Phase Six: Regulatory Action Selection

Final Project Report

SAN LUIS OBISPO CREEK TOTAL MAXIMUM DAILY LOAD AND IMPLEMENTATION PLAN FOR NITRATE-NITROGEN SAN LUIS OBISPO COUNTY, CALIFORNIA

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State of California
Central Coast Regional Water Quality Control Board
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401

Staff contact:
Christopher Rose
(805) 542-4770
crose@rb3.swrcb.ca.gov

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1 Introduction and Problem Statement

This document addresses the 303(d) listing for San Luis Obispo Creek. San Luis Obispo Creek (Creek) was placed on the 303(d) list of impaired waterbodies in 1994; the Creek was listed as impaired by nutrients.

The basis for the 303(d) listing of the Creek for nutrients is not well documented. The following subsection summarizes the events leading to the 303(d) listing, supporting a conclusion of the impairment that was intended to be associated with the listing.

1.1 Nitrate-NO_3 vs Nitrate-N

The nitrate water quality objective is expressed in the Water Quality Control Plan (Basin Plan) as 45 mg/L-NO_3. This is equivalent to nitrate-N of 10 mg/L-N. The remainder of this document will express nitrate as nitrogen, i.e. nitrate-N, and the nitrate-N objective as 10 mg/L-N.

1.2 Background of Listing

In 1990, San Luis Obispo Creek was on two lists, 304(l) and 131.11, that identify impaired waters. The impaired waters list required by Section 304(l) of the Clean Water Act identifies water bodies that do not achieve applicable water quality standards due to toxic pollutants from point sources, even after application of technology-based measures have been utilized. Section 131.11 of 40 CFR required states to list specific water bodies where toxic pollutants adversely affect attainment of designated uses.

The Creek was placed on the 304(l) and 131.11 lists for the reasons stated below:

1. Threat of drinking water impairment.
2. Fish population decline.

The threat of drinking water impairment referred to exceedence of the nitrate-N water quality objective protecting the municipal drinking water beneficial use. Nitrate-N concentration data was available through monitoring reports submitted by the city of San Luis Obispo's wastewater treatment plant, known as the Water Reclamation Facility (WRF). Data from the WRF monitoring reports were used as the basis of determination that the drinking water use was being threatened.

The fish population decline was attributed to historic unionized ammonia concentrations present at toxic levels in the Creek that were driven by the ammonia-rich effluent from the WRF. In 1994, the WRF completed and put on line a technological upgrade that significantly reduced the unionized ammonia discharge to non-toxic levels consistent with Basin Plan water quality objectives. Data gathered (after the plant upgrade) by the WRF from monitoring efforts required through the WRFs NPDES permit, confirms that unionized ammonia levels are no longer in exceedence of Basin Plan objective (this point will be elaborated on in sections that below).

In 1992, the Creek was placed on the CWA Section 319 list. The 319 list identifies water bodies which, without additional control of nonpoint sources of pollution, cannot reasonably be expected to attain water quality objectives. The reasons stated for placement of the Creek on the 319 list are the same reasons listed for placement on the 304(l) and 131.11 lists, as stated in bullets 1 and 2 above.

The 303(d) list is a list of impaired waters that do not meet water quality standards even after point source dischargers of pollution have applied the minimum required efforts of pollution control technology. The criteria for the 303(d) list are very similar to the criteria for the 304(l) list.

The State Water Resources Control Board decided that the criteria for the 304(l) list were similar enough to criteria of the 303(d) list to place all water bodies on the 304(l) list on the 303(d) list. Subsequent to this decision, San Luis Obispo Creek was placed on the 303(d) list. Central Coast Water Board staff, that were involved with creation of the 303(d) list during this period, have confirmed that water bodies on the 304(l) list were automatically placed on the 303(d) list. At that time, once a water body was placed on the 303(d) list, removal from the list was strongly discouraged by the State Water Resources Control Board and by US EPA, who had the ultimate authority to approve de-listing decisions, even if it was later found that evidence supporting impairment was insufficient.

In 1994, San Luis Obispo Creek was placed on the 303(d) list. The Creek was listed as impaired for "nutrients." There was no accompanying data supporting the listing. The listing, however, articulates that the source was "municipal." The municipal source is the WRF, and staff believes that data from the WRF prompted placement of the Creek on the 304(l) list for threat of drinking water impairment.

Given the information leading to the 303(d) listing of the Creek, staff concludes that San Luis Obispo Creek was placed on the 303(d) list as a result of being rolled over from the 304(l) list, which was prompted by nitrate-N and ammonia values reported in the WRF monitoring reports. As such, the listing intended to address impairments to drinking water supply and fish population decline, driven by nitrate-N and unionized ammonia concentrations, respectively.

1.3 Potential Impairments

The impairment leading to the 303(d) listing was due to threat to drinking water and fish population decline, driven by nitrate-N and unionized ammonia, respectively. However, staff has investigated other impairments that could be driven by nutrient enrichment. Using existing Basin Plan water quality objectives as a determination of potential impairment, staff has formulated three categories of impairment related to nutrient enrichment. The categories are briefly discussed in the following three subsections, which support the finding articulated in the Problem Statement.

1.3.1 Threat to Drinking Water

The municipal water supply beneficial use (MUN) is in part protected by the nitrate-N water quality objective. The water quality objective for nitrate-NO_3 is 45 mg/L-NO3, which is equivalent to nitrate-N of 10 mg/L-N. Therefore, nitrate-N concentration exceeding 10 mg/L-N in the Creek implies that the MUN beneficial use is not being protected, and therefore would be a reason for impairment due to nitrate-N.

1.3.2 Threat of Toxicity

The threat of toxicity to aquatic organisms is in part protected by the unionized ammonia water quality objective. The water quality objective for unionized ammonia is stated as follows:

"The discharge of wastes shall not cause concentration of unionized ammonia (NH_3) to exceed 0.025 mg/L (as N) in receiving waters."

Therefore, unionized ammonia concentration exceeding 0.025 mg/L-N in receiving water indicates impairment due to toxicity.

1.3.3 Impairments from Aquatic Growths and Biostimulatory Substances

The negative effect to beneficial uses from aquatic plant growths is a common and sometimes logical consideration when addressing impacts due to nutrients. Types of aquatic growths often considered are benthic algae, suspended algae, and rooted aquatic plants that may have adverse impacts to beneficial uses. The potential for negative impacts from aquatic growths is reflected in the Water Quality Control Plan (Basin Plan) through the narrative biostimulatory substances water quality objective, which 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."

In the narrative objective, the key phrase (with respect to impairment) is that growths shall not cause nuisance or adversely affect beneficial uses. The Porter-Cologne Water Quality Control Act defines nuisance as:

1. "Injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property."
2. "Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal."
3. "Occurs during, or as the result of, the treatment or disposal of wastes."

An adverse effect on beneficial uses generally means any condition that impairs or threatens the beneficial use.

There is currently no data that indicates that impairment to a beneficial use due to biostimulation in San Luis Obispo Creek is present. Data on algal presence, neither numeric nor anecdotal, accompanied the 303(d) listing, nor does recently collected data indicate a violation of the biostimulation objective.

1.4 Basis of TMDL Development

The 303(d) listing of San Luis Obispo Creek was based on impairment from nitrate-N and unionized ammonia and their threat to drinking water and aquatic toxicity, respectively. However, as will be discussed in the sections that follow, only nitrate-N is causing a verifiable impairment in San Luis Obispo Creek. Therefore, a total maximum daily load for nitrate-N is developed.

1.5 San Luis Obispo Creek Watershed and Setting

The San Luis Obispo Creek Watershed (Watershed) is located on the Central Coast of California, approximately 240 miles south of San Francisco and 200 miles north of Los Angeles, as shown in Figure 1.1, below. The Watershed encompasses 84.6 mi^2 (54,142 acres), and is home to the 44,000 residents of the city of San Luis Obispo (City). The City encompasses 9 mi^2, and lies nearly in the middle of the watershed, with San Luis Obispo Creek (Creek) flowing through the downtown area.

The main stem of the Creek is approximately 17 miles in length. The headwaters flow from an elevation of 1700 feet to the mouth at Avila Bay at the Pacific Ocean. Eleven tributaries contribute flow to the Creek, including:

- Brizziolari Creek
- Davenport Creek
- East Fork
- Froom Creek
- Old Garden Creek
- Prefumo Creek
- Reservoir Canyon Creek
- San Miguelito Creek
- Squire Canyon Creek
- Stenner Creek
- Sycamore Creek.

In addition, the damming of Prefumo Creek has created Laguna Lake, which provides recreation for local residents as well as habitat for wildlife. Figure 1.2 illustrates the Watershed and its tributaries.

Climate in the watershed is Mediterranean, experiencing cool wet winters with relatively warm dry summers. Average monthly temperatures from 1950 to 1999 ranged from 41.6 F° in January to 79.2 F° in September. Annual rainfall for the same period of record ranged from 10.91 to 41.67 inches.

Average monthly flow near the mouth of the Creek ranges from 5.8 ft^3/sec in September to 127.2 ft^3/sec in March for the period of record from 1971 to 1986. The City operates and presently discharges approximately 4000 acre-feet of disinfected tertiary reclaimed municipal wastewater, accounting for an average of 5.5 ft^3/sec of flow in the Creek. Therefore, the Creek is effluent dominated in the lower 7 miles during some months of the year; the Creek is typically effluent dominated from July through October.

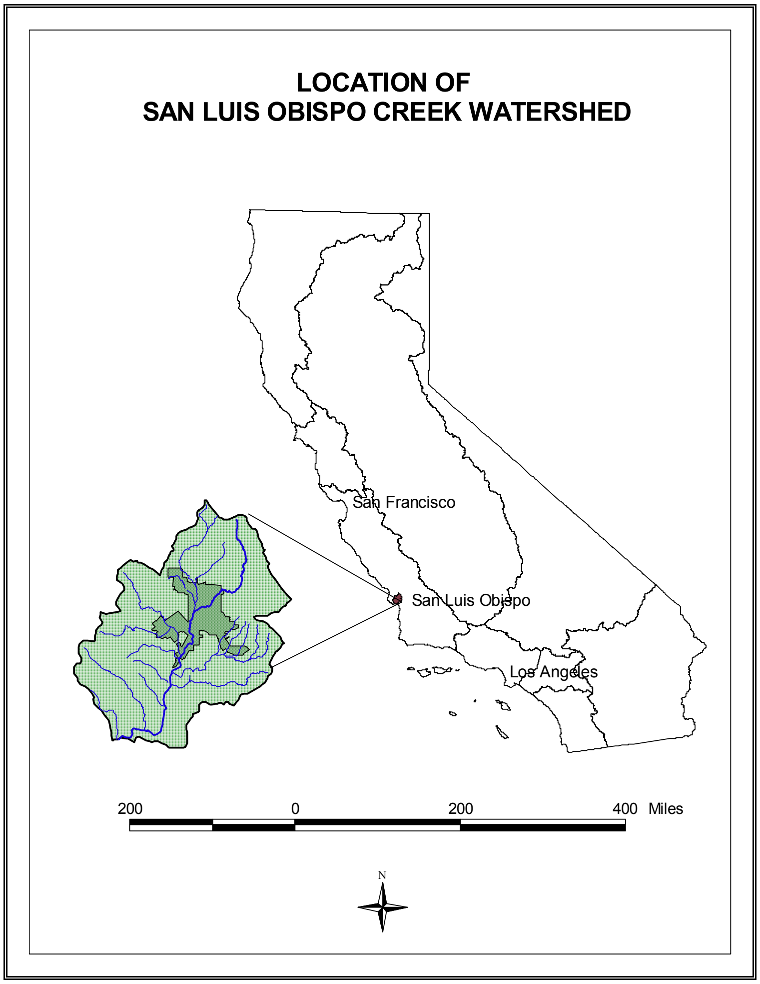

Figure 1.1 Location of San Luis Obispo Cr. Watershed

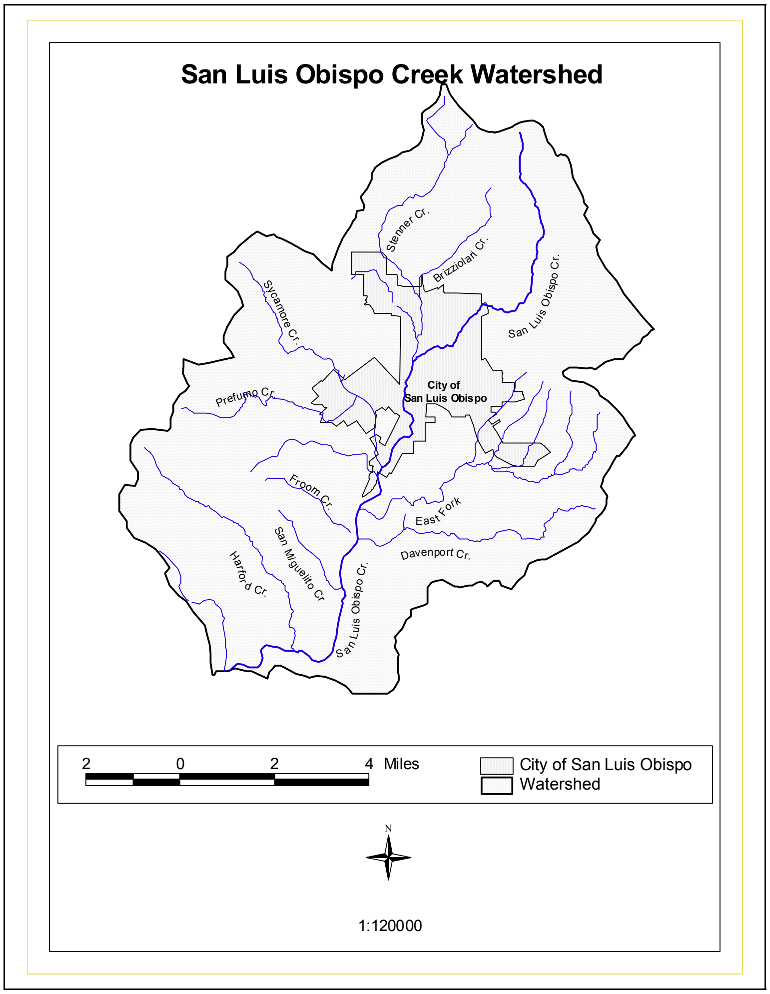

Figure 1.2 San Luis Obispo Creek Watershed

1.6 Beneficial Uses and Water Quality Objectives

The Water Quality Control Plan for the Central Coast Region (Basin Plan) identifies the following thirteen beneficial uses of the Creek and its tributaries.

- Municipal and Domestic Water Supply (MUN)
- Agricultural Supply (AGR)
- Ground Water Recharge (GWR)
- Water Contact Recreation (REC-1)
- Non-Contact Water Recreation (REC-2)
- Wildlife Habitat (WILD)
- Cold Freshwater Habitat (COLD)
- Warm Freshwater Habitat (WARM)
- Migration of Aquatic Organisms (MIGR)

– Spawning, Reproduction, and/or Early Developments (SPWN)
– Rare, Threatened, or Endangered Species (RARE)
– Freshwater Replenishment (FRSH)
– Commercial and Sport Fishing (COMM)

In addition to the beneficial uses above, the Creek is also designated to support the beneficial uses of Shellfish harvesting (SHELL) and Aquaculture (AQUA) near the mouth of the system.

1.7 Data Supporting Impairment and Problem Statement

1.7.1 Nitrate-N and the Municipal Water Supply Beneficial Use

The entire main stem of the Creek is designated to support the municipal water supply (MUN) beneficial use. Data collected by staff clearly indicate that nitrate-N levels in the Creek exceed the 10 mg/L-N threshold. Exceedence of the threashold only occurs downstream of the WRF discharge and confluence with Prefumo Creek. The figure below illustrates nitrate-N concentrations along the main stem of the Creek, each diamond represents a nitrate-N concentration.

Note from Figure 1.3 that nitrate-N levels are consistently above the 10 mg/L-N objective in the lower portion of the watershed. Specifically, nitrate-N levels are above the Basin Plan objective downstream of mile point 7.0, corresponding to the WRF discharge point and confluence with Prefumo Creek.

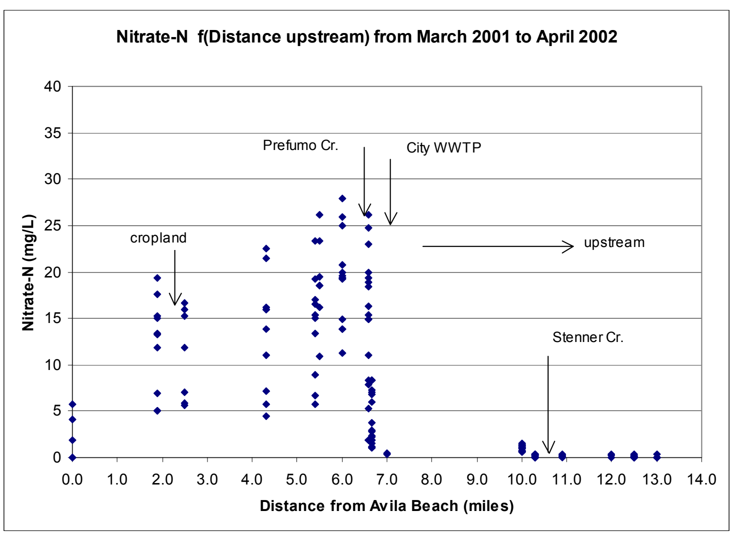

Figure 1.3 Nitrate-N Concentrations Along Main Stem

1.7.2 Unionized Ammonia Water Quality Objective

The unionized ammonia objective states that the discharge of wastes cannot cause unionized ammonia concentration to exceed 0.025 mg/L-N.

The WRF discharges treated wastewater into the Creek. In 1994 the WRF completed and put online a technological upgrade resulting in a significant reduction of unionized ammonia in the effluent. The upgrade was completed specifically to address ammonia discharge with the intent to achieve the unionized ammonia objective.

The WRF is required to monitor and report various constituent concentrations in their influent, effluent, and receiving water. Specifically, unionized ammonia concentration is monitored weekly both upstream and downstream of the discharge point in an effort to verify non-exceedence of the ammonia objective. Unionized ammonia data is summarized for the period of record from February 2000 to April 2001 in the table below.

Table 1.1 Exceedences of Unionized Ammonia Objective from WRF

Monitoring Site	No. of Non-detects[1]	No. of Exceedences[2]	% Exceedences of Total[3]
Upstream of Discharge	103	0	0
Downstream of Discharge	98	9	8%

1 Of the samples drawn, number of samples where unionized ammonia was non-detected (<0.01 mg/LN).
2 Number of exceedences of the unionized ammonia objective.
3 Number of unionized ammonia exceedences expressed as the percent of total samples drawn.

Note that eight exceedences occurred downstream of the discharge point. All eight exceedences occurred within a 68-day period from August 2001 to October 2001. The exceedences were due to an illegal discharge, by an unknown party, of solvent into the sewer system. The discharge was well documented at the time. The WRF attempted unsuccessfully to locate the source of the discharge. The illegal discharge of solvent created an upset in the biologically dependent treatment, resulting in the eight exceedences. The illegal spill ceased, and subsequent data leads staff to conclude that unionized ammonia levels in the Creek meet the unionized ammonia objective.

Given the information presented above, staff concludes that the Creek is no longer impaired for unionized ammonia.

1.8 Problem Statement

Upon consideration of the information outlined above, staff has determined that one beneficial use is not being protected in San Luis Obispo Creek due to nutrients. Specifically, the municipal water supply beneficial use (MUN) is not being protected due to exceedence of the water quality objective for nitrate-N. The water quality objective for nitrate-N is 10 mg/L-N, which is exceeded in the lower reaches of the watershed, corresponding to flows downstream of monitoring site 7.0, which is located approximately 7 miles upstream from the mouth of the Creek.

A source analysis and corresponding TMDL is developed herein with the objective of achieving the nitrate-N water quality objective, and subsequent protection of the municipal water supply beneficial use.

2 Numeric Targets

The numeric target used to calculate the TMDL and subsequent allocations is consistent with the water quality objective for the protection of the municipal water supply (MUN) beneficial use. A discussion supporting the target is provided in the former section.

The numeric target used to calculate the TMDL is a nitrate-N target of 10 mg/L-N.

3 Source Analysis

3.1 Introduction

The Source Analysis will:

1. Identify sources of nitrate-N to the main stem of the Creek.
2. Categorize the identified sources.
3. Identify the relative contributions of nitrate-N by source.

The flowchart in Figure 3.1 briefly outlines the source analysis process.

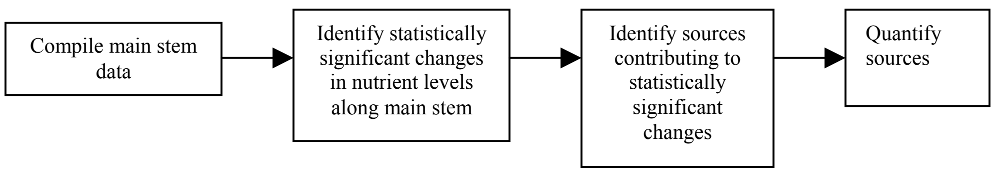

Figure 3.1 Source analysis flowchart

3.2 Methods

3.2.1 Data

Staff utilized two sources of data: 1) data from creek monitoring conducted by staff, and 2) data collected by the City in accordance with the Monitoring and Reporting Program under their NPDES Water Reclamation Facility permit.

3.2.1.1 Spreadsheet Data and Calculations

The TMDL is the result of hundreds of calculations utilizing multiple data points. Key calculations and data summaries in this document will reference a spreadsheet accompanying this document.

3.2.2 Creek Monitoring and Year of Record

Staff began a Creek monitoring program in March 2001. Monitoring efforts ceased in April 2002. Data collected from March 2001 to March 2002 is referred to as the "year of record" in this report.

Forty-one sites throughout the watershed, including 15 along the main stem of the Creek, were used to collect data. Water column data were analyzed for nitrate-N (NO3-N), nitrite, total ammonia, and total nitrogen. Sampling procedures, holding times, and transportation protocol followed methods as outlined in Standard Methods (*Amer. Pub. Hlth. Assoc., 18th Ed.*, 1992).

Flow measurements were accomplished using two methods: 1) area/surface velocity method, and 2) Pygmy flow meter. In the area/surface velocity method, velocity was determined at the stream surface by allowing a stick to float a measured distance. Areas at cross-sections were determined by first determining the geometry of the cross-section. Cross-section geometry was noted as rectangular, triangular, or trapezoidal, and the area calculated. Discharge was then calculated using: $Q = AV$, where Q is discharge, A is area, and V is velocity. Linear measurements were accomplished with a 100-meter cloth tape, or, in the case of small-width channel sections, with a measuring rod with 0.1-foot graduations. Channel depth was accomplished with the measuring rod as well. Flow measurements were also made using a Pygmy Flow meter Model 6205. The flow meter became available to staff in November 2001.

Table 3.1 lists the methods used by the laboratory, as well as instruments used by Staff for *in situ* creek monitoring.

Table 3.1 Methods and instruments for creek monitoring.

Constituent	Method[1]	Reporting Limit
Nitrite	EPA 300.0	0.1 mg/L-N
Nitrate-N	EPA 300.0	0.1 mg/L-N
Total Ammonia	SM 4500 NH3-F	0.02 mg/L-N
Total Kjeldahl Nitrogen	EPA 351.3	0.5 mg/L-N
Ortho Phosphorus	EPA 365.1	0.01 mg/L-P
Total Phosphorus	EPA 365.1	0.02 mg/L-P
Chlorophyll-a	(*In situ*) Hydrolab 4a	
Dissolved Oxygen	(*In situ*) YSI 95	
Temperature	(*In situ*) YSI 95	
Canopy	(*In situ*) Spherical Densiometer, Model C	
Flow	USGS Pygmy current meter	

[1] EPA Methods: (*EPA,* 2005), SM 4500 methods: (*Amer. Pub. Hlth. Assoc.,* 1992)

Monitoring sites were established upstream and downstream of major tributaries, as well as up and downstream from known and suspected sources. Sites were also established at locations designed to reflect background nutrient levels. Figures 3.2 and 3.3 below illustrate the monitoring sites along the main stem and tributaries, respectively.

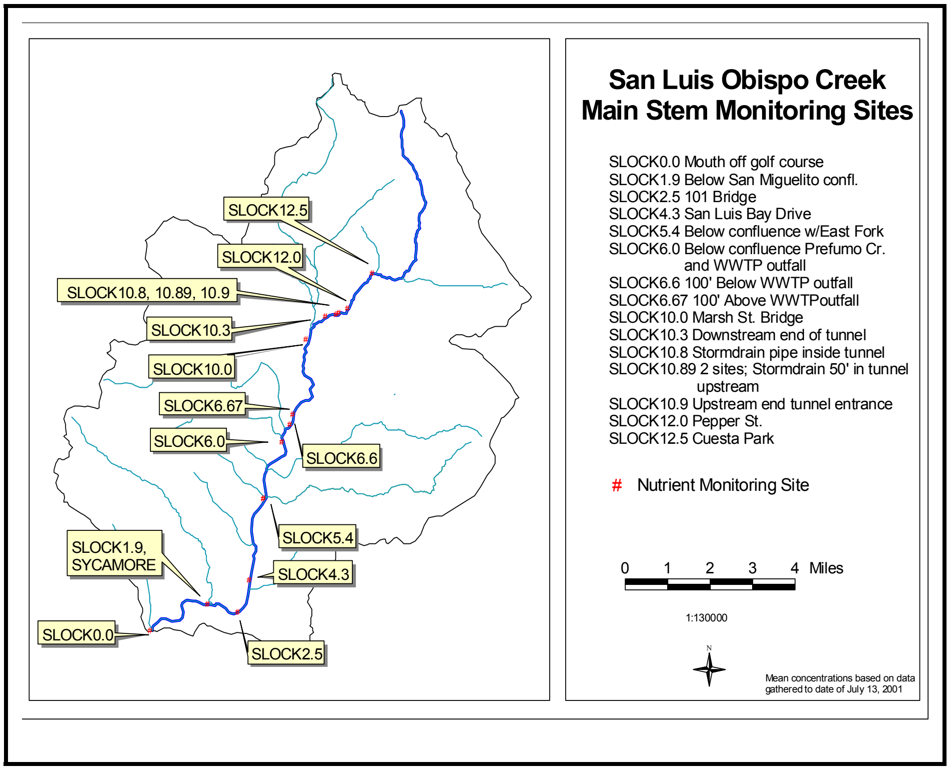

Figure 3.2 Regional Board Monitoring Stations along San Luis Obispo Creek

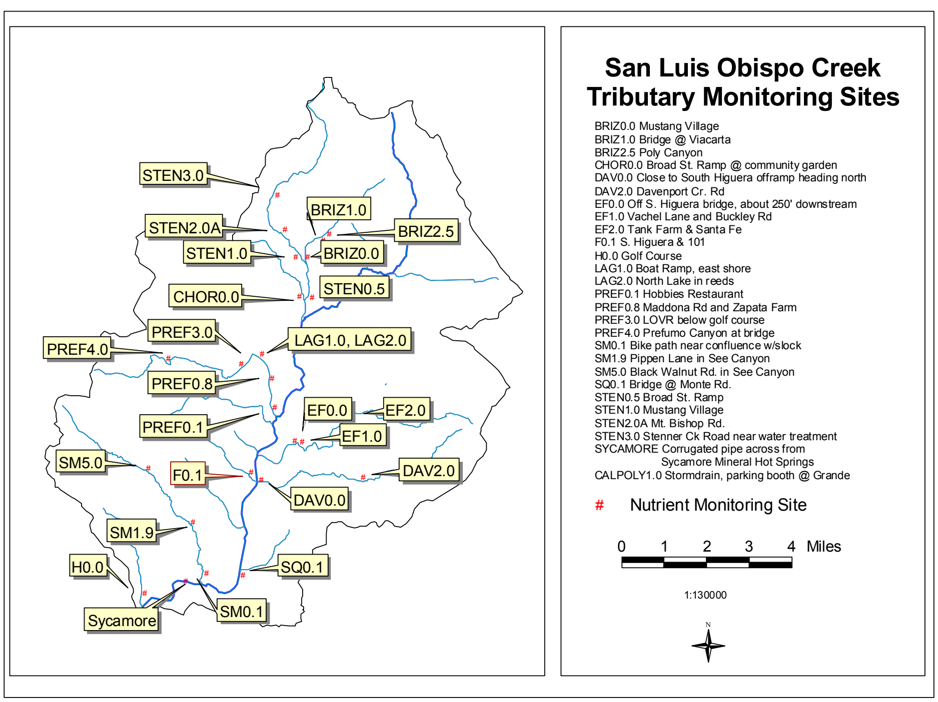

Figure 3.3 Regional Board Monitoring Sites along tributaries to San Luis Obispo Creek

3.2.3 City Monitoring and Reporting

The City is required to monitor and report under their Monitoring and Reporting Program (Program) No. 01-05 for the Water Reclamation Facility (on file at the Central Coast Water Board). Methods of collection, frequency, reportable limits, and analytical methods are documented in the Program and meet Regional Board requirements.

The City monitors effluent from the plant for various constituents, including NO_2 and NO_3-N, dissolved phosphorus, total phosphorus, and flow. The City also monitors 7 sites along the main stem of the Creek, as well as one of its tributaries, and is referred to as the Creek Monitoring Program. The Creek Monitoring Program monitors temperature, dissolved oxygen, NO_2 and NO_3-N, algae cover, and flow from April through November.

Monitoring data from Staff monitoring efforts were compiled in an MS Excel spreadsheet. The laboratory electronically reports sample analysis in MS Excel format, which are subsequently incorporated into the larger spreadsheet by staff. The laboratory follows electronic copies with hard copies of sample analysis, which are used by staff to check the electronic file data for consistency. Data collected from the YSI and Hydrolab units is saved electronically in the field, and then downloaded in spreadsheet format.

Monitoring reports from the City are delivered by hand in hard copy. Data from these reports are entered by hand into the larger spreadsheet.

3.2.4 Data Management

Elements of the flowchart of Figure 3.1 were completed by querying data from the spreadsheet using MS Access. Key data points were queried, resulting in tables that were exported to MS Excel spreadsheet files for further analysis.

3.2.5 Geographic Data

Watershed and subwatershed areas were determined using GIS software (ESRI, 2002). Watershed boundary polygons were manually delineated using 30-meter digital elevation model data. Watershed and subwatershed boundary polygons were overlayed with land use data to obtain land use polygons within subwatershed boundaries. The land use data was obtained from digital land use data compiled by the United States Geological Society (USGS); the EPA modeling Software Basins, Version 3.0 (USEPA, 2001), includes this land use data set. Staff obtained the land use data through this software package. Land use polygons requiring ground-truthing were done so by field reconnaissance and digital orthophotos.

Fourteen separate land use categories resulted from the overlay of land use data and subwatershed data. Staff in turn aggregated the fourteen land use categories into 6 categories based on observed similar water-quality data. The six land use categories are:

1. Natural (includes forests, range, shrub-land, and transitional areas)
2. Reservoir
3. Commercial/Urban (includes commercial, industrial, and roadways)
4. Residential

5. Confined animal operations
6. Cropland.

3.3 Land use

Land uses were delineated on a watershed and subwatershed basis. Ten subwatersheds have been delineated for the purpose of this TMDL. However, in some cases, further refinement was needed in subwatersheds delivering significant nitrate-N loads. A more detailed discussion is provided in sections to follow. Figure 3.4 below illustrates the subwatersheds in the system.

The watershed supports 6 land uses in an area of 84.6 mi^2, or 54,142 acres. Table 3.2 below identifies the total area of each land use category as well as the relative area it occupies. Figure 3.5 below illustrates the land use distribution in the Watershed.

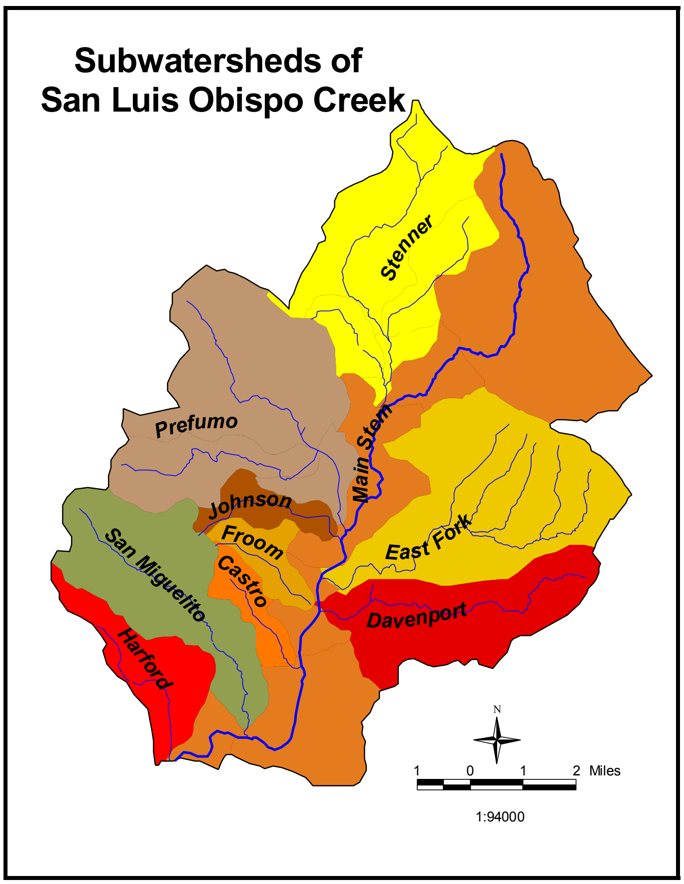

Figure 3.4 Subwatersheds of San Luis Obispo Creek

Table 3.2 Land uses in San Luis Obispo Creek Watershed

Land use	Area (acres)	Relative Area (%)
Natural	40618	75.02
Commercial/Urban	2782	5.14
Confined animal operations	39	0.07
Cropland	7651	14.13
Reservoirs	106	0.20
Residential	2947	5.44
TOTAL	54142	100.00

Note from Table 3.2 that natural and croplands are the dominant and subdominant land use types in the Watershed, respectively. Figure 3.4 illustrates the Watershed and its delineated subwatersheds. Figure 3.5 illustrates the land uses.

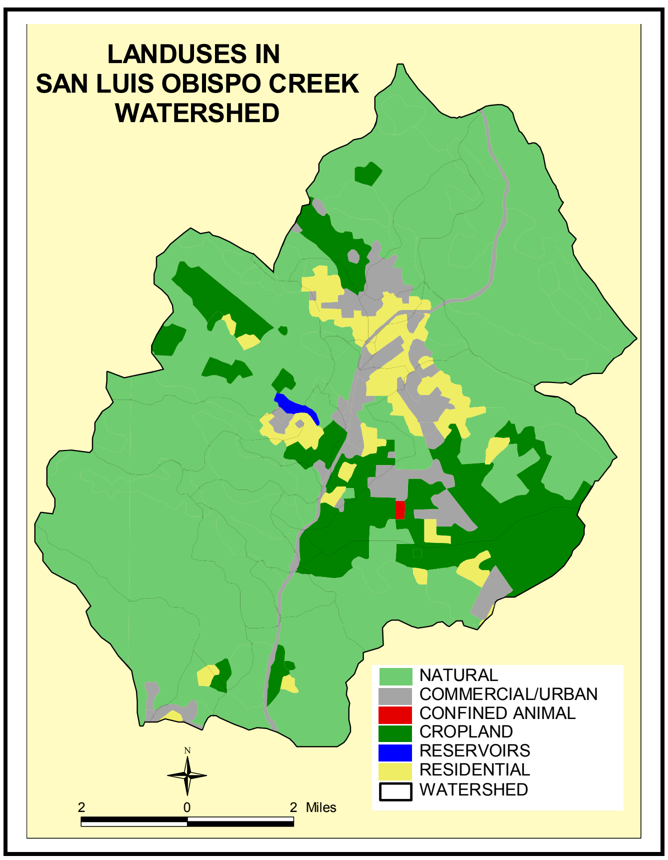

Figure 3.5 San Luis Obispo Creek Watershed Land uses

It is clear from Figure 3.5 that the dominant land use in the watershed is natural.

Table 3.3 below identifies land uses and their respective areas within each subwatershed.

Table 3.3 Land use and relative area by Subwatershed

Subwatershed:	**Castro Canyon**	
Land uses	Area (acres)	Relative area (%)
Natural	992.8	100
Subwatershed:	**Davenport**	
Land uses	Area (acres)	Relative area (%)
Natural	2135.3	47.2
Commercial/Urban	231.7	5.1
Cropland	1950.8	43.1
Residential	204.8	4.5
Total	4522.6	100.0
Subwatershed:	**East Fork**	
Land uses	Area (acres)	Relative area (%)
Natural	3575.9	45.5
Commercial/Urban	836.3	10.6
Confined Animal OPS	38.6	0.5
Cropland	2663.2	33.9
Residential	739.9	9.4
Total	7853.8	100.0
Subwatershed:	**Froom**	
Land uses	Area (acres)	Relative area (%)
Natural	1059.4	99.1
Cropland	10.0	0.9
Total	1069.4	100.0
Subwatershed:	**Harford**	
Land uses	Area (acres)	Relative area (%)
Natural	2218.7	96.2
Commercial/Urban	86.6	3.8
Total	2305.3	100.0
Subwatershed:	**Johnson**	
Land uses	Area (acres)	Relative area (%)
Natural	1054.7	100.0
Cropland	0.3	0.03
Total	1055.0	100.0
Subwatershed:	**Main stem**	
Land uses	Area (acres)	Relative area (%)
Natural	12607.9	83.7
Commercial/Urban	757.7	5.0
Cropland	807.9	5.4
Residential	886.1	5.9
Total	15059.5	100.0
Subwatershed:	**Prefumo**	
Land uses	Area (acres)	Relative area (%)
Natural	6831.4	76.3
Commercial/Urban	180.9	2.0
Cropland	1408.4	15.7

Table 3.3 Con't. Prefumo Creek Subwatershed		
Reservoirs	106.1	1.2
Residential	429.1	4.8
Total	8955.9	100.0
Subwatershed:	**San Miguelito**	
Land uses	Area (acres)	Relative area (%)
Natural	5105.1	98.4
Cropland	65.9	1.3
Residential	17.7	0.3
Total	5188.8	100.0
Subwatershed:	**Stenner**	
Land uses	Area (acres)	Relative area (%)
Natural	5036.9	70.6
Commercial/Urban	689.0	9.7
Cropland	744.1	10.4
Residential	669.0	9.4
Total	7138.9	100.0

See accompanying spreadsheet: SLOnutTMDL, "LANDUSE" worksheet.

3.4 Data Analysis

The following discussions will refer to monitoring sites illustrated in Figures 3.2 and 3.3 presented above.

3.4.1 Land Use/Source Nomenclature

Six land use categories have been identified in the Watershed, including:

1. Natural
2. Reservoirs
3. Commercial/urban
4. Residential
5. Confined animal operations
6. Cropland

The land use categories are used to describe source categories. The five source categories used in the document are:

1. Background (draining natural lands)
2. Reservoirs
3. Residential
4. Confined animal operations
5. Croplands

As will be discussed in sections below, the commercial/urban land use discharges a negligible mass of nitrate-N, and will therefore not be considered a source category.

3.4.2 Significant Nitrate-N Sources

Staff used main stem water quality data to determine where along the channel significant increases in nitrate-N levels occur. Data points were tabulated and graphed as a function of distance upstream from the mouth. Notable increases in nitrate-N concentration were then tested for significance using statistical software. Statistical tests compared nitrate-N concentrations of sites where an increase was evident to the site immediately upstream. The analysis aided staff in determining where significant nitrate-N sources are located. Figure 3.6 below illustrates nitrate-N values along the main stem of the channel. The x-axis refers to locations along the main stem of the Creek. Monitoring stations are geographically illustrated in Figures 3.2 and 3.3 in the preceding section.

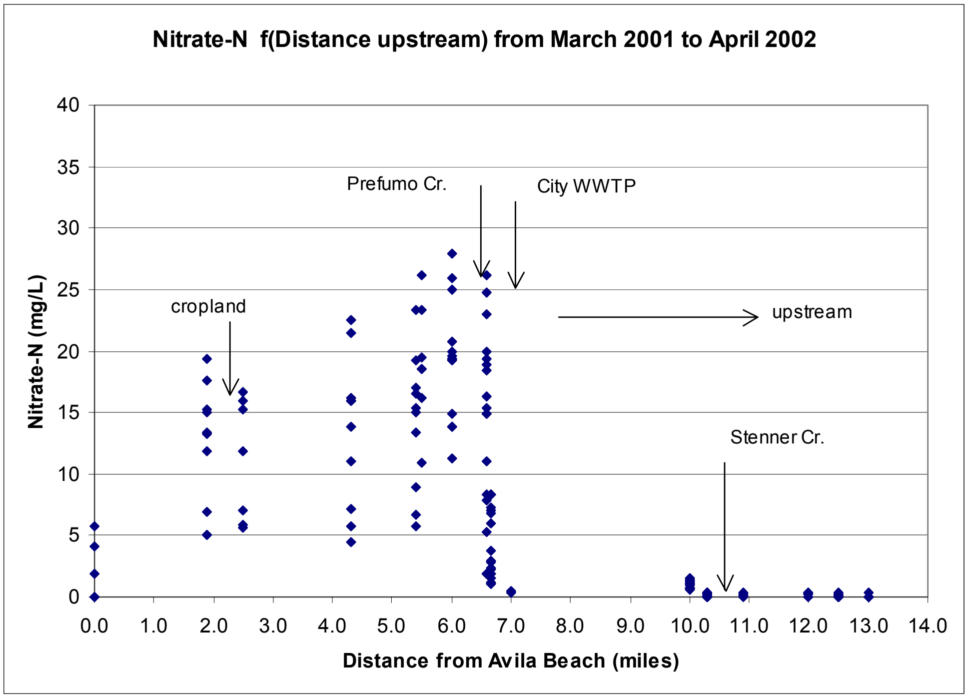

Figure 3.6 Nitrate-N levels along main stem

See accompanying spreadsheet: SLOnutTMDL, "NITRATE" worksheet, cell BP2.

Note in Figure 3.6 that nitrate-N levels increase immediately downstream of:

1. The confluence with Stenner Creek.
2. The confluence with Prefumo Creek.
3. The discharge of the City's waste water treatment plant (WWTP), also known as the Water Reclamation Facility (WRF).
4. Downstream of a cropland area.

The sites described in bullets 1-4 above correspond to monitoring sites 10.0, 6.6, 6.0, and 1.9, respectively, and are illustrated in Figure 3.2. Staff used the Mann-Whitney non-parametric analysis to test if median nitrate-N concentration significantly increases at these sites, relative to the adjacent upstream sites. An alpha level of 0.05 is used to test significance. The results of the analysis are summarized in Table 3.4 below.

Table 3.4 Test for significant increases in median nitrate-N concentration using Mann-Whitney Test

Site	Is median NO_3-N concentration statistically > than upstream?	P-Value
10.0	Yes	0.0000
6.6	Yes	0.0000
6.0	Yes	0.0328
1.9	No	0.4611

See full analysis in Appendix.

The analysis indicates that the median nitrate-N concentration at sites 10.0, 6.6, and 6.0 is statistically greater than the sites immediately upstream from each of the sites. The results of the analysis are reasonable as each of these sites is immediately downstream of either a tributary or point source. Tributary and point source data further corroborate results of the statistical analysis, as discussed below.

3.4.2.1 Stenner Creek

Site 10.0 is a main stem site immediately downstream from the confluence with the tributary Stenner Creek. The median nitrate-N concentration in Stenner Creek for the year of record is 1.80 mg/L-N, flowing at an average rate of 5.6 ft^3/sec. The median nitrate-N concentration at site 10.3 (site above site 10.0 and confluence with Stenner Cr.) is 0.075 mg/L-N. The resulting median nitrate-N concentration downstream of the confluence is 0.95 mg/L-N. It is apparent that the higher concentration of nitrate-N flowing from Stenner Creek into the main stem of San Luis Obispo Creek is causing an increase in nitrate-N concentration in the main stem. Figure 3.7 below illustrates how the confluence affects nitrate-N concentrations in the main stem.

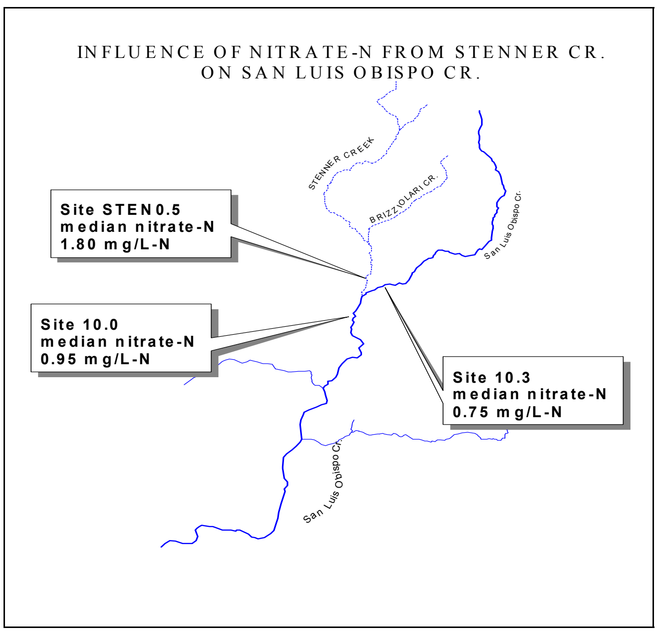

Figure 3.7 Confluence of Stenner Creek and San Luis Obispo Cr.

See accompanying spreadsheet: SLOnutTMDL, "NITRATE" worksheet, cell BW33.

Land use activities in Stenner Creek subwatershed are illustrated in Table 3.3 above.

Note that the dominant land use in Stenner Creek subwatershed is natural. Staff has reviewed data and has determined that background nitrate-N concentrations average 0.09 mg/L-N. The subdominant land use activity is cropland. Staff has determined that the average nitrate-N concentration adjacent to other croplands in the Watershed is 26 mg/L-N. Although this magnitude of nitrate-N is not present in receiving waters adjacent to croplands in Stenner Creek watershed, an increase in nitrate-N in Stenner Creek watershed is present. In addition, water quality sampling along the tributary Brizziolari Creek indicate an increase in nitrate-N concentration downstream of a small bull-pen where animals are confined near the waters edge (see data at monitoring sites BRIZ1.0 and BRIZ2.5). Average concentrations upstream of the bull-pen are 0.24 mg/L-N, and 0.98 mg/l-N downstream of the pen.

Staff, therefore, conclude that:

- The elevation in nitrate-N at site 10.0 along the main stem of the Creek is due primarily to cropland activities and confined animal operations in Stenner Creek subwatershed.
- The nitrate-N concentration in Stenner Creek is well below the TMDL numeric target.
- Elevated nitrate-N concentration from Stenner Creek does not cause nitrate-N levels downstream of the confluence with San Luis Obispo Creek to rise above the numeric target.

3.4.2.2 City of San Luis Obispo Water Reclamation Facility

Site 6.6 is a main stem site immediately downstream of the point-source discharge from the City of San Luis Obispo's Water Reclamation Facility (WRF). The median concentration of nitrate-N from the discharge for the year of record is 23.6 mg/L-N, flowing at an average rate of 4.3 million gallons/day. The median nitrate-N concentration at the site upstream of the discharge is 0.95 mg/L-N. The median nitrate-N concentration immediately downstream of the WRF discharge is 15.15 mg/L-N for the year of record. The volume of flow from the discharge represents a significant proportion of the total stream volume at site 6.6. Figure 3.8 below illustrates the influence of the WRF on nitrate-N levels in the Creek

The information presented lead staff to conclude that:

- The elevation in nitrate-N concentration at site 6.6 along the main stem of the Creek is due to nitrate-N loading from the WRF, located immediately upstream of site 6.6, and is a significant source of nitrate-N to downstream waters.
- Discharge from the WRF causes nitrate-N concentration in the Creek to rise above the numeric target for nitrate-N of 10.0 mg/L-N.

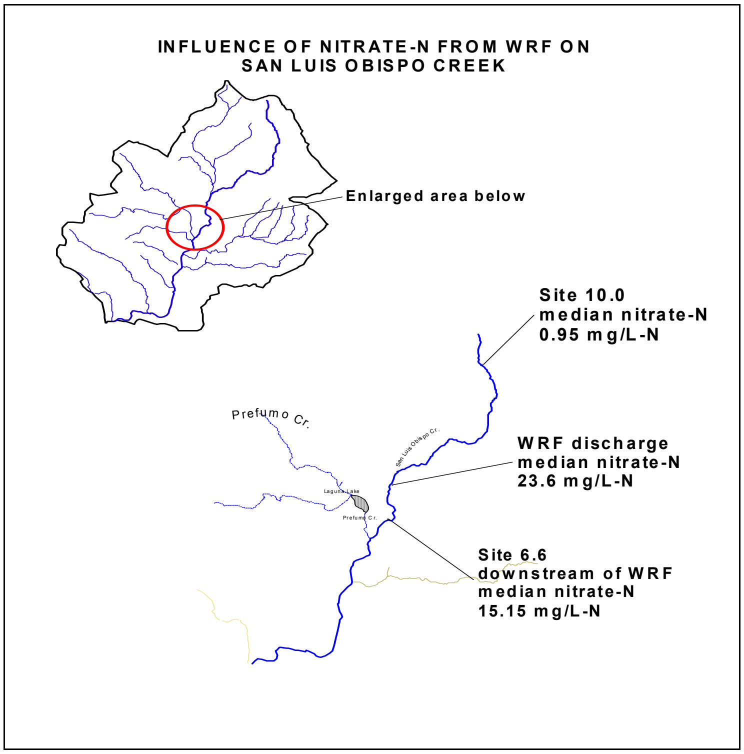

Figure 3.8 Nitrate-N Concentration Downstream of WRF

See accompanying spreadsheet: SLOnutTMDL, "NITRATE" worksheet, cells BY53 and DY22.

3.4.2.3 Prefumo Creek Subwatershed

Site 6.0 is a main stem site immediately downstream from the confluence with the tributary Prefumo Creek. The median nitrate-N concentration flowing from Prefumo Creek at the confluence with San Luis Obispo Creek is 31.0 mg/L-N, flowing at an average rate of 1.7 ft^3/sec. The median nitrate-N concentration at the site above the confluence, i.e., site 6.6 is 15.15 mg/L-N, resulting in a median nitrate-N concentration below the confluence of 19.3 mg/L-N at site 6.0. Figure 3.9 below illustrates how the confluence affects nitrate-N concentrations in the main stem.

Notice from Table 3.3 that the dominant land use in Prefumo Creek watershed is natural, with the subdominant land use being cropland. The cropland area occurs near the confluence of Prefumo Creek with the San Luis Obispo Creek, whereas the natural areas occur in the north and west portions of the watershed.

Data analysis of monitoring points located in the watershed (see Figure 3.3, PREF sites) clearly indicate that nitrate-N loading into San Luis Obispo Creek from Prefumo Creek is largely due to croplands, and more specifically, irrigated agricultural activities. The following considerations support this determination:

- The average nitrate-N concentration in Prefumo Creek below cropland activities is 26.3 mg/L-N, whereas the average nitrate-N concentration immediately upstream of the cropland activity (which is discharge water from Laguna Lake) is 0.09 mg/L-N.

- The average nitrate-N concentration in Laguna Lake, as well as below residential and natural areas which provide flow to the downstream cropland area, is 0.06 mg/L-N (see land use maps above, Figure 3.5).

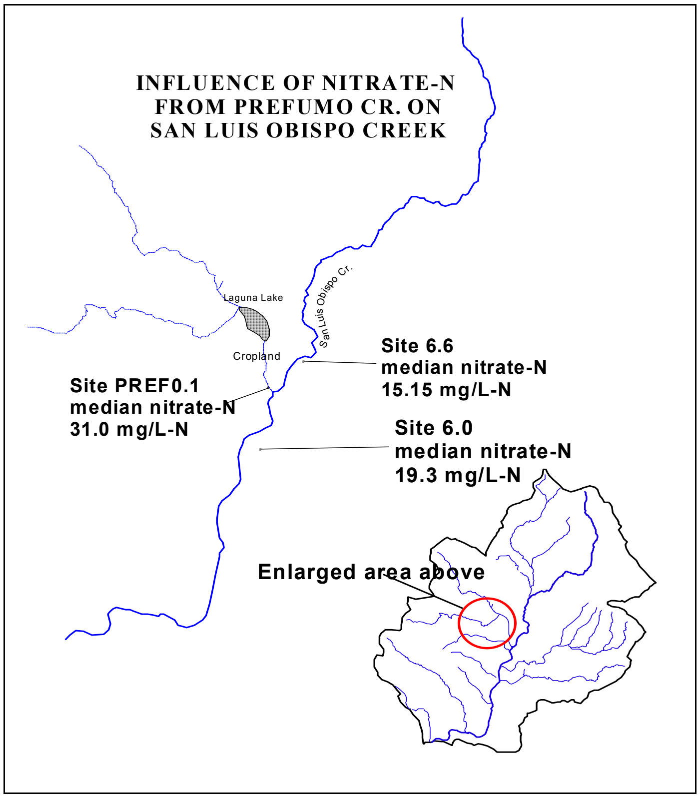

Figure 3.9 Confluence of Prefumo Creek and San Luis Obispo Creek

See accompanying spreadsheet: SLOnutTMDL, "NITRATE" worksheet, cells BW33 and CN53

3.4.2.3.1 Nitrate-N Regime and Land use Change in Lower Prefumo

There are approximately 300 acres in irrigated cropland production in the lower Prefumo Creek Watershed, i.e., downstream of Laguna Lake. It is this cropland area that is largely responsible for the nitrate-N loading from Prefumo Creek. The owner of the cropland is planning to convert the land use to commercial. Approximately 25% of the cropland area could be affected by the land use change. If the development is approved, another 25% of the cropland area will be deeded and annexed to the City of San Luis Obispo. The land use after the annexation is not yet determined, but it is probable that this area will not be in crop production.

Finally, the growers in the Prefumo Creek watershed will take management measures aimed at meeting the numeric target. This is anticipated because the Conditional Waiver of Waste Discharge Requirements for Discharges from irrigated lands (Agricultural Waiver) requires growers to take such action.

3.4.2.4 Main stem site 1.9

Note from Table 3.4 that the increase in nitrate-N at site 1.9, relative to the monitoring site upstream of site 1.9, is not statistically significant. Staff, therefore, conclude that land uses immediately upstream of site 1.9 are not significantly increasing nitrate-N concentrations in the Creek. In addition, subsequent to the data collection period, a land use change has occurred at this site. This site was adjacent to croplands that has been developed and converted to commercial buildings.

3.4.2.5 Summary of Nitrate-N Sources

Table 3.5 below identifies the sources of nitrate-N to the Creek. Sources listed in the table are not the only sources of nitrate-N, but represent those that have a statistically significant impact on nitrate-N concentration in the Creek.

Table 3.5 Significant nitrate-N sources

Source	**Location**
Cropland	Stenner Creek subwatershed
Cropland	Prefumo Creek subwatershed
Point source	City's Water Reclamation Facility

3.4.2.6 Other Sources of Nitrate-N

Other sources of nitrate-N to the Creek include those that are present, but do not create a measurable (statistically significant) impact to Creek concentration. It is clear that all land use types contribute nitrate-N to some degree, insofar as all land use types play a role in nitrogen cycling. Although other sources of nitrate-N may not have a measurable impact to the Creek, it is necessary to list these sources, as it will become necessary to quantify their contribution to total loading.

Sources that were *not* accounted for in Section 3.4.1 include:

- Background
- Residential
- Commercial/Urban
- Reservoir
- Atmospheric deposition

3.4.2.6.1 Background, Residential, and Commercial/Urban Sources

The headwaters of the Creek begin in areas that are relatively undisturbed, i.e., in areas considered to contribute background levels of nitrate-N. The Creek then flows in a southwesterly direction through residential then commercial/urban areas of the City of San Luis Obispo. Staff has compiled nitrate-N data from locations along the Creek where land use changes occur. This has enabled staff to make conclusions regarding loading from these land use activities.

The following monitoring sites were chosen to aid staff in determining nitrate-N loading due to various land uses (refer to Figure 3.2 above):

- Site 12.5; situated upstream of the City limits, draining areas from natural sources,
- Site 13.0; situated upstream of site 12.5, is also draining areas from background sources; monitored by the City staff.
- Site 12.0; situated downstream of site 12.5, draining areas flanked by residential land use on both side of the Creek,
- Site 10.9; situated downstream of site 12.0, draining areas flanked by commercial/urban land use on both sides of the Creek,
- Site 10.3, situated downstream of site 10.9, draining areas flanked by commercial/urban land use on both sides of the Creek.

Figure 3.10 graphically illustrates the minimum, maximum, and average nitrate-N concentrations for each site referred to above. Because all sites are adjacent to each other, with natural sites being furthest upstream, staff noted whether nitrate-N levels increased while flowing from background sources through residential and urban/commercial.

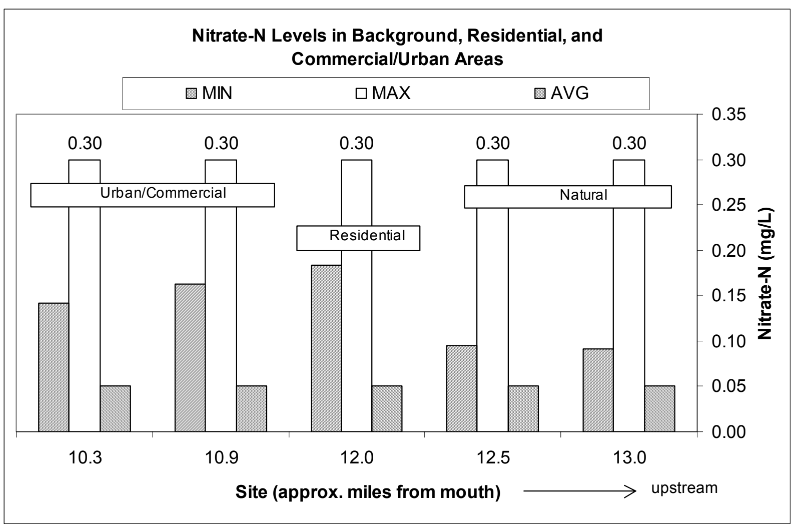

Figure 3.10 Minimum, maximum, and average nitrate-N levels among land uses.

The following observations can be made of Figure 3.10:

- Maximum nitrate-N levels do not increase while flowing from natural through residential or urban/commercial areas.
- Minimum nitrate-N levels do not increase while flowing from natural through residential or urban/commercial areas.
- Average nitrate-N levels increase (from 0.10 mg/L at 12.5 to 0.18 mg/L at 12.0), over background levels, after flowing through residential areas.
- Average nitrate-N levels slightly decrease in urban/commercial areas, relative to residential.

- All levels, including maximum nitrate-N levels, are two orders of magnitude below the proposed numeric target.

Note that because there is not a tributary or point source between sites 12.0 and 12.5, that the volume of water flowing past either site is approximately the same. Also note that site 12.5 carries loading from background sources whereas site 12.0 carries loading from background and residential sources. Therefore, a ratio of residential to background loading can be determined and used in the loading analysis. The ratio of residential to background loading is:

$$\text{Where } L = \text{Loading} = \text{Discharge } (Q) \text{ x Concentration } (C)$$
$$\text{Therefore: } Q_{12.0}C_{12.0} = Q_{Background}C_{Background} + Q_{Residential}C_{Residential}$$
$$\text{Since } Q_{12.0} = Q_{12.5}$$
$$C_{12.0} = C_{Background} + C_{Residential}$$
$$\text{Therefore: } C_{Residential} = C_{12.0} - C_{Background} = 0.18 - 0.10 = 0.08$$

The ratio therefore becomes:

$$\frac{residential...loading}{background...loading} = \frac{0.08}{0.10} = 0.8$$

Staff has made the following conclusions based on the observations above:

1. Residential loading is approximately 0.8 of background.
2. Commercial/urban sources are negligible.

3.4.2.6.2 Reservoirs

Laguna Lake is situated in Prefumo Creek subwatershed. The lake outlet is the continuation of Prefumo Creek (refer to Figure 3.8 above), and flows through croplands in lower Prefumo Creek watershed. Staff conducted monitoring near the outlet of Laguna Lake, and have quantified the nitrate-N contribution of the lake to the Creek (refer to section 3.4.2.3 above). The contribution is minimal, relative to the contribution due to croplands in the lower portion of the watershed. However, the lake does deliver some nitrate-N, and will be considered in the loading analysis. Furthermore, because the lake captures loading by sources that flow to the lake, e.g. natural and residential areas, these sources will not be considered in the loading analysis as they will already be accounted for as a reservoir source.

Similar to the ratio determination in Section 3.4.2.6.1, the ratio of reservoir sources to cropland sources is determined as follows:

$$\text{Where } L = \text{Loading} = \text{Discharge } (Q) \text{ x Concentration } (C)$$
$$\text{Therefore: } Q_{Pref0.1}C_{Pref0.1} = Q_{Reservoir}C_{Reservoir} + Q_{Crop}C_{Crop}$$
$$\text{Since } Q_{Pref0.1} = Q_{0.7}$$
$$C_{Pref0.1} = C_{Reservoir} + C_{Crop}$$
$$\text{Therefore: } C_{Crop} = C_{Pref0.1} - C_{Reservoir} = 26.30 - 0.09 = 26.21$$

The ratio therefore becomes:

$$\frac{reservoir...loading}{cropland...loading} = \frac{0.09}{26.3} = 3.43 \cdot 10^{-3}$$

Staff has therefore concluded that:

- Sources of nitrate-N due to reservoirs in the Watershed are a factor 3.43 * E^{-3} that of the cropland area in the Prefumo watershed.

3.4.2.6.3 Atmospheric Deposition

Atmospheric deposition can be a significant source if a lake or reservoir is present, particularly if the area of the lake or reservoir is a significant portion of the entire watershed. This, however, is not the case with Laguna Lake in the Watershed.

Laguna Lake encompasses 106 acres of the 54,142-acre watershed, making the lake 0.19% of the total watershed area. Additionally, any atmospheric deposition occurring will be accounted for in the reservoir source category. Staff has therefore concluded that:

- Atmospheric deposition is not a significant source of nitrate-N in the Watershed.
- Any atmospheric deposition occurring will be accounted for in the reservoir source category.

3.4.2.6.4 Other Cropland Areas

The *other cropland* source category includes those areas not explicitly discussed above. Although other cropland areas are not significantly impacting nitrate-N concentrations along the main stem, nitrate-N loading is present.

East Fork and Davenport subwatersheds support 4600 acres of cropland (see land use map). They are located in the lower half of San Luis Obispo Creek Watershed in an area of low gradient, resulting in lower water velocities, which in turn supports infiltration. East Fork and Davenport are ephemeral streams, being two of the first tributaries to stop flowing as summer approaches; they had minimal flows from November 2001 until flow ceased in April 2002. Additionally, much of the cropland is not adjacent to the main stem of San Luis Obispo Creek and many of the crops are dry-farmed only. Finally, a significant vegetative buffer strip flanks San Luis Obispo Creek in this area. As a result of these features, East Fork and Davenport deliver lower nitrate-N loads to San Luis Obispo Creek, relative to cropland areas in Prefumo Creek watershed, and helps explain why a significant increase in median nutrient-N concentrations is not observed below their confluence with San Luis Obispo Creek.

An analysis of data collected at the mouths of Davenport and East Fork Creek indicate the following:

- Davenport Creek delivers non-detectable levels of nitrate-N to San Luis Obispo Creek,

- Although nitrate-N levels are non-detectable, staff use ½ detection limit for loading calculation, as some minimal amount of loading is occurring.
- East Fork delivers a wet season nitrate-N average of 2.68 mg/L NO_3-N to San Luis Obispo Creek. East Fork is dry during summer months.

3.4.2.7 Summary of Other Nitrate-N Sources

Table 3.6 identifies other sources of nitrate-N, i.e., those that are present but not significantly impacting nitrate-N concentrations in the main stem. The list below is based on the findings discussed above. Recall that the commercial/urban source category is negligible.

Table 3.6 Other nitrate-N sources

Source	Location
Background	Many
Residential	Primarily w/in City of San Luis Obispo
Reservoir	Laguna Lake
Irrigated lands	Davenport and East Fork

3.4.3 Sources from Future Development

The potential exists for development within the watershed that would impact the sources of nitrate-N to the Creek. However, staff believes that development within the watershed will not add significant nitrate-N loading. This determination is made for the following reasons:

- Future development will increase residential and commercial/urban land uses, and
    - It was demonstrated above that commercial/urban nitrate-N sources are negligible.
- Development will primarily occur in existing cropland areas:
    - Conversion of cropland land use to residential or commercial/urban will have a net decrease in nitrate-N loading.
    - Current development proposals include a large land use conversion from cropland to commercial in the Prefumo Creek subwatershed. The development is planned by the owner but not yet approved.

4 Load Analysis

4.1 Introduction

The load analysis section identifies the total and relative mass loading of nitrate-N for each of the sources identified in the previous section. The loading analysis sets the stage for the next section, the linkage analysis, which in turn will be used to develop the TMDL.

4.2 Methods Used to Determine Nitrate-N Mass Loading

4.2.1 Nitrate-N Non-point Source Loading

Both in-stream nitrate-N concentration and flow data are needed at each point where mass loading is to be determined. Nitrate-N loading was calculated using the general formula:

Concentration x Flow x Conversion factor = Nitrate-N Mass

Staff utilized concentration data obtained from March 2001 to April 2002 for loading calculations. Data prior to March 2001 were obtained from various sources, including results of the City's monitoring efforts for their NPDES permit of the WRF. The City's data strongly corroborates the findings of staff insofar as:

1. Peak main stem nitrate-N concentrations occur downstream of the WRF discharge and confluence with Prefumo Creek.
2. The highest main stem nitrate-N concentrations occur during late summer.
3. Background nitrate-N levels are less than 0.5 mg/L-N.

The daily loading was established at a monitoring point, based on the assumption that the nitrate-N concentration from a sampling point reflected levels throughout that day. Daily loadings were calculated at monitoring sites located at the mouth of tributaries draining subwatersheds. With this approach, the total loading from subwatersheds could be summed to determine the total loading in the watershed. This approach also lends itself to identification of key areas where loading is the greatest.

1. Daily loads were then plotted as a function of time from March 21, 2001 to March 21, 2002. These are the dates staff conducted water quality monitoring. The daily loads act as known measured loading points between which calculated loading could be determined; known daily loading points were used as two points of a line, under which is the sum of nitrate-N loading for the period between the two points.

Figure 4.2 illustrates how nitrate-N loading between two known loading points is determined.

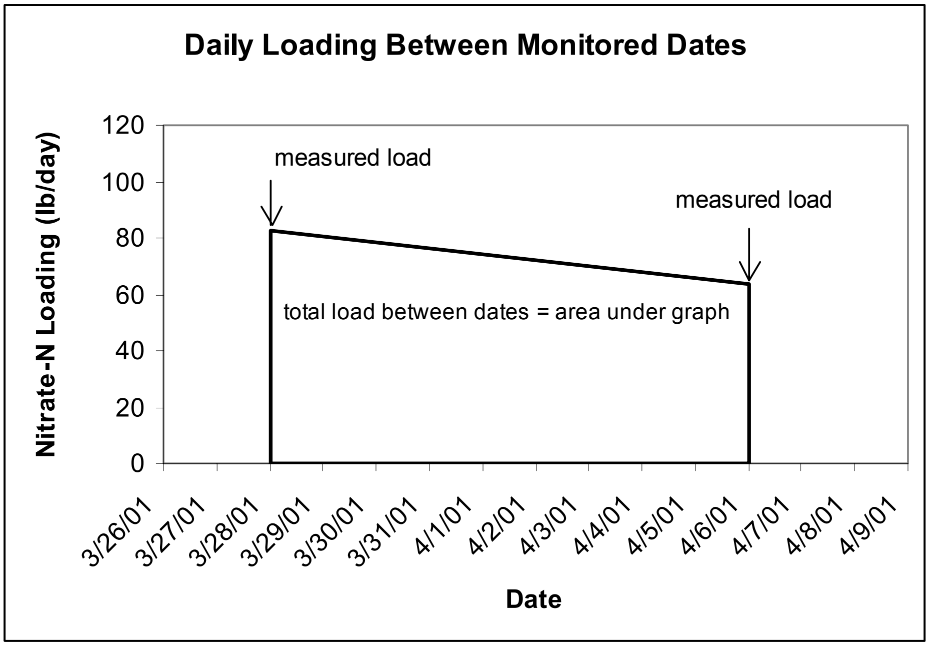

Figure 4.1 Determining nitrate-N loading between two monitoring dates.

.
See accompanying spreadsheet: SLOnutTMDL, "MeasuredLoad and MeasuredWLoad" worksheets for integration calculations.

Once the total annual load was determined by subwatershed, the total load was distributed among various sources present in that watershed. The distribution of the total load was accomplished by first determining a loading flux rate for the background source.

A flux rate is the loading mass per acre of land use over a period of time, for example pounds per acre per year (lb/ac/yr) from natural areas in a subwatershed.

The flux rate was determined for background sources using the monitoring site SLOCK12.5, above which is primarily a natural land use. The area of land used is all area within 50-meters of a tributary of the main stem occurring in the watershed above the monitoring site SLOCK12.5. The 50-meter buffer was used because it is this land-area contributing the greatest proportion of nitrate-N to the Creek. The 50-meter buffer around the streams was accomplished using a GIS. The buffered area was then intersected with the land use data to obtain land use areas occurring within 50-meter of the stream.

The following components were used to determine the flux rate for the background source:

1466 acres = Natural area within 50-meter of stream above site 12.5
579 lb-NO_3-N/year = loading at site 12.5 for the year of record
0.395 lb/ac/yr = flux rate for background source

Once the background flux rate is determined, loading due to background sources in a subwatershed can be calculated. The loading due to background sources is then subtracted from the total load. The remaining load to be distributed depends on the sources remaining in the subwatershed:

- For residential, loading is 0.08 that of background (see section 3.4.2.6.1 above).
- For reservoir, only one source is present occurring in the Prefumo Creek Watershed. Loading is calculated as 3.43×10^{-3} of croplands in this watershed. The total loading in Prefumo Creek watershed is calculated with concentration and flow data.
- Urban/commercial is a negligible source (see section 3.4.3.1 above).
- For confined animal operations, the load is that remaining after all other sources have been accounted for.

The largest cropland areas occur in Prefumo, East Fork, and Davenport subwatershed areas. Monitoring data along the tributaries for these subwatersheds is used to determine total loading, which is then used to back-calculate for the sources discussed above. However, relatively small subwatersheds along the main stem have some cropland areas for which loading is to be determined. A flux rate is used for these areas along the main stem using the calculated total loading (from monitoring) and cropland areas in Prefumo Creek subwatershed. The total cropland area is used to develop the flux rate, rather than the area falling within 50-meter of the Creek because the cropland areas lack riparian vegetation, and often have drains returning tail water to the Creek. As a result, it is more likely that nitrate-N applied to a cropland area a distance away from the Creek will be transported to the Creek, relative to natural areas with dense vegetative cover.

A relatively small portion of the loading from Prefumo Creek is from sources other than cropland, i.e. Laguna Lake (See Section 3.4.2.6.2). This proportion was quantified above as 3.43×10^{-3} of the cropland area in Prefumo. Since the total loading in Prefumo is determined using the monitoring data, the approximate cropland source can be calculated using:

$$\text{Cropland(C)} + \text{Reservoir(R)} = \text{Total Load(T)}$$
$$C + R = T$$
$$R = 3.43 \times 10^{-3}\,C;\ R = .00343C$$
$$\text{Therefore: } C + .00343C = T$$
$$1.00343C = T$$
$$C = \frac{T}{1.00343}$$

and T = 67,787 lb NO_3-N/year, so

$$C = \frac{67{,}787}{1.00343} = 67{,}555 lb$$

Total Cropland area in Prefumo is 1408 acres, therefore
48.0 lb/ac/yr = flux rate for cropland sources

This flux rate is consistent to the flux rate determined for cropland sources in a 1994 nutrient study (47.7 lb/ac/yr) of San Luis Obispo Creek Watershed (Hallock *et al*, 1994). Note that the flux rate for cropland areas is only used in the absence of monitoring data.

A confined animal flux rate is needed to determine nitrate-N loading due to this source. Staff obtained upstream/downstream monitoring data from a background and confined animal area to determine a ratio of loading between the two. A flux rate for confined animal operations was then calculated using the developed flux rate for background sources.

The flux rate is determined as follows:

Where L = Loading = Discharge (Q) x Concentration (C)

Therefore: $Q_{BRIZ1.0}C_{1.0} = Q_{Background}C_{Background} + Q_{Confined\ animal}C_{Confined\ animal}$

Since $Q_{Briz1.0} = Q_{Briz2.5}$ (BRIZ2.5 draining background area)

$C_{Briz1.0} = C_{Background} + C_{Confined\ animal}$

Therefore: $C_{Confined\ animal} = C_{Briz1.0} - C_{Background} = 0.98 - 0.24 = 0.74$

The ratio of confined animal to background then becomes:

$$\frac{confined...animal...loading}{background...loading} = \frac{0.74}{0.24} = 3.08$$

and

background flux rate = 0.395 lb/ac/yr, therefore

1.22 lb/ac/yr = confined animal operation flux rate for nitrate-N

Once the total amount of load is distributed for each subwatershed, the loadings from all sources are summed, and relative contributions by sources are then calculated. The result of this calculation is expressed in Table 4.2 below.

4.2.1.1 Negligible Source Areas of Nitrate-N

Staff has concluded that some watershed areas are contributing negligible masses of nitrate-N. The following list identifies these areas as well as the reasons behind staff's decision:

- Castro Canyon: no observable flow for the year (small watershed area).
- Froom Creek: no observable flow, in addition, flow is discharged to land, not the main stem of the Creek; there is no confluence of Froom and San Luis Obispo Creeks.
- Johnson Creek: flow observed for one month only, relatively little flow with average nitrate-N concentrations at background levels.

- Harford Canyon: discharges almost directly to the ocean, only impact to San Luis Obispo Creek would be with incoming tide, in addition, nitrate-N levels are non-detectable.

4.2.2 Water Reclamation Facility Discharge

The City's wastewater treatment plant, referred to as the Water Reclamation Facility (WRF) discharges to San Luis Obispo Creek. The City collects both discharge and receiving water monitoring data.

The discharge data is used to determine the total nitrate-N load from the WRF from 3/21/2001 to 3/20/2002 using the same method described above, i.e., utilizing concentration and flow data to determine daily loading.

See the accompanying spreadsheet: SLOnutTMDL, "MeasuredWLoad" worksheet, cell B27 for calculations.

4.3 Annual Nitrate-N Loading by Watershed

Tables 4.1 and 4.2 below identify the results of the calculations described above. Table 4.1 tabulates loading by source for each subwatershed, as well as the relative contribution of each source by subwatershed. Table 4.2 summarizes Table 4.1 by aggregating the sources for all subwatersheds in order to show loading by source, as well as its relative contribution, for the entire watershed. The accompanying spreadsheet "SLOnutTMDL" contains the individual calculations; please see the worksheet titled "MeasuredLoad."

Table 4.1 Annual Nitrate-N loading by subwatershed and source category.

Subwatershed name	NO_3-N (lb/yr)	Relative Contribution (%)
Mainstem		
Background	798	2.0
Cropland	38,779	97.9
Residential	33	0.1
Sub-total	39,610	100.0
Stenner		
Background	348	2.46
Cropland	13,767	97.25
Residential	42	0.29
Sub-total	14,157	100.0
Prefumo		
Background	to lake	0.0
Cropland	59,102	99.7
Reservoirs (lake)	203	0.3
Residential		0.0
Sub-total	59,305	100.0
East Fork		
Background	259	4.1
Confined animal	14	0.2
Cropland	5,950	95.2

Table 4.1 Con't. East Fork		
Residential	30	0.5
Sub-total	6,253	100.0
Davenport		
Background	45	78.2
Cropland	12	21.8
Residential	neg.	0.0
Sub-total	57	100.0
San Miguelito		
Background	335	9.6
Cropland	3,163	90.4
Residential	2	0.0
Sub-total	3,500	100.0
Castro Canyon	0	
Froom Creek	0	
Harford Creek	0	
Johnson Creek	0	
Total Non-Point Source	122,882	28.8
Total Point Source	310,083	71.62
Total Load	432,964	100.0

Table 4.2 Summary of annual nitrate-N contributions by source category throughout the watershed.

Source	**NO_3-N load (lb/yr)**	**Relative NO_3 Contribution (%)**
Background	1,785	0.42
Confined Animal	14	0.00
Croplands	120,773	28.26
Reservoir	203	0.05
Residential	107	0.02
Point-Source Load	310,083	71.62
Total	432,964	100.0

See worksheet titled "TotLoad" in accompanying spreadsheet file (SLOnutTMDL) for calculations.

5 Critical Flow Period

The nitrate-N concentration in the Creek is at a maximum during the low flow season downstream of the WRF discharge and confluence with Prefumo Creek. This fact plays a key role in determining the allocations necessary to achieve the TMDL.

Figure 5.1 illustrates nitrate-N concentrations from all monitoring sites along the main stem. The horizontal lines on the bars of the graph in Figure 5.1 denote concentration values observed for all sites monitored along the main stem for the period April 2000 to April 2002. Therefore, the horizontal line at the top of each bar represents the highest concentration observed during a month for all sites monitored. Figure 5.1 helps depict *when* the highest nitrate-N concentrations occur.

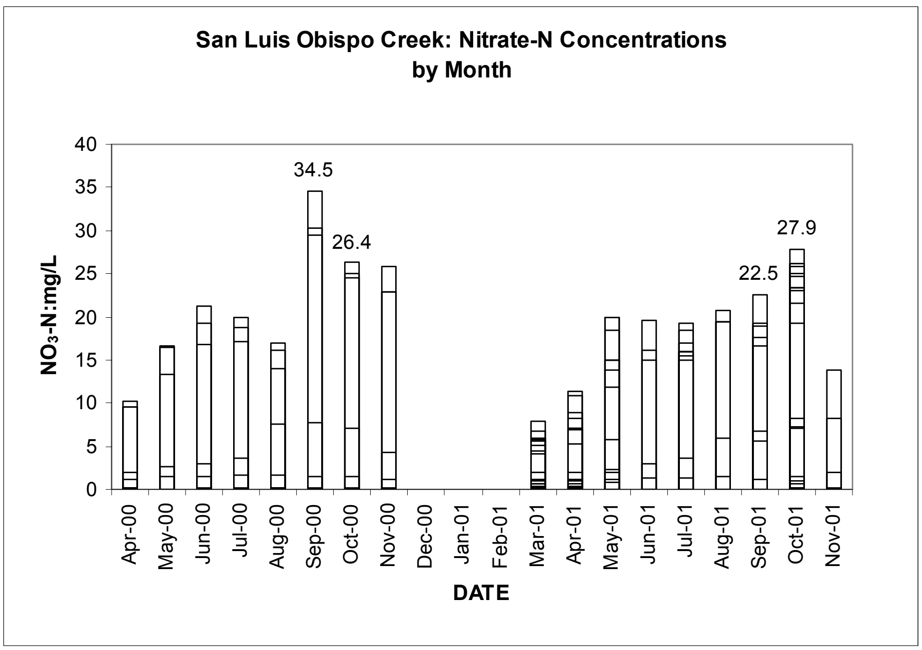

Figure 5.1 Nitrate-N levels as function of month and year.

*Absence of columns indicate no data available for those months.

Note from the Figure 5.1 that peak concentrations occur during the early fall months of September and October. It is clear that during this period of time, stream flow volume is at a minimum, and dilution of nitrate-N is at a minimum.

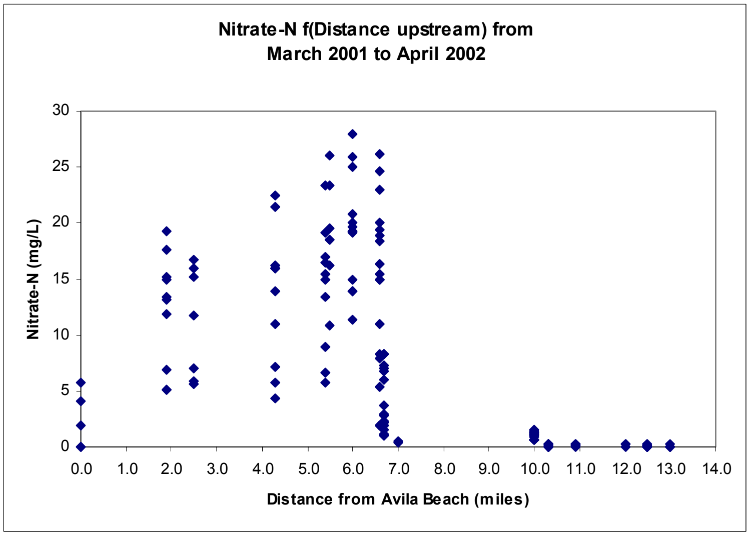

Figure 5.2 Nitrate-N concentrations along main stem

Figure 5.2 illustrates *where* the highest nitrate-N levels occur. The graph was first presented in the source analysis section above, and is presented here for ease of reading this section.

It is clear from Figure 5.2 that maximum levels of nitrate-N occur at site 6.0. Recall that site 6.0 is immediately downstream of the WRF discharge and confluence with Prefumo Creek.

The graphs above indicate that the timing of loading and flow volume create a condition where maximum nitrate-N concentration occurs during late summer, i.e., when flow is at a minimum. The flow during this period, or *critical flow period*, can be used to calculate the TMDL. As nitrate-N concentration is inversely proportional to flow, and flow decreases during summer months, implementing the TMDL based on the critical flow period will effect protection throughout the year.

The graphs above also indicate that nitrate-N levels are highest at site 6.0. This site is immediately downstream of both the WRF point source discharge and the confluence with Prefumo Creek. Together, the City's point source and the cropland source in Prefumo make up 85% total nitrate-N loading (on an annual basis from March 2001 to March 2002). It is reasonable that nitrate-N levels are at a maximum downstream of these sources.

Attention now turns towards a loading analysis at site 6.0 during the critical flow period.

5.1 Load Analysis During Critical Flow Period

Staff determined total nitrate-N loading and relative contribution by source during the critical flow period at site 6.0 (also referred to as SLOCK6.0, see map Figure 3.2). The following discussion explains the method for determining the nitrate-N loading during the critical flow period at site 6.0.

The nitrate-N load at site 6.0 is calculated by summing the loading from site 10.0, the WRF point source, and Prefumo Creek. Figure 5.3 below illustrates the location of these sites are in relation to each other. Flow and water quality data from staff monitoring, as well as the City's monitoring effort, are used. Note that this approach does not use flux rates to determine total loading (as is used for the annual load calculation), but rather uses concentration data and flow volume to calculate the total load. Total nitrate-N mass loading from each site is calculated for the months of September and October of 2001. An average of the two months loading is then determined. Therefore, the loading is determined as follows:

Mass load @ Site 6.0 = Σ [avg. Sept/Oct loads from (10.0, point source, Prefumo Cr.)]

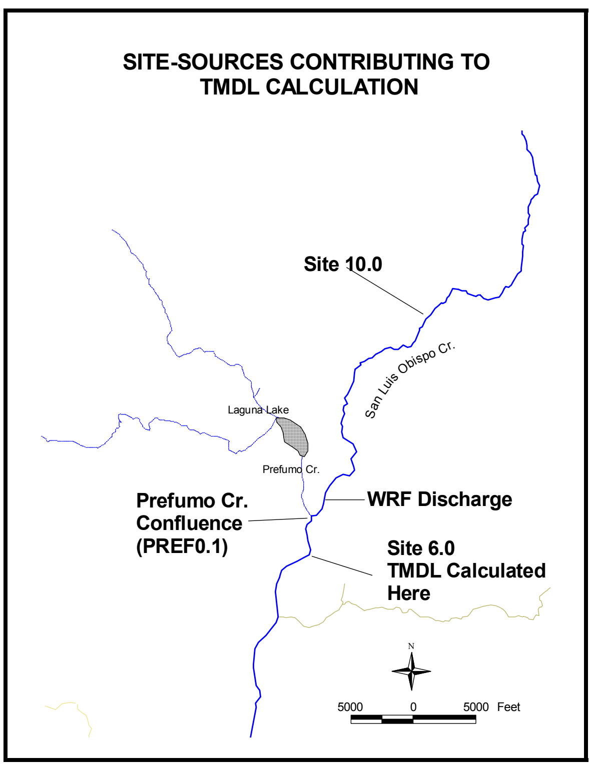

Figure 5.3 Monitoring sites used to calculate loading at site 6.0 during critical flow

Once the total load at site 6.0 during the critical flow period is calculated, the relative contribution of each source to the total load can be determined. Staff utilized the percent contribution rates determined in the Source Analysis of Prefumo Creek subwatershed to determine contributions of various sources during the critical flow period in this subwatershed. To determine the relative contributions of the site 10.0 source, staff used the percent contribution rates determined in the Source Analysis of Stenner Creek as well as main stem subwatersheds. The percent contributions for each source in these subwatersheds were averaged, and this average used to develop relative contributions during critical flow loading. The confined animal source is considered zero during the critical flow period, as the stream is dry in this area during summer months. Please refer to Table 4.1 in the Source Analysis section for a description of contribution rate by source. Table 5.1 shows mean flow, concentration, and loading from the sources upstream of site 6.0, as well as the resulting loading and flow at site 6.0.

Table 5.1 Mean flow, concentration, and loading at sites contributing to site 6.0 during critical flow period.

Mean Flow (ft^3/sec)			
Site	SEPT'01	OCT'01	MEAN
Site 10.0	No data	2.20	2.20
Point Source	5.72	6.35	6.04
PREF0.1	0.55	0.55	0.55

Mean Nitrate-N (mg/L)			
Site	SEPT'01	OCT'01	MEAN
Site 10.0	1.10	1.03	1.07
Point Source	19.73	16.13	17.93
PREF0.1	33.80	42.43	38.12

Mean Oct/Sept Nitrate-N Loading (lbs/mo)			
Site	SEPT'01	OCT'01	MEAN
Site 10.0		366.96	**367**
Point Source	18,220.44	16,515.37	**17,368**
PREF0.1	2,983.01	3,780.61	**3,382**

Loading and flow at site 6.0 is the sum of these sources		
Flow (ft^3/sec)	NO_3-N (lb/mo)	
8.79	21,117	

The calculated load is predicated on flow volume from the three main sources: site 10.0, the WRF point source, and flow from PREF0.1 (Prefumo Creek). It is important to note that site 10.0 is approximately 3 miles upstream from the WRF point source. Although site 10.0 has measurable flow, there is no flow immediately upstream of the WRF source during the critical flow period. The geology immediately upstream of the WRF source is exposed bedrock. Staff believes that water from site 10.0 flows subterranean downstream to mix with point source flow. However, the volume of water flowing from site 10.0 to the point source cannot be precisely quantified. The inclusion of nitrate-N load from site 10.0 does not significantly affect the load calculation because this flow carries relatively lower nitrate-N levels. However, using flow from site 10.0 does affect the potential dilution in waters downstream of the WRF point source and PREF0.1, which carry relatively higher nitrate-N concentration values. This dilution potential will play a role in the allocations to sources discussed below.

Once the total nitrate-N load is determined for site 6.0, the load is distributed to the various sources using the loading rates developed in the Source Analysis. Table 5.2 identifies loading during the critical flow period at site 6.0 by source.

Table 5.2 Relative and total nitrate-N loading by source at site 6.0 during critical flow

Source	NO_3-N (lb/mo)	NO3 Relative Contribution (%)
Background	8	0.04
Commercial/Urban	< 1.0	0.00
Cropland	3627	17.18
Confined animal	0	0
Reservoirs (lake)	112	0.53
Residential	2	0.00
Point Source	17,368	82.25
Total	21,117	100.00

Note that the nitrate-N loading to site 6.0 is 21,117 lb/mo during the critical flow period of September and October. Of this total nitrate-N load, the WRF point source contributes 82%, and the cropland source (in lower Prefumo Creek watershed) contributes 17%.

The information presented above lead staff to conclude that in order for the numeric target to be achieved in San Luis Obispo Creek during the critical flow period, flow from the WRF point source and croplands in the lower Prefumo Creek watershed will need to carry nitrate-N levels equal to the numeric target. Staff make this conclusion for the following reasons:

- The combined load from the WRF point source and Prefumo Creek tributary is 99% of the total nitrate-N load during the critical flow period.
- Dilution from flows originating upstream (site 10.0) can only be estimated, and is not verifiable.

6 TMDL

The TMDL is a concentration equal to the numeric target, i.e. a stream nitrate-N concentration of 10 mg/L-N. The allocations necessary to achieve the TMDL are outlined in the following subsections.

6.1 Allocations

The allocations required to attain the TMDL are divided into the categories of wasteload allocations (WLA), referring to point sources, and load allocations (LA), referring to non-point sources.

Figure 6.1 illustrates the sites that will be referenced with respect to allocations.

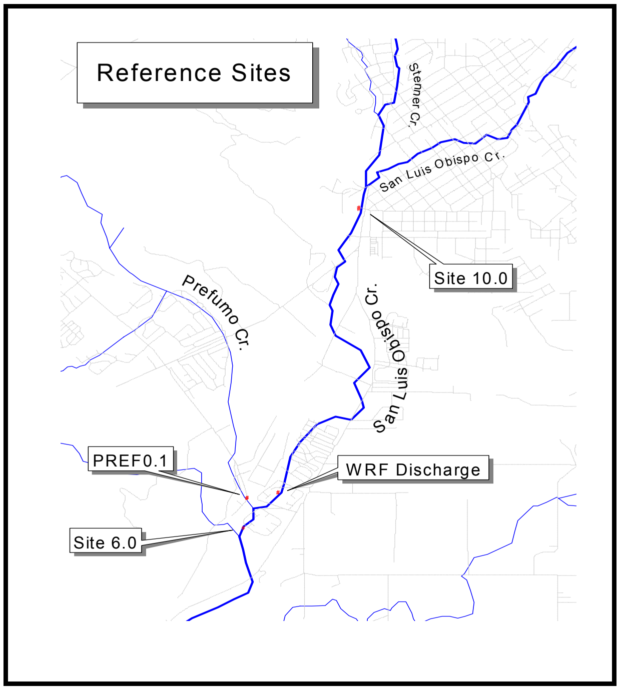

Figure 6.1 Reference Sites

The following are descriptions of the locations illustrated in the map above:

- Site 10.0: in San Luis Obispo Creek at Marsh Street bridge near Highway 101 onramp.
- WRF Discharge: the outlet pipe discharging effluent from the City's Water Reclamation Facility.
- PREF0.1: Prefumo Creek under the bridge crossing at Calle Joaquin Street.
- Site 6.0: San Luis Obispo Creek under the bridge crossing on Los Osos Valley Road.

6.1.1 Wasteload Allocations

Wasteload allocations include allocations to the City of San Luis Obispo for the Water Reclamation Facility (WRF), and for the residential sources, which are conveyed through storm water.

Since the numeric target is based on the Basin Plan objective protecting the MUN beneficial use, the allocation is also expressed in terms of concentration. Expressing the allocation in terms of concentration ensures the TMDL will be achieved, irregardless of flow conditions.

The wasteload allocation for the WRF point source is:

The monthly mean nitrate-N concentration of effluent shall not exceed 10 mg/L-N.

The wasteload allocation to residential sources is essentially an allocation to urban storm water sources since the source is conveyed through stormwater infrastructure. Since this source is not causing exceedence of the numeric target, the allocation is equal to current loading.

The wasteload allocation for stormwater discharge is:

Storm water discharge shall not cause an increase in receiving water nitrate-N concentration greater than the current increase in nitrate-N concentration resulting from the discharge.

6.1.2 Load Allocations

Load allocations refer to sources from background, reservoirs (Laguna Lake), and croplands.

Load allocations are as follows:

Background: **nitrate-N concentration of 0.1 mg/L-N.**

The allocation to background is predicated on average nitrate-N concentrations observed in natural areas (see Section 3.4.2.6.1).

The load allocation for reservoirs is:

Reservoir discharge shall not cause an increase in receiving water nitrate-N concentration greater than the current increase in nitrate-N concentration resulting from the discharge.

The allocation to reservoirs is predicated on average nitrate-N concentration from Laguna Lake (see Section 3.4.2.3).

The load allocation to croplands in Prefumo Creek Watershed is:

Croplands in Prefumo Creek watershed shall not cause nitrate-N concentration in receiving waters to exceed 10 mg/L-N.

The allocation to croplands in Prefumo Creek is predicated on the numeric target.

The allocation to croplands in Prefumo Creek Watershed is the only load allocation less than current loading.

6.1.3 Margin of Safety

Section 303(d)(1)(C) of the Clean Water Act requires a margin of safety to account for uncertainties existing between the pollutant loads and resulting receiving water body water quality. This TMDL utilizes an explicit numeric margin of safety to account for uncertainties. As a concentration of nitrate-N, the margin of safety is 2.2 mg/L-N, which represents 20% of the total nitrate-N mass load converted to a concentration. The margin of safety is calculated based on the difference between the total maximum daily load and the allocated load. The allocations will result in an in-stream nitrate-N concentration of 7.8 mg/L-N.

Uncertainties accounted for in the margin of safety include:

1. Use of two years of data to predict future loading.
2. Use of two years of data to predict stream flow.
3. Limited data during rain-events.

The TMDL is estimated based on a finite amount of data, including flow and water quality data. Since rain, and therefore stream flow, varies from year to year, as does nitrate-N loading from various sources, assumptions must be made regarding the prediction of future conditions based on the limited available data.

7 Linkage Analysis

The objective of the linkage analysis is to demonstrate a cause and effect relationship between mass loading and the water quality indicators, i.e., resulting nitrate-N concentration.

The TMDL demonstrates a linkage between the source loads and the resulting water quality parameter of nitrate-N concentration by setting the TMDL equal to the water quality objective, which is a nitrate-N concentration. Thus, the loading to the creek will be directly indicated and measured by concentrations of nitrate-N in the creek.

8 Implementation and Monitoring

8.1 Implementation to Achieve Waste Load Allocations

8.1.1 WRF Source

The Central Coast Water Board will incorporate an effluent limit for nitrate-N in the City of San Luis Obispo's National Pollutant Discharge Elimination System permit (NPDES permit) for the WRF, consistent with the allocations described in the Wasteload Allocations section above. The effluent limit will be incorporated in the NPDES permit at the first permit renewal following TMDL approval by the Central Coast Water Board (expected in May 2007).

The Central Coast Water Board intends to issue a Cease and Desist Order (CDO) or Time Schedule Order to the WRF concurrently with the NPDES permit, requiring the WRF to reduce nitrate-N concentration in the effluent. The CDO will contain a time schedule establishing the time allowed to comply with the order.

The Central Coast Water Board will consider a revision of the wasteload allocation and corresponding effluent limit for the WRF if an amendment to the Basin Plan removing or revising the MUN beneficial use and corresponding numeric objective for nitrate is approved by USEPA.

Regional Board staff does not intend to pursue a de-designation of the MUN beneficial use of San Luis Obispo Creek.

8.1.2 Residential Sources

The allocation to storm water is equal to current loading. As such, it is only necessary to confirm that loading from this source is not increasing. Nitrate-N from storm water is regulated through the Small MS4 permit regulating stormwater discharge. The Small MS4 permit describes minimum measures that the regulated entity must take in order to protect water quality. Annual reports are required of permit holders. Staff will utilize annual reports associated with the MS4 permit to verify that minimum measures are taken to reduce, or hold at current levels, nitrate-N loading to receiving water bodies. The Executive Officer will ensure that the monitoring and reporting program includes sufficient data to allow staff to verify this. In addition, the permit allows the Executive Officer to require revisions to the storm water management plan as necessary to achieve the wasteload allocation.

Entities that are currently, or are expected to be, regulated through the Small MS4 permit include: the City of San Luis Obispo, the County of San Luis Obispo, and Cal Poly State University.

8.2 Implementation to Achieve Load Allocations

The croplands source is the only nonpoint source that must reduce loading to achieve allocations.

8.2.1 Cropland Sources

Nitrate-N sources from irrigated lands in the Prefumo Creek watershed are required to reduce nitrate-N loading in order to achieve allocations. Regulation and monitoring of nitrate-N sources from croplands will occur through the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (conditional waiver, see RWQCB, Central Coast Region, Resolution R3-2004-0117). No additional regulatory tools will be utilized to regulate this source.

Implementation requirements for irrigated landowners is consistent with, and relies upon, the conditions set forth in the conditional waiver. Implementation requirements are described in the conditional waiver. It is estimated that the allocations will be met on or before 2012. This estimate is based on projected land use conversion in Prefumo Creek watershed and implementation of management practices required under the Conditional Waiver.

8.3 Summary of Implementation Measures

The bulleted items below summarize the implementation measures used to achieve the TMDL.

Regulation of point sources:

- The Regional Board will issue a Cease and Desist Order (CDO) to the WRF requiring the WRF to reduce nitrate-N concentration in the effluent. The CDO will contain a time schedule describing the time allowed to comply with the order. The Regional Board will incorporate an effluent limit for nitrate-N in the City's NPDES permit for the WRF. The effluent limit will be consistent with the WRF wasteload allocation for nitrate-N needed to achieve the TMDL.
- Regional Board staff will utilize annual reports associated with existing and future Small MS4 permits regulating storm water discharge in the watershed. The annual reports will be used to determine whether implementation actions taken are to sufficient to achieve the TMDL. If implementation actions are insufficient to achieve the TMDL, additional implementation actions will be required through approval by the Executive Office (e.g. pursuant to CWC section 13267 or section 13383) or by the Regional Board (e.g. through revisions of existing storm water management plans and/or a Basin Plan Amendment).

Regulation of nonpoint sources

- Implementation actions needed to achieve the allocations to croplands will be required pursuant to the conditional waiver. Implementation and monitoring requirements of this TMDL are consistent with, and rely upon, the conditional waiver.

8.4 Monitoring

Monitoring efforts are designed to gauge the impact of implementation actions on nitrate-N concentration in San Luis Obispo Creek. The results of monitoring will also be used to determine when the TMDL is achieved, or, if it is likely to be achieved in the future. Existing regulatory authority will be used to require monitoring.

8.4.1 Monitoring the WRF Source

The City of San Luis Obispo is required to monitor effluent from the WRF as well as receiving water (San Luis Obispo Creek). Monitoring is required pursuant to the City's NPDES permit for the WRF. The Monitoring and Reporting Plan (M&RP) associated with the City's NPDES permit for the WRF describes the location and frequency of monitoring as well as the reporting requirements.

The City's NPDES permit for the WRF will be amended, upon permit renewal, to include the following:

1. Effluent monitoring: monitor nitrate-N concentration weekly.
2. Receiving water monitoring (San Luis Obispo Creek): monitor nitrate-N concentration monthly at the following locations:
    a. Marsh Street bridge (TMDL site number 10.0, WRF site number RW-3).
    b. Immediately downstream of WRF discharge (TMDL site number 6.6, WRF site number RW-5).
    c. Los Osos Valley Road bridge (TMDL site number 6.0, WRF site number RW-7).

The monitoring requirements stated above are additions to current monitoring requirements outlined in the M&RP and do not replace other requirements.

8.4.2 Monitoring Cropland Sources

Monitoring and reporting requirements for cropland owners is consistent with, and relies upon, the conditions set forth in the conditional waiver.

The Monitoring and Reporting requirements are described in the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (see RWQCB, Central Coast Region, Resolution R3-2004-0117).

8.4.3 Assessment and Review

Regional Board staff will conduct a review every three years beginning three years after TMDL approval by the Office of Administrative Law. Regional Board staff will utilize Annual Reports, as well as other available information, to review water quality data and implementation efforts of responsible parties and progress being made towards achieving the allocations and the numeric target. Regional Board staff may conclude and articulate that ongoing implementation efforts may be insufficient to ultimately achieve the allocations and numeric target. If staff makes this determination, staff will recommend that additional reporting, monitoring, or implementation efforts be required either through approval by the Executive Officer (e.g. pursuant to CWC section 13267 or section 13383) or by the Regional Board (e.g. through revisions of existing permits and/or a Basin Plan Amendment). Regional Board staff may conclude and articulate 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.

Three-year reviews will continue until the TMDL is achieved. The target date to achieve the TMDL is by the end of the NPDES permit life of the WRF following adoption of this TMDL.

9 Timeline and Milestones

Achieving the TMDL is dependent on the WRF and croplands in Prefumo Creek watershed achieving allocations. Since the relative contribution of nitrate-N mass of the WRF exceeds all other sources, milestone reductions will be realized when this allocation is achieved. It is expected that the WRF will meet the allocation on or before the year 2012. It is estimated that allocations to the irrigated agriculture source will be met on or before 2012 as well.

10 Cost Estimate to Achieve TMDL

Achieving the TMDL will largely be accomplished by the reduction of nitrate-N mass loading from the WRF. Although the Central Coast Water Board cannot prescribe the method by which allocations are met, it is expected that a technological upgrade will be necessary for the WRF to achieve the allocation. The technological upgrade is expected to cost from 20-25 million dollars. The cost is based on the City of San Luis Obispo's projected cost to construct a plant upgrade (per personal communication with City staff). The cost of the upgrade will be paid over a period of time through receipt of sewer charges imposed on the residents of the City of San Luis Obispo.

Reduction of nitrate-N loading from cropland sources in Prefumo Creek watershed will occur through mechanisms in place to implement the conditional waiver. The conditional waiver utilizes education, outreach, and monitoring to reduce loading of many constituents into receiving water bodies. The TMDL does not impose additional costs on growers, since these requirements are already part of the conditional waiver. However, an estimated cost to comply with the conditional waiver is approximately three dollars an acre per year. Since there are 1408 acres in Prefumo Creek watershed, the cost will be $4224 per year until the allocation is achieved. Staff anticipate that the allocation will be achieved in five years from the time implementation commences, putting the total cost at $21,120.

11 References

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12 Appendix

Statistical Results: Mann-Whitney Tests

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Mann-Whitney Test and CI: site10.0, site10.3

```
site10.0   N =  16     Median =      0.9500
site10.3   N =  12     Median =      0.0750
Point estimate for ETA1-ETA2 is      0.8000
95.2 Percent CI for ETA1-ETA2 is (0.6500,1.0500)
W = 328.0
Test of ETA1 = ETA2  vs  ETA1 > ETA2 is significant at 0.0000
The test is significant at 0.0000 (adjusted for ties)
```

Mann-Whitney Test and CI: site6.6, site10.0

```
site6.6    N =  18     Median =      15.150
site10.0   N =  16     Median =       0.950
Point estimate for ETA1-ETA2 is      14.200
95.3 Percent CI for ETA1-ETA2 is (7.298,17.999)
W = 459.0
Test of ETA1 = ETA2  vs  ETA1 > ETA2 is significant at 0.0000
The test is significant at 0.0000 (adjusted for ties)
```

Mann-Whitney Test and CI: site6.0, site6.6

```
site6.0    N =  13     Median =      19.300
site6.6    N =  18     Median =      15.150
Point estimate for ETA1-ETA2 is       4.650
95.2 Percent CI for ETA1-ETA2 is (-0.103,11.000)
W = 254.5
Test of ETA1 = ETA2  vs  ETA1 > ETA2 is significant at 0.0328
The test is significant at 0.0326 (adjusted for ties)
```

Mann-Whitney Test and CI: site1.9, site2.5

```
site1.9    N =  10     Median =      13.300
site2.5    N =   7     Median =      11.800
Point estimate for ETA1-ETA2 is       0.500
95.5 Percent CI for ETA1-ETA2 is (-3.500,7.496)
W = 91.5
Test of ETA1 = ETA2  vs  ETA1 > ETA2 is significant at 0.4611
The test is significant at 0.4611 (adjusted for ties)

Cannot reject at alpha = 0.05
```