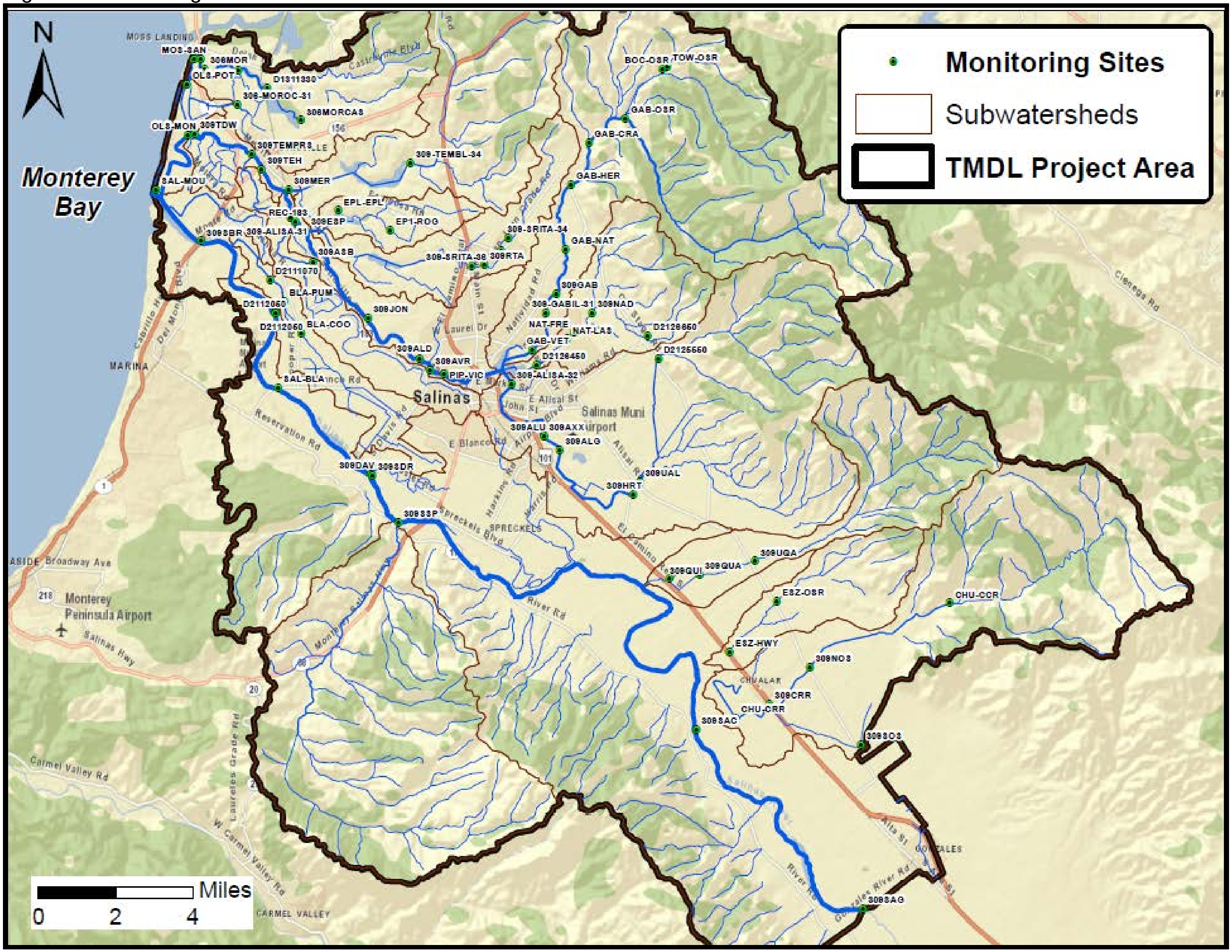

Figure 4. Estimated nitrogen loading risk based on Export Coefficient Model assessment.