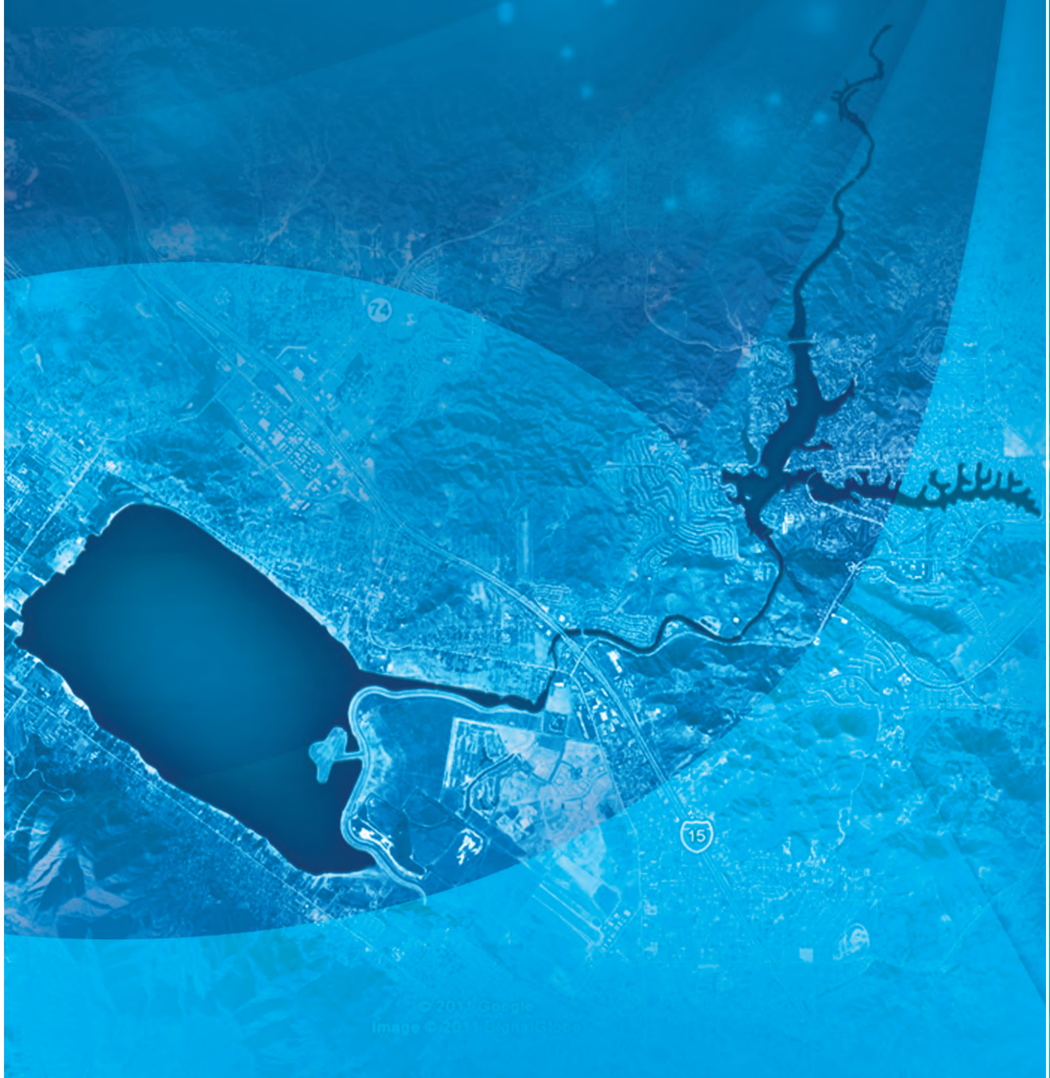
Comprehensive Nutrient Reduction Plan for Lake Elsinore and Canyon Lake

July 2, 2012



Riverside County Flood Control & Water Conservation District on behalf of:

County of Riverside and the Cities of Beaumont, Canyon Lake, Hemet, Lake Elsinore, Menifee, Moreno Valley, Murrieta, Perris, Riverside, San Jacinto, and Wildomar

CDM Smith

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List of Acronyms

Al	Aluminum
BMPs	Best Management Practices
CAFO	Concentrated Animal Feeding Operations
CAP	Compliance Assistance Program
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CL	Canyon Lake
CNRP	Comprehensive Nutrient Reduction Plan
CWA	Clean Water Act
CWP	Center for Watershed Protection
DAMP	Drainage Area Management Plan
EPA	Environmental Protection Agency
LE	Lake Elsinore
LID	Low Impact Development
mL	Milliliters
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
PTP	Pollutant Trading Plan
RCFC&WCD	Riverside County Flood Control and Water Conservation District
ROWD	Report of Waste Discharge
RWQCB	Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Protection Authority
SCAG	Southern California Association of Governments
SJR	San Jacinto River
TMDL	Total Maximum Daily Load
USGS	United States Geological Study
WQMP	Water Quality Management Plan
WQO	Water Quality Objective

Section 1
Background and Purpose

The Santa Ana Regional Water Quality Control Board ("Regional Board") adopted a Municipal Separate Storm Sewer System (MS4) permit for Riverside County on January 29, 2010 that requires the development of a Comprehensive Nutrient Reduction Plan (CNRP). The CNRP is a long term plan designed to achieve compliance with wasteload allocations (WLAs)[1]established in the Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Loads ("Nutrient TMDLs"). This document fulfills this MS4 permit requirement. The following sections provide the regulatory background, purpose, and framework of the CNRP.

1.1 Regulatory Background

The 1972 Federal Water Pollution Control Act and its amendments comprise what is commonly known as the Clean Water Act (CWA). The CWA provides the basis for the protection of all inland surface waters, estuaries, and coastal waters. The federal Environmental Protection Agency (EPA) is responsible for ensuring the implementation of the CWA and its governing regulations (primarily Title 40 of the Code of Federal Regulations) at the state level.

California's Porter-Cologne Water Quality Control Act of 1970 and its implementing regulations establish the Santa Ana Regional Board as the agency responsible for implementing CWA requirements in the Santa Ana River Watershed. These requirements include adoption of a Water Quality Control Plan ("Basin Plan") to protect inland freshwaters and estuaries. The Basin Plan identifies the beneficial uses for waterbodies in the Santa Ana River watershed, establishes the water quality objectives required to protect those uses, and provides an implementation plan to protect water quality in the region (RWQCB 1995, as amended).

The CWA requires the Regional Board to routinely monitor and assess water quality in the Santa Ana River watershed. If this assessment indicates that beneficial uses are not met in a particular waterbody, then the waterbody is found to be impaired and placed on the state's impaired waters list (or 303(d) list[2]). This list is subject to EPA approval; the most recent EPA-approved 303(d) list for California is the 2010 list[3].

Waterbodies on the 303(d) list require development of a Total Maximum Daily Load (TMDL). A TMDL establishes the maximum amount of a pollutant that a waterbody can receive (from both point and nonpoint sources) and still meet water quality objectives.

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[1] As set forth in Tables 9 and 10 in the MS4 permit (Order No. R8-2010-0033), the CNRP is addressing both urban WLAs and loads from septic systems.

[2] 303(d) is a reference to the CWA section that requires the development of an impaired waters list.

[3] On November 12, 2010, EPA approved California's 2008-2010 Section 303(d) list of impaired waters and disapproved the omission of several water bodies and associated pollutants that meet federal listing requirements. EPA identified additional water bodies and pollutants for inclusion on the State's 303(d) list. On October 11, 2011, EPA issued its final decision regarding the waters EPA added to the State's 303(d) list.

1.2 Lake Elsinore and Canyon Lake Nutrient TMDLs

Through its bi-annual water quality assessment process, the Regional Board determined that Lake Elsinore was not attaining its water quality standards due to excessive nitrogen and phosphorus. This finding led to the Regional Board placing Lake Elsinore on the 303(d) list in 1994 as a result of the impairment of the following uses: warm water aquatic habitat (WARM), and water contact and non-water contact recreation (REC1 and REC2).

Similarly, a Regional Board water quality assessment of Canyon Lake identified excessive nutrients causing impairment of the lake. Accordingly, Canyon Lake was listed on the 303(d) list in 1998. The following uses were identified as impaired by nutrients: municipal water supply (MUN), warm water aquatic habitat (WARM), and water contact and non-water contact recreation (REC1 and REC2).

Regional Board staff prepared the Lake Elsinore Nutrient TMDL Problem Statement and the Canyon Lake Nutrient TMDL Problem Statement in October 2000 and October 2001, respectively. These reports documented the impairment caused by excessive nutrients and provided preliminary recommendations for numeric targets to ensure beneficial uses of both lakes would be protected.

Following completion of the Lake Elsinore and Canyon Lake Problem Statements, a number of studies were conducted:

- UC Riverside conducted studies to quantify the internal nutrient loading from Lake Elsinore and Canyon Lake sediments, as well as the response of the lakes to these internal nutrient loadings.
- Regional Board staff and watershed stakeholders conducted in-lake monitoring to evaluate the current nutrient cycling processes and to determine the in-lake response to nutrient loads from the watershed and characterize spatial and temporal trends of nutrients, algal biomass, dissolved oxygen, and other water quality parameters.
- Regional Board staff and watershed stakeholders implemented a watershed-wide monitoring program that assessed nutrient loadings from various land uses in the watershed.
- Lake Elsinore San Jacinto Watershed Authority (LESJWA), a joint powers authority, implemented watershed modeling to simulate nutrient loads under different hydrologic conditions and assess the impact of various implementation plans on the water quality of each lake.
- LESJWA conducted a survey of lake users from April through September 2002 to link lake users' opinions of Lake Elsinore to water quality parameters monitored on the same day as surveys were conducted.

The Regional Board used the data developed from the above studies to develop the Nutrient TMDLs. This information was reported in the Regional Board's Staff Report, released for public review May 21, 2004. The purpose of the Staff Report was to provide the technical basis for the proposed TMDLs. Table 1-1 summarizes the nutrient numeric targets applicable to Lake Elsinore and Canyon Lake.

Public workshops were held on June 4 and September 17, 2004 to gather public comment on the proposed Nutrient TMDLs. Based on the comments received, the Regional Board prepared final Nutrient TMDLs that were adopted on December 20, 2004 (Order No. R8-2005-0037). The subsequent TMDL approval process included: State Water Resources Control Board (State Board) approval on May 19, 2005, Office of Administrative Law approval on July 26, 2005, and EPA approval on September 30, 2005.

Table 1-1. TMDL Compliance Requirements

Indicator	Lake Elsinore	Canyon Lake
Total Phosphorus Concentration (Final)	Annual average no greater than 0.1 mg/L to be attained no later than 2020	Annual average no greater than 0.1 mg/L to be attained no later than 2020
Total Nitrogen Concentration (Final)	Annual average no greater than 0.75 mg/L to be attained no later than 2020	Annual average no greater than 0.75 mg/L to be attained no later than 2020
Ammonia Nitrogen Concentration (Final)	Calculated concentrations to be attained no later than 2020 Acute: 1 hour average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Maximum Concentration (CMC) (acute criteria), where $CMC = 0.411/(1+10^{7.204-pH}) + 58.4/(1+10^{pH-7.204})$ Chronic: 30-day average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Continuous Concentration (CCC) (chronic criteria), where $CCC = (0.0577/(1+10^{7.688-pH}) + 2.487/(1+10^{pH-7.688})) * \min(2.85, 1.45*10^{0.028(25-T)})$	Calculated concentrations to be attained no later than 2020 Acute: 1 hour average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Maximum Concentration (CMC) (acute criteria), where $CMC = 0.411/(1+10^{7.204-pH}) + 58.4/(1+10^{pH-7.204})$ Chronic: 30-day average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Continuous Concentration (CCC) (chronic criteria), where $CCC = (0.0577/(1+10^{7.688-pH}) + 2.487/(1+10^{pH-7.688})) * \min(2.85, 1.45*10^{0.028(25-T)})$
Chlorophyll a concentration (Interim)	Summer average no greater than 40 µg/L; to be attained no later than 2015	Summer average no greater than 40 µg/L; to be attained no later than 2015
Chlorophyll a Concentration (Final)	Summer average no greater than 25 µg/L; to be attained no later than 2020	Summer average no greater than 25 µg/L; to be attained no later than 2020
Dissolved Oxygen Concentration (Interim)	Depth average no less than 5 mg/L; to be attained no later than 2015	Minimum of 5 mg/L above thermocline; to be attained no later than 2015
Dissolved Oxygen Concentration (Final)	No less than 5 mg/L 1 meter above lake bottom to be attained no later than 2015	Daily average in hypolimnion no less than 5 mg/L; to be attained no later than 2015

TMDL coordination efforts have been underway since August 2000, well before adoption of the Nutrient TMDLs. These activities were coordinated and administered through the LESJWA. Following TMDL adoption, the existing TMDL stakeholders formally organized into a funded TMDL Task Force ("Task Force") in 2006. This Task Force in coordination with LESJWA has been actively involved in the implementation of the TMDL requirements, which include 14 tasks. Attachment A summarizes the status of the implementation of these tasks, in particular those that are relevant to the MS4 Permittees in Riverside County subject to the Nutrient TMDLs.

1.3 Riverside County MS4 Permit

In large metropolitan areas with interconnected MS4s, MS4 permits are often issued to multiple Permittees that work cooperatively to implement the requirements. This is the case for the Riverside County area where the MS4 facilities within the Santa Ana Region of Riverside County are permitted under a single area-wide MS4 permit. The Riverside County Flood Control and Water Conservation District (RCFC&WCD) is the Principal Permittee and the County of Riverside and the Cities of Beaumont, Calimesa, Canyon Lake, Corona, Eastvale, Hemet, Jurupa Valley, Lake Elsinore, Menifee, Moreno Valley, Murrieta, Norco, Perris, Riverside, San Jacinto, and Wildomar are the Co-Permittees.

The first MS4 permit was issued by the Regional Board to the MS4 Permittees in 1990. The 1990 MS4 permit was followed by MS4 permits issued in 1996, 2002 and 2010. The 2002 MS4 permit included a general requirement to update MS4 program documents, as appropriate, to support TMDL implementation requirements. As a result, the Permittees amended their Drainage Area Management Plan (DAMP) and Water Quality Management Plan (WQMP) on July 29, 2006 to incorporate Chapter 13 – TMDL Implementation. This Chapter included specific initial actions taken to address the Lake Elsinore/Canyon Lake Nutrient TMDLs (See Sections 13.1 – 13.4)

The Regional Board adopted a new MS4 permit for the Santa Ana Region of Riverside County on January 29, 2010 (Order No. 2010-0033, NPDES No. CAS618033). This permit is the first to incorporate requirements directly addressing the WLAs for Lake Elsinore and Canyon Lake. Specifically, this permit explicitly requires implementation of tasks contained within the TMDLs and compliance with the WLAs. The permit also requires preparation of a CNRP; which describes the specific actions that have been taken or will be taken to achieve compliance with the TMDL's WLA by December 31, 2020.

1.4 Comprehensive Nutrient Reduction Plan

This section provides information on the requirements for CNRP development and the applicability of the plan to urban discharges in the watershed that drains to Canyon Lake and Lake Elsinore. In addition, information is provided on the general framework of this plan and the process associated with its development.

1.4.1 Purpose and Requirements

The need for the development of the CNRP is described in the findings section of the MS4 permit, e.g.:

- *Section II.F.23* – Interim compliance (compliance determination prior to the final WLA compliance dates) determination with the WLAs in the TMDLs will be based on the Lake Elsinore and Canyon Lake (LE/CL) Permittees progress towards implementing the various TMDL Implementation Plan tasks as per the resultant studies and plans approved by the Regional Board. The LE/CL Permittees [MS4 Permittees] are required to develop a CNRP designed to achieve compliance with the WLAs by the final compliance date for approval of the Regional Board. In the absence of an approved CNRP, the WLAs specified in the approved Canyon Lake/Lake Elsinore Nutrient TMDL will constitute the final numeric WQBELs [Water Quality Based Effluent Limits].

- ***Section II.K.4.b.v*** – The Regional Board recognizes that additional research is needed to determine the most appropriate control mechanism to attain water quality standards for nutrients in these two lakes. This Order provides the LE/CL Permittees the flexibility to meet the WLAs through a variety of techniques. Even though the WLAs for the Canyon Lake and Lake Elsinore Nutrient TMDLs are expressed as WQBELs, if water quality standards in the Lakes are met through biological or other in-Lake control mechanisms, the LE/CL Permittees' obligation to meet the WLAs is satisfied as the impairment for which the TMDLs were developed would not exist anymore. The Permittees in the affected watersheds are required to develop a CNRP designed to achieve the WLAs by the compliance dates specified in the TMDL. In the absence of an approved CNRP, the WLAs become the final numeric WQBELs for nutrients.

Based on these findings, the Regional Board established specific requirements for the CNRP's content. These requirements, found in Section VI.D.2.d in the MS4 permit, need to achieve compliance with TMDL WLAs as per the TMDL Implementation Plans, the LE/CL Permittees shall submit a CNRP by December 31, 2011, describing, in detail, the specific actions that have been taken or will be taken to achieve compliance with the urban WLA by December 31, 2020. The CNRP must include the following:

- Evaluation of the effectiveness of BMPs [Best Management Practices] and other control actions implemented. This evaluation shall include the following:
  - The specific ordinance(s) adopted or proposed for adoption to reduce the concentration of nutrients in urban sources.
  - The specific BMPs implemented to reduce the concentration of urban nutrient sources and the water quality improvements expected to result from these BMPs.
  - The specific inspection criteria used to identify and manage the urban sources most likely causing exceedances of water quality objectives for nutrients.
  - The specific regional treatment facilities and the locations where such facilities will be built to reduce the concentration of nutrient discharged from urban sources and the expected water quality improvements to result when the facilities are complete.
- Proposed method for evaluating progress towards compliance with the nutrient WLA for Urban Runoff. The progress evaluation shall include:
  - The scientific and technical documentation used to conclude that the CNRP, once fully implemented, is expected to achieve compliance with the urban waste load allocation for nutrient by December 31, 2020.
  - A detailed schedule for implementing the CNRP. The schedule must identify discrete milestones decision points and alternative analyses necessary to assess satisfactory progress toward meeting the urban waste load allocations for nutrient by December 31, 2020. The schedule must also indicate which agency or agencies are responsible for meeting each milestone.
  - The specific metric(s) that will be established to demonstrate the effectiveness of the CNRP and acceptable progress toward meeting the urban waste load allocations for nutrient by December 31, 2020.
  - The DAMP, WQMP and LIPs [Local Implementation Plans] shall be revised consistent with the CNRP no more than 180 days after the CNRP is approved by the Regional Board.
  - Detailed descriptions of any additional BMPs planned, and the time required to implement those BMPs, in the event that data from the watershed-wide water quality monitoring program indicate that water quality objectives for nutrients are still being exceeded after the CNRP is fully implemented.

1.4.2 Applicability

The applicability of this CNRP is limited to the MS4 Permittees in the following jurisdictions: County of Riverside and the Cities of Beaumont, Canyon Lake, Hemet, Menifee, Moreno Valley, Murrieta, Perris, Riverside, San Jacinto, and Wildomar[4].

[4] An agreement with the San Diego Regional Water Quality Control Board ("San Diego Regional Board") allows the cities of Wildomar and Murrieta to be wholly regulated by the Santa Margarita Region MS4 permit issued by the San Diego Regional Board; however, these cities continue to be subject to the TMDL requirements of the Santa Ana Region MS4 permit (RWQCB, San Diego Region, 2010).

1.4.3 Compliance with Urban Wasteload Allocation

The Riverside County MS4 Permittees have developed a CNRP that is designed to achieve compliance with the urban WLAs by the compliance date of December 31, 2020. Per MS4 permit Section VI.D.2.k, compliance with the urban WLAs can be measured using one of the two following methods:

- Directly, using relevant monitoring data and/or approved modeling procedures to estimate actual nitrogen and phosphorus loads being discharged to the lakes, or,
- Indirectly, using water quality monitoring data and other biological metrics approved by the Regional Board, to show water quality standards are being consistently attained (as measured by the response targets identified in the Nutrient TMDLs).

Compliance with the urban WLAs may also be accomplished through the trading of pollutant allocations among sources to the extent that such allocation tradeoffs optimize point and non-point source control strategies to achieve the compliance in an efficient manner. The Task Force is developing a Pollutant Trading Plan (PTP) separately from this CNRP to provide a basis for pollutant trading.

1.4.4 CNRP Conceptual Framework

Based on the analysis contained herein, compliance with the urban WLAs will require implementation of nutrient mitigation activities in both the watershed and the lakes. Accordingly, the CNRP is built around a framework that includes both watershed-based BMPs and in-lake remediation activities. Coupled with this framework is a monitoring program to evaluate progress towards compliance with urban WLAs and an adaptive implementation program to provide opportunity to make adjustments to the CNRP, where deemed necessary to achieve the urban WLAs.

- *Watershed-based BMPs* – The CNRP identifies the specific ordinance and BMPs that will be implemented by the MS4 Permittees in the watersheds that drain to Lake Elsinore or Canyon Lake. These activities focus on targeting and mitigating nutrients at their source, prior to discharge during wet weather events.
- *In-lake Remediation Projects* – A significant source of nutrients to Lake Elsinore and Canyon Lake are nutrient releases from in-lake sediments. Practical remediation projects for reducing or managing sediment releases of nutrients have been identified and incorporated into the CNRP. In some cases these projects are already ongoing; in others, new project activities will be initiated. The CNRP identifies the MS4 Permittee commitments to the implementation of these projects – in terms of the commitment to initiate the project through capital expenditures and the long-term commitment to the operation and maintenance of the project.
- *Monitoring Program* – The original monitoring program (Lake Elsinore, Canyon Lake and San Jacinto watershed) established in 2006 was modified in 2010 to allow resources dedicated to monitoring activities to be used to support implementation of in-lake remediation projects. Further reductions in monitoring were discussed with Regional Board staff and documented in correspondence from Regional Board staff to the TMDL Task Force dated September 2, 2011. Under the CNRP, monitoring will continue to be implemented at a reduced level through 2014 (anticipated date for completion of in-lake remediation project for Canyon Lake) to facilitate dedicating resources to necessary in-lake projects. Following 2014, monitoring will be increased to provide sufficient data to evaluate progress towards achieving the urban WLAs. Section 2.2.3 describes the monitoring program that will be implemented as part of the CNRP.

- *Special Studies* – The CNRP describes several special studies that may be undertaken by the MS4 Permittees to support changes to the CNRP and/or the TMDL. Execution of these studies is optional and at the discretion of the MS4 Permittees. If the Permittees decide to implement any of these studies, efforts will be coordinated with the Regional Board and Task Force.

- *Adaptive Implementation* – Implementation of the CNRP will be an iterative process that involves implementation of watershed BMPs and in-lake remediation projects followed by monitoring to assess compliance with urban WLAs. As additional data become available, the CNRP may need to be revised as part of an adaptive implementation process.

1.4.5 CNRP Development Process

The CNRP was developed by the MS4 Permittees subject to the TMDL requirements. In parallel with and prior to CNRP development, the Permittees have actively participated in TMDL related implementation activities (e.g., see Attachment A). Coordination activities since January 2010 have included:

Management Steering Committee Meetings

- May 20, 2010
- August 19, 2010
- October 21, 2010
- May 19, 2011

LE/CL TMDL Task Force Meetings

- January 25, 2010
- February 22, 2010
- April 12, 2010
- June 28, 2010
- August 23, 2010
- February 22, 2011
- April 19, 2011
- May 31, 2011
- July 12, 2011
- January 23, 2012
- February 14, 2012
- March 27, 2012
- April 23, 2012
- May 21, 2012
- June 18, 2012

LE/CL TMDL Task Force Technical Advisory Committee Meetings

- August 4, 2010
- September 27, 2010
- October 25, 2010
- November 18,2010
- December 15, 2010
- March 22, 2011
- November 15, 2011
- April 6, 2011
- May 18, 2011
- June 14, 2011
- August 15, 2011
- September 13, 2011
- October 19, 2011

Other TMDL-related Meetings

- October 5, 2011 – LESJWA TMDL Workshop
- November 17, 2011 – Western Riverside Council of Governments Technical Advisory Committee Meeting - Presentation to Riverside County City Managers
- December 7, 2011 – Presentation to Canyon Lake City Council

1.4.6 CNRP Roadmap

The CNRP is presented in two parts: (1) primary sections that provide an executive level summary of the components, schedule, strategy, and technical basis for the CNRP; and (2) supporting attachments that provide additional information to support the primary sections. Following is a summary of the purpose and content of each part of the CNRP:

- ***Section 2*** – Describes the CNRP program elements, the CNRP implementation schedule and the incorporation of an adaptive implementation strategy into the plan.
- ***Section 3*** – Provides the technical basis for the conclusion that full implementation of the CNRP will achieve compliance with the urban WLAs applicable to each lake.

The above sections are supported by the following attachments:

- ***Attachment A, TMDL Implementation*** – Documents TMDL implementation activities completed to date by the Task Force and MS4 Permittees.
- ***Attachment B, Watershed Characterization*** – Provides background information regarding the general characteristics of the watersheds draining to Canyon Lake and Lake Elsinore and existing water quality in each lake.
- ***Attachment C, Canyon Lake Nutrient TMDL In-Lake Strategies Evaluation*** – Provides additional information to support the selection of in-lake remediation projects for Canyon Lake.
- ***Attachment D, Existing Nutrient Source Control Programs*** - Documents existing MS4 permit activities that have been implemented by the MS4 permit program that reduce the runoff of nutrients to Canyon Lake and Lake Elsinore.
- ***Attachment E, Implementation Schedule*** – Provides additional information regarding the implementation schedule summarized in Section 2.3.
- ***Attachment F, Other Supporting Documents***
- ***Attachment G, References***

Section 2
CNRP Implementation Program

2.1 Introduction

The MS4 Permittees have been actively participating in the implementation of the Nutrient TMDLs through the activities of the Task Force since 2006. Substantial effort, e.g., data collection, in-lake and watershed modeling, program development and BMP implementation, have been completed to date. This compilation of work provides the foundation for this CNRP, which establishes the additional actions that will be carried out by MS4 Permittees to achieve compliance with the urban WLAs.

The MS4 Permittees will achieve compliance with the urban WLAs applicable to the Lake Elsinore and Canyon Lake through a combination of watershed-based BMPs and in-lake remediation projects. For the most part, the watershed-based BMPs implemented under the CNRP will be an extension or continuation of ongoing BMP implementation carried out by the MS4 program and individual Permittee jurisdictions. For example, an extension may be the revision of ordinances to provide tighter controls on nutrient sources in the watershed or the implementation of newly required low impact development (LID)-based BMPs in all new development or significant redevelopment projects. A continuation of a BMP would include existing public education and outreach (PEO) activities that already target nutrient sources.

While some watershed-based BMP implementation activities are expected to be generally uniform across the area, e.g., through implementation of area-wide MS4 programs, others may vary by jurisdiction, i.e., implementation is dependent on each Permittee's current local program, available resources and opportunities, and local sub-watershed needs. Each Permittee's LIP will describe in more detail the specific actions that will be taken by the Permittees to address CNRP implementation requirements.

In addition to the watershed-based BMPs implemented through the area-wide MS4 program or by local Permittee jurisdictions, the CNRP identifies specific in-lake remediation projects and monitoring activities planned for implementation under the CNRP. These CNRP elements will be implemented collectively by all MS4 Permittees subject to the requirements of the TMDLs.

The following sections describe the key elements contained in this CNRP and provide an implementation schedule to achieve compliance by December 31, 2020. Where necessary, CNRP attachments provide supplemental information.

2.2 CNRP Program Elements

CNRP implementation consists of the following key implementation activities:

- Watershed-based BMPs to reduce nutrient loading in urban runoff, primarily wet weather flows.
- In-lake remediation projects to mitigate nutrient impacts from in-lake sediments. Separate remediation projects are included for Lake Elsinore and Canyon Lake.
- Monitoring activities to assess compliance with TMDL WLAs.
- Optional special studies to develop data to support BMP implementation or provide the basis for revisions to the TMDL.

Each of these implementation activities is described in more detail below. In addition to these activities, the CNRP program includes an adaptive implementation element to provide opportunity to make changes to the CNRP or TMDL as more information is developed over time.

2.2.1 Watershed-based BMPs

The level of implementation of watershed-based BMPs will vary by MS4 Permittee. As will be discussed in Section 3, the estimated number of acres requiring implementation of watershed-based BMPs varies considerably from one Permittee to another. Given the range of watershed-based BMPs available for implementation and the specific exposure of individual Permittees to the TMDL (due to geographic location, portion of jurisdiction subject to TMDL, etc.), each Permittee will determine the degree to which it will incorporate a particular BMP into its TMDL compliance activities. For example, one Permittee may determine that increased emphasis on street sweeping/debris removal BMPs provides the needed nutrient source reduction that it needs to comply with its WLA. Another Permittee may find that other programs such as pet waste management or better management of fertilizer use provides the necessary load reductions.

Watershed-based BMPs include both non-structural programmatic BMPs and post-construction BMPs associated with the implementation of WQMP requirements for new development and significant redevelopment activities. The CNRP accounts for water quality improvements that have already occurred since TMDL adoption (January 1, 2005, see Attachment D) and anticipated improvements expected from implementation of specific non-structural program elements in the future (see Section 2.2). Watershed-based BMPs include the following activities:

- Ordinance Development
- Street Sweeping/Debris Removal
- Low Impact Development and Land Use Conversion (WQMP Implementation)
- Septic System Management
- Public Education and Outreach
- Inspections and Enforcement

The CNRP quantifies the expected water quality benefits associated with implementation of street sweeping/debris removal, septic system management and WQMP implementation. The remaining BMPs, ordinance development, public education and outreach, and inspections and enforcement, provide water quality benefits, but these benefits were not quantified as part of the compliance analysis. Instead, implementation of these BMPs provides an planned additional margin of safety with regards to the compliance analyses completed as part of this CNRP.

Post-construction LID-based BMPs required for new development and significant re-development projects are the only structural watershed-based BMPs currently included in the CNRP. The newly developed WQMP requirements ensure that a portion of the wet weather runoff will be contained onsite for all future development projects subject to WQMP requirements[5]. Implementation of WQMP requirements over time coupled with the in-lake remediation projects (described below) are expected to provide sufficient mitigation of nutrients. However, if over time it is determined that additional watershed-based structural BMPs are necessary (as would be determined through the adaptive implementation process, as described in Section 2.4), then specific structural BMP projects could be identified. The Permittees are currently conducting retrofit studies of their MS4 systems that will help develop a list of additional structural watershed controls that can be considered in the future if needed.

If additional structural watershed-based BMPs are needed, then the project would be implemented according to the Capital Improvement Project (CIP) Process, as described in Figure 2-1. Because the completion of the CIP process, from project identification through construction, requires adequate funding, completion of the California Environmental Quality Act (CEQA) process, and obtaining all appropriate permits and approvals, the timeline associated with implementation of a watershed-based structural BMP may be lengthy.

The following sections provide additional information regarding each of the watershed-based BMPs incorporated into the CNRP.

2.2.1.1 Ordinances

The CNRP requires the identification of specific ordinances that when implemented will reduce nutrient loads from various urban sources in the watershed (MS4 permit *Section VI.D.2.d.i.(a)*) Implementation of this CNRP element will occur either through the adoption of a new ordinance or modification of an existing ordinance. Decisions regarding the use of ordinances to reduce nutrients will be made at the individual Permittee level. Some MS4 Permittees may choose to make no changes to their ordinances.

Three types of ordinances are included in the CNRP for evaluation by the individual MS4 Permittee jurisdictions: Pet waste, Fertilizer Application Management, and Yard Waste Management (leaf litter). The following sections provide additional information regarding potential use of each ordinance type as a tool to manage nutrients at the local level.

Pet Waste Ordinance

Purpose – Evaluate existing ordinances to determine need to improve management of animal wastes to reduce nutrients in urban runoff from entering MS4 storm drains.

[5] The MS4's revised WQMP guidance and template are currently under review by the Regional Board; however, Regional Board approval and full-scale implementation are expected to coincide with the implementation of this CNRP.

Figure 2-1. Typical MS4 Permittee's Capital Improvement Project (CIP) Process

Project Identification - Identification of a CIP project occurs through one of two mechanisms:

- Public agency assessment of a particular site's current conditions to evaluate the need for structural improvements. These needs may be identified from observations of agency staff, routine maintenance / replacement schedules, or other sources internal to the agency.
- Receipt of public complaints (presented directly to agency staff or a governing body) regarding an infrastructure concern (e.g., potholes, street flooding), which may result in a site investigation. Based on the outcome of the investigation, an agency may decide that a project needs to be constructed.

Budgeting / Planning - After a project need has been established, staff implement a process to have the proposed project included in the CIP. Agency staff begins preliminary planning steps to verify the viability of the project and prepares a cost estimate, which along with other new or ongoing infrastructure needs, is used to prioritize the project based on public need, necessity and available funds. This phase typically involves both project planning and preparation of a preliminary design to support development of the cost estimate. With a project budget prepared, staff seeks approval to incorporate the project in the CIP. In some cases preliminary planning efforts may determine that a proposed project is not viable due to environmental constraints, community opposition, engineering limitations or other factors. In such cases a project is typically abandoned and alternative solutions are considered.

Design - Once a project is in the CIP, design work to prepare construction drawings and project specifications can begin. Based on project complexity, the time required to complete the design varies from less than a year to several years. During the design phase, and sometimes beginning in the budgeting / planning phase, staff initiates the CEQA process. Depending on the nature of the project or the need for special permits, obtaining CEQA approval can significantly affect the timeline to construct a project. Projects may also be abandoned in the design phase as the project is further refined. Factors such as changes to the project's preliminary design parameters, soils, groundwater and utility investigations, and regulatory issues can impact the viability of a project during its refinement in the design stage.

Permitting– During this phase, all required permits and approvals for construction are obtained. The process for obtaining permits and approvals typically begins during the design phase and sometimes begins as early as the budgeting / planning phase. Depending on the nature of the project or the need for special permits, obtaining all required permits and approvals can significantly affect the timeline to construct a project and in some cases result in cancellation of the project. If this occurs, then alternative solutions are considered.

Construction– Construction can begin upon design completion, receipt of all required permits and approvals, completion of all administrative requirements and availability of funds. Depending on the complexity and size of the project, right of way acquisition timelines, CEQA documentation and approvals, and involvement of other agencies, e.g., utilities, the construction phase can take anywhere from a few months to several years.

Implementation Approach - Apart from the City of Canyon Lake's recently adopted pet waste disposal ordinance (Ordinance No. 138U), existing ordinances do not establish specific requirements to properly dispose of pet waste with accompanying penalties for failure to comply. As part of CNRP implementation, the Permittees will evaluate existing ordinances that address any type of animal waste and examine ways to enhance waste management requirements, compliance, and enforcement. For example, a control ordinance could specifically require owners/keepers of pets to properly dispose of pet waste that is deposited on any property, whether public or private. Proper disposal would be defined as placement of pet waste in waste receptacles or containers that are regularly emptied or to a sanitary sewage system for proper treatment. Penalties or fines could be also included.

The evaluation of the need for pet waste ordinance would be coordinated with the Riverside County MS4 permit requirement for MS4 Permittees to evaluate the need for modifications to existing ordinances or establishment of a new ordinance to manage pathogens or bacterial indicators:

- *Riverside County MS4 Permit Section VIII.C* – "Within three (3) years of adoption of this Order, the Co-Permittees shall promulgate and implement ordinances that would control known pathogen or Bacterial Indicator sources such as animal wastes, if necessary."

With a permit adoption date of January 29, 2010, this MS4 permit requirement must be addressed by January 29, 2013. While the emphasis of the permit language is on pathogens or bacterial indicators, adoption of an ordinance to manage animal wastes can also reduce a potentially important source of nutrients in the watershed.

Expected Benefits – Establishing requirements to manage animal wastes in a manner that reduces opportunity for nutrients contained in these wastes to be mobilized in urban runoff reduces nutrients potentially discharged to receiving waters through the MS4. Given variable levels of implementation by jurisdiction, the expected water quality benefits of this BMP have not been quantified; instead the benefits are included in the margin of safety.

Fertilizer Management Ordinance

Purpose – Evaluate existing ordinances regarding the appropriate use and management of fertilizers within the local jurisdiction.

Implementation Approach – Currently, existing ordinances do not regulate the content of manufactured fertilizers as applied within the jurisdictions. Under this element, the MS4 Permittees will evaluate and consider adoption of new ordinances to include lawn application control, specifically, the content of phosphorus in commercial fertilizers[6].

Expected Benefit – Establishment of fertilizer application ordinances reduces the source of phosphorus available to runoff from lawn or turf areas in the watershed. Given variable levels of implementation by

[6] Examples of this type of fertilizer ordinance are codified in the Cities of Ann Arbor, Michigan (Ord. No. 1-06) and Plymouth, Minnesota (City Code 1170.05). In the City of Ann Arbor, the fertilizer ordinance regulates the use and application of manufactured fertilizer containing phosphorus. The ordinance also requires commercial applicators or institutional applicators (e.g., those applying fertilizer to parks, schools, etc.) to sign a sworn statement abiding by the ordinance and to submit fertilizer samples upon request. The ordinance does allow for exemptions in cases where soil testing shows phosphorus levels to be insufficient for turf growth or for applications on newly established or developed turf areas in the first growing season. For a three year period following the implementation of the Ann Arbor ordinance limiting application of lawn fertilizers containing phosphorus, Lehman at al. (2011) reported statistically significant reductions in total phosphorus (TP) to the Huron River. TP showed an average reduction from 11 to 23 percent at monitored study sites.

jurisdiction, the expected water quality benefits of this BMP have not been quantified; instead the benefits are included in the margin of safety.

Yard Waste Management Ordinance

Purpose – Evaluate existing ordinances which regulate the depositing of yard waste debris into the MS4.

Implementation Approach - The Permittees have existing legal authority within each jurisdiction establishing stormwater ordinances to prohibit the depositing of yard waste into the MS4. Permittees will review these existing ordinances to evaluate ways to enhance public education or inspection/enforcement activities to provide additional reductions in nutrients from these sources. For example, approaches to better manage these potential nutrient sources include establishing yard waste/leaf blowing requirements for commercial yard businesses, sweeping and returning yard clippings to lawn areas, collecting and disposing yard wastes for green recycling, or recycling yard waste by composting.

Expected Benefit - Reducing the volume of yard waste blown into or washed into the MS4 decreases the nutrient load to downstream waters. Given variable levels of implementation by jurisdiction, the expected water quality benefits of this BMP have not been quantified; instead the benefits are included in the margin of safety.

2.2.1.2 Specific Watershed-based BMPs

The MS4 permit requires that the CNRP identify the specific BMPs that, when implemented, will reduce the concentration of urban nutrient sources in the watershed (MS4 permit Section VI.D.2.d.i.(b)). The following sections describe each of the specific watershed-based BMPs included in the CNRP. Section 3 describes the expected water quality benefits, where such benefits may be quantified. As noted above, the level of implementation of each of these BMPs will be determined by the local jurisdiction.

Under this BMP, the MS4 Permittees will evaluate existing street sweeping and MS4 facility cleaning programs to determine if ongoing programs can be enhanced to further reduce presence of nutrient sources on street surfaces and MS4 facilities.

Street Sweeping and Debris Removal

Purpose – Street sweeping and MS4 facility debris removal activities reduce a significant source of nutrients in urban environments.

Implementation Approach – The MS4 Permittees will continue to perform street sweeping, MS4 facility inspections and cleaning programs for storm drain pipes, catch basins and storm channels. Under this BMP element, each Permittee will review their existing programs (e.g., methods, frequency of implementation, and equipment use) to evaluate the potential to modify these programs to further reduce nutrient loads from streets and MS4 facilities. Where opportunities exist, changes will be made to the program. If it is determined that a change in equipment may provide water quality benefits, the Permittees will work with their respective governing bodies to obtain funding to upgrade/replace equipment.

Expected Benefits – Existing street sweeping/debris removal practices have already provided important reductions from these nutrient sources in the watershed. Given the important benefits of these types of BMPs, a review of these programs could identify additional opportunities to further reduce nutrients from these sources. Quantification of the water quality benefits is provided in Section 3.

Septic System Management

Purpose – Continue ongoing efforts to reduce nutrients associated with the use of septic systems in the watershed.

Implementation Approach – Task 6 of the TMDL Implementation Plan required the County of Riverside and Cities of Perris, Moreno Valley, and Murrieta to collectively or individually develop and submit to the Regional Board a Septic System Management Plan (SSMP) to identify and address nutrient discharges from septic systems within the San Jacinto watershed. This plan, *San Jacinto Onsite Wastewater Management Program report*, was submitted to the Regional Board on November 17, 2007. The County and Cities are currently implementing the plan in their respective jurisdictions. In addition, the City of Perris is currently implementing a project to convert septic to sewer in the Enchanted Heights area of the City. There are also plans for septic conversions in other areas of the San Jacinto Watershed, including Quail Valley. However, these other plans are not finalized yet and therefore are not credited for load reduction in the CNRP. Should additional septic systems be converted to sewer, these activities would be reported and credited in future annual reports on CNRP implementation.

The SSMP was also intended to incorporate pending regulations from the State Water Resource Control Board (State Board). The State Board is developing a Water Quality Control Policy for Siting, Design, Operation, and Management of Onsite Wastewater Treatment Systems (OWTS or "septic systems") ("OWTS Policy"). The OWTS Policy is being developed pursuant to California Assembly Bill 885 (AB 885). The State Board released a draft OWTS Policy for public comment on September 30, 2011. The draft policy establishes a multi-tiered regulatory system for the management of septic systems. For example, Tier 3 (Impaired Areas) includes specific performance requirements for new or replacement OWTS in areas near waterbodies impaired for pathogens or nitrogen (unless it is determined that the OWTS is not contributing to a local water quality problem). Tier 4 (OWTS Requiring Corrective Action) establishes requirements for septic systems that are failing. When finalized, implementation of the State Board's OWTS Policy will support efforts to reduce impacts from OWTS in the area covered by the CNRP.

Expected Benefits – Implementation of this BMP (as required currently or as will be required following State Board adoption of the OTWS Policy) reduces the potential for leakage from septic systems to contribute nutrients to the MS4 during wet weather conditions. The Section 3 Compliance Analysis quantifies the expected benefits from septic to sewer conversions as well as improved management of septic systems at risk of failure.

Low Impact Development (LID) and Land Use Conversion

Purpose – The MS4 Permit requires the implementation of LID practices to reduce runoff from new development and significant redevelopment activities. Implementation of these practices over time will reduce the nutrient load during wet weather runoff events.

Implementation Approach – Each of the MS4 Permittee jurisdictions include areas of open space , agricultural lands and other non-urban land uses that are expected to be converted to urban land use over the next ten years. This land use conversion can result in significant positive or negative effects to nutrient loading to the lakes. BMPs, including LID BMPs, that are required of new development and significant redevelopment projects (as defined in Board Order R8-2010-0033) help to offset the negative loading impacts of urbanization. The MS4 program recently revised its WQMP to incorporate the new LID requirements for development activities. The WQMP was submitted to the Regional Board July 29, 2011 and approval is expected within the next several months. The LID practices in the revised WQMP are expected to be fully implemented within six months of Regional Board approval.

Expected Benefits – WQMP implementation has already provided water quality benefits throughout the watershed since TMDL adoption in December 2004. The compliance analysis incorporates these benefits by taking into account where BMPs have been implemented for removal of nutrients. As each MS4 Permittee jurisdiction develops, i.e., approves projects that convert non-urban areas to urban land uses or projects that redevelop existing urban areas, implementation of the new LID-based BMP requirements will provide additional water quality benefits. Section 3, Compliance Analysis, describes how these benefits were incorporated into the CNRP.

Public Education and Outreach

Purpose –Continue implementation of PEO activities that target nutrients as a pollutant of concern

Implementation Approach – The MS4 program has developed an extensive PEO program that targets nutrient sources that impact wet weather water quality, specifically – sediment management, fertilizer management and pet waste (see Attachment D). These PEO programs will be regularly evaluated and updated as needed to continue efforts to communicate the need to manage nutrients at the source, especially on commercial and residential properties. This BMP will be coordinated with the ordinance BMP, described above. If cities decide to modify existing or establish new ordinances to improve management of nutrient sources, PEO materials will be updated to communicate the new requirements to city or county residents and businesses.

Expected Benefits – Increased awareness of pollutant sources reduces nutrients at the source, thus minimizing the opportunity for nutrients to be mobilized during wet weather events. Given the difficulty of equating PEO impressions to specific reductions in nutrient loads, the expected water quality benefits of this BMP have not been quantified; instead the benefits are included in the margin of safety.

Inspections and Enforcement

*Purpose –*Continue implementation of inspection and enforcement programs that target activities that can contribute pollutants, in particular nutrients, to storm drains.

Implementation Approach – Each MS4 Permittee has an active inspection and enforcement program to comply with MS4 permit requirements applicable to their jurisdictions. These programs will continue to be implemented (see Attachment D). This BMP will be coordinated with the ordinance BMP, described above. If cities decide to modify existing or establish new ordinances to improve management of nutrient sources, inspection and enforcement programs will be reviewed, and if necessary modified, to implement new ordinance requirements.

Expected Benefits – Inspection and enforcement activities help ensure compliance with local stormwater management requirements, which maximizes the potential benefits of BMP implementation. Given the year-to-year variability in inspection activities and potential follow-up enforcement actions, the expected water quality benefits of this BMP have not been quantified; instead the benefits are included in the margin of safety.

2.2.2 In-Lake Remediation Activities

The MS4 permit requires that the CNRP identify the specific regional treatment facilities and the locations where such facilities will be built to reduce the concentration of nutrient discharged from urban sources and the expected water quality improvements to result when the facilities are complete (MS4 Permit Section VI.D.2.d.i.(d)). The CNRP includes implementation of in-lake remediation activities that serve as regional treatment facilities for Canyon Lake and Lake Elsinore. The following sections describe the remediation activities planned for each lake; information regarding the expected water quality improvements to result from implementation of these activities is provided in Section 3.

Canyon Lake

In its December 31, 2010 letter to the Regional Board, LESJWA stated that stakeholders, including the MS4 Permittees, had narrowed the list of candidate in-lake remediation projects for Canyon Lake to the following:

- *Hypolimnetic Oxygenation System (HOS)* – Implementation of a HOS would directly oxygenate the lower depths of Canyon Lake and prevent the reducing conditions that allow phosphorus to be released from sediments. The benefits of a HOS would benefit both Canyon Lake (directly improve water quality in the lake) and Lake Elsinore, through a reduction in phosphorus loads transferred from Canyon Lake to Lake Elsinore during wet years.

- *Phoslock Application* – Phoslock is a commercially available, modified bentonite clay product containing the naturally occurring element lanthanum that has been shown to be effective in the treatment of excessive internal nutrient loading in lakes and reservoirs. It has been successfully used in a number of waterbodies around the world. Phoslock is applied to the waterbody at the surface in the form of a slurry which may take several days to settle to the bottom. As it settles, the Phoslock interacts with bioavailable phosphorus (phosphate) in the water column, binding the lanthanum and phosphate into the highly stable mineral Rhabdophane. Phoslock is applied in quantities great enough to form a sediment cap of no less than 0.5 mm thickness. This capping effect prevents the bioavailable phosphorus in the sediment from recycling back into the water column. Phoslock, which is effective over a wide range of naturally occurring pH values, has shown to have no toxicity to aquatic organisms at the recommended application rates. However, there has been insufficient testing of the material to show that it is 100 percent-non-toxic. Phoslock has also been shown to be somewhat effective in reducing nitrogen cycling from the sediment, although no quantitative estimates are available or claimed by the manufacturer.

Additional information regarding these two remediation project candidates is provided in Attachment C. Attachment C also provides information regarding two other chemical solutions (alum and zeolite) that were evaluated as alternatives to Phoslock application.

Based on the MS4 Permittee's evaluation of the Canyon Lake candidate strategies, the CNRP includes the following implementation strategy for in-lake remediation of nutrients:

- MS4 Permittees are preliminarily committed to the planning, design, construction and operation of a HOS for Canyon Lake, consistent with Alternative 10b[7]. Implementation of HOS will require additional planning and design as well as extensive coordination with a number of agencies to arrange for ownership and operation agreements, arrange financing, fulfill CEQA and secure necessary permits. Figure 2-1 summarizes the CIP process that the MS4 program will go through to implement HOS. Section 2.3, below, provides the anticipated implementation schedule considering the CIP. This schedule depends on successful navigation of the process summarized in Figure 2-1. As there may be unanticipated roadblocks to the deployment of the HOS, the Permittees are continuing to evaluate alternatives including phoslock and zeolite applications to Canyon Lake. These alternatives may be equally beneficial to Canyon Lake, safe to implement, and more cost effective. However, their viability is dependent on further analysis by Dr. Anderson of

[7] See *Canyon Lake Hypolimnetic Oxygenation System, Preliminary Design Phase 1 Report* prepared for LESJWA by Pace, April 2011

UCR to demonstrate the efficacy of the approach. To ensure that the Permittees can achieve the TMDL WLA, the Permittees are moving forward with planning for the HOS while Dr. Anderson completes his studies. However, the Permittees may recommend switching to an alternative in-lake BMP should roadblocks to the HOS prevent timely deployment, or should one of these alternatives be determined to be a superior solution. A final decision would be made well before the expected start date for HOS construction (July 2014).

- The effectiveness of in-lake remediation using HOS (or alternative in-lake strategies) will be evaluated as part of the adaptive management process incorporated into this CNRP (see Section 2.4). At this time, based on lake-modeling and compliance analyses, the MS4 Permittees believe HOS will provide the necessary nutrient load reductions to offset current and future urban loads as well as achieve in-lake response targets. In the event that HOS does not provide the expected water quality benefits for nutrient offsets, the MS4 Permittees may augment HOS with the addition of either Phoslock or Zeolite (see Attachment C for discussion of pros and cons of each chemical additive).

Lake Elsinore

Work completed through the Task Force identified several recommended Phase 1 in-lake remediation activities, as well as potential supplemental BMPs, for deployment in Lake Elsinore (*In-Lake Sediment Nutrient Reduction Plan for Lake Elsinore*, October 22, 2007). Of these remediation activities, the CNRP includes participation in the operation of the in-lake aeration system. This in-lake aeration/mixing system was installed in Lake Elsinore in two phases. The first phase, implemented by LESJWA in 2005, involved the construction of axial flow water pumps to improve lake circulation. A second phase, implemented in 2007, involved construction of an in-lake aeration project designed to pump air through a system of twelve perforated pipelines submerged along the bottom of lake. The intent of the aeration system is to improve circulation so that oxygen levels are better distributed throughout the water column. The bubble diffuser "lifts" oxygen-deficient bottom waters to the surface where it can be re-saturated through direct contact with the atmosphere.

Through agreements established with other stakeholders and as part of CNRP implementation, the MS4 Permittees will participate in the operation of the in-lake aeration system. At this time, based on lake modeling and compliance analyses, the MS4 Permittees believe the aeration system will provide the necessary nutrient load reductions to comply with urban WLAs. In the event that additional BMPs are necessary, the *In-Lake Sediment Nutrient Reduction Plan for Lake Elsinore* (October 22, 2007) identified a number of other in-lake control strategies. Of these strategies, participation in fishery management activities or the application of metal salts, are the preferred next steps if additional BMPs are necessary.

Similar to Canyon Lake, the Permittees are continuing to evaluate alternative compliance options (such as the application of Zeolite) should the Permittees determine that an alternative compliance approach is needed to achieve in-lake response targets for Lake Elsinore. If the Permittees determine that an alternative compliance approach is necessary, the Permittees may propose revisions to this CNRP to incorporate the alternative compliance approach.

2.2.3 Monitoring Program

The MS4 permit requires that the CNRP include inspection criteria that will be used to identify and manage the urban sources most likely causing exceedances of urban WLAs for nutrients (MS4 permit Section VI.D.2.d.i.(c)). This requirement will be fulfilled through (a) implementation of watershed and in-lake monitoring programs (MS4 permit Section VI.D.2.g); and (b) the requirement to provide a summary in the MS4 program's Annual Report of all relevant data from water quality monitoring programs and an evaluation of compliance with the Nutrient TMDLs by reporting the effectiveness of the BMPs implemented in the watershed to control nutrient inputs into the lake from urban runoff (MS4 Permit Section VI.D.2.h).

Monitoring activities have been implemented in a phased manner since adoption of the TMDL. The following sections provide a brief history of the monitoring program and expectations for continued monitoring under the CNRP.

Phase 1 Monitoring

The MS4 Permittees, as participants in the Task Force, have conducted water quality monitoring on Lake Elsinore and Canyon Lake since 2006. The Task Force prepared the *Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan* ("Monitoring Plan") in February 2006. Monitoring began after the Regional Board approved the Monitoring Plan in March 2006. This plan included three components:

- Lake Elsinore – Provide data to evaluate compliance with interim and final nitrogen, phosphorus, chlorophyll *a*, and dissolved oxygen numeric targets.
- Canyon Lake - Provide data to evaluate compliance with interim and final nitrogen, phosphorus, chlorophyll *a*, and dissolved oxygen numeric targets..
- San Jacinto River watershed – Provide data to evaluate compliance with interim and/or final nitrogen and phosphorus TMDL WLAs and load allocations.

The original monitoring program included a multi-phase approach:

- *Phase 1 (Intensive Lake Elsinore and Canyon Lake Study)* - Phase 1 focused on collecting data to evaluate in-lake processes and develop a linkage analysis to relate external pollutant loading to the in-lake response, e.g., with regards to nutrient concentrations. Phase 1 was scheduled to occur over a two to three-year period.
- *Phase 2 (Intensive Watershed Study)* - Phase 2 is an intensive watershed study that provides data to support compliance analyses and provide data to understand external nutrient source contributions from the watershed.
- *Phase 3 (Compliance Monitoring)* – Upon completion of Phases 1 and 2, a compliance monitoring phase would begin. Phase 3 monitoring would consist of an agreed upon base level of in-lake and watershed compliance monitoring based on the findings from the previous phases.

Revision to Phase 1 Monitoring

In December 2010, the Task Force, in consultation with the Regional Board, revised the Phase 1 monitoring program for Lake Elsinore and Canyon Lake. The revised Phase 1 program decreases the number of sample locations in these waterbodies. The watershed monitoring program was not revised. Table 2-1 summarizes the currently approved Phase 1 monitoring program elements.

Table 2-1. Phase 1 Monitoring Summary

Monitoring Program	Sample Stations	Sampling Frequency	Field Parameters	Laboratory Parameters
Lake Elsinore	Station E2 (lake center)	16 events/year: Monthly (Oct to May); Bi-weekly (June to September)	Temperature, dissolved oxygen, conductivity, pH, turbidity, and redux potential	Chlorophyll *a*, hardness, total phosphorus, soluble reactive phosphorus, total organic phosphorus, nitrogen (total N, nitrite + nitrate, Ammonia N, total inorganic nitrogen, total organic nitrogen, iron, and total dissolved solids
Canyon Lake	Station C7 (deep lake)	16 events/year: Monthly (Oct to May); Bi-weekly (June to September)		
	Station C8 (mid-lake)			
	Station C10 (east bay)			
San Jacinto River Watershed	Site 3 - Salt Creek at Murrieta Rd	Three storm events per wet season	Temperature, turbidity, pH	Total organic nitrogen, nitrite nitrogen, nitrate N, ammonia, total phosphorus, soluble reactive phosphorus, total suspended solids, chemical oxygen demand, biological oxygen demand
	Site 4 –San Jacinto River at Goetz Road			
	Site 6 – San Jacinto River at Ramona Expressway			
	Site 30 – Canyon Lake Spillway			
	Site 1 – San Jacinto River, Cranston Guard Station			

CNRP Monitoring Program

Through fiscal year 2014-2015 the Permittees propose to continue the existing Phase I watershed monitoring program (see Table 2-1). The Permittees also propose to eliminate existing in-lake monitoring programs through the same period to ensure that resources are dedicated to facilitating and constructing in-lake BMPs. The Permittees will propose a revised comprehensive watershed and in-lake monitoring program by December 31, 2014 based on the final configuration of the HOS and Lake Elsinore in-lake BMPs for implementation in fiscal year 2015-2016.

2.2.4 Special Studies

As resources allow, the MS4 Permittees may implement a number of studies during CNRP implementation to provide additional data to support TMDL implementation efforts. These studies are optional; MS4 Permittees implementation of or participation in these studies (if initiated by other TMDL stakeholders) is solely at their discretion. Where implemented, the outcome from various analyses or studies would be used to support the adaptive implementation process (see Section 2.4). The purpose of such studies is to provide data to refine TMDL parameters, e.g., development of more accurate land use data, revisions to the TMDL watershed and lake models based on updated water quality and land use data, and technical data to support use of supplemental BMPs should the effectiveness of planned in-lake remediation strategies be lower than anticipated. The implementation and timing of such studies is solely at the discretion of the MS4 Permittees; however, implementation would consider regular triennial reviews of the TMDL and TMDL compliance milestones.

2.3 Adaptive Implementation

The MS4 permit requires that the CNRP be updated as needed based on BMP effectiveness analyses completed as part of annual reporting activities (MS4 permit Section VI.D.2.f). In addition, the MS4 permit requires that the CNRP provide descriptions of any additional BMPs planned, and the time required to implement those BMPs, in the event that monitoring data indicate that water quality objectives for nutrient are still being exceeded after the CNRP is fully implemented (MS4 permit Section VI.D.2.d.ii.(e)). These requirements will be addressed through the adaptive implementation process that has been incorporated into this CNRP.

This CNRP establishes a program to reduce urban sources of nutrients through the implementation of watershed-based BMPs and to reduce nutrients already entrained in Canyon Lake and Lake Elsinore through the application of in-lake remediation strategies. With regards to the in-lake remediation projects proposed for Lake Elsinore, the following has been stated previously:

> "It is unlikely that the stakeholders will implement the perfect solution on the first try. Rather, success will depend on an iterative process of developing mitigation projects, measuring results, updating the predictive models and refine the follow-on strategy. This process of "adaptive implementation" makes best use of scarce public resources and reduces the risk of unforeseen consequences by emphasizing incremental changes. Using the lake as a laboratory, successful projects can be repeated or expanded. Unsuccessful projects can be terminated and resources shifted to alternative approaches. Moreover, as additional data becomes available, the ability to accurately assess the lake's true potential, and the steps necessary to achieve that potential, will also improve." (*In-Lake Sediment Nutrient Reduction Plan for Lake Elsinore*, October 22, 2007, page 28).

This statement applies to any of the proposed watershed-based BMPs and in-lake remediation projects in either Canyon Lake or Lake Elsinore. For example, the Permittees may determine prior to 2014 that Zeolite or other remediation tool will provide a more cost effective method to address urban nutrient loads and/or attain in-lake response targets. If such a finding is made, the Permittees may propose a revision to the CNRP based on this new information.

The compliance analysis (Section 3) quantifies the expected water quality benefits from implementation of this comprehensive nutrient management program. Based on this analysis, the CNRP, when fully implemented, is expected to result in compliance with the TMDL WLAs applicable to the MS4 Permittees. This finding is based on the quantified compliance analysis results coupled with the margin of safety associated with the implementation of watershed-based BMPs that could not be quantified. All analyses are based on currently available data, including what is known regarding the effectiveness of the various BMPs included in the CNRP.

Over time, through the monitoring program and information collected through the MS4 Permit Annual Report, additional data will be developed to evaluate the effectiveness of various CNRP elements. These data may be supplemented by additional information developed through the optional special studies described above. In total, new data and information will be used to annually report and assess the effectiveness of CNRP implementation. As part of this effort, the Permittees will prepare a trend analysis for the response targets and nutrient levels in Lake Elsinore and Canyon Lake by November 30, 2018. This analysis will be included in the fiscal year 2017-2018 MS4 Annual Report. Based on the outcome of this analysis, the Permittees will make recommendations for additional BMPs and a schedule for deployment of those BMPs for incorporation into a revised CNRP by June 30, 2019. Upon Regional Board approval, the Permittees will implement the revised CNRP.

If it is determined that additional BMP implementation will be necessary to comply with urban WLAs, it is anticipated that the focus will be on additional in-lake remediation strategies, rather than additional watershed-based BMPs. This expectation is based on what is most likely to be most cost effective in terms of implementation. Specifically, other than implementation of large regional structural projects in the watershed, which would be very costly and potentially not practical given the potential size of storm flows, additional watershed-based BMPs are not expected to provide needed water quality benefits in a cost effective manner. As noted earlier in this chapter, there are several additional in-lake options that may be considered for both Lake Elsinore and Canyon Lake.

2.4 Implementation Schedule

The MS4 permit requires that the CNRP include a detailed schedule that provides the following information that includes the following:

- Identifies the discrete milestones, decision points and alternative analyses necessary to assess satisfactory progress toward meeting the urban WLAs for nutrient by December 31, 2020.
- Indicates which agency or agencies are responsible for meeting each milestone.
- Establishes the specific metric(s) that demonstrate the effectiveness of the CNRP and acceptable progress toward meeting the urban WLAs for nutrient by December 31, 2020

Figure 2-2 shows the overall tasks and schedule for CNRP implementation. Presented as a timeline, this figure illustrates the relationship among tasks over the period from 2012 through the December 31, 2020 compliance date. Attachment E provides the detailed information required above for each CNRP task.

The implementation schedule includes tasks associated with each of the following elements:'

- *Watershed-based BMPs* – This element includes six BMPs. Three of these BMPs (ordinance development, street sweeping & debris removal, and inspection & enforcement) include time for the evaluation and, if appropriate, revision to the program element (shown as a "Development Activity"). For example, the Permittees will evaluate the need to revise existing ordinances to provide better tools to target nutrient sources. If needed changes are identified, then the Permittees will need to work through the process to revise the ordinance per local requirements. Once development is complete, then the schedule shows the element as an "implementation activity". Two BMPs (PEO and septic system management) will continue to be implemented as currently prescribed, i.e., the BMP can be implemented now. The final watershed-based BMP (LID-based WQMP implementation) will be implemented within six months of Regional Board approval of the MS4 program's revised WQMP.
- *In-Lake Remediation Activities*
  - *Lake Elsinore* – The in-lake aeration system is already being implemented in Lake Elsinore. As shown in the schedule, the MS4 Permittees propose to support continuation of aeration and mixing activities in the lakes through participation in cost-sharing agreements.
  - *Canyon Lake* – The MS4 Permittees propose to implement a HOS in Canyon Lake. The schedule establishes a development period (design, operation agreements, CEQA, permits and construction) that is expected be completed by the end of 2014. This schedule is dependent on obtaining all required regulatory approvals for construction of HOS in a timely manner.

  As noted in Section 2.2.2, the Permittees will continue to evaluate potential use of an alternative compliance approach, e.g., use of Zeolite or Phoslock, to comply with urban WLAs in either lake. If an alternative approach is determined to be viable to achieve compliance, the Permittees will prepare a proposal to modify the in-lake remediation activities currently proposed under this CNRP.
- *Monitoring Program* – In-lake monitoring activities are expected to occur at a reduced level while the proposed HOS is being developed. Watershed-based monitoring will continue as approved under the Phase I watershed monitoring program through fiscal year 2014-2015. By the end of 2014,

the Permittees will propose a revised comprehensive watershed and in-lake monitoring program. If approved, this revised program will be implemented in fiscal year 2015-2016.

- Special Studies – The CNRP identifies special studies that may be implemented by the MS4 Permittees. The schedule for implementation of various studies is related to the need for new information that may be used to support the 2015 compliance assessment, need for any revisions to the CNRP, and anticipated TMDL triennial reviews.

- Adaptive Implementation – This element includes TMDL implementation activities that could affect other stakeholders (e.g., TMDL revision, Task Force activities, PTP implementation) and the potential need to revise the CNRP based on the findings from monitoring activities. The TMDL triennial review dates are based on the assumption that a triennial review will occur in 2012 and then every three years beyond 2012.

2.5 Water Quality Standards Attainment

The TMDL WLAs are based on a 10-year average nutrient load to Lake Elsinore and Canyon Lake. However, in reality nutrient loading to these lakes occurs asymmetrically with the most significant loading occurring during extreme wet weather events (e.g., see Figure 3-10). When these extreme events occur, the nutrient load reaching the lakes could be substantially higher than the capacity of the lakes to absorb the nutrients with a corresponding response that results in non-attainment of annual and/or season water quality standards (e.g., algal blooms, low dissolved oxygen). The CNRP, when implemented, provides the basis for achieving compliance with the 10-year average urban WLAs. However, because of asymmetric loading, even with full CNRP implementation, Lake Elsinore and Canyon Lake may still not be in attainment with response targets at times for reasons beyond the control of the MS4 dischargers. While temporary non-attainment may still occur following extreme wet weather events, CNRP implementation is expected to reduce the potential duration and magnitude of impact from these events resulting in longer periods of attainment over 10-year average periods.

This is supported by modeling results show that non-attainment of water quality standards would have occurred even under predevelopment conditions (e.g., see Section 3.5). For example, model results for 1993, 1998 and 2005 show that the nutrient loads from wet years would likely have caused temporary non-attainment of water quality standards even if there was no development in the watershed.

Should this become a significant issue, the Permittees may request revisions to the TMDL to reflect water quality naturally attainable.

Figure 2-2. CNRP Implementation Schedule

Legend: Development Activity (orange bar); Implementation Activity (purple bar)

Year of CNRP Implementation: 2012 (Q3–Q4), 2013–2020 (Q1–Q4); Post 2020 - Continuous improvement through Adaptive Implementation

CNRP Activity	CNRP Program Elements		Description/Purpose	Development Activity	Implementation Activity
Watershed-based BMPs	Ordinances Development		Review and revise existing ordinances as needed to increase legal authority, e.g., pet and yard waste management, fertilizer use	2012 Q3 – 2013 Q4	2014 Q1 – Post 2020
Watershed-based BMPs	Street Sweeping & Debris Removal		Evaluate existing programs; enhance where needed to increase debris removal/decrease potential nutrient loads	2012 Q3 – 2013 Q4	2014 Q1 – Post 2020
Watershed-based BMPs	Inspection & Enforcement		Implementation of inspection and enforcement programs to target nutrient sources; enhance activity as needed based on revisions or new ordinances	2012 Q3 – 2014 Q2	2014 Q3 – Post 2020
Watershed-based BMPs	Septic System Management		Implement guidance (either existing or as required by State OTWS Policy); convert areas with septic systems to sewer		2012 Q3 – Post 2020
Watershed-based BMPs	Public Education & Outreach		Continue to implement public education and outreach programs that target nutrient sources, e.g., pet waste, fertilizer application, sediment deposition		2012 Q3 – Post 2020
Watershed-based BMPs	WQMP Implementation		Implement LID requirements in revised WQMP (within 6 months of Regional Board approval of revised WQMP)	2012 Q3	2012 Q4 – Post 2020
In-Lake Remediation	Lake Elsinore	Aeration System	Establish agreements; participate in the operation and maintenance of the existing Lake Elsinore aeration system	2012 Q3 – 2012 Q4	2013 Q1 – Post 2020
In-Lake Remediation	Canyon Lake	Alternatives Analyses	Complete alternatives analysis, which will include further evaluation of use of chemical additives as an in-lake remediation alternative	2012 Q3 – 2014 Q2	
In-Lake Remediation	Canyon Lake	HOS System	Prepare preliminary design of HOS	2013 Q1 – 2013 Q2	
In-Lake Remediation	Canyon Lake	HOS System	Complete CEQA process; obtain all necessary permits and approvals to construct (if implemented as an in-lake remediation alternative)	2013 Q2 – 2014 Q2	
In-Lake Remediation	Canyon Lake	HOS System	Complete final design of HOS (if implemeted as an in-lake remediation alternative)	2013 Q3 – 2014 Q2	
In-Lake Remediation	Canyon Lake	HOS System	Construct HOS (includes bid and award process, if implemented as an in-lake remediation alternative)	2014 Q3 – 2015 Q2	
In-Lake Remediation	Canyon Lake	HOS System	Implement operation and maintenance activities (if implemented as an in-lake remediation alternative)		2015 Q3 – Post 2020
Monitoring Program	In-Lake Monitoring		Prepare revised comprehensive monitoring program	2014 Q3 – 2015 Q2	
Monitoring Program	In-Lake Monitoring		Implement revised comprehensive monitoring program		2015 Q3 – Post 2020
Monitoring Program	Watershed Monitoring		Continue implementation of Phase I watershed monitoring program		2012 Q3 – 2015 Q2
Monitoring Program	Watershed Monitoring		Prepare revised comprehensive monitoring program	2014 Q3 – 2015 Q2	
Monitoring Program	Watershed Monitoring		Implement revised comprehensive monitoring program		2015 Q3 – Post 2020
Monitoring Program	Annual Reports		Complete annual reports by November 30 each year; reports assess effectiveness of in-lake and watershed-based BMPs, coincide with MS4 Annual Report submittal	● Q4 of each year, 2013–2020	
Monitoring Program	Interim ComplianceAssessment		Demonstrate compliance with interim TMDL requirements		2015 Q3 – 2015 Q4
Monitoring Program	Final Compliance Assessment		Demonstrate compliance with final TMDL requirements		2019 Q3 – 2019 Q4
Special Studies (Optional)	Use of Chemical Additives		Evaluate potential to use chemical additives, e.g., alum, as an in-lake remediation alternative	2012 Q3 – 2013 Q2	
Special Studies (Optional)	Land Use Updates		Update watershed urban land use based on 2010 data to support potential revisions to TMDL WLAs	2018 Q1 – 2018 Q2	
Special Studies (Optional)	TMDL Model Update		Revise/update the TMDL model for Canyon Lake and Lake Elsinore based on new data (e.g., land use, water quality)	2018 Q2 – 2018 Q4	2020 Q3 – 2020 Q4
Adaptive Implementation	Task Force		Continue participation in Task Force to coordinate Nutrient TMDL implementation activities, as needed		2012 Q3 – Post 2020
Adaptive Implementation	Pollutant Trading Plan		Participate in the development/establishment of the PTP; implement PTP as appropriate	2012 Q3 – 2012 Q4	2013 Q1 – Post 2020
Adaptive Implementation	CNRP Revisions		Review progress towards achieving interim TMDL requirements based on compliance assessments; modify CNRP as needed	2015 Q3 – 2015 Q4	
Adaptive Implementation	CNRP Revisions		Review progress towards achieving final TMDL requirements based on compliance assessments; modify CNRP as needed	2019 Q3 – 2019 Q4	
Adaptive Implementation	TMDL Revision		Based on degree of Regional Board support, prepare materials to support revision to the TMDL as part of the Triennial Review process, if revision is appropriate		2015 Q3 – 2015 Q4; 2018 Q3 – 2018 Q4

Section 3
Compliance Analysis

3.1 Introduction

The MS4 permit requires that the Permittees provide the scientific and technical documentation used to conclude that the CNRP, once fully implemented, is expected to achieve compliance with the urban WLA and septic LA for total nitrogen (TN) and total phosphorus (TP) by December 31, 2020 (MS4 permit Section VI.D.1.d.ii.(a)). The TMDL sets 10-year average WLAs for urban and LAs for septic sources of nutrients (Table 3-1) that will result in reductions needed to achieve numeric targets for response variables in Lake Elsinore and Canyon Lake (see Table 1-1). In the Nutrient TMDLs, sources with WLAs include urban, septic, reclaimed water, agriculture, and Concentrated Animal Feeding Operation (CAFO) sources. This compliance analysis only addresses the urban and septic WLAs associated with the MS4 Permittees and presumes other TMDL Stakeholders reduce loads to their respective WLAs to achieve numeric targets in the lakes.

Table 3-1. Wasteload Allocations for Urban and Load Allocations for Septic Nutrient Sources in Canyon Lake and Lake Elsinore Watersheds

Nutrient Source	Canyon Lake		Lake Elsinore	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Urban	306	3,974	124	349
Septic	139	4,850	69	608

Per MS4 permit Section VI.D.2.k, compliance with the urban WLAs can be measured using one of the following methods:

- Directly, using relevant monitoring data and approved modeling procedures to estimate 10-year average nitrogen and phosphorus loads being discharged to the lakes, or,
- Indirectly, using water quality monitoring data and other biological metrics approved by the Regional Board, to show water quality standards are being consistently attained (as measured by the response targets identified in the Nutrient TMDLs).

3.1.1 Compliance Analysis Approach

The following sections provide detailed description of the methodology employed to demonstrate compliance with the WLAs for urban and septic sources. The analysis involved several key questions, including:

- What is the average load of nutrients from urban and septic sources in the Canyon Lake and Lake Elsinore watersheds?

Development of the TMDL involved application of lake and watershed models to characterize nutrient sources for setting WLAs and LAs. In addition, the TMDL watershed model was updated in 2010 to incorporate a more recent land use distribution. Section 3.2.1 describes the results from these models.

- To what extent does watershed loads (referred to as "washoff") translate to reductions in loads delivered to Lake Elsinore and Canyon Lake?
  Section 3.2.2 describes the estimation of loading factors to account for loss of nutrients between washoff areas and inputs to Lake Elsinore and Canyon Lake.

- What is the nutrient load reduction necessary to reduce estimates of existing loads to the WLA for urban and LA for septic sources for each MS4 Permittee?
  See Section 3.2.3.

- How much nutrient load reduction has occurred or is expected to occur from external urban and septic sources in the watershed?
  MS4 Permittees have implemented watershed-based BMPs since the adoption of the TMDL in Lake Elsinore and Canyon Lake (see Section 3.3) watersheds. In addition, projected changes in watershed nutrient loads resulting from land use change and application of new WQMP requirements are summarized for Lake Elsinore and Canyon Lake.

- What in-lake nutrient control strategy is recommended to address remaining load reduction requirements for each MS4 Permittee after accounting for watershed load reduction?
  Section 3.4 summarizes in-lake nutrient control recommendations and demonstrates how the selected strategy will provide the necessary load reduction to achieve compliance with the WLAs for urban and LAs for septic sources.

The CNRP is designed to reduce long-term average (running 10-year) annual nutrient load for urban and septic sources. Conversely, response targets for nutrient related impairments are based on shorter-term annual or seasonal averages. Section 3.5 characterizes potential temporal variability in nutrient loading and its potential impact to Lake Elsinore and Canyon Lake under a natural and post-development condition.

The analysis contained herein is based on the TMDL staff report, 2003 TMDL watershed model, 2010 watershed model and other studies and analyses conducted by various individuals, task forces and agencies. These documents and studies represent the best available data regarding the lakes, their impairments, and potential remediation strategies; however they are limited by the quality and amount of data that was available at the time of publication. This compliance analysis relies on this available information and incorporates new data where available.. However, this analysis is still an approximation based on best available data. Although this analysis presents existing load data down to the individual Permittee level, the data should be considered order of magnitude estimates of individual responsibility. The CNRP compliance analysis should ultimately be evaluated at the higher level of combined loading and load reductions due to inherent uncertainties in the underlying data sets.

3.2 Watershed Load Assessment

3.2.1 Nutrient Washoff from Urban and Septic Sources

The linkage analysis used to develop the Nutrient TMDLs and the subsequent 2010 watershed model update evaluated the role of land cover and failing septic systems in contributing to the wash off of nutrients to receiving waterbodies, such as Salt Creek, San Jacinto River, Perris Valley Channel, and other major tributaries to the lakes. The method used to simulate loads from the watershed involved a continuous simulation of pollutant buildup during dry periods and pollutant washoff as a function of hydrologic response to historical (1990-2009) rainfall records. The Loading Simulation Program C++ (LSPC) tool was used to simulate hydrology and pollutant buildup and washoff using exponential functions. Variables used to simulate hydrology and pollutant buildup and washoff for different land cover types were adjusted within expected ranges to generate results that approximate observed data at six U.S. Geological Survey streamflow gauges and six water quality monitoring sites (Tetra Tech, 2010).

The TMDL was developed based on a frequency-weighted average loading simulated from three hydrologic year types; Wet at 16 percent weight (Water Year [WY] 1997-1998); Dry at 43 percent weight (WY 1999-2000), and Moderate at 41 percent weight (WY 1993-1994). Table 3-2 summarizes for each MS4 Permittee the frequency weighted average washoff of nutrients from urban and septic sources based on the 2010 watershed model update.

Table 3-2. 2010 LSPC Update Simulated Nutrient Washoff from Urban and Septic Sources for each MS4 Permittee in the Local Lake Elsinore, Canyon Lake below Mystic Lake, and Above Mystic Lake Watersheds

MS4 Permittee[1]	TP Washoff (kg/yr)			TN Washoff (kg/yr)		
	Local Lake Elsinore	Canyon Lake below Mystic Lake	Above Mystic Lake	Local Lake Elsinore	Canyon Lake below Mystic Lake	Above Mystic Lake
Beaumont			69			362
Canyon Lake	14	130		78	765	
Hemet		235	187		1,660	1,246
Lake Elsinore	284	44		1,489	222	
Menifee	6	467		17	2,881	
Moreno Valley		1,160	1		7,255	2
Murrieta		1			5	
Perris		388			2,222	
Riverside		37			268	
Riverside County	116	485	697	585	2,374	2,632
San Jacinto		0	201		1	1,294
Wildomar	127	0		639	0	
Septic	13	83	63	176	1109	841
Other Jurisdictions	50	355	103	248	1,877	403
Total	610	3,386	1,339	3,232	20,640	6,902

3.2.2 Estimation of Washoff Loading Factors

Nutrients washed off from source areas are transported to Canyon Lake and Lake Elsinore by a variety of drainage courses. Characteristics of these drainage courses control how much of the washed off pollutant reaches the downstream lakes. Reduction of nutrient loads within conveyance systems, referred to as natural decay in the CNRP, is generally the result of settling of suspended solids and stormwater infiltration within channels and upstream lakes, most notably Mystic Lake. The LSPC model accounted for this decay in the runoff routing simulation. Based on these results loading factors (ratios of lake loading to watershed washoff) were computed for three aggregated analysis zones: Local Lake Elsinore (Figure 3-1, Zone 1); Canyon Lake below Mystic Lake (Figure 3-1, Zones 2-6); and Above Mystic Lake (Figure 3-1, Zones 7-9) (Table 3-3).

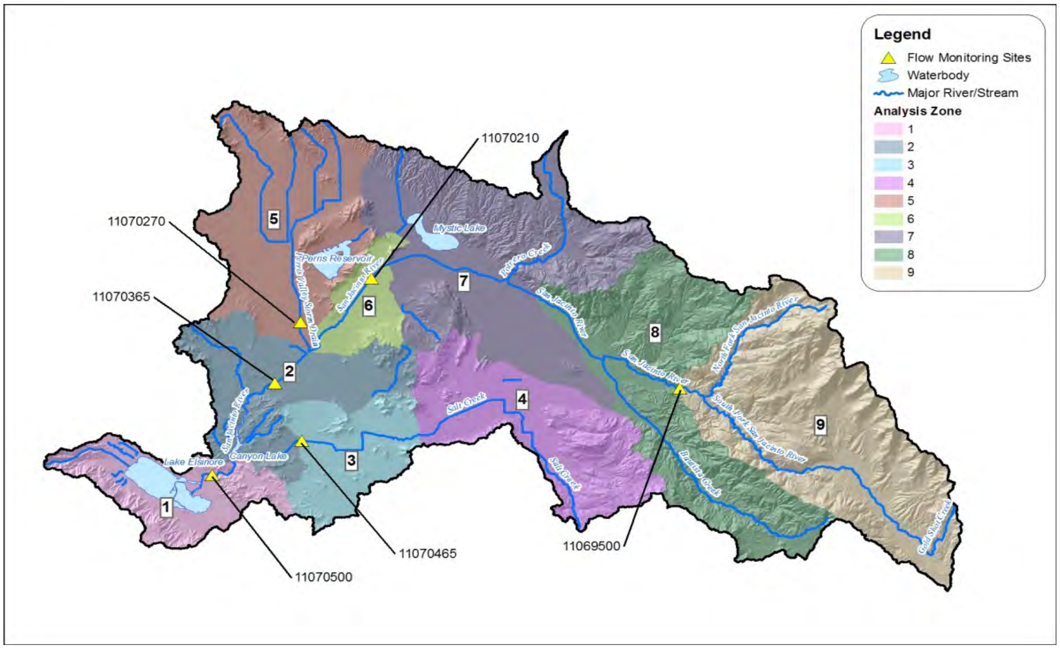

Figure 3-1
San Jacinto River Watershed Analysis Zones

Table 3-3. Estimation of Loading Factors for the Portion of Urban and Septic Watershed Nutrient Washoff that Reaches Lake Elsinore or Canyon Lake

Watershed Analysis Zone	Watershed Washoff[1]		Loads to Lakes[1]		Loading Factor	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP	TN
Local Lake Elsinore (Zone 1)	610	3,232	610	3,232	100%	100%
Canyon Lake below Mystic Lake (Zones 2-6)	3,386	20,640	1,765	12,515	52%	61%
Above Mystic Lake (Zones 7-9)	1,339	6,902	<1	<1	<0.01%	<0.01%

1) Watershed washoff and loads to lakes from urban sources are inclusive of state, federal, and tribal jurisdiction lands

The computed loading factors for the three aggregated zones show that all urban and septic nutrient washoff in the local Lake Elsinore watershed reaches Lake Elsinore. For the Canyon Lake watershed, roughly half of nutrient washoff from urban land areas from the portion of the drainage area that is downstream of Mystic Lake reaches Canyon Lake. For MS4 drainages upstream of Mystic Lake, any loading to Canyon Lake is extremely rare (11 of 240 months) and of small magnitude relative to flow in the Upper San Jacinto River, as has been shown with extensive analysis of flow gauge data and simulation models (http://www.sawpa.org/documents/2010-9-27SanJacintoWatershedModelUpdate.pdf). Thus, it is assumed that nutrients conveyed to Canyon Lake are from drainage areas downstream of Mystic Lake.

These loading factors must be included in any estimate of reduced loading to Lake Elsinore or Canyon Lake from implementing watershed BMPs to avoid double counting reductions that would have been achieved through natural in-stream decay. Therefore, in the Canyon Lake watershed, washoff reductions in MS4 drainage areas do not achieve an equivalent benefit in load reduction to the lakes. For example, watershed BMPs in MS4 drainages in the Canyon Lake watershed below Mystic Lake have to reduce washoff by 1.9 kg TP and 1.6 kg TN to achieve a 1 kg TP or TN reduction in loads to Canyon Lake. This compliance analysis does not evaluate washoff reduction from urban and septic sources above Mystic Lake, where the loading factor is negligible, making washoff reduction ineffective.

3.2.3 Gap Analysis for Urban WLAs and Septic LAs

The load reduction to Lake Elsinore and Canyon Lake necessary to demonstrate compliance with the urban WLA and septic LA is equal to the difference between existing loads and the allocated loads. The relative contribution from each MS4 Permittee drainage area to existing loads into Lake Elsinore and Canyon Lake is used to allocate urban WLAs and septic LAs and determine each Permittees' responsibility for reducing nutrient loads from urban and septic sources. Different approaches are necessary to estimate nutrient loads to the lakes from urban and septic sources, as follows:

- Urban Sources - Washoff from the watershed is modeled for each Permittee. Nutrient washoff from MS4 drainage areas is then translated to an existing load in Lake Elsinore or Canyon Lake by applying the appropriate decay factors depending upon acreage within each aggregated zone.

- Septic Sources - The watershed model simulated total septic loads only from each of the three aggregated zones; No assessment of the distribution of septic systems among individual MS4 Permittees was made. The County's GIS shapefile of septic systems at risk provided a means to develop a distribution of existing septic loads for each MS4 Permittee within each aggregated zone.

The urban WLA was divided between the MS4 Permittees based on the relative contribution by each MS4 Permittee to the total urban load (as estimated from the 2010 watershed model). The total septic load to Lake Elsinore and Canyon Lake, as estimated in the 2010 watershed model, is less than the septic LA in the TMDL, hence, there is allowable load in excess of what is attributed to existing septic systems. The reason for this is that analysis to support the development of the 2007 SSMP significantly reduced the estimate of potentially failing septic systems in the San Jacinto River watershed from levels assumed during the TMDL development (Tetra Tech, 2007). The Regional Board required the MS4 Permittees to take the full responsibility of the septic LA therefore, it is appropriate to shift the allocation, including credits, to urban MS4 sources. Tables 3-4 and 3-5 show how the septic LA and excess credits are shifted to MS4 Permittees. For Permittees with septic systems within their jurisdiction, the existing septic load was added to the urban WLA, based on the number of septic systems within 500 feet of a drainage facility within the watershed (see Section 3.3.3 for detailed breakout by jurisdiction). The load allocation in excess of the existing septic load (i.e. credits) was divided between all MS4 Permittees based on relative portion of existing urban load, estimated in the 2010 watershed model update. The final columns of Tables 3-4 and 3-5 compute the gap or load reduction that must be achieved by each MS4 Permittee for both urban and septic sources.

For Lake Elsinore, the majority of existing urban and septic load comes from stormwater that flows through Canyon Lake in moderate rainfall years. For purposes of the CNRP compliance analysis, compliance with the Canyon Lake TMDL is assumed to translate to a sufficient reduction in Canyon Lake outflow load to meet the WLA for flows from Canyon Lake to Lake Elsinore (see Attachment F - Pollutant Trading Plan). If future data demonstrates that exceedances of WLA for flows from Canyon Lake to Lake Elsinore are still occurring despite compliance with the Canyon Lake TMDL, then these issues will be addressed through the adaptive implementation process that has been incorporated into this CNRP.

Table 3-4. Gap Analysis for Existing Urban and Septic Total Phosphorus Loading to Lake Elsinore and Canyon Lake for MS4 Permittees (all values in kg/yr)

MS4 Permittee	Existing Load	Urban WLA Septic LA	Load Reduction (Needed) / Credit	Reallocation of Existing Septic Load	Reallocation of Septic Credits	WLA (Urban + Septic)	Remaining Load Reduction (Needed)
Local Lake Elsinore Watershed[1]							
Canyon Lake	14	3	(11)	0	+1	4	(10)
Lake Elsinore	310	65	(246)	+11	+29	104	(206)
Menifee	6	1	(5)	0	+1	2	(4)
Riverside County	119	25	(94)	0	+11	36	(83)
Wildomar	147	31	(116)	+2	+14	47	(100)
Urban Subtotal	597	124	(473)	+13	+56	193	(404)
Septic Total	13	69	56	(13)	(56)	n/a	n/a
Canyon Lake Watershed							
Beaumont	0.0	0	(0)	0	0	0	(0)
Canyon Lake	67	12	(55)	0	+3	15	(52)
Hemet	125	22	(102)	+1	+6	29	(96)
Lake Elsinore	24	4	(20)	0	+1	5	(18)
Menifee	257	46	(211)	+16	+12	74	(183)
Moreno Valley	659	118	(541)	+7	+32	157	(502)
Murrieta	1	0	(1)	0	0	0	(1)
Perris	218	39	(179)	0	+11	50	(169)
Riverside	20	4	(17)	0	+1	5	(16)
Riverside County	337	60	(277)	+32	+16	109	(228)
San Jacinto	0	0	(0)	0	0	0	(0)
Wildomar	0	0	(0)	0	0	0	(0)
Urban Total	1,709	306	(1,403)	+56	+83	445	(1,264)
Septic Total	56	139	83	(56)	(83)		

1) Assumes pass through TP load from Canyon Lake to Lake Elsinore is reduced to the pass through WLA of 2,770 kg if all entities upstream of Canyon Lake reduce loads to their respective WLAs or LAs for the Canyon Lake nutrient TMDL.

The MS4 Permittees plan to implement a CNRP that will achieve the WLAs, as set in the TMDL. However, if implementation demonstrates that load reduction targets cannot feasibly be met, then the MS4 Permittees may recommend on the TMDL be revised to consider naturally attainable water quality standards and/or achievable wash-off rates.

Table 3-5. Gap Analysis for Existing Urban and Septic Total Nitrogen Loading to Lake Elsinore and Canyon Lake for MS4 Permittees (all values in kg/yr)

MS4 Permittee	Existing Load	Urban WLA Septic LA	Load Reduction (Needed) / Credit	Reallocation of Existing Septic Load	Reallocation of Septic Credits	WLA (Urban + Septic)	Remaining Load Reduction (Needed)
Local Lake Elsinore Watershed							
Canyon Lake	78	9	(69)	0	+11	20	(58)
Lake Elsinore	1,615	184	(1,430)	+143	+228	555	(1,059)
Menifee	17	2	(15)	0	+2	4	(13)
Riverside County	600	68	(531)	0	+85	153	(446)
Wildomar	747	85	(662)	+33	+106	224	(523)
Urban Subtotal	3,056	349	(2,707)	+176	+432	957	(2,099)
Septic Total	176	608	432	(176)	(432)		
Canyon Lake Watershed							
Beaumont	0.0	0	(0)	0	0	0	(0)
Canyon Lake	459	156	(302)	0	+157	313	(145)
Hemet	1,011	344	(666)	+9	+346	700	(311)
Lake Elsinore	139	47	(91)	0	+48	95	(44)
Menifee	1,825	622	(1,203)	+241	+625	1,488	(337)
Moreno Valley	4,694	1,600	(3,094)	+112	+1,608	3,320	(1,374)
Murrieta	7	2	(4)	0	+2	5	(2)
Perris	1,437	490	(947)	+1	+492	983	(453)
Riverside	165	56	(109)	0	+57	113	(52)
Riverside County	1,925	656	(1,269)	+491	+660	1,807	(119)
San Jacinto	1	0	(1)	0	0	1	(0)
Wildomar	0	0	(0)	0	0	0	(0)
Urban Total	11,661	3,974	(7,687)	+854	+3,996	8,824	(2,837)
Septic Total	854	4,850	3,996	(854)	(3,996)		

1) Assumes pass through TN load from Canyon Lake to Lake Elsinore is reduced to the pass through WLA of 27,699 kg if all entities upstream of Canyon Lake reduce loads to their respective WLAs or LAs for the Canyon Lake nutrient TMDL.

3.3 Load Reduction from Watershed BMPs

Since TMDL adoption, MS4 program implementation has resulted in reductions of nutrient washoff from MS4 drainage areas. For stormwater program activities involving changes to human behavior, the nutrient washoff reduction benefit may not be quantifiable due to uncertainty in effectiveness (see Section 2.2.1). Watershed BMPs that provide a quantifiable reduction of nutrient washoff are detailed in the following sections.

3.3.1 Street Sweeping and MS4 Debris Removal

Street sweeping and MS4 facility debris removal activities reduce a significant source of nutrients in urban environments. Estimated reductions of TP and TN washoff achieved by the MS4 Permittees through street sweeping and MS4 debris removal programs required assessment of sediment and debris mass removal data and development of an analysis to convert tonnage of sediment and debris collected to reductions in washoff sediment load and associated nutrients. The MS4 Permittees provided street sweeping and MS4 debris removal data for the reporting period from 2005 to 2010 (see Table D-2, Annual Street Sweeping Summary). This data was the basis for quantifying nutrient washoff reduction for the CNRP compliance analysis.

A continuous simulation analysis was developed to compute sediment and debris accumulation prior to each storm event, or buildup, and transport of sediment and debris from the watershed surface to downstream waterbodies during each storm event, or washoff (Wolosoff et. al., 2010). The consecutive sequence of storm events (rainfall depth >0.1 inches) provided a basis to perform a simulation of pollutant buildup during inter-event periods and washoff as a function of event runoff. Historical daily rainfall data for the Lake Elsinore NCDC meteorological station was used to estimate average runoff depth from a typical urban street, assuming a runoff coefficient of 0.9 for the impervious drainage area (i.e. runoff depth is 90 percent of rainfall depth to allow for depression storage and other initial abstractions).

The buildup/washoff model determined a long-term average washoff ratio (W_r) of roughly 50 percent. This is the portion of collected sediment and debris that would have otherwise been washed off to MS4s and receiving waterbodies. Translating avoided sediment and debris washoff into a potential reduction in nutrient loads requires an estimate of expected concentrations in typical street sediment and debris (C_s), measured as kg/metric ton, within MS4s for TP and TN. The City of San Diego Targeted Aggressive Street Sweeping Pilot Program, completed in 2011 measured concentrations of nutrients in sediment and debris on streets and found approximately 0.3 kg/metric ton for TP and 1.0 kg/metric ton for TN (City of San Diego, 2011). These values are comparable to nutrient concentration data reported by Pitt et al. (1973) from sites in Wisconsin (0.07-0.6 kg/metric ton TP and 0.5-1.9 kg/metric ton TN), Walch, 2006 from sites in Delaware (0.3 kg/metric ton TP and 0.7 kg/metric ton TN), and Breault et. al., 2005 from sites in Massachusetts (0.3-0.16 kg/metric ton TP). Therefore, for every metric ton of sediment and debris removed (M_{swept}), 0.15 kg of TP and 0.5 kg of TN is reduced from washoff, as;

$$\mathbf{W_{BMP} = M_{swept} * W_r * C_s}$$

Table 3-6 presents the baseline mean quantity of debris removed from street sweeping activities and MS4 facilities cleaning, between the 2005 and 2010 reporting years, within the San Jacinto River watershed and the estimated nutrient washoff reduction based on the method described above.

3.3.2 Structural Post Construction BMPs

MS4 Permittees within the San Jacinto River Watershed first required new development projects to establish post-construction stormwater BMPs that provide nutrient load reduction benefits as part of the San Jacinto Watershed Construction Permit requirements (Regional Board Permit No. CAG 618005, Order 01-34). These Permit requirements were effective from 2002 until the adoption of the Water Quality Management Plan for New Developments and Redevelopments pursuant to the third-term Riverside County MS4 Permit in 2005. Structural post-construction BMPs constructed as a result of these requirements were not accounted for in the 2010 watershed model update. The MS4 Permittees have researched historic development and provided data for structural post-construction BMPs constructed within the San Jacinto River watershed and they are now accounted for in this compliance analysis (see Attachment D, Table D-6).

Table 3-6. Estimated Total Phosphorus and Total Nitrogen Annual Load Reduction (kg/yr) from Street Sweeping and MS4 Debris Removal

Jurisdiction	Debris Removal Average [1] (metric tons/yr)	Street Sweeping Average Removal [1] (metric tons/yr)	Baseline Metric Tons/yr (2005-2010)	TP Removed (kg/yr)	TN Removed (kg/yr)
Local Lake Elsinore					
Canyon Lake	1	8	8	0	0
Lake Elsinore	0	350	350	47	157
Menifee	24	5	29	0	0
Riverside County	182	538	720	6	20
Wildomar	0	25	25	4	13
Total				57	189
Canyon Lake Watershed					
Beaumont	23	23	45	0	0
Canyon Lake	1	8	8	1	4
Hemet	2	1,080	1,082	114	380
Lake Elsinore	0	350	350	6	19
Menifee	36	0	36	5	18
Moreno Valley[2]	18	893	911	132	442
Murrieta[2]	24	5	29	4	14
Perris	66	506	573	86	286
Riverside	0	29	29	4	14
Riverside County	182	538	720	52	175
San Jacinto	6	128	134	0	0
Wildomar	0	25	25	0	0
Total	359	3,584	3,942	406	1,352

1) Tonnage data is based on an extrapolation for catch basins cleaned, sweepers filled, and other metrics. Permittees are evaluating alternatives to more directly measure the mass removed from streets and MS4 facilities. Values are less than total reported debris removal for some Permittees (shown in Table D-2) due to discounting sweeping performed upstream of Mystic Lake according to proportion of road miles upstream of Mystic Lake.
2) Permittees reported MS4 debris data as volumetric measurements. Conversion to tonnage assumed debris density of 1.5 g/cm^3.

The 2010 watershed model update provides estimated pollutant loading rates or export coefficients (L_{EC}) for TP and TN of 0.08 kg/acre/yr and 0.42 kg/acre/yr, respectively. These loading rates do not account for inclusion of structural BMPs in WQMP projects. Reduction in washoff due to implementation of WQMP projects is estimated by reducing the modeled loading rate for new urban development since adoption of the TMDL. Two factors are applied, including:

- Average annual percent of runoff capture ($V_{capture}$) - Since BMPs in Riverside County are designed to meet MS4 Permit water quality volume criteria (Section VII.D.4(a)), constructed BMPs were assumed to treat approximately 80 percent of the volume of long-term average annual storm water runoff.

- Pollutant removal efficiency (R_{eff}) - BMP removal efficiency for infiltration is assumed to be 100 percent. For BMPs that treat and release runoff, average stormwater BMP effluent concentrations reported in the international BMPs database were compared with MS4 outfall concentrations at NPDES monitoring locations in the San Jacinto River watershed to approximate pollutant removal efficiency (ASCE, 2010). Results are summarized below:

- Infiltration – 100 percent removal for the $V_{capture}$
- Extended detention – TP 75 percent; TN 24 percent
- Hydrodynamic separators – TP 33 percent; TN 13 percent
- Vegetated swale - TP 47 percent; TN 0 percent
- Media filter – TP 69 percent; TN 0 percent

For each jurisdiction in this analysis, the area of new development tributary to structural stormwater BMPs in acres (DA_{WQMP}), provided by the MS4 Permittees, was used to determine the TP and TN washoff reduction as follows:

$$\mathbf{W_{reduction} = DA_{WQMP} * L_{EC} * V_{capture\%} * R_{eff\%}}$$

Table 3-7 shows the estimated annual nutrient washoff reduction for each MS4 Permittee associated with implementation of structural BMPs in WQMP projects. It should be noted that not all Permittees were able to track deployment of BMPs constructed under the San Jacinto construction permit. Only those BMPs that could be verified were included in Table 3-7.

Table 3-7. WQMP Project BMPs and Nutrients Load Reduction (kg/yr)

Jurisdiction[1]	BMP Treatment Area (acres)					TP Washoff Reduction (kg/yr)	TN Washoff Reduction (kg/yr)
	Infiltration	Extended Detention	Hydrodynamic Separator	Vegetated Swale	Media Filter		
Local Lake Elsinore Watershed							
Lake Elsinore	707	1995		9		145	395
Canyon Lake Watershed							
Hemet	54	44		10		6	22
Menifee		75				4	6
Moreno Valley	159	1,032	8	21		61	136
Murrieta	34					2	11
Perris	513	768	819	114	18	92	267
City of Riverside[2]		511				25	41
County of Riverside		25				1	2
Subtotal	735	2,455	827	145	18	452	485

1) Recent WQMPs assumed to be entirely within the local Lake Elsinore watershed portion of the City of Lake Elsinore's jurisdictional area. For Cities of Canyon Lake, Menifee, and Wildomar, and County of Riverside, recent WQMPs are assumed to be entirely within the Canyon Lake watershed portion of their respective jurisdictional areas
2) Extended detention basins located in March Joint Powers Authority treats all runoff from city of Riverside

3.3.3 Septic System Management

Each Permittee with septic systems within their jurisdiction will implement the System Management Plan (SSMP) aimed to reduce nutrient washoff from failing septic systems to MS4s in the San Jacinto River watershed. The SSMP includes proposed activities such as enhancing performance requirements for new systems, examining existing systems near impaired waters to determine potential impacts, and repairing or replacing existing systems that may threaten valuable water resources.

The SSMP development employed a GIS screening approach to approximate properties with potentially failing septic systems based on distance from sewer lines and proximity to watercourses, assuming that 10 percent of properties are uninhabited and a 30 percent failure rate for properties with operating septic systems. The current condition washoff of nutrients attributed to septic sources was simulated in the 2010 watershed model update, and is used herein to estimate the load reduction benefits from correcting failing septic systems or improving sewering projects. Modeled loads from septic systems divided into the number of potentially failing septic systems, provides an approximate nutrient load reduction that could be achieved for each septic system corrected by the Permittees (Table 3-8).

Table 3-8. Estimation of Failing Septic System Washoff Rates in Local Lake Elsinore and Canyon Lake Watersheds based on 2010 Watershed Model Update

Variable	Local Lake Elsinore	Canyon Lake below Mystic Lake
Properties w/ septic systems at risk	106	2,204
Properties w/ potentially failing septic	29	595
Modeled TN washoff (kg/yr)	176	854
Modeled TP washoff (kg/yr)	13	56
TN Washoff Rate (kg/failing septic/yr)	6.1	1.4
TP Washoff Rate (kg/failing septic/yr)	0.5	0.1

1) Potentially failing systems assumes 10 percent of properties with septic system at risk are uninhabited and 30 percent of inhabited properties with a septic system at risk are failing

The estimated washoff rate in Table 3-8 is used to approximate the washoff reduction that could be achieved from implementation of the SSMP and sewering projects, assuming either septic system repair for 25 percent of potentially failing septic systems or complete reduction of all septic washoff in areas planned for sewering projects (Table 3-9).

Table 3-9. Estimated Washoff Reduction from SSMP Implementation and Sewering Projects in San Jacinto River Watershed

Jurisdiction	Number of Septic Systems	Failing Septic Systems Managed	TP Washoff Reduction (kg/yr)	TN Washoff Reduction (kg/yr)
Local Lake Elsinore Watershed				
Lake Elsinore	86	6	0.7	9.2
Wildomar	20	2	0.2	3.1
Total	106	8	0.9	12.3
Canyon Lake Watershed				
Canyon Lake	54	4	0.4	5.7
Hemet	20	2	0.2	2.9
Menifee	544	37	3.5	53.1
Moreno Valley	253	18	1.7	25.8
Murrieta	1	0	0.1	1.4
Perris (Enchanted Heights)	223	61	5.7	87.5
Riverside County	1,109	75	7.1	107.6
Total	2,204	198	19	284

In the City of Perris, the Enchanted Heights neighborhood has approximately 223 dwelling units on septic systems. Using the 2010 Model's 10 percent vacancy consideration and a 30 percent septic system failing rate, the number of potentially failing septic systems that would benefit from sewering is 61. In 2011, construction began on a three-year sewer system project to replace the existing septic systems. Converting the Enchanted Heights neighborhood to a wastewater treatment system would provide a conservative nutrient reduction of approximately 6 kg/year of TP and 88 kg/year of TN.

In 2008, the Quail Valley development was incorporated into the City of Menifee. The majority of homes in the development are served by septic systems. There are 1,390 existing dwelling units in Quail Valley of which 1,057 are located in areas scripted to be converted from septic to the regional sewer treatment facility. This potential project would increase the CNRP estimate of septic load reduction from the Quail Valley area if it is implemented in the future; however, it is not included in the load reductions shown in Table 3-9.

3.3.4 Future Low Impact Urban Development

The San Jacinto watershed has significant urban growth potential, which over the long-term will alter the distribution of land use. Since nutrient loading rates or export coefficients vary for different land uses, loading to Lake Elsinore and Canyon Lake will change. Depending upon the pre-developed land use, loads could increase (e.g. converting from open space land use) or decrease (e.g. converting from CAFO land use). Land use types have an associated nutrient loading rate or export coefficient, which contributes to non-point source loading within a watershed. For example, in the Canyon Lake below Mystic Lake watershed, modeled TP loads from urban land use is 0.08 kg/acre/year, while forested land use TP loading rate is 0.02 kg/acre/year.

Current land use was compared to long-term general plan land use projections provided by each Permittee. Figure 3-2 shows the change in land use projected for each Permittee from current to buildout conditions. Only jurisdiction areas in the local Lake Elsinore and Canyon Lake below Mystic Lake watersheds are included in the assessment of future low impact development as the majority of washoff from above Mystic Lake is retained within Mystic Lake. Urban growth potential in the San Jacinto River watershed is an approximate even split between conversion of agricultural lands and development of open spaces (Figure 3-2). For Permittees that are largely built out, washoff reductions may be achieved through re-development of existing land uses with implementation of new LID requirements in WQMPs; however this was not included in the quantification for the CNRP compliance analysis. Tables 3-10 and 3-11 provide current and buildout land use distributions for each for the MS4 Permittees within the local Lake Elsinore and Canyon Lake below Mystic Lake watersheds.

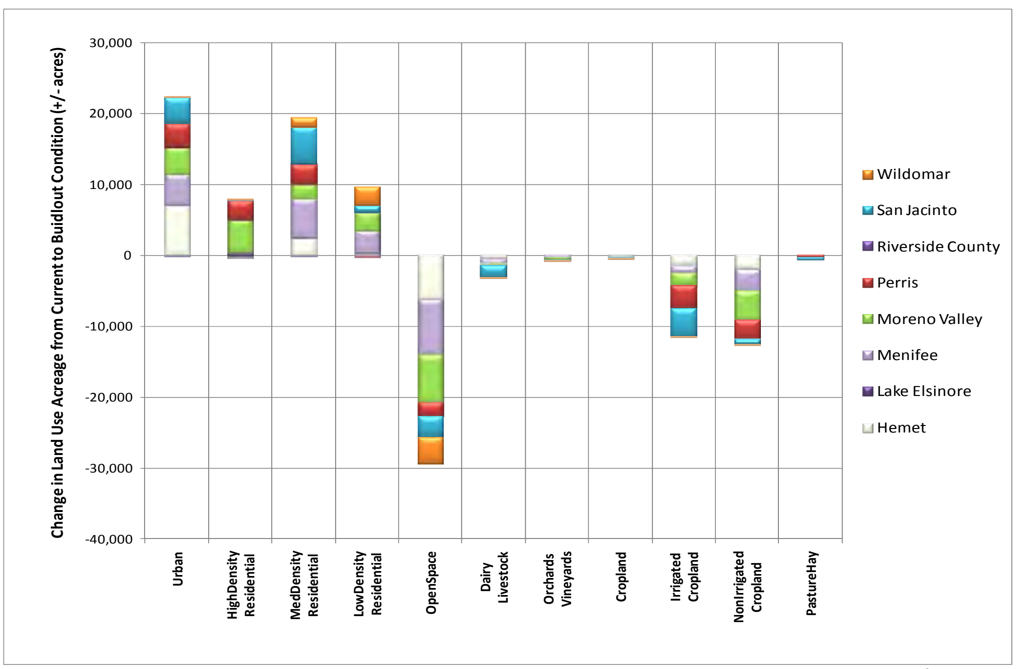

Figure 3-2
Change in Land Use from 2010 Watershed Model Update to Permittee General Plans

Table 3-10. Current Land Use for MS4 Permittees in the Local Lake Elsinore and Canyon Lake below Mystic Lake Watersheds

Jurisdiction	Acres	Urban	High Density Residential	Med Density Residential	Low Density Residential	Open Space	Forested	Water	Dairy / Livestock	Orchards / Vineyards	Cropland	Irrigated Cropland	Non Irrigated Cropland	Pasture / Hay
Local Lake Elsinore														
Canyon Lake	316	29		102	3	81	102							
Lake Elsinore	13,376	1,525	145	1,910	327	259	6,026	3,095		18	3	0	69	
Menifee	414				125		273				13	3		
Riverside County	10,574	155	8	787	1,000	57	8,334	110	42	14	24	31	12	
Wildomar	5,074	480		531	1,345	31	2,532		7	32	2	32	84	
Subtotal	29,754	2,188	153	3,330	2,799	428	17,267	3,205	48	63	43	66	164	0
Canyon Lake Watershed (below Mystic Lake)														
Canyon Lake	2,653	46	17	1,128	63	61	853	470	9				6	
Hemet	13,020	1,916	414	2,973	105	930	3,537	191	181	3	20	867	1,883	
Lake Elsinore	1,573	124		254	11	13	1,171							
Menifee	28,580	3,194	292	4,675	3,413	1,594	6,412	640	746	210	199	1,232	5,971	
Moreno Valley	27,009	3,316	339	8,512	2,224	1,004	6,605	331	125	236	56	1,814	2,447	
Murrieta	375	75	18	235	9	26								12
Perris	20,277	2,925	154	2,056	1,055	2,151	4,917	470	50	144	49	3,269	2,710	327
Riverside	511	39		459		13								
Riverside County	105,128	4,655	174	1,571	10,591	6,600	61,047	3,215	2,636	705	337	7,960	5,637	
San Jacinto	223	30			7	14	60	27	15			34	35	
Wildomar	7	0					7							
Subtotal	199,496	16,396	1,404	21,833	17,487	12,387	84,656	5,356	3,771	1,298	661	15,178	18,742	327

Table 3-11. General Plan Buildout Land Use for MS4 Permittees in the Local Lake Elsinore and Canyon Lake below Mystic Lake Watersheds

Jurisdiction	Acres	Urban	High Density Residential	Med Density Residential	Low Density Residential	Open Space	Forested	Water	Dairy / Livestock	Orchards / Vineyards	Cropland	Irrigated Cropland	Non Irrigated Cropland	Pasture / Hay
Local Lake Elsinore														
Canyon Lake	316	29		102	3	81	102							
Lake Elsinore	13,376	1409	511	1823	215	2226	4423	2770	0	0	0	0	0	0
Menifee	414	110	2	150	99	46	7	0	1	0	0	0	0	0
Riverside County	10,574	196	9	1,003	1,203	31	7,900	110	42	14	24	31	12	0
Wildomar	5,074	376	80	1402	3048	168	0	0	0	0	0	0	0	0
Subtotal	29,754	2,119	602	4,480	4,567	2,551	12,432	2,879	43	14	24	31	12	0
Canyon Lake Watershed (below Mystic Lake)														
Canyon Lake	2,653	46	17	1,128	63	61	853	470	9				6	
Hemet	13,020	7,014	414	4,763	638	0	0	191						
Lake Elsinore	1,573	209	76	270	32	330	656	0						
Menifee	28,580	7,503	292	10,104	6,750		70	640	79			79	3,062	
Moreno Valley	27,009	5,966	4,180	8,823	4,009	3,701	0	331						
Murrieta	375	75	18	235	9	26								12
Perris	20,277	6,213	2,791	4,729	1,051	3,643	1,380	470						
Riverside	511	39		459		13								
Riverside County	105,128	9,007	255	12,145	32,786	5,552	37,309	3,215	1,272	705	337	1,272	1,272	0
San Jacinto	223	30			7	14	60	27	15			34	35	
Wildomar	7	0					7	0						
Subtotal	199,496	36,180	8,038	42,625	45,353	13,321	40,381	5,356	1,384	705	338	1,385	4,428	0

For each Permittee in each watershed analysis zone, area-weighted averages of land use specific TP and TN loading rates were computed for current and projections at buildout as well as estimates of urban growth by the year 2020. The Riverside County economic forecast developed by Caltrans provided a means to project the portion of urban growth that will occur by 2020, when compliance with the LE/CL nutrient TMDL must be achieved (http://www.dot.ca.gov/hq/tpp/offices/eab/socio_economic_files/2011/Riverside.pdf). Figure 3-3 shows the projected rate of growth over time from 2010 until the projected buildout date of 2035. This growth rate was used to compute dynamic land use based loading between 2010 and 2020 for TP and TN in Canyon Lake below Mystic Lake (Figures 3-4 and 3-5) and local Lake Elsinore (Figures 3-6 and 3-7) watersheds. The impact of urbanization is not as significant in the Lake Elsinore watershed.

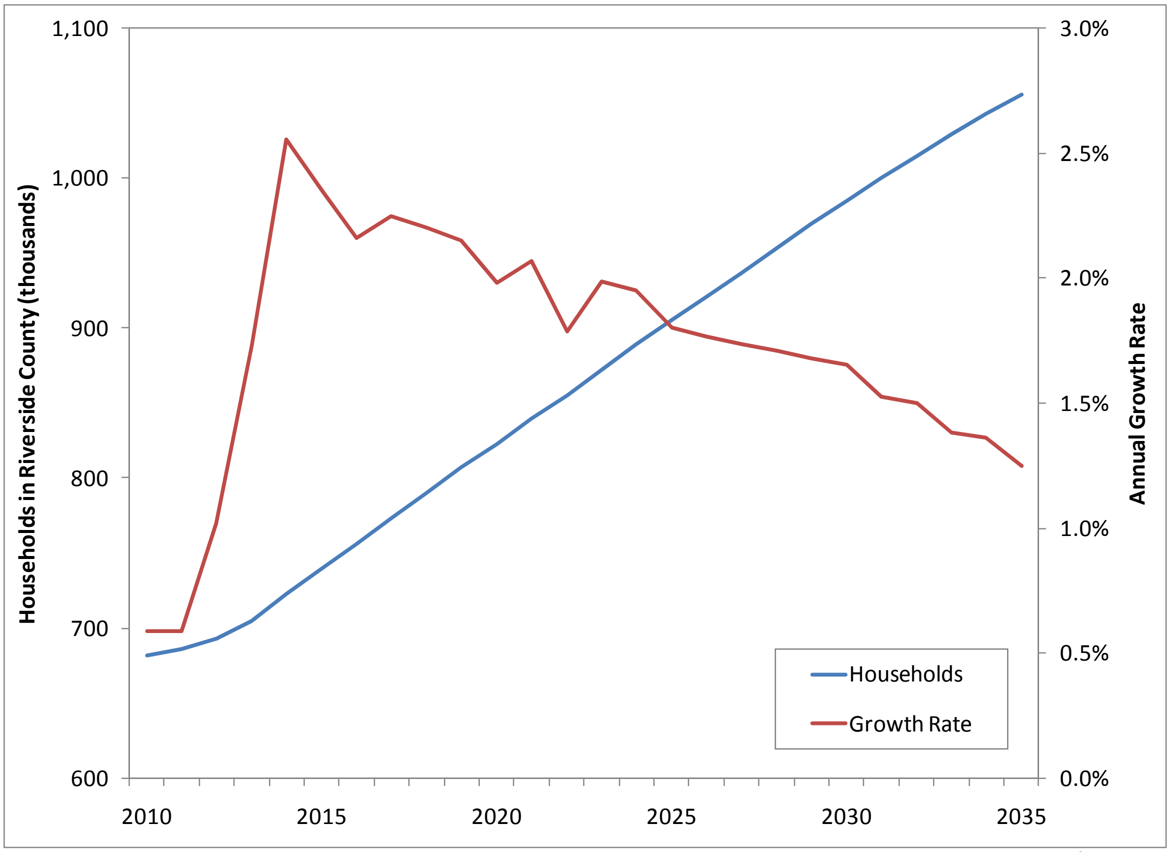

Figure 3-3
Projected Growth Rate for Urban Development in Riverside County (from Caltrans, 2011)

Also accounted for in these estimates of loading rate change are assumed reductions to account for LID requirements in WQMPs. LID BMPs will reduce nutrient washoff from rates currently used for urban land uses in the watershed model. For planning purposes, 40 percent of future WQMPs are assumed to provide complete on-site retention of the water quality volume. For the remaining 60 percent of future WQMPs, it was assumed that biotreatment of the water quality volume would be 75 and 24 percent effective in removing TP and TN, respectively.

The expected change in nutrient washoff from urban growth and future LID is summarized for each Permittee in Table 3-12. Figure 3-8 shows the difference between current and 2020 land use area weighted average loading rate for TP and TN for Permittees jurisdictions with significant growth potential (positive = net increasing load; negative = net load reduction).

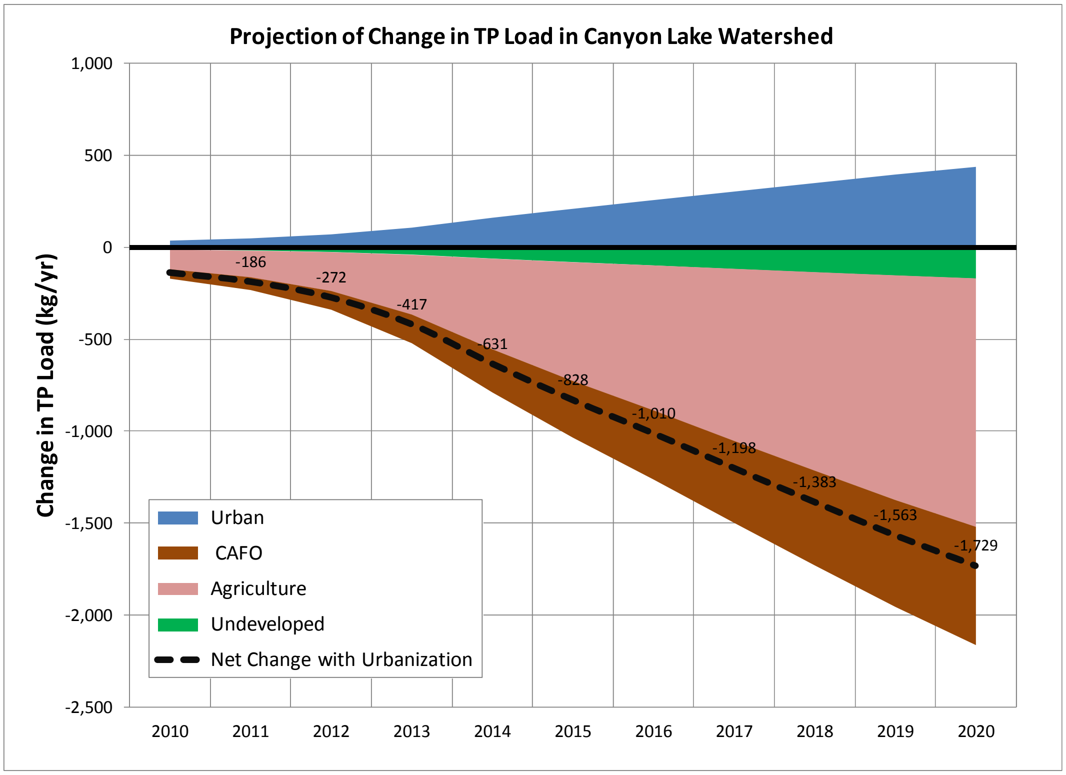

Figure 3-4
Projected TP Load from Urban, Agriculture, CAFO, and Undeveloped Lands in Canyon Lake Watershed

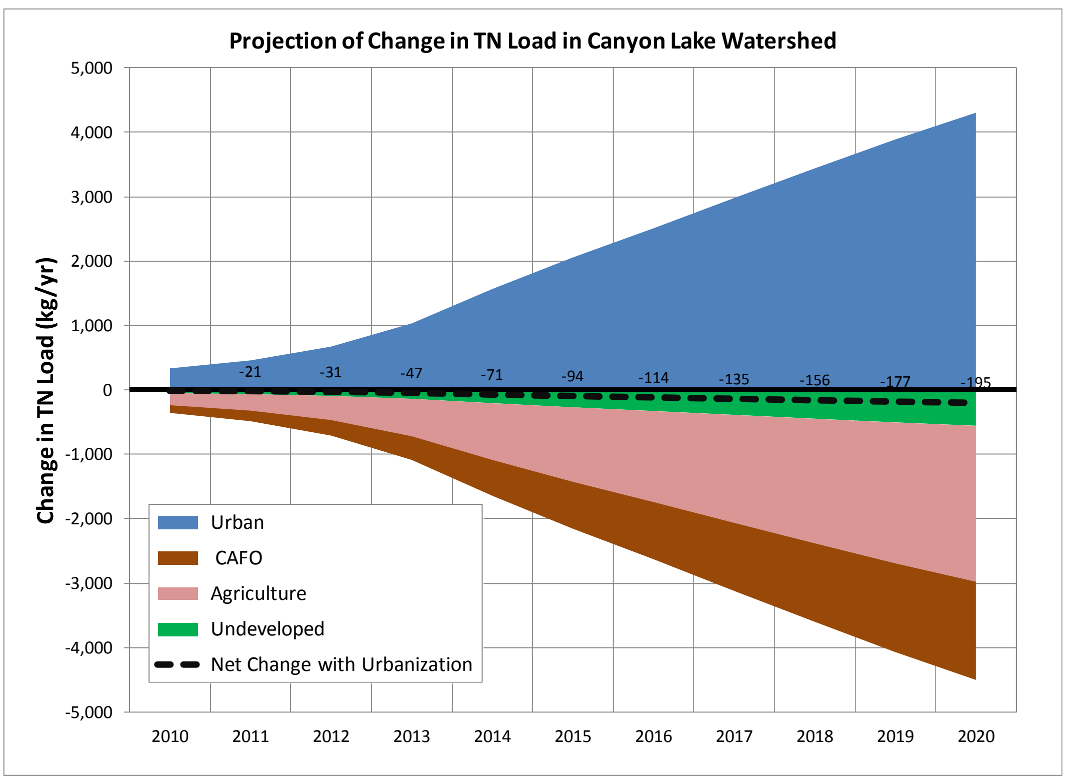

Figure 3-5
Projected TN Load from Urban, Agriculture, CAFO, and Undeveloped Lands in Canyon Lake Watershed

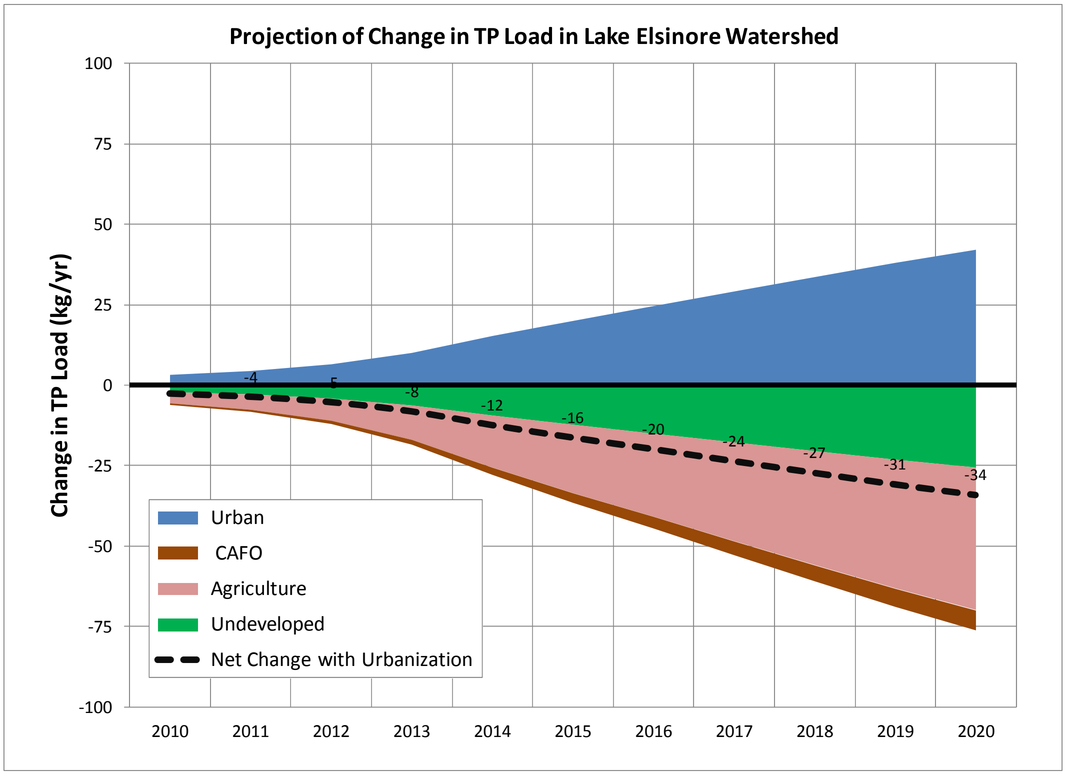

Figure 3-6

Projected TP Load from Urban, Agriculture, CAFO, and Undeveloped Lands in Lake Elsinore Watershed

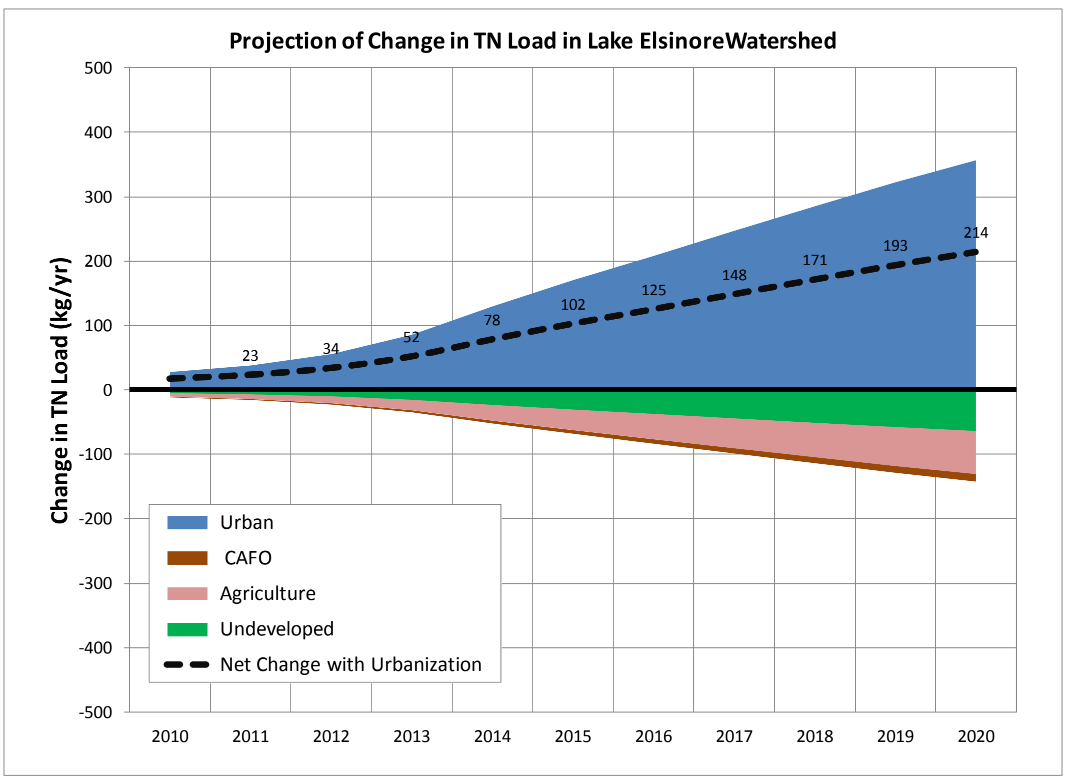

Figure 3-7

Projected TN Load from Urban, Agriculture, CAFO, and Undeveloped Lands in Lake Elsinore Watershed

Table 3-12. Change in Washoff as a Result of Urban Development for MS4 Permittees based on Projections of Buildout Land Use Distribution

MS4 Permittee	Jurisdictional Area (acres)	Current Loading Rate (kg/ac/yr)		Projected Buildout Loading Rate (kg/ac/yr)		Washoff Reduction / (Increase) (kg/yr)	
		TP	TN	TP	TN	TP	TN
Local Lake Elsinore Watershed							
Canyon Lake	316	0.06	0.25	0.06	0.25	0	(0)
Lake Elsinore	13,376	0.04	0.17	0.04	0.18	16	(63)
Menifee	414	0.06	0.16	0.05	0.27	2	(46)
Riverside County	10,574	0.05	0.15	0.05	0.16	(2)	(78)
Wildomar	5,074	0.07	0.23	0.05	0.29	60	(287)
Total	29,754					75	(474)
Canyon Lake Watershed [1]							
Canyon Lake	2,653	0.05	0.28	0.05	0.28	0	0
Hemet	13,020	0.10	0.31	0.05	0.32	652	(90)
Lake Elsinore	1,573	0.03	0.15	0.04	0.18	(3)	(42)
Menifee	28,580	0.12	0.32	0.07	0.31	1450	369
Moreno Valley	27,010	0.09	0.32	0.06	0.33	881	(154)
Murrieta	375	0.08	0.46	0.08	0.46	0	0
Perris	20,277	0.09	0.24	0.04	0.25	1083	(152)
Riverside	511	0.09	0.53	0.09	0.53	0	0
Riverside County	105,127	0.08	0.18	0.05	0.17	3317	792
San Jacinto	223	0.16	0.32	0.16	0.32	0	0
Wildomar	7	0.02	0.05	0.02	0.05	0	0
Total	199,496					7380	722

1) Only areas below Mystic Lake were evaluated for change in watershed washoff as a result of future urban development incorporating LID requirements in WQMPS

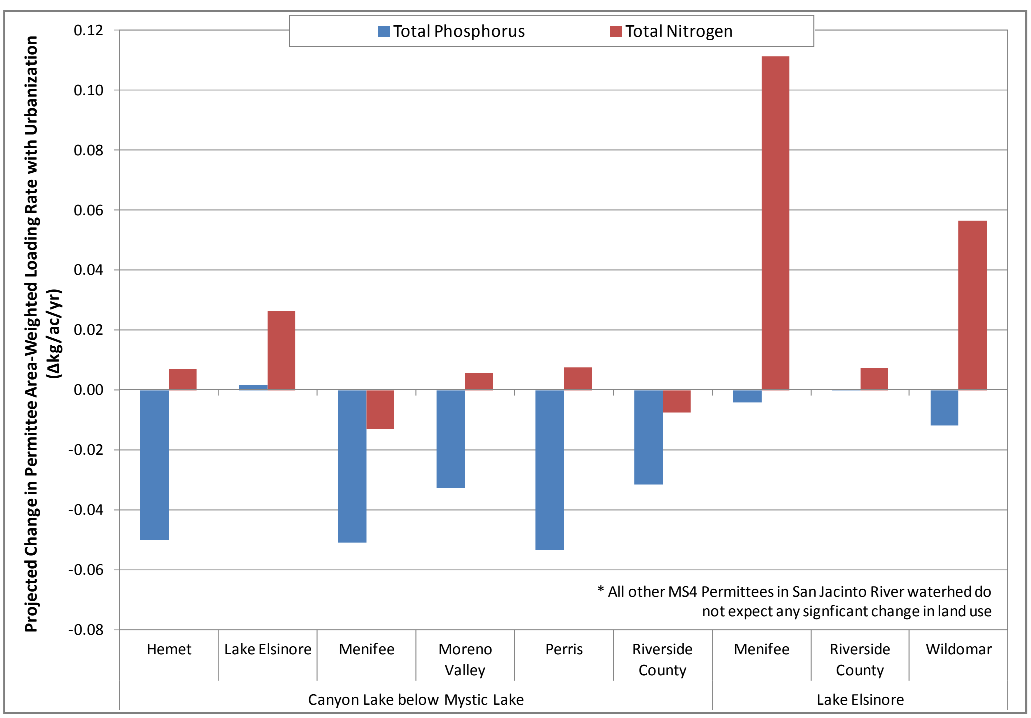

Figure 3-8
Change in Land Use Area Weighted Loading Rates from 2010 to 2020 for Permittees with Urban Growth Potential in the San Jacinto River Watershed

3.3.5 Watershed BMP Summary

Table 3-13 provides a summary of the estimated reduction of TP and TN washoff from MS4 drainage areas in the local Lake Elsinore and Canyon Lake watersheds. Washoff reductions include accrued benefits from MS4 program implementation since the adoption of the TMDL as well as future projections of program implementation. Future development in the watershed generates the greatest reduction in TP loading for the Canyon Lake watershed, due to the combined benefit of lower TP washoff rates for urban land uses (as compared to agricultural land uses) and the additional reduction in urban washoff from new WQMP requirements. Conversely, future development is expected to result in a net increase in loading for TN in Canyon Lake and TN and TP in the Lake Elsinore watershed. Increased washoff of nutrients occurs when expected benefits of new LID requirements for new development do not offset higher washoff rates for urban land use relative to pre-developed condition (open space/forest have lower TP and TN washoff rates and some agricultural land uses have lower TN washoff rates relative to some urban land use categories).

Table 3-13. Summary of Expected Watershed Nutrient Washoff Reduction from Implementation of MS4 Stormwater Programs for Lake Elsinore and Canyon Lake Watersheds

MS4 Permittee	Street Sweeping and Debris Removal (kg/yr)		Existing WQMP BMPs (kg/yr)		Septic System Management / Sewering (kg/yr)[1]		2010-2020 Average Future Urban LID (kg/yr)[2]		Total Watershed Washoff Reduction (kg/yr)	
	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN
Local Lake Elsinore Watershed										
Canyon Lake	0	0					0	(0)	0	0
Lake Elsinore	47	157	145	395	3	37	4	(14)	198	575
Menifee	0	0					0	(10)	0	-10
Riverside County	6	20					(0)	(17)	5	3
Wildomar	4	13			1	12	13	(63)	18	-38
Total	57	189	145	395	4	49	17	(104)	222	529
Canyon Lake Watershed below Mystic Lake										
Canyon Lake	1	4			0.4	6	0	0	2	10
Hemet	114	380	9	22	0.2	3	143	(20)	267	385
Lake Elsinore	6	19					(1)	(9)	5	9
Menifee	5	18	4	6	3.5	53	319	81	331	158
Moreno Valley	132	442	70	136	1.7	26	194	(34)	398	570
Murrieta	4	14	2	11	0.1	1	0	0	7	27
Perris	86	286	341	267	5.7	88	238	(33)	671	607
Riverside	4	14	25	41			0	0	29	56
Riverside County	52	175	1	2	7.1	108	730	174	790	458
Total	406	1352	450	476	19	284	1,624	159	2,500	2,280

1) Loading factor not required for is accounting failing septic system reductions in lake loads. For all other watershed BMPs, loading factor must be included in determining resulting reduction in loads to lakes

2) Negative values indicate an increase of watershed nutrient washoff. Change in loads as a result of urbanization is representative of roughly 22 percent of buildout growth forecasted to occur by 2015.

Reductions of watershed nutrient washoff (using the appropriate loading factors in Table 3-3) translate to reductions in nutrient load to Canyon Lake and Lake Elsinore. Table 3-11 shows the remaining load reduction requirement after accounting for watershed washoff reductions. The MS4 Permittees will meet these load reductions through implementation of in-lake remediation projects. The values reported in Table 3-14 are based on a projection of 22 percent of urban growth occurring by 2015 in the San Jacinto River watershed. This closely approximates the 2010-2020 average and is therefore consistent with averaging period for WLAs included in the TMDL. Figure 3-9 shows the projected trend in load reduction needs from in-lake remediation strategies in both Canyon Lake and Lake Elsinore. The changes in load reduction requirements over time show an increasing need to reduce TN and a decreasing need to reduce TP. This is largely due to higher TN loading rates for residential land uses in the 2010 watershed model.

Table 3-14. Calculation of Load Reduction Requirements to be Achieved with In-Lake Remediation

MS4 Permittee	Total Load Reduction Requirement (kg/yr)		Watershed Load Reduction / (Debit) [1] kg/yr)		In-Lake BMP Load Reduction Requirement (kg/yr) [2]	
	TP	TN	TP	TN	TP	TN
Local Lake Elsinore Watershed [2]						
Canyon Lake	10	58	0	0	10	58
Lake Elsinore[3]	217	1,202	198	575	19	627
Menifee	4	13	0	(10)	4	23
Riverside County	83	446	5	3	78	443
Wildomar	103	556	18	(38)	85	594
Total	417	2,275	222	529	195	1745
Canyon Lake Watershed						
Canyon Lake	52	145	1	8	51	137
Hemet	96	320	139	232	(43)	88
Lake Elsinore	18	44	3	6	15	38
Menifee	199	578	174	116	25	462
Moreno Valley	509	1,486	208	352	301	1,134
Murrieta	1	2	3	17	(2)	(15)
Perris	169	455	352	399	(183)	56
Riverside	16	52	15	33	1	19
Riverside County	261	609	414	318	(153)	291
Total	1,320	3,691	1308	1477	11	2,209

1) Load reduction from watershed takes into account a washoff loading factor, whereby only a portion of the expected washoff reduction in Table 3-10 is translated to a reduction in loading to Lake Elsinore and Canyon Lake. Load reductions for septic system management and sewering projects are not subject to this loading factor, because the watershed model simulated failing septic systems as direct points sources to Lake Elsinore and Canyon Lake.

2) Does not include baseline sediment nutrient flux reduction necessary to create assimilative capacity for phosphorus in Lake Elsinore, allowing for TMDL WLAs above zero.

3) The City of Lake Elsinore currently participates in, or operates, several in-lake watershed programs that exceed their current load reduction obligations shown above. These programs include aeration, fishery management and lake-water addition

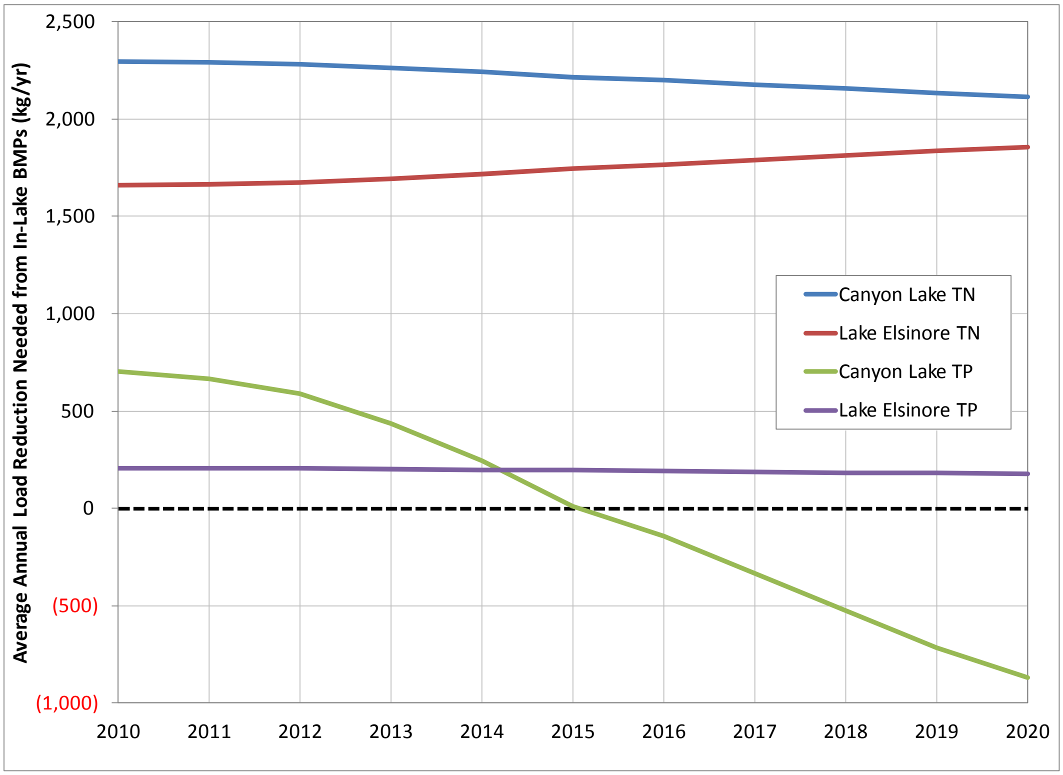

Figure 3-9
Projection of Load Reduction Needed from In-Lake Nutrient Reduction BMPs

3.4 Load Reduction from In-Lake Remediation Projects

Reducing loads to the WLA via watershed-based BMPs would be nearly impossible and extremely costly. Watershed-based BMPs would need to be designed to treat extreme storm events; whereas they are typically designed to treat smaller storm events (e.g. 1" or less of rainfall). Additionally, watershed controls would require significant rights-of-way to store and treat rainfall runoff from the 740 sq. mi. watershed. For example, using unit costs of $20,000-$80,000 per impervious acre treated (CWP, 2007) and an estimate of total watershed imperviousness of ~25,000 acres (30% of urbanized land use), estimated total cost for the Lake Elsinore and Canyon Lake watersheds could range from $500 million to $2 billion if watershed BMPs were solely deployed.

Alternatively, for lake nutrient TMDLs, water quality objectives can be achieved through the implementation of in-lake remediation projects in Lake Elsinore and Canyon Lake. Reduction of internal nutrient loads can offset reductions required from urban and septic sources that cannot be achieved with existing and planned watershed BMPs. The Task Force is developing a Pollutant Trading Plan (PTP) that describes the approach to be used by all stakeholders to offset watershed load reductions using in-lake BMPs (see Attachment F). The following sections describe existing in-lake remediation activities ongoing in Lake Elsinore and in-lake remediation project planned for Canyon Lake.

3.4.1 Lake Elsinore

Three in-lake remediation projects (or BMPs) are being implemented currently in Lake Elsinore: operation of an aeration system, fishery management, and lake stabilization through the addition of reclaimed water. Various parties subject to the TMDL have implemented each of these projects through the Task Force. The Permittees have determined that support of aeration is sufficient to achieve in-lake nutrient load reduction needed to offset remainder of urban and septic load in excess of WLAs and LAs, as demonstrated in this section.

An average annual estimate of internal TP loading from sediments of 33,160 kg/yr for Lake Elsinore was found to exceed the TMDL allocation of 28,634 kg/yr, leaving no assimilative capacity for external loading (Regional Board, 2004). However, since the Lake Elsinore aeration system was planned for implementation at the time of TMDL adoption, a 35 percent TP reduction was assumed to create assimilative capacity and allow for development of LAs and WLAs for external sources, including open space. This assumed reduction in TP requires that all sources with WLA or LAs in the San Jacinto River watershed continue to operate the aeration system to achieve the presumed 35 percent TP reduction, referred to as the baseline sediment nutrient reduction requirement. For the MS4 Permittees, the baseline sediment nutrient reduction requirement is approximately 875 kg/yr, 7.5 percent of the total presumed load reduction of 11,606 kg/yr (35 percent of 33,160 kg/yr internal TP load). Table 3-15 provides the basis for determining the MS4 Permittee portion of the baseline sediment nutrient reduction requirement.

Table 3-15. Baseline Sediment Nutrient Reduction Requirement for MS4 Permittees

Nutrient Source	Watershed	WLA/LA Relative to Total Lake Elsinore WLA[1]	Baseline Sediment Nutrient Reduction Requirement (kg/yr)
Urban	Local Lake Elsinore	1.8%	208
	Canyon Lake [2]	3.3%	379
Septic	Local Lake Elsinore	1.0%	116
	Canyon Lake [2]	1.5%	172
Total		7.5%	875

1) For the local Lake Elsinore watershed, the urban WLA of 124 kg/yr is 1.8% and the septic LA of 69 kg/yr is 1.0% of total external load allocation of 6,922 kg/yr for reclaimed water, urban, septic, agriculture, and transfer from Canyon Lake
2) Transfer WLA from Canyon Lake watershed of 2,770 kg/yr is 40% of total external load allocation of 6,922 kg/yr. The urban and septic portion of the transfer from Canyon Lake to Lake Elsinore was assumed to be equal to the relative allocation of allowable loads in the Canyon Lake TMDL; urban WLA of 306 kg/yr is 8.0% and septic LA of 139 kg/yr is 3.6% of the total external load allocation of 3,845 kg/yr. Therefore the portion of baseline sediment nutrient reduction requirement assigned to urban and septic nutrient sources in Canyon Lake watershed is 3.3% (0.40 * 0.08) and 1.5% (0.40 * 0.036), respectively.

In addition to the baseline sediment nutrient reduction requirement, the MS4 Permittees in the local Lake Elsinore watershed must demonstrate ~200 kg/yr TP reduction and ~1,800 kg/yr TN reduction. Alternatively, in-lake BMPs that have the potential to achieve numeric targets for response variables (DO, Chlorophyll-a) can substitute for a demonstration of nutrient mass reduction. Table 3-16 summarizes the water quality benefits of existing Lake Elsinore in-lake BMPs. As shown, the aeration system has more than enough capacity to meet baseline sediment nutrient reductions and additional needs to meet urban WLAs and septic LAs.

The addition of reclaimed water and fishery management do not provide a direct TN reduction, but may achieve compliance by helping to meet numeric targets for response variables DO and chlorophyll-a in Lake Elsinore, although this relationship is currently not clearly documented. Table 3-17 shows the portion of TP and TN load reduction required for each MS4 Permittee, including the baseline sediment nutrient reduction. If monitoring data show that the existing BMPs are not sufficient to achieve the WLA or in-lake response variable numeric targets, supplemental nutrient control strategies may be a part of an adaptive implementation strategy.

Table 3-16. Summary of Water Quality Benefits of Existing and Potential Supplemental Lake Elsinore In-Lake BMPs

In-Lake BMP	Nutrient / Response Variable	Benefit	Process
Aeration system	Phosphorus	11,606 kg/yr [1]	Suppression of sediment nutrient flux
	Nitrogen	69,080 kg/yr [2]	Suppression of sediment nutrient flux
		11,600 kg/yr [3]	Nitrification / denitrification
		17,500 kg/yr [3]	Sequestration in benthic felt
	Dissolved Oxygen	~2 mg/L at bottom	Mixing of water column
Fishery management	Phosphorus	1,670 kg/yr [4]	Reduction of bioturbation by Carp
	Chlorophyll	Unknown	Reduction of zooplankton predation by Shad
Reclaimed water addition / lake level stabilization	Chlorophyll	10.2 ug/L	Increased depth increases light limitation needed for algal growth; increased habitat for zooplankton that predate algae; decreased salinity allows for zooplankton survival
	Nitrogen	700 kg/yr [5]	Increased bank vegetation density provides sink for nutrient
	Phosphorus	Unknown	Increased bank vegetation density provides sink for nutrient and stabilizes bottom sediment; Prevention of wind-driven resuspension; dilution of Soluble Reactive Phosphorus (SRP) released from sediment

1) Assumed reduction in TMDL
2) Based on model of aeration included in Attachment C
3) Based on estimate of study of Lake Elsinore following aeration (Horne, 2009)
4) Based on study of bioturbation role in internal nutrient flux (Anderson, March 2006). Bioturbation by Carp are estimated to cause 6.9% of internal loading. Reduction of carp by 75% would reduce total TP internal load by 1,570 kg/yr (33,160*0.069*0.75)
5) Horne, 2011 developed a relationship between nutrient load reduction and reduced chlorophyll concentration of 10.2 ug/L per foot of water level rise observed in the summer season following the 2004-05 wet season. For an average annual water level increase of 1.7 ft achieved by addition of 6,000 AFY of reclaimed water, an estimated 0.9 tons TP and 9.0 tons TN would offset nutrients associated with reclaimed water addition. For TP, this offset is less than reclaimed water addition, thus reclaimed water is only partially offset, For TN, this offset is 0.8 tons (~700kg/yr) greater than TN in reclaimed water addition, thus there is a net reduction in TN as a result of lake water addition. The City of Lake Elsinore has a 50/50 cost share with EVMWD for current reclaimed water additions to stabilize lake levels.

3.4.2 Canyon Lake

Concurrent to the development of the CNRP, the MS4 Permittees have initiated an independent review and evaluation of different strategies for in-lake reduction of nutrient levels in Canyon Lake (see Attachment C). A technical memorandum was completed that describes the approaches under consideration, evaluates and compares the approach on the basis of technical feasibility, load reduction potential for both TP and TN, cost-effectiveness, potential environmental issues, regulatory permitting requirements, public acceptance and other factors. Evaluated in-lake BMPs included:

- Installation of a HOS
- Addition of nutrient-reducing chemical compounds: alum, Phoslock®, and Zeolites
- Combination of HOS and chemical compound addition

Table 3-17. Lake Elsinore In-Lake BMP Load Reduction Requirements for MS4 Permittees

Jurisdiction	Baseline Sediment Nutrient Reduction (kg TP/yr)	Load Reduction Needed to Meet WLA (kg TP/yr)	Total TP Load Reduction Needed (kg/yr)	Total TN Load Reduction Needed (kg/yr)
Beaumont [1]	0.01		0.01	
Canyon Lake	20	10	30	57
Hemet [1]	29		29	
Lake Elsinore[2]	207	19	226	627
Menifee	108	4	112	23
Moreno Valley [1]	169		169	
Murrieta [1]	0.4		0	
Perris [1]	49		49	
Riverside [1]	4		4	
Riverside County	215	77	293	444
San Jacinto [1]	0.04		0.04	
Wildomar	73	85	158	594
Total	875	195	1,070	1,745

1) MS4 Permittees in Canyon Lake watershed responsibility is only to meet the baseline sediment nutrient reduction requirement only

2) The City of Lake Elsinore currently operates several in-lake treatment systems that result in load reductions exceeding their regulatory requirements including aeration, fishery management and lake water addition.

This evaluation recommended that the MS4 Permittees select HOS to address nutrients and nutrient related impairments in the main body of Canyon Lake. To ensure that the Permittees can achieve the TMDL WLA, the Permittees are moving forward with the HOS. However, the Permittees are continuing to evaluate alternatives including phoslock and zeolite applications to Canyon Lake and if roadblocks to the HOS prevent timely deployment, or should one of these alternatives be determined to be superior, the Permittees may recommend switching to an alternative in-lake BMP.

The detailed basis for this recommendation can be reviewed in Attachment C. HOS is used to inject pure oxygen into the anoxic water layer overlying the sediment, which can rapidly increase DO concentrations throughout the hypolimnion. The increase in DO greatly reduces the cycling of nutrients from the sediment into the water column. This can result in significant reductions in the overall nutrient concentrations in the lake, or to the desired TMDL endpoints.

If the full Option 10b system installed in the main body is operated, and the increased dissolved oxygen in the hypolimnion maintained as projected, it is anticipated that a relatively large reduction in the release of phosphorus and a lesser reduction in the release of ammonia from the sediments could be achieved. Furthermore, it is anticipated that the system would be able to maintain its effectiveness fairly consistently from year to year. Incubation testing predicted that the HOS system could be effective in reducing the SRP flux from the sediments by 71 percent and the ammonia (NH_4-N) flux by 35 percent (Anderson, 2007). As an independent check, a limited evaluation of the potential for sediment flux reduction was performed, using a modeling approach and parameters developed from a recent study for the City of Los Angeles for Machado Lake (CDM, 2010). This analysis suggested that there is potential to achieve even larger reduction in sediment flux, approaching 90 percent SRP and 60 percent NH_4-N.

Table 3-18 shows that the estimated internal load reductions from the HOS are expected to be sufficient to offset the nutrient load reduction requirement for urban and septic sources for TP (~10 kg/yr) and TN (~2,200 kg/yr), based on land use projection and watershed BMP implementation for the 2010 to 2020 period (see Table 3-14). As can be seen from Table 3-14, most of the HOS TN reduction capacity is needed to achieve compliance with the WLA for total nitrogen, while TP is expected to be mostly reduced to the urban WLA and septic LA with implementation of watershed BMPs. Thus, operation of the HOS, could reduce TP in excess of the urban WLA and septic LA, which provides an additional margin of safety for the CNRP to meet numeric targets in Canyon Lake.

3.5 Compliance Summary

Table 3-18. Internal Nutrient Load Reduction from Implementation of HOS in Main Body of Canyon Lake

Nutrient	Lake Segment	TMDL Estimate of Sediment Nutrient Flux (kg/yr)	HOS Effectiveness (kg/yr)	Load Reduction (kg/yr)	Load Reduction Needed from MS4 Permittees (kg/yr) [1]
Nitrogen as NH_4-N	Main Body	8,578	35%	3,002	2,209
	East Bay [2]	4,971	n/a	n/a	
Phosphorus as SRP	Main Body	2,685	70%	1,880	11
	East Bay [2]	1,940	n/a	n/a	

1) See Table 3-14 for division of load reduction needs for each Permittee in Canyon Lake watershed

2) Proposed HOS does not extend into shallower East Bay of Canyon Lake. Sediment nutrient flux would only be achieved in the Main Body

3.5.1 Wasteload and Load Allocations

WLAs and LAs for Lake Elsinore and Canyon Lake are expected to be achieved following implementation of watershed and in-lake BMPs included in the CNRP. Table 3-4 shows the load reduction requirements to reduce existing loads to the urban WLAs and septoic LAs, Table 3-14 shows how watershed BMPs contribute to this required reduction, and Tables 3-16 and 3-18 show that existing and proposed in-lake BMPs in Lake Elsinore and Canyon Lake have sufficient nutrient load offset capacity for the MS4 Permittees to achieve urban WLAs and septic LAs.

Compliance with WLAs and LAs is evaluated by assessing 10-year running averages of modeled TP and TN loading to Lake Elsinore and Canyon Lake. Presuming all other allocations are achieved by open space/forest, reclaimed water, agriculture, and CAFOs, the 10 year running average of TP and TN loads will be reduced to levels determined in the TMDL to be protective of water quality objectives in Lake Elsinore and Canyon Lake. Since the 10 year running average in 2020 includes lake water quality data beginning in 2010, some portion of the compliance period will not reflect conditions of a) a completed HOS operating in Canyon Lake or b) the aeration system in Lake Elsinore operated at optimal capacity. There are numerous elements of the CNRP intended to provide a margin of safety that could help alleviate the higher internal loading rates in the beginning years of the 2010-2020 compliance averaging period. The CNRP implementation schedule provides a roadmap to assist the MS4 Permittees to implement key elements of the plan as efficiently as possible to increase the number of years when water quality benefits from internal loading offset are able to accrue.

The 2010 watershed model was modified to also evaluate watershed loads to Canyon Lake and Lake Elsinore[1] for a pre-development or natural condition in the San Jacinto River watershed. Figure 3-10 compares existing and pre-development scenarios annual loading and 10-year running averages for TP and TN in the local Lake Elsinore and Canyon Lake watersheds.

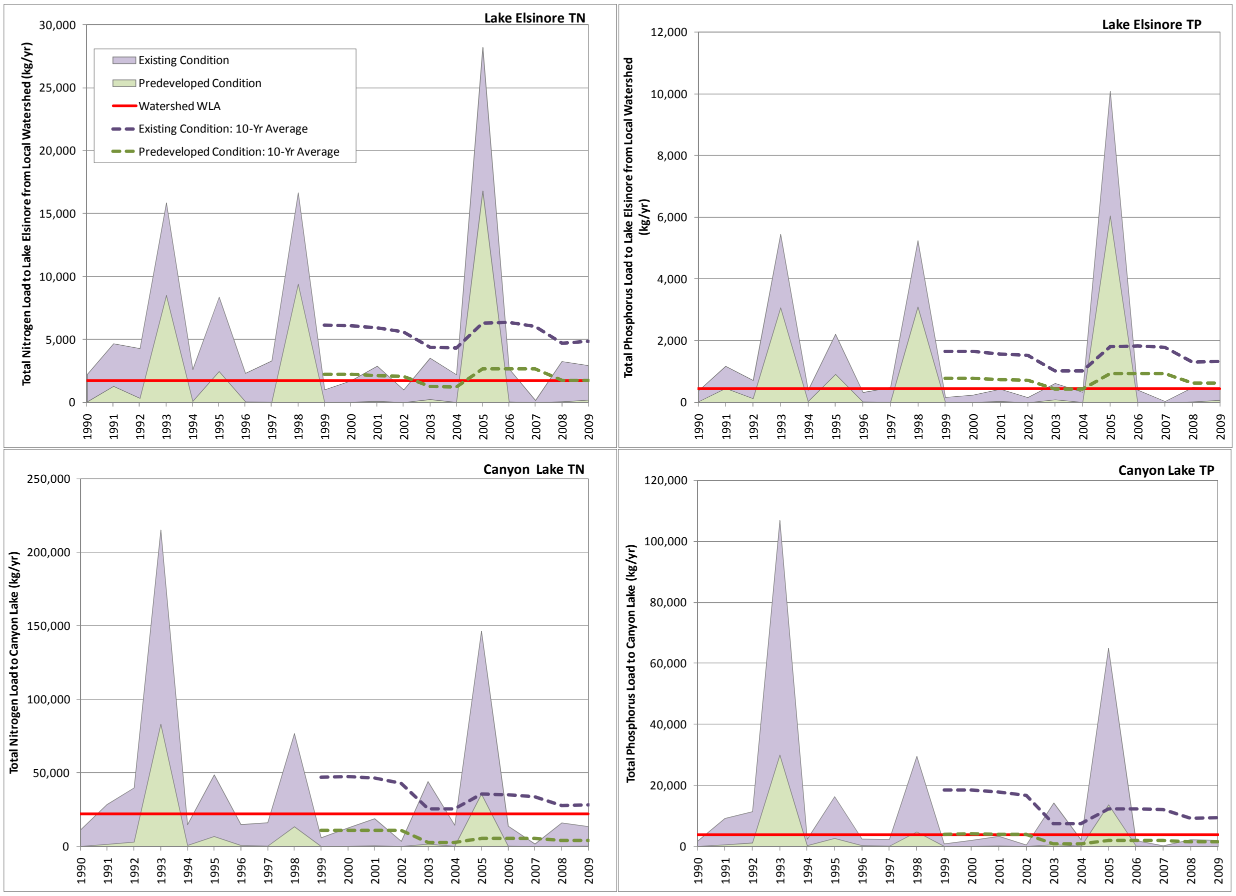

Figure 3-10
Comparison of Modeled Existing Load with Natural Conditions Assessment Scenario

These charts show that even in a predevelopment scenario, it is common for wetter hydrologic years to result in 10-year average watershed loads in excess of the WLA, which suggests that numeric response targets in Lake Elsinore and Canyon Lake may not be attained in natural conditions. Thus, it may be appropriate to propose a revision of numeric targets from use of daily, seasonal, or annual averages, to incorporate a provision to allow for a natural background standard. The Permittees reserve the right to request such amendments should effectiveness data indicate that the current TMDL is unattainable.

3.5.2 Environmental Response Variables

The eutrophic impairment in Lake Elsinore and Canyon Lake is attributable to increased nutrient loading to a waterbody and the resulting increased growth of biota, phytoplankton and other aquatic plants.

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[1] The 2010 watershed model did not explicitly simulate loading to Lake Elsinore for the pre-development scenario. Instead, nutrient loading rates for open space from the calibrated model, were extrapolated over the entire local Lake Elsinore watershed to approximate loading. This approach neglects decay that may have occurred as nutrients are transported from sources areas to Lake Elsinore.

Phosphorus and nitrogen are recognized as key nutrients for phytoplankton growth in lakes and are responsible for the eutrophication of surface waters. It may be possible to achieve numeric targets for eutrophic response variables with nutrient loads in excess of TP and/or TN WLAs and LAs. The MS4 Permit allows for the Permittees to achieve compliance with the LE/CL Nutrient TMDL by either achieving urban WLAs and septic LAs or meeting numeric targets for eutrophic response variables, including chlorophyll-a and dissolved oxygen (see Table 1-1). A study of in-lake BMP effectiveness indicated that HOS combined with external watershed load reduction of 25 percent should be sufficient to attain both chlorophyll and DO targets (Anderson, 2007).

3.5.3 Uncertainty

The CNRP is expected to achieve compliance with long-term average annual WLAs for urban and septic sources. The CNRP is conservative in its approach as evidenced by the factors described below.

Use of 2010 Watershed Model Update

Load reduction requirements for this CNRP compliance analysis were based on existing load estimates from the 2010 watershed model update. Since the adoption of the TMDL, urban land use has increased while agricultural land use has declined and this trend is expected to continue as the watershed approaches a buildout condition. Accordingly, the 2010 watershed model update generally showed an increased nutrient load from urban sources and a decreased nutrient load from agricultural sources. Septic loads also decreased based on the more accurate accounting of septics resulting from the 2007 SSMP. CAFO loads increased. The TMDL did not account for future changes in land use distribution in the watershed. To assess the impact of these changes on the feasibility of meeting the TMDL, WLAs were converted to per acre allowable loading rates using land use acreage used to develop the TMDL and the 2010 watershed model update (Figure 3-12). Figure 3-12 shows that maintaining the same mass based WLAs, as set in the TMDL, would reduce the allowable per acre loading rate for urban and septic sources, and increase the allowable per acre loading rate for agricultural and CAFO sources. Ultimately, this issue should be addressed in a supplemental Basin Plan Amendment as per acre loading rates should be based on achievable wash-off rates for each land use and not subject to change due to land use conversion.

Potential Benefit of Margin of Safety BMPs

Studies have shown that education and outreach programs and/or ordinance enforcement actions may result in a measureable change in human behavior, thereby providing a reduction in a specific source of nutrients available for washoff into MS4s in the watershed. However, quantification of potential washoff reductions entail estimations with a high level of uncertainty. This compliance analysis estimates the potential washoff reduction for education, outreach and enforcement programs, but then uses these estimations as a "margin of safety" for MS4 compliance with the TMDL. Therefore, the load reduction value of these BMPs are not included to attain TMDL WLA as a result of the reduced load reduction from reduced street sweeping. To approximate the additional MOS provided by such BMPs for this CNRP, it was assumed that 15 percent of pollutant sources in the watershed could be reduced from current conditions with enhanced and targeted education and outreach programs or by enforcement of existing ordinances. Rough estimates were developed to approximate the additional MOS provided by improvements to how residents manage potential sources of nutrients in the watershed (Table 3-19).

Table 3-19. Estimate of Potential Load Reduction provided by Margin of Safety BMPs which Target Human Behaviors

Targeted Source	Variable	Local Lake Elsinore	Canyon Lake below Mystic Lake[1]
Fertilizer Management	Urban Acreage	8,469	57,609
	TP Reduction (kg/yr)	34	120
	TN Reduction (kg/yr)	102	415
Pet Waste Management	Dog Population	22,259	129,043
	TP Reduction (kg/yr)	17	50
	TN Reduction (kg/yr)	17	58
Green Waste Management	Residential Road Miles	137	959
	TP Reduction (kg/yr)	9	34
	TN Reduction (kg/yr)	62	261
Total MOS BMPs	TP Reduction (kg/yr)	60	204
	TN Reduction (kg/yr)	180	733
% of Required Load Reduction[2]	TP	14%	15%
	TN	8%	20%

1) Incorporates loading factors of 52 percent for TP and 60 percent for TN to account for nutrients that may have been retained in-stream between the source areas and Canyon Lake without BMP implementation
2)k Load reduction required in TMDL, used for developing the CNRP already includes a 10 percent MOS, thus these BMPs provide additional MOS

The basis for these estimates involves an assessment of the relative role of targeted nutrient sources in the downstream load of nutrients. Estimates of reductions in loads to Canyon Lake also incorporated a loading factor to account for nutrients that would be retained in-stream between the source area and lake inflow without BMP implementation (see Table 3-3).

In the case of the CNRP, education and outreach programs and ordinance enforcement actions are focused on three main sources of nutrient in urban watersheds; fertilizer, pet waste, and green waste. A nitrogen budget for an urban watershed developed for the Central Arizona-Phoenix long term ecological research (LTER) site found that fertilizer and pet waste may account for as much as 60 percent and 14 percent of total nitrogen inputs (Baker et. al., 2001). Also, the study estimated green waste to account for 28 percent of outputs in the total nitrogen budget. Consequently, there is significant opportunity for reducing downstream nitrogen loads with improved management of these sources in the urban watershed. Load reductions for MOS BMPS targeting each of these sources are described below:

- To quantify reductions in mobilization of fertilizer from application sites to MS4 drainage facilities, several factors were applied to an estimate of the total nutrient load applied to fertilized lawns (assumed to cover 20 percent of the total urban acreage) in the local Lake Elsinore and Canyon Lake watersheds. According to a UCR Agricultural and Natural Resources Publication (Pub No. 8065), typical fertilizer application rates for grass lawns in southern California are 20 kg/ac/yr nitrogen and 7 kg/ac/yr phosphorus. Several studies have found nutrient loss in surface runoff as a result of fertilizer application to be about 2-5 percent for nitrogen (Groffman et al., 2004; Baker et al., 2001) and less than 10 percent for phosphorus (Soldat and Petrovich, 2008). Thus, a

CDM Smith

conservative factor of 2 percent was used to estimate the mass of nutrients that could be reduced through fertilizer management that is 15 percent more effective than current conditions (Table 3-20).

- For MOS BMP implementation addressing pet waste, the method used to estimate nutrient washoff involved several factors to convert dog population to nutrient accumulation, and loss from lawns during a rain event. The population of dogs in the Canyon Lake and Lake Elsinore watersheds was approximated by applying a US average dog ownership ratio of 1 dog per four persons to the approximate population within the watershed (see Table B-1). An average dog generates about 125 kg/yr of feces which has a composition of roughly 1 percent nitrogen and 1 percent phosphorus. If 50 percent of dog feces is available for washoff (i.e. not picked up), then the annual accumulation would be about 0.6 kg/dog/yr for both TP and TN. For pet waste it was assumed that loss of nutrients in surface runoff is 1 percent, which is half of the abovementioned value used for fertilizer, a more readily soluble material. Assuming 15 percent effectiveness in the MOS BMPs, the reduction in nutrient washoff related to pet waste management is estimated, as shown in Table 3-20.

- The method used to estimate nutrient washoff reduction from improved green waste management on impervious surfaces, such as roads and driveways, involved application of the same model developed to simulate benefits of street sweeping (see Section 3.3.1). The buildup/washoff model determined a washoff reduction benefit of improved green waste management of approximately 0.07 kg/mi/yr for TP and 0.45 kg/mi/yr for TN. The basis for the buildup model was a study of green waste in Plymouth and Maple Grove, MN, which found a grass clipping accumulation rate on average to be 3 kg/curb mi/day and a composition of TP and TN in grass clippings of 0.3 and 2.0 percent, respectively (Minnesota Pollution Control Agency, 2008). Assuming 15 percent effectiveness in the MOS BMPs, the buildup of green waste on impervious areas was reduced for the buildup/washoff simulation. The estimated reductions from MOS BMPs targeting green waste left on impervious surfaces, such as roads and driveways, are shown in Table 3-20.

We believe these conservative factors offset the other sources of uncertainty in the determination that the CNRP, once implemented will achieve the WLAs for urban and septic sources. Specifically, estimates of reduction in nutrient washoff from MS4 drainage areas involved many assumptions on effectiveness, urban growth rates, and stormwater program implementation. Also, through nutrient offsets, in-lake BMPs are responsible for the majority of load reduction by MS4 Permittees needed to achieve WLAs, yet nutrient load reduction estimated from implementation of the HOS in Canyon Lake and aeration system in Lake Elsinore are based on limited empirical modeling and incubation studies.

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Attachment A
TMDL Implementation

A.1 Introduction

TMDL coordination efforts have been underway since August 2000, well before adoption of the Lake Elsinore and Canyon Lake Nutrient TMDLs ("Nutrient TMDLs"). These activities were coordinated and administered through the Lake Elsinore San Jacinto Watersheds Authority (LESJWA), a joint powers authority. The Santa Ana Regional Water Quality Control Board (Regional Board) adopted the Nutrient TMDLs on December 20, 2004; the Nutrient TMDLs became effective on September 30, 2005, after EPA approval. The existing TMDL stakeholders formally organized into a funded TMDL Task Force in 2006. This Task Force in coordination with LESJWA has been actively involved in the implementation of the TMDL requirements. The following sections describe the organizational structure and responsibilities of LESJWA and the Task Force and status of TMDL implementation activities, as applicable to the MS4 Permittees.

A.2 Lake Elsinore San Jacinto Watersheds Authority

LESJWA is made up of representatives from the Santa Ana Watershed Project Authority, Elsinore Valley Municipal Water District, City of Lake Elsinore, City of Canyon Lake and County of Riverside. LESJWA was formed in April of 2000 after California voters passed Proposition 13, a bond measure to fund water projects throughout the State. Proposition 13 earmarked $15 million for LESJWA to implement projects to address the impairments in Lake Elsinore and Canyon Lake. LESJWA is charged with improving water quality and protecting wildlife habitats, primarily in Lake Elsinore, but also in Canyon Lake and the surrounding watershed. Several LESJWA projects are central to the stakeholder TMDL compliance strategies, including:

- Lake Elsinore Aeration System
- Lake Elsinore Wetland Enhancement
- Lake Elsinore Carp Removal
- Lake Elsinore Axial Flow Pumps
- Lake Elsinore Island Wells
- Lake Elsinore Dredging Project

LESJWA has conducted several studies to evaluate lake conditions, alternative management measures and potential funding mechanisms. These efforts provide the basis for ongoing compliance work of the TMDL Task Force. In addition, the TMDL Task Force continues to rely on the LESJWA Technical Advisory Committee for technical guidance.

A.3 Lake Elsinore and Canyon Lake TMDL Task Force

In December 2004, all responsible parties named in the TMDL began the process of creating a formal cost-sharing body, or Task Force, to collaboratively implement various requirements defined in the implementation plan for the nutrient TMDLs. A Task Force Agreement was signed March 5, 2007. The purpose of the Task Force is to conduct studies necessary to collect data to analyze the appropriateness of the TMDL, identify in-lake and regional watershed solutions, pursue grants, coordinate activities among all of the various stakeholders, and recommend appropriate revision to the Basin Plan language regarding Lake Elsinore and Canyon Lake based on data collection and analysis. The Task Force includes the following participants:

- County of Riverside
- Riverside County Flood Control & Water Conservation District
- City of Beaumont
- City of Canyon Lake
- City of Hemet
- City of Lake Elsinore
- City of Menifee
- City of Moreno Valley
- City of Murrieta
- City of Riverside
- City of San Jacinto
- City of Wildomar
- Elsinore Valley Municipal Water District
- Eastern Municipal Water District
- California Transportation Department
- California Department of Fish & Game
- March Air Reserve Joint Powers Authority
- US Air Force (March Air Reserve Base)
- Western Riverside County Agriculture Coalition on behalf of Agricultural & Dairy Operators in the San Jacinto River Basin

SAWPA serves as the administrator for the Task Force. In this role, SAWPA provides all Task Force meeting organization/facilitation, secretarial, clerical and administrative services, management of Task Force funds, annual reports of Task Force assets and expenditures and hiring of Task Force authorized consultants. SAWPA maintains a website with all information developed to date through the Task Force: www.sawpa.org/roundtable-LECLTF.html.

A.4 TMDL Tasks Applicable to MS4 Permittees

The Nutrient TMDLs include 14 tasks in the TMDL implementation Plan (Resolution No. R8-2004-0037). Not all tasks are applicable to the MS4 Permittees. Table A-1 briefly describes each TMDL task, its relevance to the MS4 Permittees, and general status. Further discussion on the status and work performed for each task for which the MS4 Permittees have responsibilities is detailed in the subsections that follow.

A.4.1 Task 2.1 – Review and/or Revise Existing Waste Discharge Requirements, Riverside County MS4 Permit

This task requires that the MS4 permit that authorizes the discharge of stormwater in the Lake Elsinore/Canyon Lake watershed incorporate TMDL provisions. When the TMDL was adopted, the Riverside County MS4 permit (Waste Discharge Requirements for the Riverside County Flood Control and Water Conservation District, the County of Riverside and the Incorporated Cities of Riverside County within the Santa Ana Region, Areawide Urban Runoff, NPDES No. CAS 618033; Regional Board Order No. R8-2002-0011) did not include requirements directly related to the TMDL Implementation Plan or require the Permittees to address the TMDL WLAs. Since the adoption of the TMDL, a new MS4 permit has been adopted (NPDES No. CAS 618033; Regional Board Order No. R8-2010-0033). This permit not only requires completion of the tasks identified by the TMDL, but it also requires the preparation of this CNRP to address the Nutrient TMDL WLAs for urban runoff and LAs for septic sources.

A.4.2 Task 2.2 – Review and/or Revise Existing Waste Discharge Requirements, New Development, San Jacinto Watershed

In 2001 the Regional Board adopted Order No. 01-34 (NPDES No. CAG 618005) that established requirements for discharges of stormwater runoff associated with new developments in the San Jacinto Watershed. The TMDL stated that this Order would be rescinded once the Regional Board approves a WQMP under Order R8-2002-0011 (existing MS4 permit at time of TMDL permit adoption).

The Regional Board approved the MS4 program's revised WQMP (Order R8-2004-0080), which became effective September 17, 2004. Subsequent to the approval of this Order, the Regional Board approved Order R8-2005-0038 that amended Order 01-34 to state that projects that implement an approved WQMP are exempt from Order 01-34.

The Riverside County MS4 program is currently revising its WQMP again to incorporate LID-based BMP requirements contained in the most recently adopted MS4 permit (January 29, 2010). A draft WQMP was submitted to the Regional Board on July 29, 2011; a final WQMP was submitted June 28, 2012 and is pending Regional Board approval.

Table A-1. TMDL Implementation Plan Tasks Applicable to MS4 Permittees

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
Task 1	Establish new Waste Discharge Requirements (WDR)	Issue new WDR to Elsinore Valley Municipal Water District for supplemental discharges to Canyon Lake	March 31, 2006	Not applicable to MS4 dischargers; per Regional Board status is ongoing
Task 2	2.1 – WDR for Riverside County MS4 Permittees	Revise existing MS4 permit (Order R8-2002-0011) as needed to incorporate TMDL requirements	March 31, 2006	2002 MS4 permit was not revised; new MS4 permit issued on January 29, 2010 includes both TMDL requirements and requirement to complete CNRP.
	2.2 – Watershed-wide WDRs for Discharges of Storm Water Runoff associated with new developments in the San Jacinto Watershed	Rescind Order 01-34 when revised Water Quality Management Plan (WQMP) approved under Order R8-2002-0011	March 31, 2006	Revised WQMP approved by Order R8-2004-0080; Order R8-2005-0038 amends Order 01-34 to state that projects that implement an approved WQMP are exempt from Order 01-34
	2.3 – General WDR for Concentrated Animal Feeding Operations (CAFOs)	Revise existing General WDR (Order 99-11) as needed to incorporate TMDL requirements	March 31, 2006	Not applicable to MS4 dischargers; CAFP WDR adopted per Regional Board Order R8-2007-001
	2.4 – Waste Discharge and Producer/User Reclamation Requirements for the EVMWD, Regional Water Reclamation Facility	Revise Order No. 00-1 to take into consideration Lake Elsinore Recycled Water Pilot Project findings	March 31, 2006	Not applicable to MS4 dischargers; per Regional Board status is complete/ongoing-as needed
	2.5 – WDR for Eastern Municipal Water District (EMWD), Regional Water Reclamation System	If needed, revise order No. 99-5 to address EMWD discharge of recycled water to Lake Elsinore and to take into consideration Lake Elsinore Recycled Water Pilot Project findings	March 31, 2006	Not applicable to MS4 dischargers; per Regional Board status is complete/ongoing-as needed
	2.6 – WDR for US Air Force, March Air Reserve Base	Revise Order R8-2004-0033 to incorporate TMDL requirements	March 31, 2006	Not applicable to MS4 dischargers; per Regional Board status is complete/ongoing-as needed
Task 3	Identify Agricultural Operators	Regional Board will develop a list of all known agricultural operators in the San Jacinto watershed responsible for TMDL implementation	October 31, 2005	Complete

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Table A-1. TMDL Implementation Plan Tasks Applicable to MS4 Permittees (Continued)				
Task No.	**Task Name**	**Task Description**	**Compliance Date (per TMDL)**	**Relevance to Riverside County MS4 Permit and Status**
Task 4	4.1 – Watershed-wide Nutrient Monitoring Plan(s)	TMDL responsible parties to submit collectively or individually a watershed-wide nutrient water quality monitoring program for Regional Board approval; submit modified program as needed	Initial plan due December 31, 2005; Revised plan due December 31, 2006 Annual report due by August 15 each year	Monitoring Program approved by Regional Board in March 2006 (Order R8-2006-0031); Amended monitoring program approved in March 2011 (Order R8-2011-0023; Annual reports submitted through August 25, 2011
	4.2 – Lake Elsinore Nutrient Monitoring Plan(s)	TMDL responsible parties to submit collectively or individually a Lake Elsinore in-lake nutrient water quality monitoring program for Regional Board approval; submit modified program as needed		
	4.3 – Canyon Lake Nutrient Monitoring Plan(s)	TMDL responsible parties to submit collectively or individually a Canyon Lake in-lake nutrient water quality monitoring program for Regional Board approval; submit modified program as needed		
Task 5	Agricultural Discharges – Nutrient Management Plan	Agricultural operators collectively or individually shall submit an NMP that addresses a range of agricultural-related activities	Plan/Schedule due September 30, 2007	Not applicable to MS4 dischargers; draft submitted; final plan due by December 31, 2011
Task 6	On-site Disposal System (Septic Systems) Management Plan	County of Riverside and Cities of Perris, Moreno Valley, and Murrieta shall submit collectively or individually a Septic System Management Plan	Dependent on State Board approval of relevant regulations	Relevant to the following MS4 Permittees; County of Riverside and the Cities of Perris, Moreno Valley and Murrieta; San Jacinto Onsite Wastewater Management Program report was submitted on November 17, 2007; implementation ongoing

Table A-1. TMDL Implementation Plan Tasks Applicable to MS4 Permittees (Continued)

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
Task 7	7.1 – Revision of Drainage Area Management Plan (DAMP)	Revise DAMP to include TMDL requirements	August 1, 2006, ff.	Revised DAMP July 24, 2006, as required by existing permit and TMDL. Entire DAMP revised again July 29, 2011.
	7.2 – Revision of the Water Quality Management Plan (WQMP)	Review WQMP to include TMDL requirements	August 1, 2006,ff.	Revised WQMP submitted July 24, 2006 approved by Order R8-2004-0080; Order R8-2005-0038 amended Order 01-34; additional revision to WQMP to comply with new MS4 permit (Order R8-2010-0033) submitted July 29, 2011; revised WQMP under Regional Board review
	7.3 – Update of the Caltrans Stormwater Management Plan (SWMP) and Regional Workplan	Revise SWMP annually as required; submit a Regional Workplan that includes plans and schedules for meeting TMDL requirements	August 1, 2006	Not applicable to MS4 dischargers; revisions to occur as part of permit renewal process
	7.4 – Update of US Air Force, March Air Reserve Base SWPPP	Revise facility SWPPP as needed to incorporate TMDL requirements	Dependent on nutrient monitoring program results	Not applicable to MS4 dischargers; revisions to occur as part of permit renewal process
Task 8	Forest Area – Review/Revision of Forest Service Management Plans	Submit for approval a plan with a schedule for the identification and implementation of Management Practices to reduce nutrients from Cleveland and San Bernardino National Forests	Plan/schedule due September 30, 2007	Not applicable to MS4 dischargers; considered complete – draft submitted to the Regional Board on September 27, 2007 that stated the existing Forest Plans are sufficient to meet TMDL requirements. Regional Board found the proposed plan and schedule for BMP implementation satisfies TMDL requirements
Task 9	Lake Elsinore In-Lake Sediment Nutrient Reduction Plan	TMDL responsible parties (including MS4 Permittees) to submit collectively or individually a proposed plan and schedule for in-lake sediment nutrient reduction that includes a monitoring program	Plan/schedule due March 31, 2007	Complete; implementation ongoing
Task 10	Canyon Lake In-Lake Sediment Treatment Evaluation	TMDL responsible parties (including MS4 Permittees) to submit collectively or individually a proposed plan and schedule for in-lake sediment nutrient reduction that includes a monitoring program	Plan/schedule due March 31, 2007	Complete

Table A-1. TMDL Implementation Plan Tasks Applicable to MS4 Permittees (Continued)

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
Task 11	Watershed and Canyon Lake and Lake Elsinore In-Lake Model Updates	TMDL responsible parties (including MS4 Permittees) to submit collectively or individually a proposed plan and schedule to update the existing Lake Elsinore/San Jacinto River Nutrient Watershed Model and the Canyon Lake and Lake Elsinore in-Lake models	Plan/schedule due March 31, 2007	Modeling efforts completed December 23, 2010 per June 30, 2011 RCFC&WCD letter to the Regional Board
Task 12	Pollutant Trading Plan	TMDL responsible parties (including MS4 Permittees) to submit collectively or individually a proposed plan, schedule and funding strategy for project implementation, an approach for tracking pollutant credits and a schedule for reporting status of implementation	Plan/schedule due September 30, 2007	Initial plan/schedule for developing Pollutant Trading Plan has been submitted and approved; implementation on-going
Task 13	Review and Revise Nutrient Water Quality Objectives (WQOs)	For Canyon Lake and Lake Elsinore, the Regional Board will (a) review and revise as necessary the total inorganic nitrogen WQOs; and (b) evaluate the appropriateness of establishing total phosphorus and un-ionized ammonia WQOs	December 31, 2009	Regional Board action pending collection of additional data
Task 14	Review of TMDL/WLA/LA	Regional Board will re-evaluate basis for the TMDLs and implementation at least once every three years, and revise TMDL as needed	Once every 3 years	To date, TMDL has not been revised; the next triennial review is scheduled for 2012

A.4.3 Task 4 - Nutrient Water Quality Monitoring Program

Task 4 of the TMDL implementation plan requires the responsible jurisdictions to submit to the Regional Board for approval a proposed watershed-wide compliance monitoring program (Task 4.1) and in-lake compliance monitoring plans for Lake Elsinore (Task 4.2) and Canyon Lake (Task 4.3). The required Monitoring Program should include:

- A watershed-wide monitoring program to determine compliance with interim and/or final nitrogen and phosphorus allocations, and compliance with the nitrogen and phosphorus TMDL, including the waste load allocations (WLAs) and load allocations (LAs).
- A Lake Elsinore in-lake nutrient monitoring program to determine compliance with interim and final nitrogen, phosphorus, chlorophyll a, and dissolved oxygen numeric targets. In addition, this program will evaluate and determine the relationship between ammonia toxicity and the total nitrogen allocation to ensure that the total nitrogen allocation will prevent ammonia toxicity in Lake Elsinore.
- A Canyon Lake nutrient monitoring program to determine compliance with interim and final nitrogen, phosphorus, chlorophyll a, and dissolved oxygen numeric targets. In addition, the monitoring program will evaluate and determine the relationship between ammonia toxicity and the total nitrogen allocation to ensure that the total nitrogen allocation will prevent ammonia toxicity in Canyon Lake.

The Lake Elsinore & Canyon Lake Nutrient TMDL Monitoring Program was approved by the Regional Board March 3, 2006 (Order No. R8-2006-0031). The Task Force submitted a Quality Assurance Project Plan (QAPP), which was also approved by the Regional Board. All required activities have been carried out and Annual Reports prepared and submitted to the Regional Board by August 15th of each year.

The Lake Elsinore and San Jacinto Watershed Authority (LESJWA) on behalf of the Task Force submitted a revised in-lake monitoring program for Lake Elsinore and Canyon Lakes to the Regional Board on December 23, 2010. This proposal also provided a rationale for the deferral of a watershed-wide monitoring program pending development of the CNRP. The Regional Board approved the revised in-lake monitoring program and the request for deferral of the watershed-wide monitoring program to the CNRP (Order No. R8-2011-0023, March 4, 2011).

In a letter dated June 7, 2011 the Task Force requested that monitoring be reduced further to allow resources to be re-focused on the construction of a Hypolimnetic Oxygen System (HOS) in Canyon Lake. However, monitoring efforts would be restored in time to assess compliance with the 2015-16 interim targets. The Regional Board indicated by letter (September 2, 1011) that it may be supportive of further reductions in the monitoring program as long as the reductions are justified and that there are firm and certain commitments by the Task Force to move forward with specific in-lake and/or watershed projects. The Regional Board also stated that reductions in in-lake monitoring may be appropriate given the existing volume of lake data; however, reducing watershed monitoring is a concern given the need to assess compliance with the TMDL, WLAs and LAs. Regardless, the Regional Board agreed to work with the Task Force on the development of a revised monitoring program.

A.4.4 Task 6 - On-site Disposal Systems (Septic Systems) Management Plan

The TMDL implementation plan includes the following requirement, with regards to septic systems:

> "No later than 6 months after the effective date of an agreement between the County of Riverside and the Regional Board to implement regulations adopted pursuant to Water Code Sections 13290-13291.7, or if no such agreement is required or completed, within 12 months of the effective date of these regulations, the County of Riverside and the Cities of Perris, Moreno Valley and Murrieta shall, as a group, submit a Septic System Management Plan to identify and address nutrient discharges from septic systems within the San Jacinto watershed."

The latter approach, implementation of a Septic System Management Plan *(San Jacinto Onsite Wastewater Management Program)* was completed on November 17, 2007. This document establishes a general framework for an onsite wastewater management program, with the assumption that the various agencies involved will further refine their individual programs. Completion of this document satisfied the requirements of the TMDL Task; implementation of the plan is ongoing. The State Board is drafting new OWTS regulations that will enhance regulation of OWTS owners and require additional actions of local government agencies (including MS4 Permittees) with permitting powers over OWTS. Upon adoption of the policy, the MS4 Permittees will revise their programs as required.

A.4.5 Task 7.1 - Revision of Drainage Area Management Plan (DAMP)

The TMDL implementation plan required the MS4 Permittees to revise their DAMP to incorporate TMDL requirements by August 1, 2006. The MS4 program adopted a revised DAMP on July 24, 2006.

On January 29, 2010, the Regional Board adopted a new MS4 permit to authorize the discharge of urban runoff from MS4 facilities in Riverside County within the Santa Ana Region MS4 Permit area. This new permit requires additional updates to the DAMP as appropriate to incorporate interim water quality based effluent-limits established in the permit (Section VI.2.D.a, b). A revised DAMP was submitted to the Regional Board for approval on July 29, 2011 and is pending approval.

DAMP Section 13.4 (July 29, 2011 version) addresses the requirements of the Lake Elsinore/Canyon Lake TMDL. The DAMP includes the following TMDL-specific elements:

- Section 13.4.4.2 summarizes the Permittees' strategy for complying with the TMDL WLA assigned to the specified Permittees.
- Section 13.3 describes programmatic BMPs implemented by the Permittees to address TMDLs in the permitted area, including public education and outreach, inspection and enforcement actions taken by the Permittees. Section 13.4.4.2 and 13.4.4.3 describes the Permittees' participation in the TMDL Task Force and LESJWA, and their roles in assisting the Permittees in implementing TMDL implementation tasks.
- Section 13.4.4.5 describes how the Permittees propose to address BMP Effectiveness evaluations.
- Section 13.4.4.6 describes how the Permittees propose to conduct monitoring to determine compliance with Lake Elsinore and Canyon Lake Nutrient TMDL WLAs assigned to the Permittees.

- In addition to the compliance programs specified above, the Permittees also implement numerous compliance programs that manage nutrient discharges to Canyon Lake and Lake Elsinore. Section 13.4.4.3.2 of the DAMP summarizes these programs, which range from management of sanitary sewer overflows to ensuring appropriate BMP implementation for new development and redevelopment projects. Details regarding each of the summarized programs are provided in other sections of the DAMP.

The DAMP may require additional revision based on the outcome of the CNRP development and approval process. Specifically, the MS4 permit requires incorporation of relevant CNRP elements within 180 days after Regional Board approval of the CNRP.

A.4.6 Task 7.2 - Revision of the Water Quality Management Plan (WQMP)

The TMDL implementation plan required the MS4 Permittees to revise their WQMP (Appendix O of the DAMP) to incorporate TMDL requirements by August 1, 2006. The MS4 program adopted a revised WQMP on July 24, 2006.

On January 29, 2010, the Regional Board adopted a new MS4 permit to authorize the discharge of urban runoff from MS4 facilities in Riverside County within the Santa Ana Region MS4 Permit area. This new permit requires revision to the WQMP to not only incorporate LID-based BMP practices, but also, as appropriate, incorporate interim water quality based effluent-limits established in the permit (Section VI.2.D.a, b) and relevant CNRP elements.

The Riverside County MS4 program submitted a revised WQMP to the Regional Board on July 29, 2011; a final WQMP was submitted June 28, 2012 and is pending Regional Board approval. Additional revision of the WQMP may be required following approval of this CNRP. Specifically, the MS4 permit requires incorporation of relevant CNRP elements into the WQMP within 180 days after Regional Board approval of the CNRP.

A.4.7 Task 9 - Lake Elsinore In-Lake Sediment Nutrient Reduction Plan

The In-Lake Sediment Nutrient Reduction Plan, dated October 31, 2007, relies on existing projects that have been or are being implemented to improve the water quality in Lake Elsinore. These Phase 1 remediation projects include (a) stabilizing Lake Elsinore depth with recycled water; (2) reducing the carp population in Lake Elsinore through a fishery management program; and (3) installing and operating an aeration/mixing system in Lake Elsinore. The Regional Board approved this plan (Order No. R8-2007-0083) on November 30, 2007).

The October 31, 2007 plan included a preliminary list of other mitigation strategies (Phase 2 Alternatives) for potential implementation in the event that the three remediation strategies described above are not sufficient to achieve the in-lake numeric targets for Lake Elsinore. However, in a letter dated June 30, 2011 the Task Force indicated that the Phase 1 projects are performing as expected, and if continued, are likely to achieve the nutrient reductions required to comply with the WLAs and LAs in Lake Elsinore. In its response (September 2, 2011), the Regional stated that while it appears that the Phase 1 projects may be sufficient to reduce phosphorus levels in Lake Elsinore, that nitrogen and chlorophyll-a may not be controlled by the Phase 1 projects and further consideration of Phase 2 projects may be necessary.

Attachment B
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Tables

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Figures

Attachment B
Watershed Characterization

B.1 Introduction

Lake Elsinore and Canyon Lake lie within the San Jacinto Watershed, an area encompassing approximately 780 square miles in the San Jacinto River Basin. Located approximately 60 miles southeast of Los Angeles and 22 miles southwest of the City of Riverside, the San Jacinto Watershed lies primarily in Riverside County with a small portion located within Orange County.

The primary municipalities located in the San Jacinto River Basin include Lake Elsinore, Canyon Lake, Wildomar, Menifee, Perris, Moreno Valley, Hemet, San Jacinto, and Beaumont. Other jurisdictions include unincorporated Riverside County, March Air Force Base, U.S. National Forest lands, Wildlife Reserves, and Native American lands (Figure B-1,). Table B-1 summarizes the area covered by each jurisdiction.

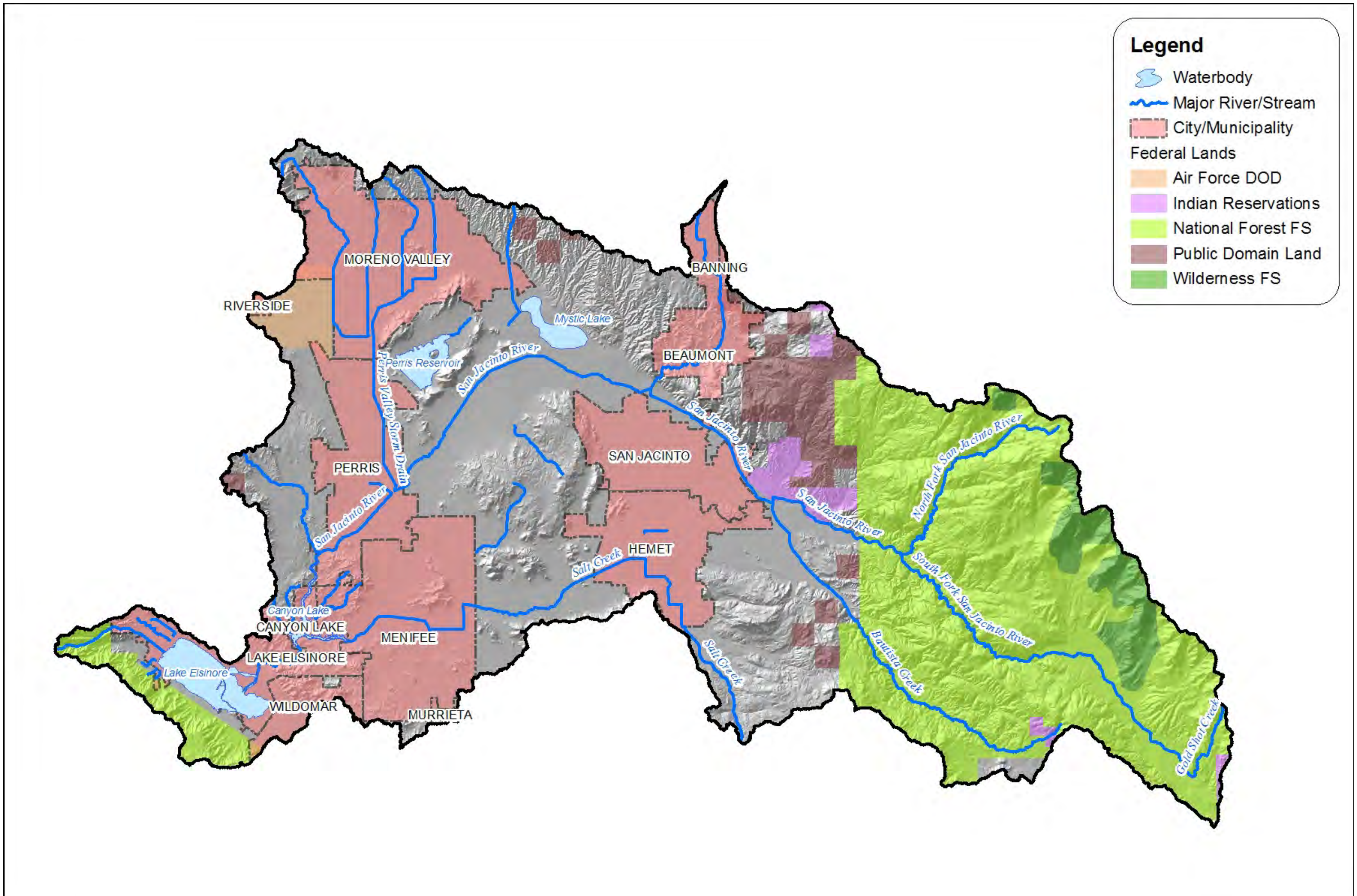
B.2 Land Use

The 2005 Southern California Association of Governments (SCAG) and the 2009 Western Riverside County Agriculture Coalition (WRCAC) land use data were used to characterize land use within the watershed. Where appropriate, land use data were consolidated into broader categories to help accurately support nutrient loading analyses (Table B-2, Figure B-2,). Tetra Tech (2010) provides additional information regarding land classification in the watershed.

Historically, land use development in the San Jacinto watershed has been associated with agricultural activities. However, over the past ten years land use has shifted markedly from agricultural-related to urban. This shift has influenced to a large degree the expected nutrient loading from various portions of the watershed. Although in the last few years the pace of urbanization has declined due to an economic downturn, continued shift from agriculture to urban land is expected to continue.

B.3 Climate

Area climate is characterized as semi-arid with dry warm to hot summers and mild winters. Average annual precipitation in Lake Elsinore/Canyon Lake area is approximately 11 inches occurring primarily as rain during winter and spring seasons (Table B-3). Precipitation in the upper watershed averages 18.7 inches annually. RCFC&WCD monitors precipitation at six rain gauges within the San Jacinto River Basin. Table B-4 lists the monitoring stations and average annual precipitation. Figure B-3 illustrates the location of these gauges.



Comprehensive Nutrient Reduction Plan For MS4 Permittees in Canyon Lake and Lake Elsinore Watershed	Dec. 1, 2011	0 2 4 8 Miles		**Figure B-1**
	Cities, Districts, and Federal Lands in San Jacinto River Watershed			

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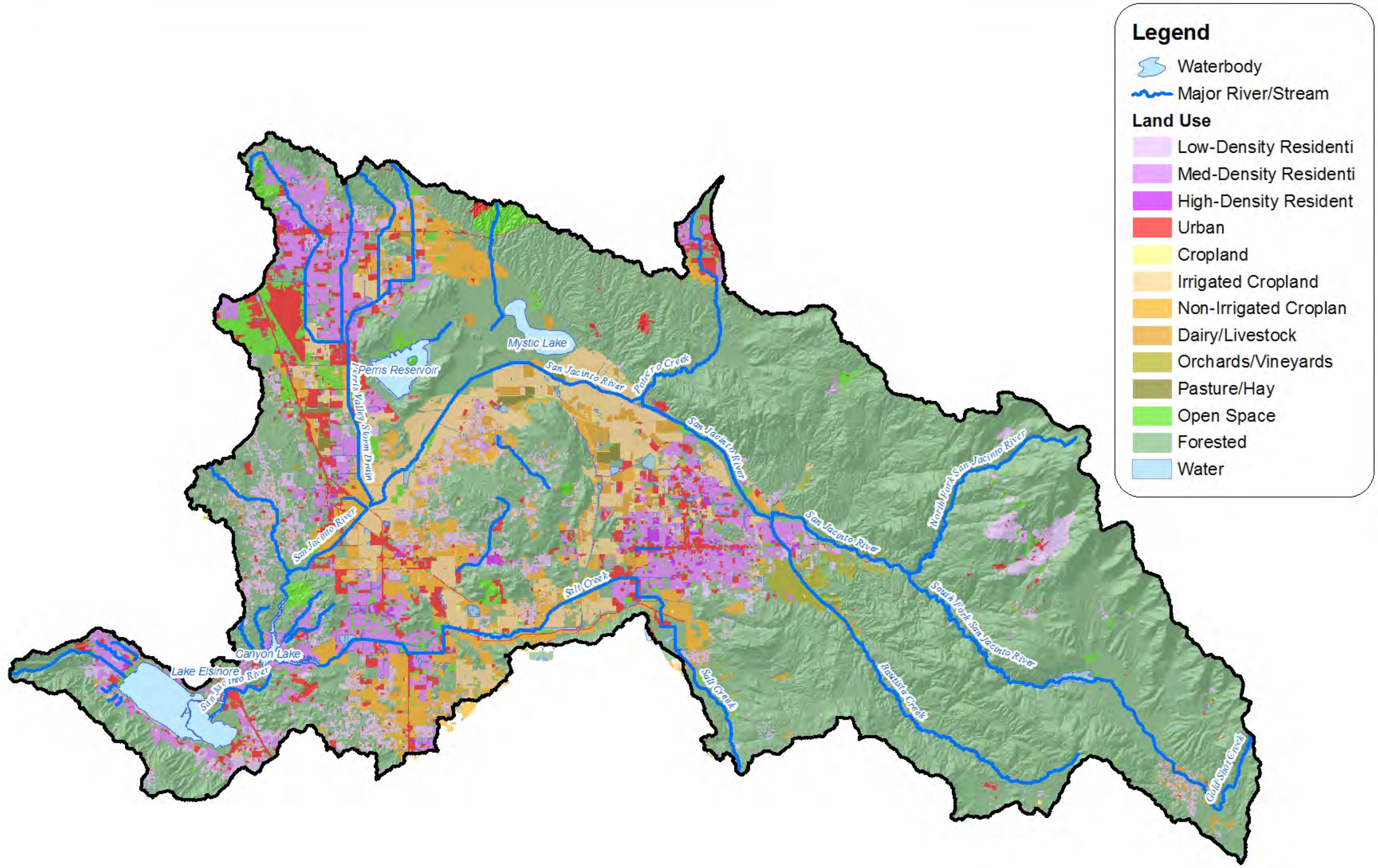
Table B-1. Area and Population for Jurisdictions Within the San Jacinto Watershed

Jurisdictions	Number of Acres	Percent of San Jacinto Watershed Area (%)	Approximate Population in SJR Watershed
Cities/County			
Riverside County	165,925	8.5	105,299
Moreno Valley	30,861	6.3%	188,636
Menifee	28,994	5.9%	71,012
Perris	20,277	4.1%	57,483
Hemet	17,306	3.5%	78,053
San Jacinto	16,132	3.3%	37,679
Lake Elsinore	14,949	3.0%	53,471
Beaumont	11,759	2.4%	9,639
Wildomar	5,080	1.0%	
Canyon Lake	2,969	0.6%	11,152
Murrieta	516	0.1%	
Riverside	511	0.1%	6,360
Banning	351	0.1%	
Other Jurisdictions			
U.S. National Forest	130,502	26.6%	
Public Domain Land BLM	18,716	3.8%	
Wilderness Lands	12,501	2.5%	
Indian Reservations BIA	7,130	1.5%	
Air Force DOD	5,875	1.2%	
Grand Total	490,354	100%	

Table B-2 Land Use Acreage Among San Jacinto River Basin Jurisdictions (source: 2010 Watershed Model Report)

Jurisdiction	Urban	Low-Density Residential	Med-Density Residential	High-Density Resident	Cropland	Irrigated Cropland	Non-Irrigated Cropland	Dairy/ Livestock	Orchards/ Vineyards	Pasture/Hay	Open Space	Forested	Water	Grand Total
Cities/County														
Banning	58	4	144	17			0				50	78		351
Beaumont	738	39	504	35			444	0	18		29	9,954		11,759
Canyon Lake	75	66	1,230	17			6	9			142	955	470	2,969
Hemet	2,666	560	4,371	632	36	1,299	2,117	511	21		674	4,114	304	17,306
Lake Elsinore	1,649	339	2,166	145	3	0	69		18		273	7,198	3,096	14,954
Menifee	3,304	3,512	4,825	294	199	1,232	5,971	746	210		1,640	6,419	640	28,994
Moreno Valley	3,341	2,245	8,520	340	56	1,862	4,388	200	261		953	8,297	398	30,861
Murrieta	152	16	203	14	1		54	10			7	47	11	516
Perris	2,925	1,055	2,056	154	49	3,269	2,710	50	144	327	2,151	4,917	470	20,277
Riverside	39		459								13			511
San Jacinto	1,617	489	1,951	169	83	4,266	757	1,737	99	339	466	3,647	513	16,132
Wildomar	480	1,346	532		2	32	84	7	32		31	2,539		5,083
Riverside County	3,406	12,891	3,640	328	580	14,926	7,488	4,360	3,898	459	4,811	104,903	4,235	165,925
Other Jurisdictions														
Air Force DOD	2,685		426				0				2,590	117	56	5,875
Indian Reservations BIA	77	222				35	325	3	102		42	6,239	83	7,130
U.S. National Forest	418	4,152	327		46	10	3	633	252		861	123,327	475	130,502
Public Domain Land BLM	26	62	66		5	36	18	2	44		590	17,868		18,716
Wilderness Lands	2	16						0			24	12,459		12,501
Grand Total	23,537	27,043	31,243	2,142	1,077	27,254	25,145	8,343	5,100	1,130	14,226	313,357	10,751	490,346
Land Use Percentage	4.8	5.5	6.4	0.4	0.2	5.6	5.1	1.7	1.0	0.2	2.9	63.9	2.2	



Comprehensive Nutrient Reduction Plan For MS4 Permittees in Canyon Lake and Lake Elsinore Watershed	Dec. 1, 2011	0 2 4 8 Miles		**Figure B-2**	CDM
	Map of Watershed Categorized Land Uses				

Table B-3 Average Monthly Temperatures and Precipitation

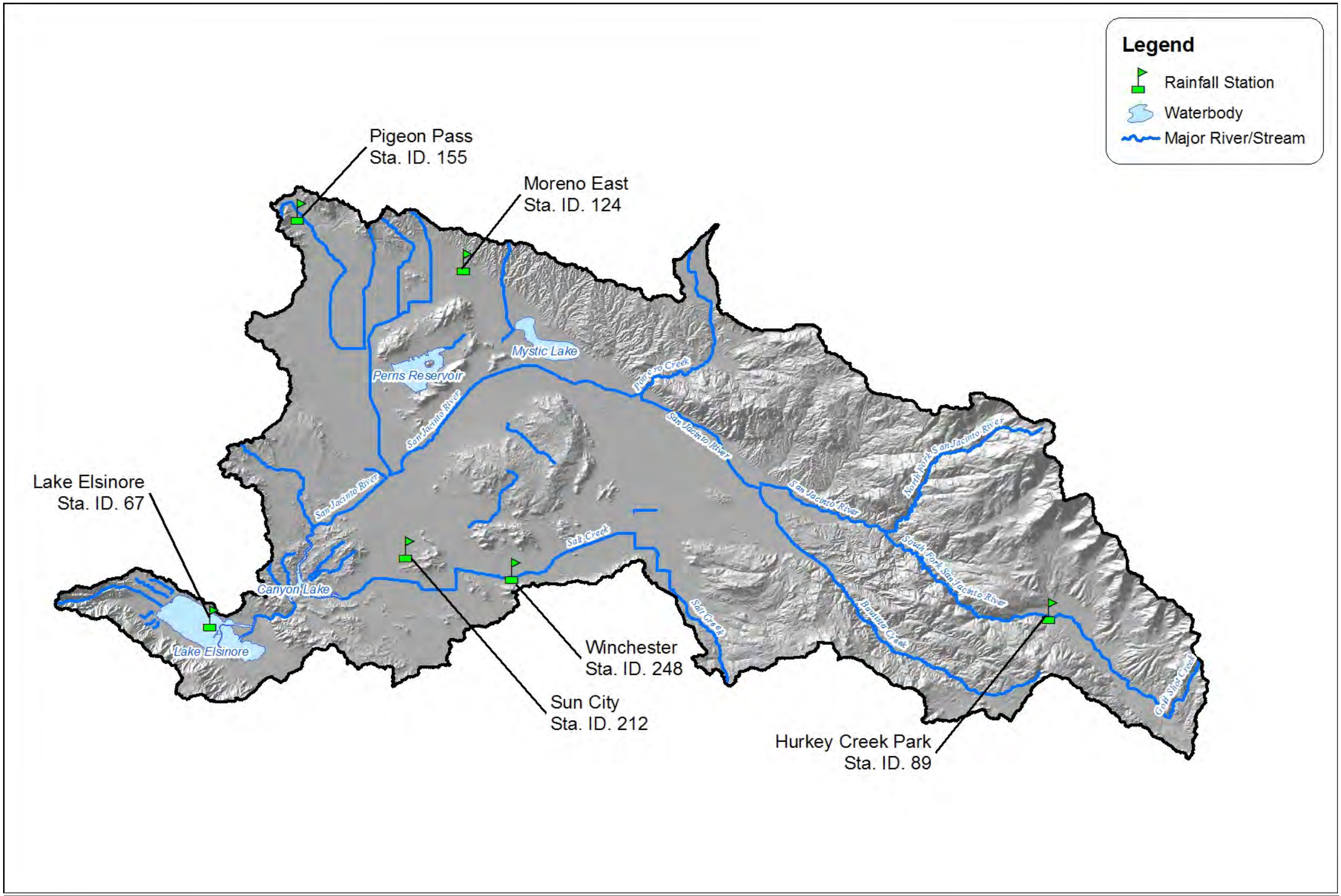
Month	Average Monthly Precipitation (in)	Average Monthly High Temperature (°F)	Average Monthly Low Temperature (°F)	Average Monthly Temperature (°F)
January	2.8	66	38	52
February	2.96	68	40	54
March	2.29	71	43	57
April	0.56	77	46	62
May	0.22	83	51	67
June	0.02	91	56	74
July	0.1	98	61	80
August	0.12	98	62	80
September	0.3	93	58	76
October	0.36	84	51	67
November	0.78	73	42	58
December	1.58	67	37	52
Annual	12.09	81	49	65

Source: Monthly Average for Lake Elsinore, CA - weather.com
http://www.weather.com/weather/wxclimatology/monthly/USCA0580

Table B-4 Precipitation Monitoring Stations in San Jacinto Watershed

Station code	Agency	Station Name	Period of Record Collected	Annual Rainfall (inches)
67	RCFC&WCD	Elsinore	7/1/1990 –7/31/2009	10.6
212	RCFC&WCD	Sun City	7/1/1990 –7/31/2009	11.2
155	RCFC&WCD	Pigeon Pass	7/1/1990 –7/31/2009	12.8
124	RCFC&WCD	Moreno East	7/1/1990 –7/31/2009	12.1
248	RCFC&WCD	Winchester	7/1/1990 –7/31/2009	10.8
89	RCFC&WCD	Hurkey Creek Park	7/1/1990 –7/31/2009	18.7

Source: Tetra Tech Inc., San Jacinto Watershed Model Update, October, 2010



Comprehensive Nutrient Reduction Plan For MS4 Permittees in Canyon Lake and Lake Elsinore Watershed	Dec. 1, 2011	0 2 4 8 Miles	**Figure B-3**	CDM
	Map of Precipitation Gauges			

B.4 Hydrology

This section presents the hydrologic characteristics for the watershed draining to Canyon Lake and Lake Elsinore. The north fork and south fork San Jacinto River are located in the upper portions of the watershed where they converge and collectively become the San Jacinto River upstream of Mystic Lake (Figure B-4). Overflow from Mystic Lake is conveyed by the San Jacinto River to Canyon Lake. Canyon Lake is formed by Canyon Lake Dam; water releases from Canyon Lake ultimately drain to the downstream Lake Elsinore.

All streams in the San Jacinto River watershed are ephemeral. Under normal dry periods, the mainstream of the San Jacinto River is dry, contributing no flow to Canyon Lake, and upstream pollutants do not reach the lakes. External sources contribute nutrients to the lakes via storm flows only during the wet season (October, through April). Further information regarding the hydrologic scenario evaluation is discussed in the Lake Elsinore and Canyon Lake TMDL.

Due to the ephemeral nature of the San Jacinto River system, the location of the various land use sources within the watershed is a major factor affecting the ultimate delivery of nutrients to Canyon Lake and Lake Elsinore. A natural sump, formed by the confluence of two faults, known as Mystic Lake, serves as a hydrologic barrier between the upper and lower San Jacinto Watershed. Mystic Lake is located north of Ramona Expressway and east of the City of Moreno Valley in the San Jacinto Wildlife Preserve. This sump is gradually subsiding providing more runoff storage capacity over time.

During dry hydrologic seasons, Lake Elsinore and Canyon Lake only receive runoff from the subwatersheds directly tributary to them. For example, Lake Elsinore would only receive runoff from the local watershed downstream of Canyon Lake. Similarly, Canyon Lake would only receive runoff from the watershed areas downstream of Mystic Lake. Under moderate hydrologic years, Canyon Lake would be expected to spill, resulting in urban development and agricultural land practices in the central portion of the San Jacinto River watershed below Mystic Lake (including Perris Valley and the Salt Creek sub-watershed) additionally impacting water quality of Lake Elsinore. Lastly, during wet hydrologic years, heavy rain and/or extended periods of rainfall may exceed the storage capacity of Mystic Lake, causing surface flow from open space areas in the headwaters, stormwater runoff from portions of the cities of Hemet and San Jacinto draining to Zones 7-9, and agricultural runoff upstream of Mystic Lake, to reach Canyon Lake. Further, if the rainfall is significant, Canyon Lake may overflow into Lake Elsinore.

Major tributaries to the San Jacinto River include the Perris Valley storm drain and Salt Creek. Perris Valley storm drain conveys flows from the northern portion of the watershed to the San Jacinto River, between Mystic Lake and Canyon Lake. Salt Creek drains to Canyon Lake from the southeast. The U.S. Geological Survey (USGS) operates several flow gauges in the watershed (Table B-5, Figure B-4,), which provide the hydrologic data that were used in the development of the TMDL. The following subsections provide more detailed information regarding the hydrology of the watershed.

Table B-5 USGS Flow Gauge Stations in the San Jacinto Watershed

Station Number	Station Name	Historical Record
11070500	San Jacinto River near Elsinore, CA	1/1/1916–present
11070365	San Jacinto River near Sun City, CA	8/25/2000–present
11070270	Perris Valley Storm Drain at Nuevo Rd. near Perris,	10/1/1969–9/30/1997; 10/1/1998–present
11070210	San Jacinto River at Ramona Expressway near	8/23/2000–9/30/2010
11069500	San Jacinto River near San Jacinto, CA	10/1/1920–9/30/1991; 10/1/1996–present
11070465	Salt Creek at Murrieta Rd. near Sun City, CA	10/1/1983–9/30/1985; 10/1/2000–present

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Representative Hydrologic Flow Scenarios

Hydrologic flow scenarios were developed in the Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Loads (TMDL) (California Regional Water Quality Control Board, 2004) to classify hydrologic conditions within the San Jacinto Watershed. Three scenarios (wet, moderate, and dry) were developed in the Lake Elsinore and Canyon Lake TMDL to evaluate the variability of nutrient loading to the lake due to the various hydrologic conditions that occur in the San Jacinto watershed. Representative years from 1991 – 2000 were initially chosen to represent various hydrologic conditions, and are described in Table B-6. Under wet conditions, the main stem of the San Jacinto River flows into and fills Mystic Lake, which then spills to Canyon Lake. Canyon Lake also spills to Lake Elsinore, and depending on the existing elevation, Lake Elsinore could fill and spill to Temescal Wash. The moderate condition is when the main stem of the San Jacinto River doesn't flow all the way to Canyon Lake, with flows from Salt Creek and the Perris Valley Storm Drain making up the water to Canyon Lake. However, Canyon Lake may have moderate spills to Lake Elsinore. Under dry conditions, the flow from the San Jacinto River watershed never reaches Lake Elsinore, with external nutrient loads to the lake coming from the runoff from the local watershed surrounding the lake.

Table B-6. Three hydrologic conditions defined in the TMDL

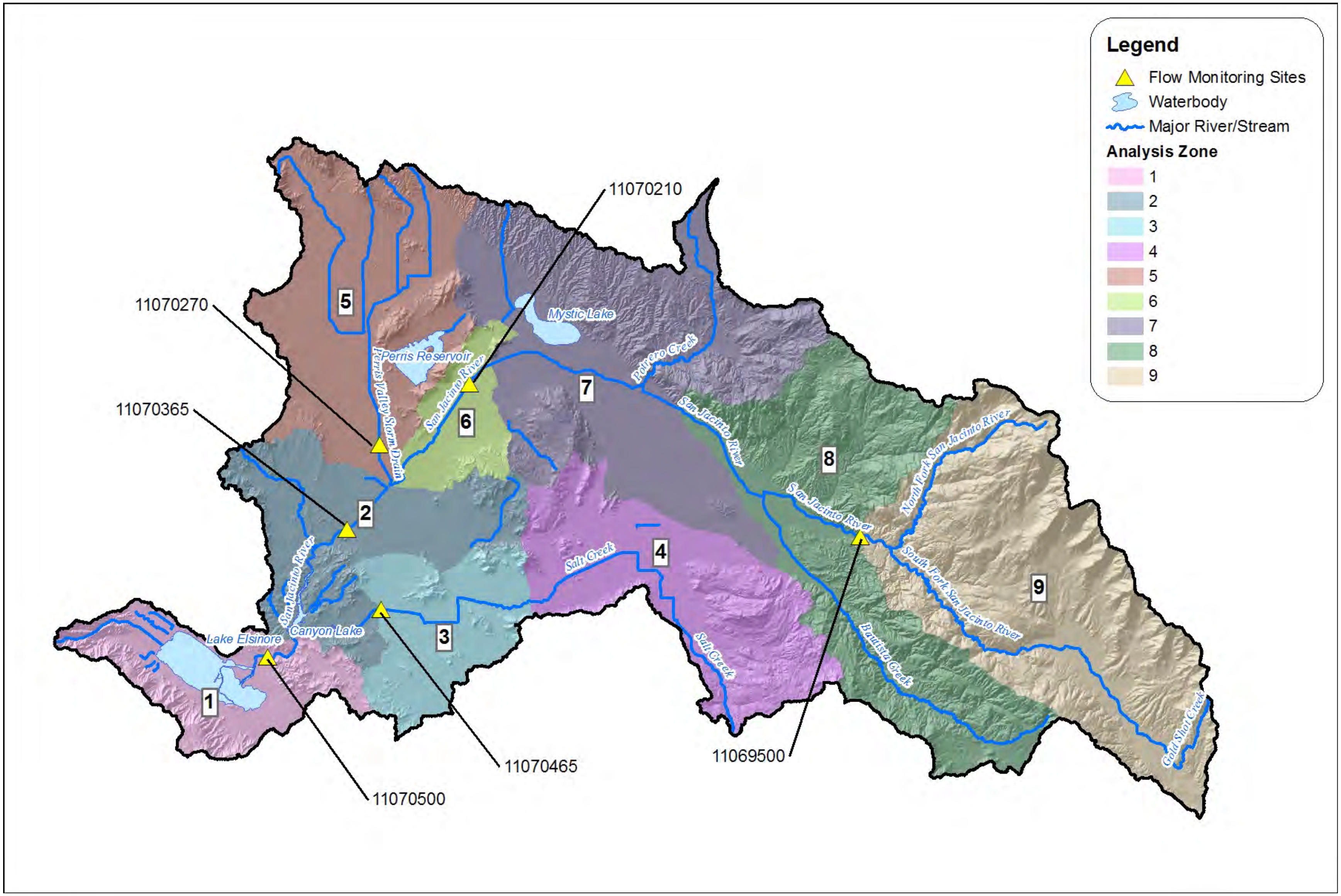
Scenario	Hydrologic Condition	Representative Water Year	Description
I	Wet	1998	Both Canyon Lake and Mystic Lake overflow; flow at the USGS gauging station 11070500 was 17,000 acre-feet
II	Moderate	1994	No Mystic Lake overflow; Canyon Lake overflowed, flow at the USGS gauging station 11070500 was 2,485 acre-feet
III	Dry	2000	No overflows from Mystic Lake or Canyon Lake, flow at the USGS gauging station 11070500 was 371 acre-feet

The relative flow frequency of each of the scenarios was determined using the annual total flow data (for each water year) at the USGS gauging station #1170500. Table B-7 lists the relative flow frequency of the wet, moderate and dry seasons.

Table B-7. Relative flow frequency at the USGS gauging station #1170500 during 1917 – 2011 period

Hydrologic Scenario (Category)	Years in Each Category	Relative Frequency (%) [1]
Wet	15	16%
Moderate	43	45%
Dry	37	39%

1) Frequency weighting in TMDL is based on 1917-2003 period of record and therefore results are slightly different than shown above



Comprehensive Nutrient Reduction Plan For MS4 Permittees in Canyon Lake and Lake Elsinore Watershed

Dec. 1, 2011

Figure B-4

Watershed Analysis Zones and Flow Monitoring Stations

CDM

B.4.1 Watershed Analysis Zones

As part of the development the TMDL model, the San Jacinto River Basin was divided into nine watershed analysis zones (Figure B-4). The delineation of these zones was based upon hydrologic features such as significant water retention features or major tributaries:

- Zones 7, 8, and 9, which drain to Mystic Lake, represent the most upstream portion of the watershed;
- Zone 6 represents the area downstream of Mystic Lake that drains directly to the San Jacinto River;
- Zone 5 drains to the Perris Valley Storm Drain which confluences with the San Jacinto River between Mystic Lake and Canyon Lake;
- Zones 3 and 4 drain to Salt Creek, which drains to Canyon Lake;
- Zone 2 drains the area downstream of the Perris Valley Storm Drain drainage area and drains to Canyon Lake; and
- Zone 1 represents that area that drains directly to Lake Elsinore.

B.4.2 Major Waterbodies

Lake Elsinore

Lake Elsinore is located in the southwest portion of the San Jacinto River Basin at the terminus of the San Jacinto River watershed. Lake Elsinore is a natural lake, which has been in existence for thousands of years. Prior to development in the area, the lake naturally experienced significant variations in lake level from being a dry lake bed to filling temporarily following extreme rain events. Today, the lake receives surface flows from local tributaries (Zone 1), which make up less than 10 percent of the overall San Jacinto River watershed and water releases from Canyon Lake. During rare overflow events, at approximately 1,255 feet water surface elevation, Lake Elsinore overflows into Temescal Creek and ultimately to the Santa Ana River.

Canyon Lake

Canyon Lake Reservoir was created in 1928 with the construction of the Railroad Canyon Dam. Over 90 percent of the San Jacinto watershed drains to Canyon Lake. Flows typically enter the reservoir from both the upper San Jacinto River watershed (Zones 5 and 6) and the Salt Creek watershed (Zones 3 and 4). Flows may also reach Canyon Lake from Zones 7-9 during rare periods when Mystic Lake overflows. The elevation of Canyon Lake Dam spillway is approximately 1,382 feet; when the lake level reaches this point flows continue downstream to Lake Elsinore. USGS flow gauge 11070500, located on the San Jacinto River downstream of Canyon Lake, has been in operation since 1916. During its operational period, it is estimated that flows from Canyon Lake have occurred 38 of the 94 years or a frequency of 40 percent.

Mystic Lake

Flows entering the San Jacinto River from upstream portions of the watershed (Zones 7-9) drain into Mystic Lake. Mystic Lake is typically a dry lake and serves as a water sink because flows entering the lake are generally lost from the system due to soil infiltration and evaporation. Mystic Lake is formed by the confluence of two faults and is located north of Ramona Expressway and east of the City of Moreno Valley in the San Jacinto Wildlife Preserve. This sump is gradually subsiding providing more runoff storage capacity over time. During high or long duration flow events, the storage capacity of Mystic Lake may be exceeded and overflow back to the San Jacinto River and downstream to Canyon Lake. Overflow at Mystic Lake occurs when the water surface elevation is approximately 1,425 feet. USGS flow gauge 11070210 is located on the San Jacinto River roughly 3.5 miles downstream of Mystic Lake. This gauge was in operation between 8/23/2000–9/30/2010 and records local runoff as well as overflows from Mystic Lake. Flow was recorded at Ramona Expressway in 2005, however field investigations determined the flow was from the local watershed area and not Mystic Lake. Given the low flow rates during the other years, it is assumed that since 2000, Mystic Lake has not overflowed.

Lake Hemet

Lake Hemet was created when Hemet Dam was constructed in 1895. The dam is owned and operated by the Lake Hemet Municipal Water District (LHMWD) and is a water source for the cities of Hemet and San Jacinto, and the San Jacinto Mountain community of Garner Valley. The lake is approximately 4,340 ft above sea level and located in the San Jacinto Mountains. The lake volume is roughly 8,100 acre-ft and the outlet flows to the south fork of the San Jacinto River. Flow data at USGS flow gage 11069500, located downstream of Lake Hemet, indicates that this area generally sustains baseflow after a rain event throughout the year. This is in contrast to flow data recorded at other gauges in the San Jacinto River Basin.

San Jacinto River

The headwaters of the San Jacinto River begin in the San Bernardino National Forest where the north and south forks converge east of Valle Vista. The San Jacinto River drains the upper portions of the San Jacinto River Basin to Mystic Lake. The river continues downstream of Mystic Lake to Canyon Lake and again downstream of the Canyon Lake Dam to Lake Elsinore where it terminates. The San Jacinto River Basin is a complex hydraulic system which includes hydraulic sinks, little or no sustained baseflow in most areas especially during dry periods, deep groundwater losses, and reduction in groundwater levels due to excessive groundwater pumping and limited recharge. Generally, the San Jacinto River is not sustained by groundwater flows during dry years and remains waterless. With limited surface water recharge from groundwater, water that infiltrates into the ground is considered to be lost from the system.

Perris Valley Storm Drain

The northwest area of the San Jacinto River watershed is drained by Perris Valley Storm Drain. The drain has its confluences with the San Jacinto River upstream of Canyon Lake. USGS gauge 11070270 is located on the Perris Valley Storm Drain near Perris, CA. Flows recorded at this gauge display high peak flow rates of short durations, a pattern commonly seen with stormwater runoff from developed areas with little or no associated groundwater flow.

Salt Creek

Salt Creek is an intermittent creek that drains southern portions of the San Jacinto River watershed. The drainage enters Canyon Lake from the southeast. USGS gauge 11070465 measures flow in Salt Creek near Sun City and displays a lower unit-area flow than other gauges in the watershed. However, the USGS rates the data recorded at this station as poor quality.

B.4.3 Flow

Wet weather runoff is the primary influence on flow rates observed in the San Jacinto watershed. Figure B-5 presents a flow duration curve for daily mean discharges at the USGS gauges (See Table B-5). The figure shows the cumulative-frequency curves, which represent the likelihood that a particular flow discharge is equaled or exceeded at the site. Figure B-5 indicates that the upstream portion of the San Jacinto River has a more stable flow rate, which suggests that this area receives groundwater inflow and snowmelt runoff that tends to infiltrate prior to reaching the Ramona Expressway gauge.

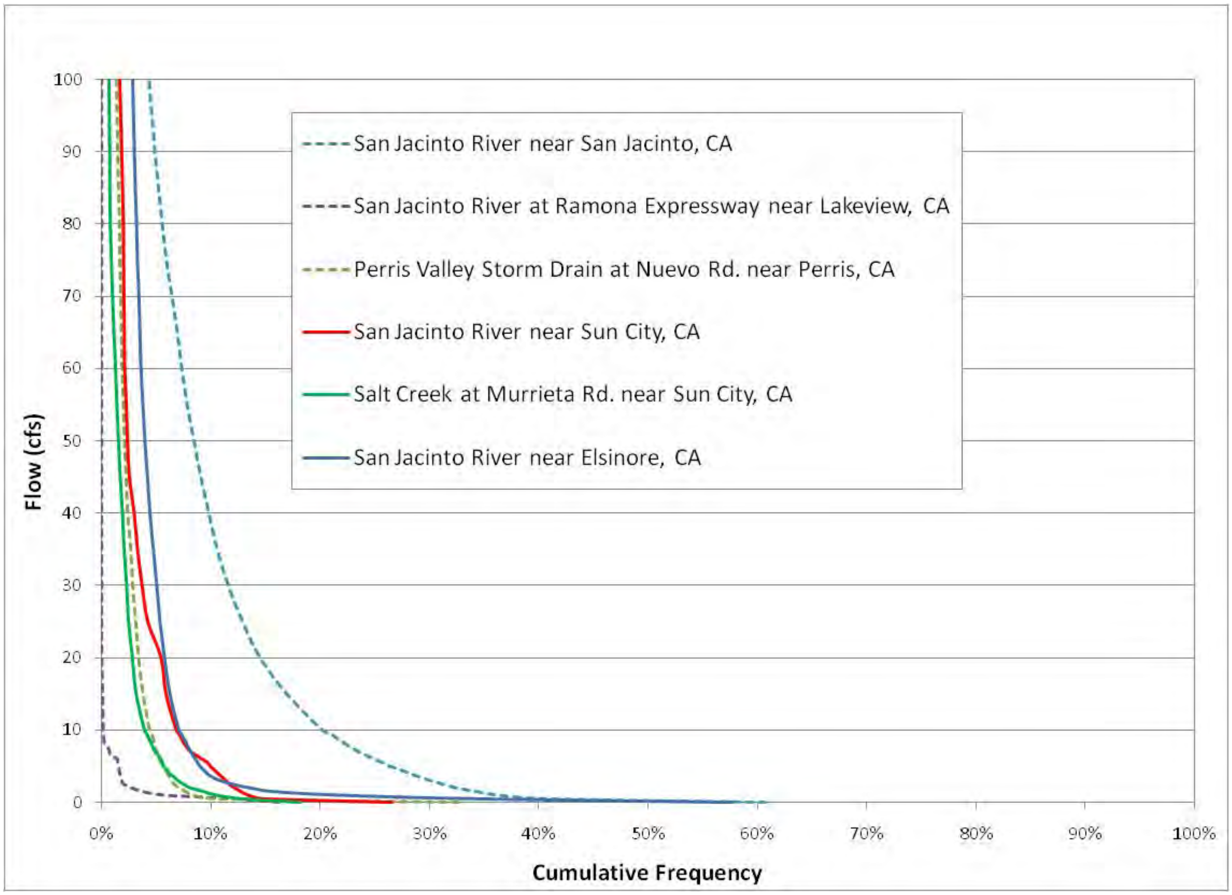
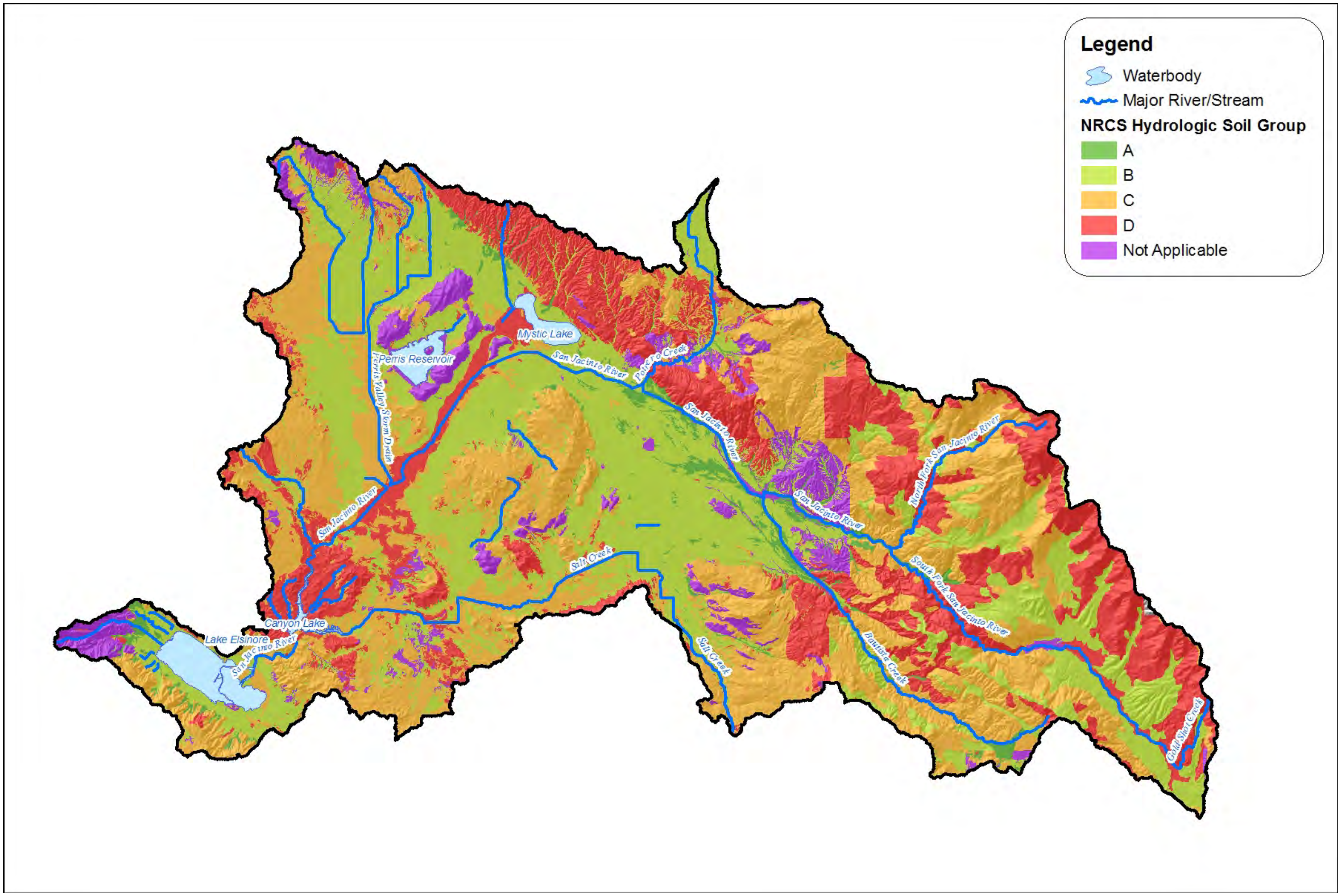


Figure B-5
Flow Duration Curves for Daily Mean Discharges at USGS Gauges in the San Jacinto River Watershed

B.4.4 Soils

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) categorizes soils into four distinct hydrologic soil groups, based on infiltration and transmission rates after prolonged wetting (Table B-8). Generally, soils in group A are well-drained and have a high infiltration while soils in group D have a slow infiltration rate. Soil data for the San Jacinto River Basin was obtained from STATSGO2 (USDA 2006) and summarized by hydrologic soil groups (Figure B-6). Areas draining to the north and south fork San Jacinto River are dominated by soil group C. Forest land is the most common land use in these areas. Areas draining to Salt Creek are also mainly represented by soil group C but differ from the north and south fork San Jacinto River drainage areas mainly because the unit-area flow for this area is lower. Potential causes for this difference may be poor quality of flow records, flows captured by the Paloma Valley Reservoir, or occasional diversions for irrigation and domestic use. The majority of the area draining to Perris Valley Storm Drain is classified as soil group B meaning the soil has moderate infiltration rates and a moderate rate of water transmission. This is a mixed land use area of the watershed and representative hydrographs show large stormwater runoff peaks with little or no associated groundwater flow. Local watersheds draining into Canyon Lake are classified as soil group D representing areas of low permeability.



Comprehensive Nutrient Reduction Plan For MS4 Permittees in Canyon Lake and Lake Elsinore Watershed	Dec. 1, 2011	0 2 4 8 Miles		**Figure B-6**	CDM
	NRCS Hydrologic Soil Type				

Table B-8. Hydrologic Soil Group Descriptions (USDA 2006)

Hydrologic Soils Group	Description
A	Soils with high infiltration rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.
Not Applicable	Limited soil, exposed bedrock, or water body.

B.4.5 Water Quality

The following sections characterize water quality in Lake Elsinore, Canyon Lake, and runoff from the San Jacinto watershed. This analysis focuses on the primary indicators of nutrient impacts to water quality: total phosphorus, total nitrogen, dissolved oxygen, and chlorophyll *a*. This section is a summary of detailed information, which can be obtained Lake Elsinore & Canyon Lake Nutrient TMDL Annual Water Quality Reports, (http://www.sawpa.org/AnnualWQReports.htm).

Lake Elsinore

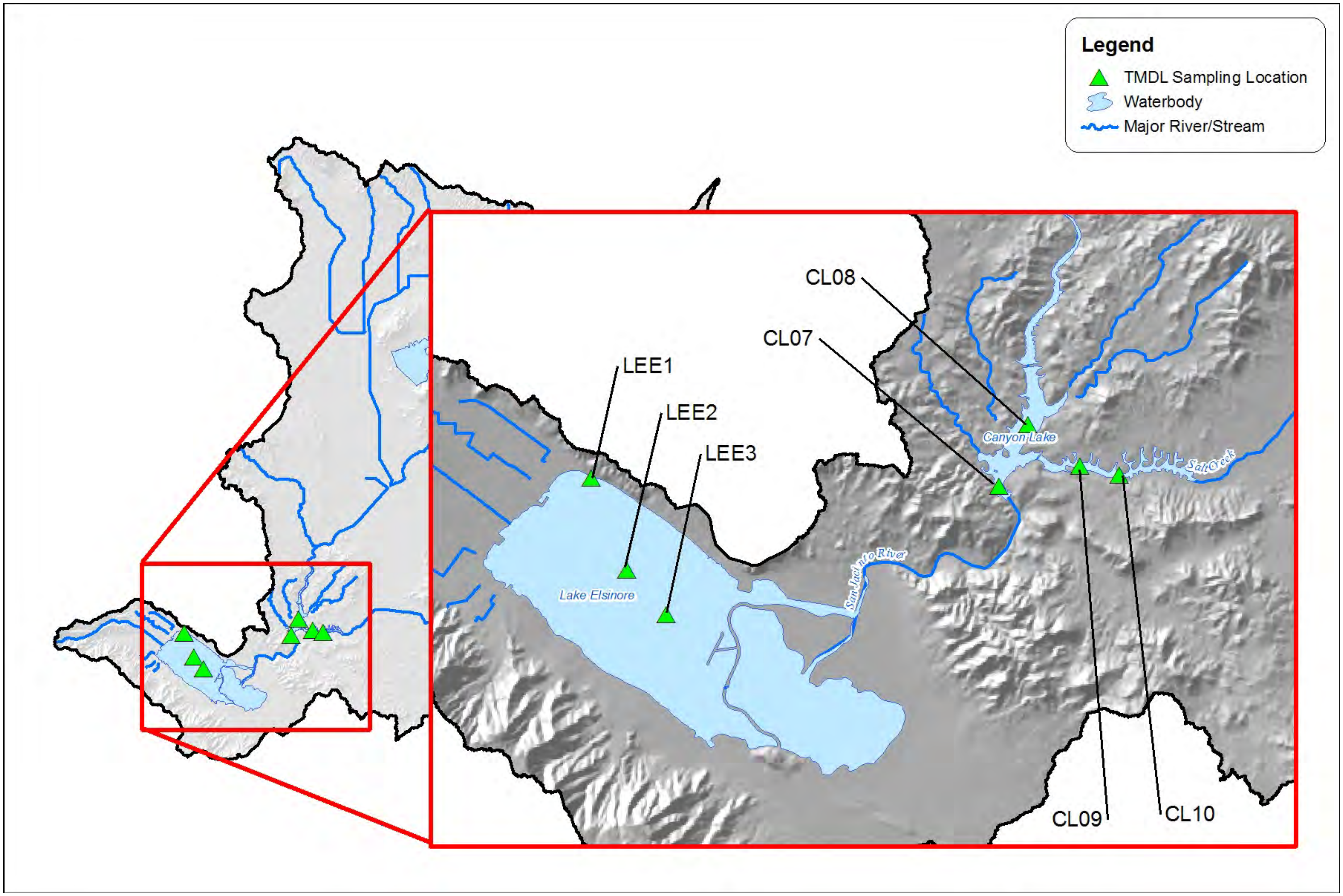
Elsinore Valley Municipal Water District's (EVMWD) initiated its NPDES compliance monitoring program for Lake Elsinore in April 2006. Initially, monitoring for nutrients occurred at three water quality sampling stations. Figure B-7 shows the sampling stations where surface, bottom, and integrated samples were collected. EMVWD collects samples monthly from October through May and biweekly from June through September.

Table B-9 summarizes monitoring results for the period July 1, 2006 through June 30, 2011 for the LEE2 sample location. Results are compared to basin plan objectives and TMDL targets.

Figure B-8 shows lake surface, integrated, and lake bottom dissolved oxygen concentrations observed at station LEE2. Summer months exhibit stratified dissolved oxygen, with the lake bottom samples declining to 0 mg/L. The winter months exhibit greater uniformity in dissolved oxygen concentrations, due to turnover and mixing of the epilimnion and hypolimnion.

Figure B-9 shows depth integrated total nitrogen and phosphorus results locations, averaged from all three sites. Nitrogen and phosphorus concentrations were generally uniform and did not exhibit seasonal fluctuations or significant changes as a result of depth. A spike in phosphorus concentrations was observed on April 11, 2011.

Figure B-10 shows depth integrated chlorophyll *a*, averaged from all three sites. There has been a gradual increase in chlorophyll *a* after October 2009, although further study is required to determine if this is a significant trend. Table B-10 provides the average chlorophyll *a* concentrations consolidated by season; concentrations decrease during the spring sample period compared to the other seasons, possibly due to an increase in precipitation which may dilute the algae.



Comprehensive Nutrient Reduction Plan For MS4 Permittees in Canyon Lake and Lake Elsinore Watershed	Dec. 1, 2011	0 2 4 8 Miles		**Figure B-7**	CDM
	Lake Water Quality Monitoring Sites				

Table B-9 Summary - Lake Elsinore Water Quality Data

Parameter	TMDL Compliance Date	Basin Plan Objectives or TMDL Targets	2006 - 2011 Results				
			No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation
Dissolved Oxygen (mg/L) (Station LEE2, depth profile)	2015	Not less than 5 mg/L as a depth average	91	0.3 - 11.65	6.35	6.20	2.02
	2020	Not less than 5 mg/L 1 meter above lake bottom	91	0.00 - 11.50	4.24	3.65	2.56
pH (3 stations, depth profile)	---	6-5 - 8.5	101	6.72 - 9.76	8.92	8.95	0.35
Ammonia N (NH4-N) (mg/L) (3 stations, integrated samples)	2020	Data Results	100	ND - 0.77	0.14	0.09	0.15
		Acute Criteria Compliance	No observed exceedances of the acute criterion at the range of pH conditions measured.				
		Chronic Criteria Compliance	Exceedance of the chronic criteria observed 7.2% of the time (80 out of 1040 ammonia readings).on the following dates: 8/29/06, 12/19/06, 1/10/07, 10/12/07, 11/28/07, 1/16/08, 5/16/08, 6/27/08, 9/18/08, 7/29/09, 8/19/09 , 8/26/09, 9/11/09, 9/25/09, 10/21/09, 12/4/09, 6/9/10, 7/23/2010, 8/18/2010, 9/30/2010, 10/12/2010, and 6/29/2011.				
Total Nitrogen (TN) (mg/L) (3 stations, integrated samples)	2020	Annual average 0.75 mg/L	90	0.50 - 8.56	3.57	3.29	1.42
Total Phosphorus (TP) (mg/L) (3 stations, integrated samples)	2020	Annual average 0.1 mg/L	81	0.09 - 0.89	0.23	0.20	0.12
Chlorophyll *a* (µg/L) (3 stations, surface samples 0-2 m, April to September)	2015	Summer average no greater than 40 µg/L	95	15.2 - 247.5	93.27	88.37	55.08
Chlorophyll *a* (µg/L) (3 stations, integrated samples, April to September)	2020	Summer average no greater than 25 µg/L	96	16.1 - 271.3	89.41	90.19	52.51
Secchi Depth (cm) (3 stations)	---	---	100	28 - 102	57.56	52.19	19.64
Total Dissolved Solids (mg/L) (3 stations, integrated samples)	---	2000 mg/L	101	1082 - 1967	1449	1437	205

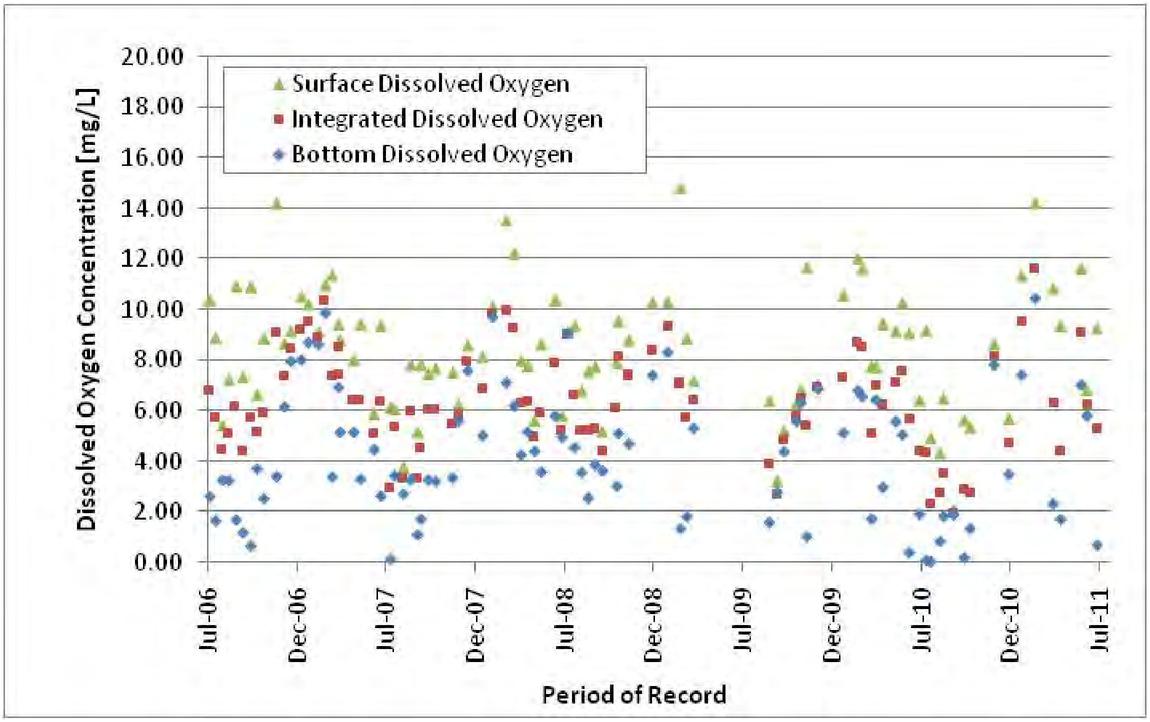


Figure B-8
Lake Elsinore Dissolved Oxygen Concentrations Observed at Station LEE2

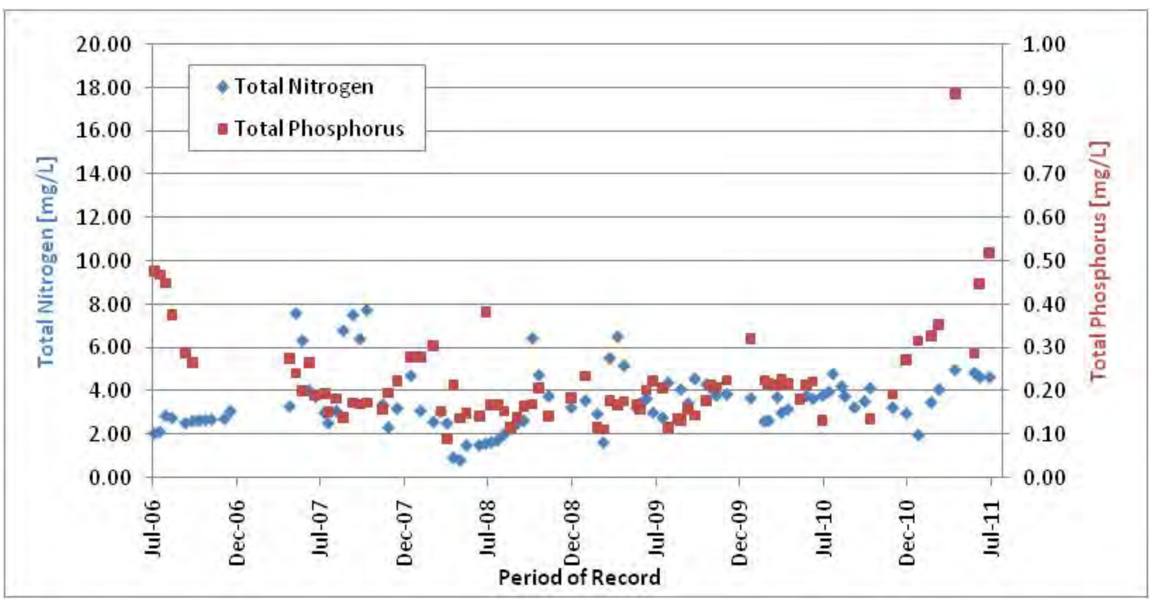


Figure B-9
Lake Elsinore Total Nitrogen and Total Phosphorus Concentrations

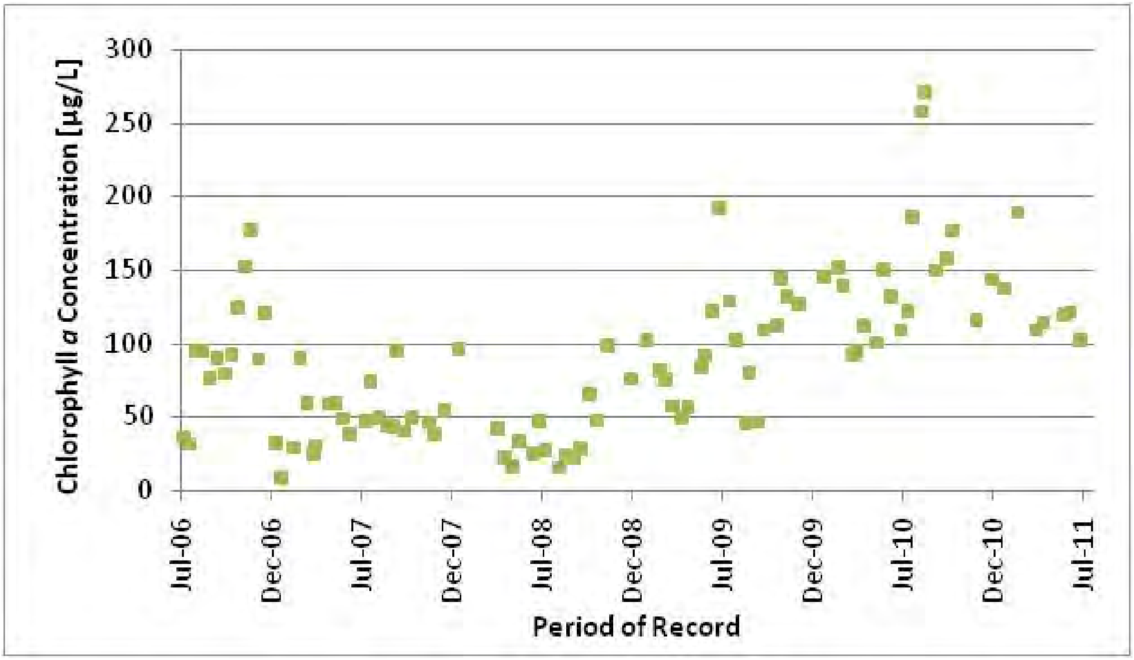


Figure B-10
Lake Elsinore Chlorophyll *a* Concentrations

Table B-10 Lake Elsinore average chlorophyll *a* concentrations consolidated by season

Season	Concentration [µg/L]
Winter	98.9
Spring	74.1
Summer	93.4
Fall	94.1

The Redfield ratio has been used to determine the limiting nutrient for algal growth in the lake. The nutrient that is below the ratio likely limits the growth of phytoplankton (Schindler et al. 2008). For this analysis, a 7:1 ratio for nitrogen to phosphorus (N:P) was used. Figure B-11 shows the N:P ratios observed in Lake Elsinore. For most of the period of record, the observed N:P ratio is greater than 7:1, indicating that phosphorus is the limiting nutrient.

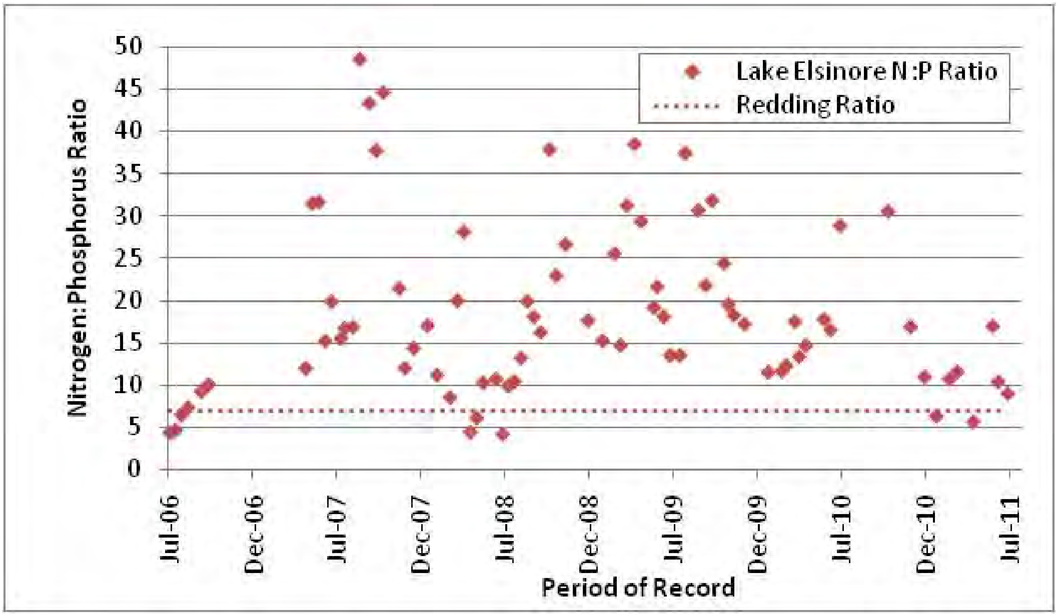


Figure B-11
Observed Lake Elsinore Nitrogen to Phosphorus Ratios

Canyon Lake

EVMWD's NPDES compliance monitoring program for Canyon Lake, which began June 2007, consists of four sampling locations (Figure B-7). Samples from Station CL07 and CL08 are located within the Main Basin and Stations CL09 and CL10 are located in the East Basin.

- Station CL07 – Located at the deepest part of the lake near the dam. The site is generally strongly stratified during the summer.
- Station CL08 – Located mid-lake in the main body of Canyon Lake.
- Station CL09 and CL10 – Two relatively shallow sample locations within the East Basin of the lake that receive local nuisance runoff and discharges from Salt Creek during wet weather events.

Unless stated otherwise, in subsequent tables and figures the Main Basin sampling results are averaged samples from Stations CL07 and CL08, and East Basin sampling results are averaged samples from Stations CL09 and CL10. Samples are collected monthly from October through May, and biweekly from June through September. Table B-11 summarizes Canyon Lake monitoring results for the period July 1, 2007 through June 30, 2011.

Table B-11 Summary - Lake Elsinore Water Quality Data

Parameter	TMDL Compliance Date	Basin Plan Objectives or TMDL Targets	Main Basin 2007- 2011 Results					East Basin 2006 - 2011 Results				
			No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation	No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation
Dissolved Oxygen (mg/L) (Station 07 for Main Basin; Stations 09 and 10 for East Basin)	2015	Not less than 5 mg/L above the thermocline	61	0.94 - 13.75	7.01	7.27	2.85	60.00	0.33 - 11.17	6.24	6.01	1.56
	2020	Not less than 5 mg/L daily average in hypolimnion	61	0 - 5.7	0.89	0.21	1.53					
pH (Station 07 for Main Basin; Stations 09 and 10 for East Basin)	---	6-5 - 8.5	68	7.43 - 8.94	8.02	7.98	0.34	68	7.30 - 9.70	8.31	8.22	0.47
Ammonia N (NH4-N) (mg/L) (Station 07 for Main Basin; Stations 09 and 10 for East Basin)	2020	Data Results	70	0.011 - 1.800	0.49	0.44	0.31	70	ND - 1.290	0.40	0.37	0.28
		Acute Criteria Compliance	Exceedances of the acute criterion on: 5/30/08; observed 0.16% of the time (1 out of 644 samples)					Exceedances of the acute criterion on: 5/30/08; observed 0.18% of the time (1 out of 551 samples)				
		Chronic Criteria Compliance	Exceedances of the chronic criterion: 6/18/08, 7/2/08, 7/1/09, 7/24/09, 5/10/10, 6/28/10, 6/12/10, 7/30/10, 8/9/10, 8/30/10, 9/17/10, 10/26/10; Exceedances observed 2.95% of the time (19 out of 644 samples)					Exceedances of the chronic criterion: 5/30/08, 6/6/08, 6/18/08, 7/2/08, 7/24/09, 11/30/09, 6/11/10, 6/28/10; Exceedances observed 4.54% of the time (25 out of 551 samples)				
Total Nitrogen (TN) (mg/L)	2020	Annual average 0.75 mg/L	68	0.33 - 4.37	2.06	2.00	0.93	69	0.35 - 5.49	2.04	1.92	0.92
Total Phosphorus (TP) (mg/L)	2020	Annual average 0.1 mg/L	70	0.33 - 1.74	0.68	0.64	0.25	70	0.09 - 2.27	0.61	0.53	0.36
Chlorophyll *a* (µg/L) (surface samples 0-2 m)	2015	Summer average no greater than 40 µg/L	40	1.5 - 138.3	34.33[1]	29.30	27.49	45	2.5 - 266.1	61.00	38.85	71.62
Chlorophyll *a* (µg/L) (integrated samples)	2020	Summer average no greater than 25 µg/L	60	1.0 - 171.8	37.56[1]	33.49	28.77	60	2.5 - 266.1	56.19	50.92	46.22
Secchi Depth (cm)	---	---	68	18 - 301	119.32	113.25	44.67	69	21 - 231	90.50	86.36	34.26
Total Dissolved Solids (mg/L) (integrated samples)	---	700 mg/L	69	152 - 901	616.63	684.00	215.96	68	336 - 1206	703.82	658.11	223.28

[1] Data presented as annual mean

Figure B-12 shows observed dissolved oxygen concentrations at Station CL07 (closest to the lake spillway). Highly stratified conditions exist throughout most of the year, with the lake bottom concentrations at 0 mg/L for most months. The winter months exhibit greater uniformity in dissolved oxygen concentrations, due to turnover and mixing of the epilimnion and hypolimnion.

Figure B-13 shows observed dissolved oxygen concentrations at Station CL08 (most representative of Main Basin). Dissolved oxygen concentrations are similar to the values found in CL07, with peaks and troughs occurring on the same sample dates as CL07. Highly stratified conditions exist throughout most of the year, with the lake bottom concentrations at 0 mg/L for most months. The winter months exhibit greater uniformity in dissolved oxygen concentrations, due to turnover and mixing of the epilimnion and hypolimnion.

Figure B-14 characterizes observed dissolved oxygen concentrations at Stations CL09 and CL10. Due to the low water depth and inflow from Salt Creek, stratification does not occur in this portion of the lake. Dissolved oxygen concentrations in the East Basin have remained relatively constant throughout the period of record.

Figures B-15 and B-16 show depth integrated total nitrogen and phosphorus observations within the Main Basin and East Basin, respectively. Similar observations occurred at both sample locations. Nitrogen and phosphorus concentrations were generally uniform and did not exhibit seasonal fluctuations or significant changes by depth. Peaks and troughs in nutrient concentrations occurred generally during the same periods. However, the spike in phosphorus concentrations, observed on April 11, 2011 and continuing to the end of the sampling season, was not observed for nitrogen.

Figure B-17 illustrates depth integrated chlorophyll *a* concentrations for the Main Basin and East Basin sample locations. Peaks and troughs of chlorophyll *a* concentrations occurred at the same time at both sites; however, concentrations in the East Basin have been typically higher than the Main Basin. Table B-12 summarizes the average seasonal chlorophyll *a* concentrations at both sample locations. The lowest concentrations have been observed in the spring.

Figure B-18 characterizes the average N:P ratio for both lake basins. For the majority of the period of record, the N:P ratio of N:P is less than 7:1, indicating that nitrogen is the limiting nutrient.

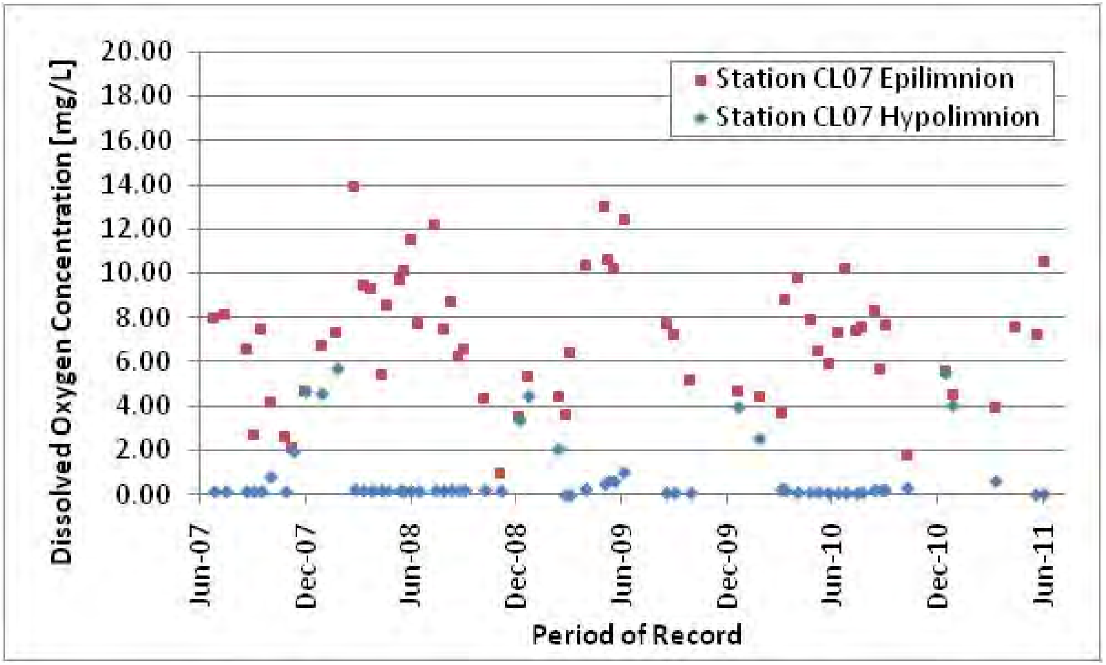


Figure B-12

Canyon Lake Dissolved Oxygen Concentrations at Station CL07

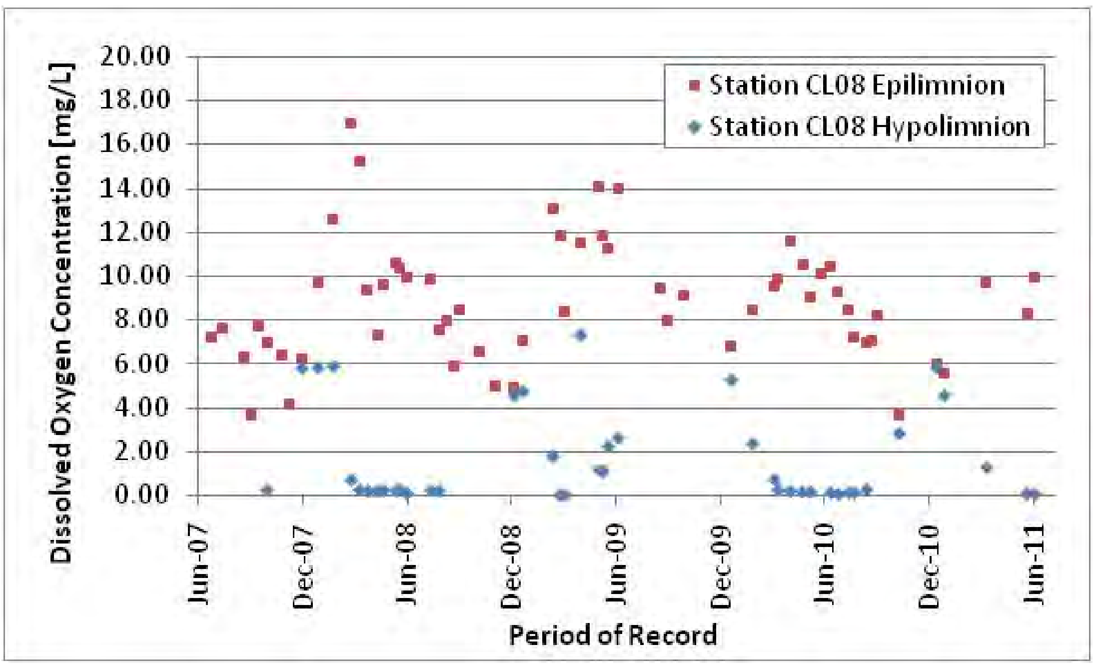


Figure B-13

Canyon Lake Dissolved Oxygen Concentrations at Station CL08

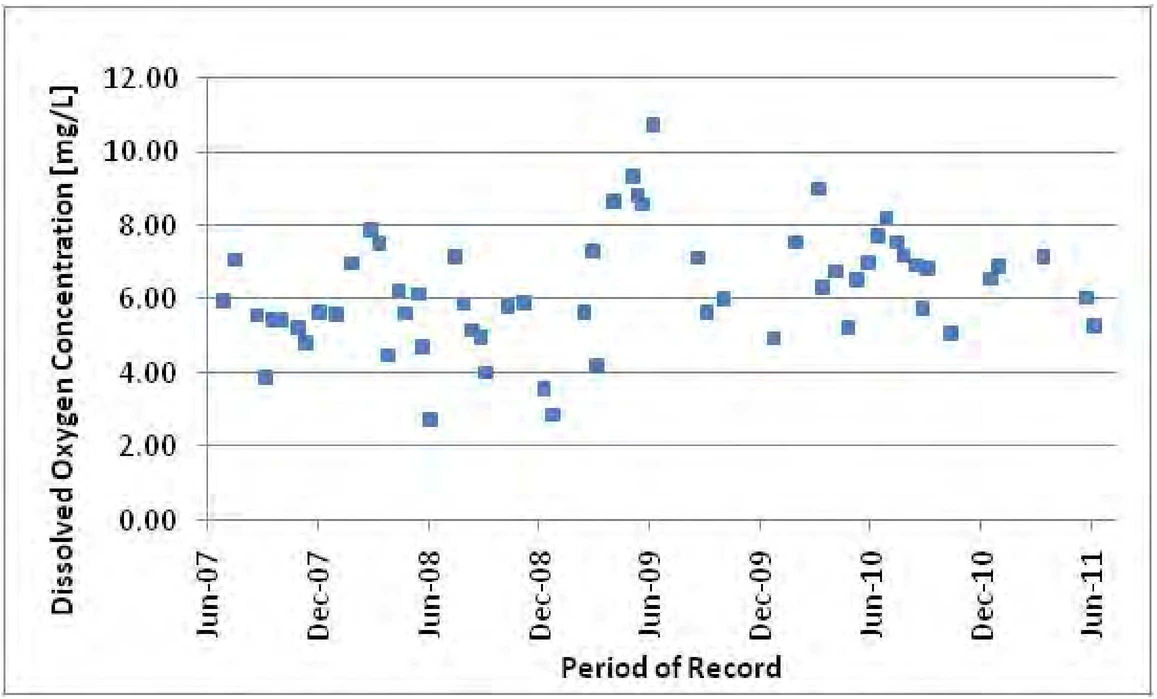


Figure B-14
Canyon Lake Dissolved Oxygen Concentrations at East Basin Sample Locations (CL09 and CL10)

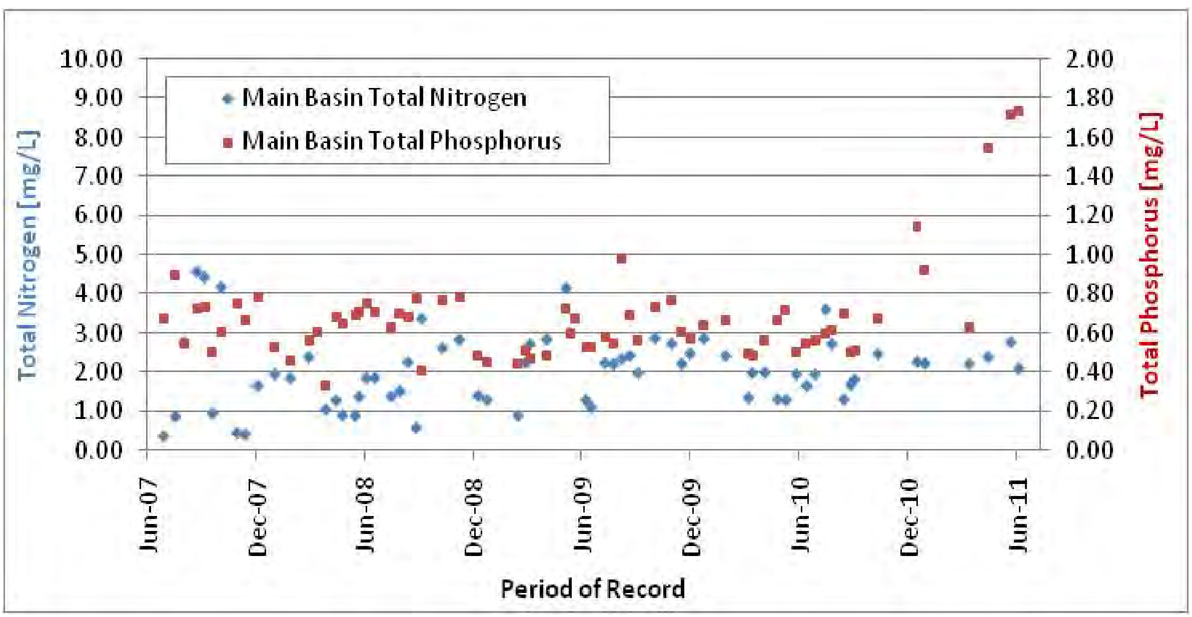


Figure B-15
Canyon Lake Total Nitrogen and Total Phosphorus Concentrations in the Main Basin

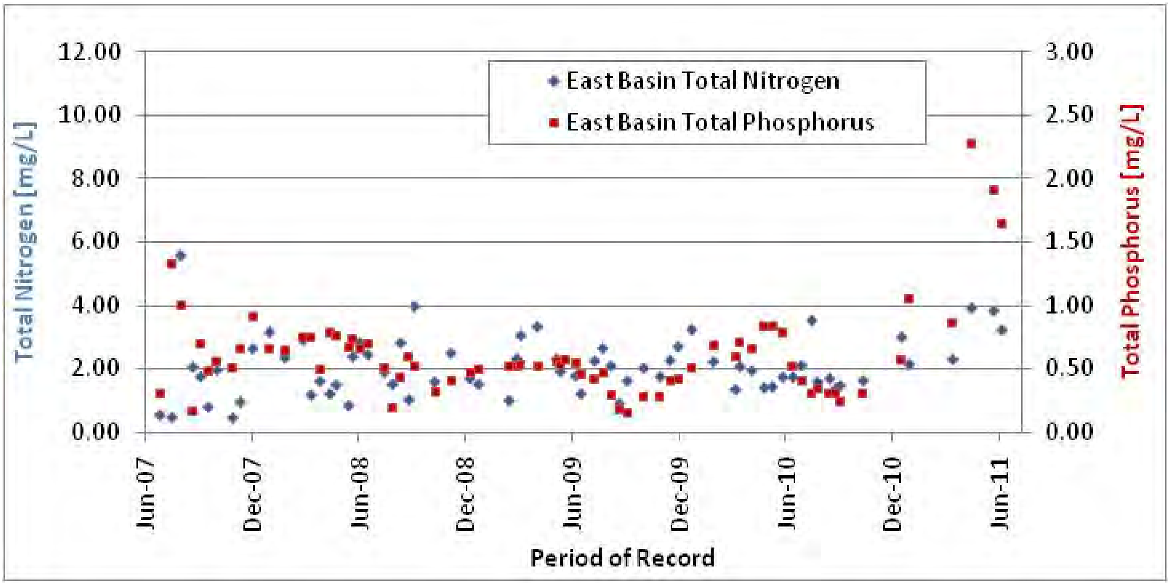


Figure B-16
Canyon Lake Total Nitrogen and Total Phosphorus Concentrations in the East Basin

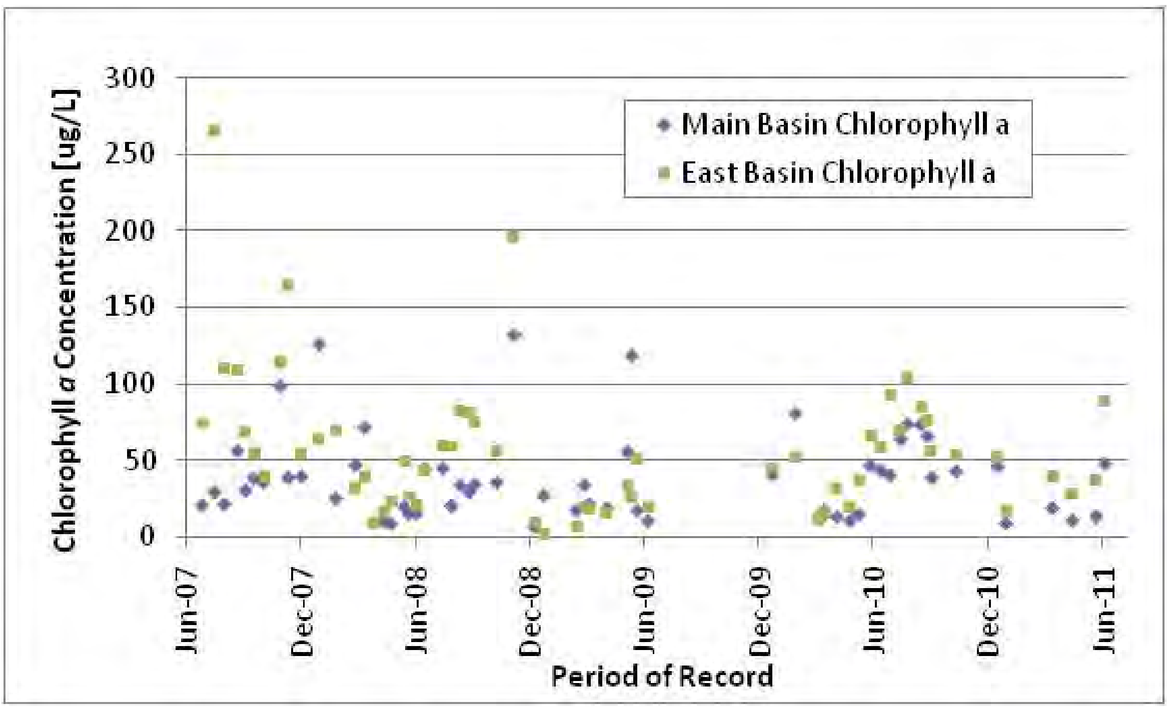


Figure B-17
Canyon Lake Chlorophyll *a* Concentrations

Table B-12 Canyon Lake average Chlorophyll *a* Concentrations (µg/L) by Season

Season	Main Basin	East Basin
Winter	41.4	36.7
Spring	27.9	25.4
Summer	35.1	74.0
Fall	51.6	87.8

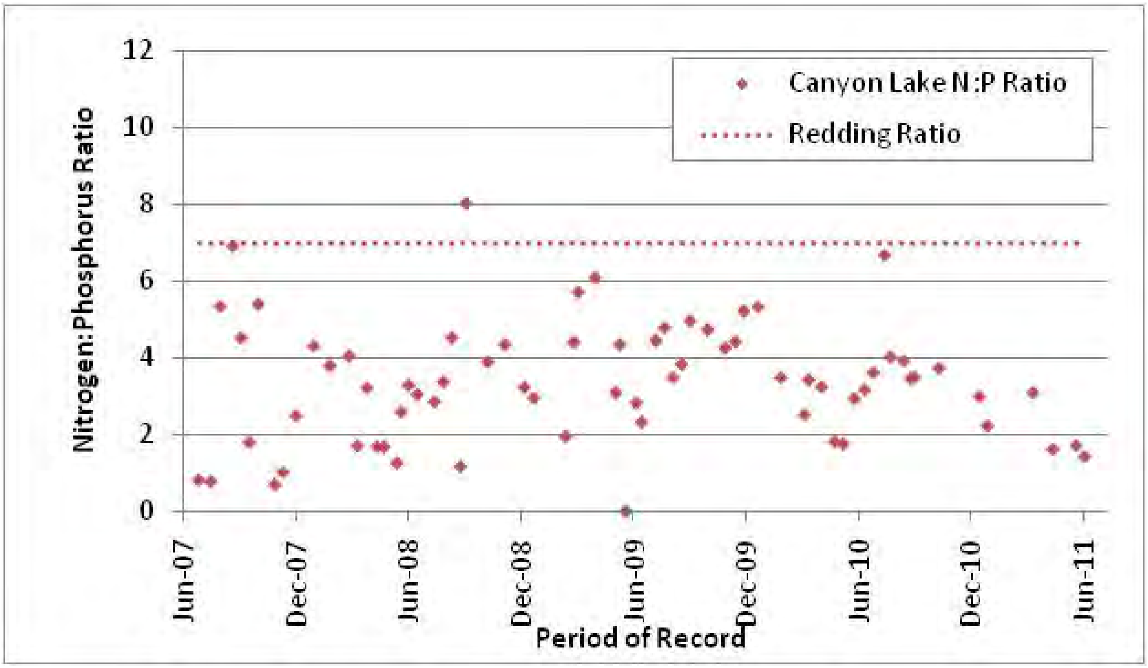


Figure B-18
Observed Canyon Lake Nitrogen to Phosphorus Ratios

San Jacinto Watershed

As part of the Phase I San Jacinto River Watershed Monitoring Program, water quality samples were collected from four sample locations during wet weather events (Figure B-19):

- Salt Creek at Murrieta Rd – Area tributary to this sample location includes the southern portion of the San Jacinto watershed, with land uses consisting of irrigated croplands and residential.
- Goetz Road – Tributary area includes the northern half of the San Jacinto watershed; land use includes urban, irrigated croplands, residential, and open space. This monitoring location has the largest tributary area, but much of the water is captured by nearby Mystic Lake.

- Canyon Lake Spillway – Only during high storm events is water released from Canyon Lake to Lake Elsinore. Samples are gathered from this site only when water is released.

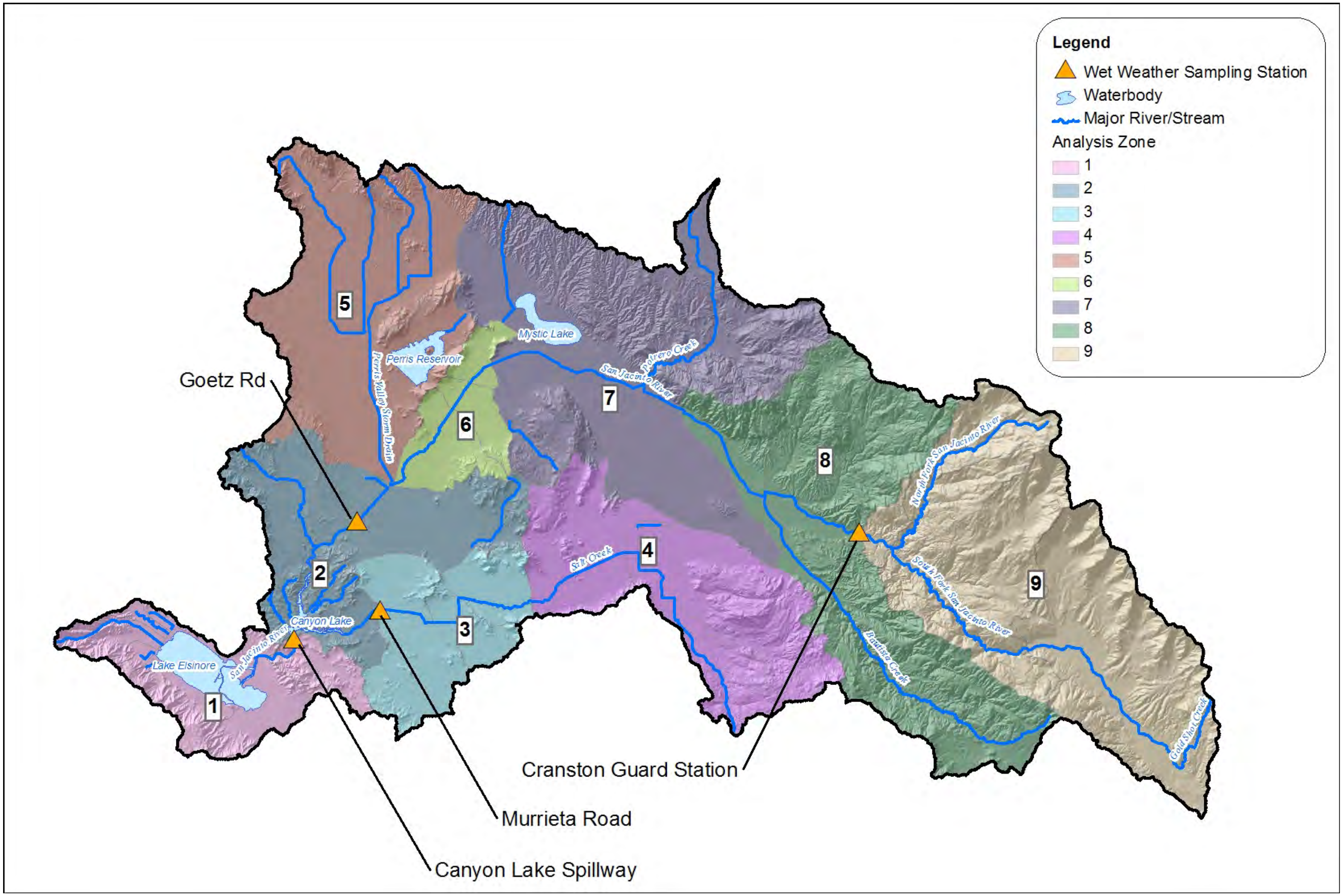
- Cranston Guard Station – This station is located at the eastern portion of the watershed. This station experiences the highest annual flows compared to the other stations. Sampling at this station is conducted by the United States Forest Service, and is dependent on whether adequate funding is allocated through Congress. Land use upstream of this site is forested area.

- A fifth station, San Jacinto River at Ramona Expressway, would be sampled if Mystic Lake overflows; however, since the implementation of this monitoring program no such overflows have occurred.

Samples are collected throughout observed storms at different points of the hydrograph to obtain a range of concentrations across the storm event. Sampling methodology is described in detail in the Lake Elsinore & Canyon Lake Nutrient TMDL Annual Water Quality Monitoring Reports. Figures B-20 and B-21 illustrate the observed water quality concentrations for total phosphorus and total nitrogen, respectively; Table B-13 summarizes the water quality data. Sample results indicate that nutrient concentrations tend to be higher during the beginning of the storm (first flush) and then decrease during later portions of the storm event. San Jacinto River at Goetz Road and Salt Creek at Murrieta Road have the highest concentrations of total nitrogen based on observed median concentrations, while the Goetz Road site has the highest total phosphorus. The average N:P ratio was calculated for each watershed water quality sample site; all ratios were less than 7.1, indicating that nitrogen is the limiting nutrient in wet weather runoff.

Table B-13. Summary of Nutrient Water Quality Data for San Jacinto Watershed (mg/L)

Waterbody	Nutrient	N	Average Concentration	Median Concentration	Standard Deviation	Average N:P Ratio
Salt Creek at Murrieta Road	Total Phosphorus	108	0.75	0.66	0.47	4.2
	Total Nitrogen	108	2.47	2.32	0.91	
San Jacinto River at Goetz Road	Total Phosphorus	90	1.44	0.95	1.84	2.7
	Total Nitrogen	90	2.73	2.26	1.70	
Canyon Lake Spillway	Total Phosphorus	59	0.57	0.50	0.21	3.2
	Total Nitrogen	59	1.78	1.76	0.55	
Cranston Guard Station	Total Phosphorus	29	0.65	0.49	0.44	2.4
	Total Nitrogen	29	1.22	1.10	0.57	



Comprehensive Nutrient Reduction Plan For MS4 Permittees in Canyon Lake and Lake Elsinore Watershed	Dec. 1, 2011		**Figure B-19**	CDM
	Watershed Water Quality Monitoring Sites and Watershed Analysis Zones			

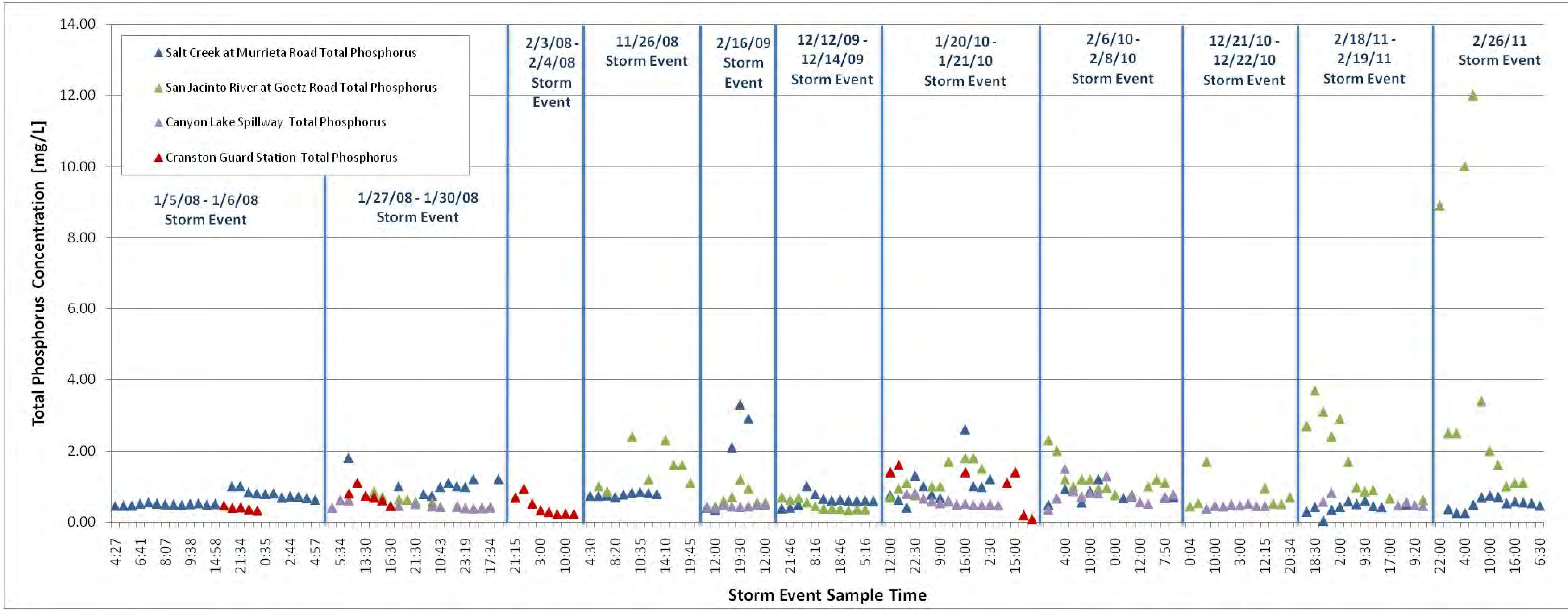


Figure B-20
Wet-Weather Sampling Total Phosphorus Concentrations

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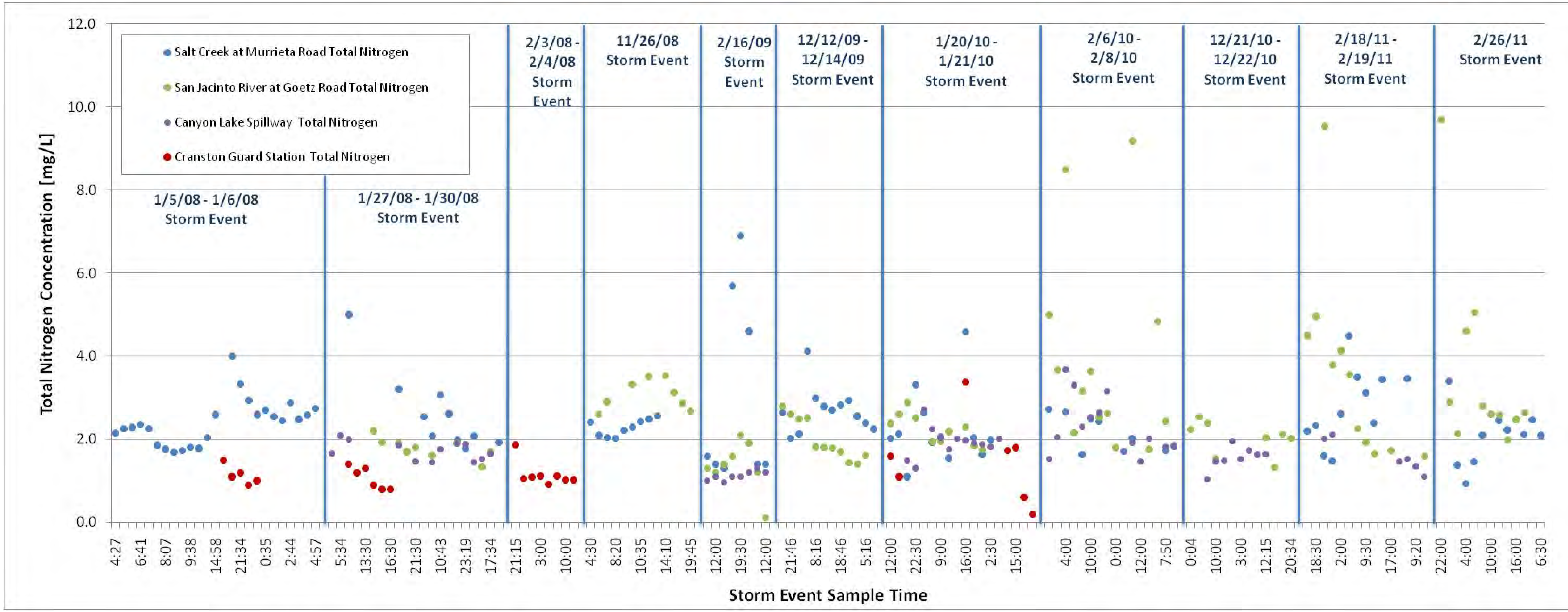

Figure B-21
Wet-Weather Sampling Total Nitrogen Concentrations

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MS4 System Monitoring

Wet weather monitoring during February 2011 was conducted by RCFCD&WCD at six outfalls to receiving waterbodies in the San Jacinto River watershed. The data collected at the Meadowbrook site consistently have significantly higher nutrient concentrations than would be expected from urban stormwater and would be candidates for follow up investigation (Table B-14). Other monitored outfalls have average nutrient concentrations that are generally lower than concentrations in CORE receiving waterbody monitoring sites for the two primary inputs to Canyon Lake from the San Jacinto River and Salt Creek.

Table B-14. Summary of Nutrient Water Quality Data for Phase 2 TMDL MS4 Outfall Monitoring during February 2011

Waterbody	Nutrient	N	Average Concentration	Coefficient of Variation
Hemet Channel at Sanderson Avenue	Total Phosphorus	9	0.28	0.28
	Total Nitrogen	9	1.19	0.25
San Jacinto River Upstream of Lake Elsinore	Total Phosphorus	7	0.59	0.26
	Total Nitrogen	7	1.59	0.22
Kitching St. Channel at Iris Avenue	Total Phosphorus	9	0.43	0.26
	Total Nitrogen	9	2.05	0.32
Meadowbrook at Highway 74	Total Phosphorus	10	1.21	0.41
	Total Nitrogen	10	11.83	0.21
Perris Valley Storm Drain at Nuevo Road	Total Phosphorus	11	0.82	0.32
	Total Nitrogen	11	2.71	0.49
Sierra Park Drain in Canyon Lake	Total Phosphorus	10	0.33	0.33
	Total Nitrogen	10	2.55	0.22

In addition to summary statistics, correlations were evaluated between nutrients and suspended sediment for samples collected during February 2011. TP showed a greater correlation strength with sediment than TN. The results showed statistically significant correlations, as follows:

- TN and TP: Pearson's r 0.78, $df = 54$, $p < 0.001$
- TN and TSS: Pearson's r 0.37, $df = 54$, $p = 0.004$
- TP and TSS: Pearson's r 0.76, $df = 54$, $p < 0.001$

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Attachment C
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CDM Smith

Attachment C
Canyon Lake Nutrient TMDL In-Lake Strategies Evaluation

C.1 Introduction

In order to achieve the nutrient wasteload allocations, and load allocations, established in the Lake Elsinore and Canyon Lake nutrient TMDLs, the responsible parties, which include the MS4 Permittees discharging urban runoff, considered: (1) implementing watershed-based activities and projects that reduce the discharge of nutrients into the lake; (2) implementing projects in the lakes that reduce in-lake loads and concentrations projects; or (3) some combination of. This evaluation provides a review of different strategies that can be considered for in-lake reduction of nutrient levels in Canyon Lake. The memorandum describes the approaches under consideration, evaluates and compares each approach on the basis of technical feasibility, load reduction potential for both Total-P and Total-N, cost-effectiveness, potential environmental issues, regulatory permitting requirements, public acceptance and other factors. The most feasible option(s) are identified with recommendations for potential inclusion in the overall CNRP in combination with other watershed based BMPs that address sources of nutrients introduced into the lake.

While the focus of the analysis is on the potential for utilizing in-lake options that at a minimum offset the remaining load reduction required from urban runoff, the analyses also show that some in-lake options could provide greater reduction that could help achieve required load reductions from other sources such as agriculture.

C.1.1 Review of Selected Treatment Strategies

Four methods of controlling nutrient loading in Canyon Lake were evaluated:

- Installation of a Hypolimnetic Oxygenation System (HOS)
- Addition of alum
- Addition of Phoslock®
- Zeolites.

Each nutrient reduction strategy is described in the sections below.

C.1.1.1 Hypolimnentic Oxygenation System (HOS)

Hypolimnentic anoxia occurs in large portions of Canyon Lake throughout much of the year. During periods of thermal stratification, generally the warmer months of the year, the hypolimnion of the lake will have dissolved oxygen concentrations approaching 0 mg/L which can result in a number of negative environmental impacts. Anoxic sediment has the potential to release nitrogen (as ammonia) and phosphorus (as orthophosphate) back into the water column. This internal cycling of nutrients from the sediment back into the water column can result in high nutrient concentrations in the hypolimnion. Each year during lake turnover, the nutrient rich Hypolimnetic waters are mixed with water in the photic zone and can result in very high concentrations of bio-available nutrients which can lead to a large increase in chlorophyll a concentrations in the lake and the potential for hazardous algal blooms.

A Hypolimnetic Oxygenation System (HOS) is used to inject pure oxygen into the anoxic water layer overlying the sediment, which can rapidly increase dissolved oxygen (DO) concentrations throughout the hypolimnion. The increase in DO greatly reduces the cycling of nutrients from the sediment into the water column. This can result in significant reductions in the overall nutrient concentrations in the lake, bringing it closer to the desired TMDL endpoints.

The use of a HOS will have similar effects to mechanical aeration of the hypolimnion using air drawn from the surface and bubbled through the hypolimnion. However, there are some distinct advantages to using pure oxygen gas as opposed to air. The HOS system will not cause the de-stratification of the water column as aeration will. This can result in a more natural temperature regime in the lake which provides valuable thermal refugia for fish and other organisms. Aeration systems typically mix the water column and de-stratify the lake, resulting in the loss of these thermal refugia. The potential advantages of using a HOS over an aeration system have led to this method being recommended as a potential strategy for treatment of internal nutrient loading in Canyon Lake (Anderson 2007).

A detailed feasibility and preliminary design study of various approaches and configurations of a HOS system was recently conducted for LESJWA by Pacific Advanced Civil Engineering, Inc (PACE) with the revised version completed in April, 2011 (PACE, 2011). The recommended option is summarized further under Concept Level Evaluation of Potential Treatment Strategies.

C.1.1.2 Chemical Treatment Strategies

Reductions in internal nutrient loading and overall nutrient concentrations at Canyon Lake may be achieved using one or more of the chemical additives alum, Phoslock, or Zeolite. Each option is potentially effective for reducing nutrient levels in the lake, but with varying costs and degrees of feasibility. With continued external loading, all three options will provide only a temporary reduction of in-lake phosphorus levels and would need to be applied on a semi-regular basis. The frequency of each application will vary based on inflow rates, additive selected and initial dose.

C.1.1.3 Alum

Aluminum sulfate (alum) is a relatively non-toxic material commonly used as a clarifier in water treatment facilities that has been shown to be an effective means of removing phosphorus from the water column under certain conditions. When alum is added to the waterbody, an aluminum hydroxide precipitate known as floc is formed. The floc binds with phosphorus in the water column to form an aluminum phosphate compound which will settle to the bottom of the lake or reservoir. Once precipitated to the bottom of the reservoir, the floc will also act as a phosphorus barrier by binding any phosphorus released from the sediments during normal nutrient cycling processes that occur under anoxic conditions such as those found in much of the hypolimnion at Canyon Lake. The aluminum phosphate compounds are insoluble in water under most conditions and will render all bound phosphorus unavailable for nutrient uptake by aquatic organisms.

There are limitations to the amount of alum that can safely be added to a waterbody in an attempt to bind available phosphorus. The chemical reactions involved in the process result in a release of 3 mols of H+ for every mol of Aluminum added, potentially causing sharp drops in the pH of the waterbody. Lowered pH can cause a number of potential risks to biota. For example, the solubility and toxicity of many metals, including aluminum, is greatly increased at pH values below 6.0. As a result of this potential for alum additions to cause dangerous drops in pH, a major factor in considering the dose and applicability of alum to a given waterbody will involve an understanding of the alkalinity (acid-neutralizing capability) of the lake. Lakes with low alkalinity will have a lower potential maximum dose of alum that can be applied and will often require the use of buffered alum or aluminate.

Alum application provides a relatively rapid way to reduce phosphorus concentrations in a reservoir; however, the effects of a treatment are often only temporary. The effectiveness and longevity of an alum application will vary greatly, depending on a water body's sedimentation and external nutrient loading rates, among other factors. The average range of effectiveness for a single treatment has been reported to be on the order of 4-13 years (HEC, 2003). The effective dose of alum for a given treatment can be calculated in three ways:

1. The first method of calculating alum dose is based on alkalinity to ensure the alum dose does not exceed the lake water buffering capacity. In lakes with low alkalinity alum addition will not be buffered effectively and the pH of lake water will drop substantially, potentially below the range of 6.0-8.0 at which alum is most effective.

2. The second method is based on the amount of phosphorus release from the sediment, and alum dose is calculated to give a stoichiometric ratio of 1.0 over five years; i.e., the dose is determined as five times the average summer internal phosphorus load.

3. Sediment phosphorus method: mobile phosphorus (iron-bound phosphorus and loosely sorbed or labile phosphorus) in sediments, the source of internal loading, is used directly with the ratio of aluminum added to aluminum-bound phosphorus formed to estimate the dose (Rydin and Welch 1998, 1999). The sediment depth over which to treat requires some judgment with this method.

In addition to calculating the dose requirements for an effective alum treatment, the following factors need to be considered prior to alum addition:

- pH – the current pH range of the lake is important as alum treatments will be most effective if pH is within the 6.0-8.0 range. High pH waters can degrade the effectiveness of floc formation and limit results.

- Alkalinity- lakes with low alkalinity (< 50mg $CaCO_3$/L) will result in sharp declines in pH upon alum addition.

- Tannins- Alum may not be effective if high concentrations of tannins are present in the target lake.

- Dissolved oxygen concentrations- waters low in oxygen can cause the floc to break down and re-release phosphorus to the water column under certain conditions. Nitrogen concentrations – studies show that alum is not an effective treatment for nitrogen removal, potentially limiting its overall effectiveness in nutrient reduction.

- Sedimentation rates- high rates reduce longevity of alum effectiveness.
- Timing of application- Alum applications are most effective when hypolimnetic P is at maximum (i.e. near end of thermal stratification)
- Mixing regime and wind exposure-
  - wind makes it difficult to evenly apply the alum to the surface of the waterbody
  - shallow lakes in especially windy locations may be continually mixed, which may expose toxic Al species to water column.
  - stratified lakes with uneven pH (high on top, low on bottom) allow toxic Al to persist until mixing
- Biota risk- pH outside of 6.0-8.0 range can be toxic to aquatic organisms, and low pH can lead to leaching of potentially hazardous metals into the water column.
- External phosphorus loads- alum has limited binding sites and will poorly treat additional loads of P

A study conducted on Canyon Lake (Anderson, 2007) assessed the potential for in-lake alternatives for nutrient reduction including the use of alum. The study determined that the approximate dose required on the order of 229 – 287 g Al/m^2 or approximately 76-95 mg/L liquid alum. The dose estimates reported in this study used both the second and third methods of dose calculation described above. The estimated dose required represent a very high dose and would require significant buffering in order to keep the pH in the lake above 6.0 at the time of application. Alum treatments would likely have the lowest long-term effectiveness compare to the other options and other studies indicate that, without significant external load reductions, alum treatment may need to be repeated after all significant run-off events. The large dose and potentially adverse effects suggest that Alum treatments may not be appropriate for Canyon Lake. Also alum has a low effectiveness for reducing nitrogen compounds.

C.1.1.4 Phoslock

Phoslock is a commercially available, modified bentonite clay product containing the naturally occurring element lanthanum that has been shown to be effective in the treatment of excessive internal nutrient loading in lakes and reservoirs. Phoslock was originally developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) and its research partner, Water and Rivers Commission (Department of Environmental Protection, Western Australia) and has been successfully used in a number of waterbodies on several continents. Similar to alum, Phoslock is applied to the waterbody at the surface in the form of a slurry which may take several days to settle to the bottom. As it settles, the Phoslock will interact with the bioavailable phosphorus (phosphate) in the water column, binding the lanthanum and phosphate into the highly stable mineral Rhabdophane. Phoslock is applied in quantities great enough to form a sediment cap of no less than 0.5mm thick. This capping effect will prevent the bioavailable phosphorus in the sediment from recycling back into the water column.

Although Phoslock has been shown to bind less phosphorus per unit of application than alum, it provides a number of advantages over the more common alum application. Phoslock has shown to have no toxicity to aquatic organisms at the recommended application rates; however, there has been insufficient testing of the material to show that it is 100 percent non-toxic. Also, Phoslock recently received NSF/ANSI standard 60 certifications to apply to potable water supplies. Unlike alum, Phoslock does not require a buffer solution as it will not cause significant changes in pH upon application to the waterbody. Phoslock is also effective over a wider range of naturally occurring pH values than alum. Phoslock also appears to be less influenced by humic substances such as tannins which may occur in abundance in some waterbodies. In addition, Phoslock has also been shown to be somewhat effective in reducing nitrogen cycling from the sediment (McIntosh, 2007) although no quantitative estimates are available or claimed by the manufacturer.

Calculating the recommended dose of Phoslock is considerably more straight-forward than calculations and considerations required for alum treatments. The manufacturer suggests that approximately 100 kg of dry Phoslock material will be required to remove 1 kg of biologically active phosphorus (BAP) in the lake. Previous studies conducted at Canyon Lake suggest that phosphorus loading in the lake is on the order of 2,000-3,000kg per year in excess of the assimilative capacity of the waterbody. This would suggest that approximately 200-300 metric tons of Phoslock would need to be applied to Canyon Lake during the initial treatment. Phoslock will remain an effective barrier to nutrient recycling from the sediments for a number of years and any subsequent doses required are likely to be considerably smaller, potentially targeted to the mass of new phosphorus brought in with annual runoff. Over time, the Phoslock cap will become buried by new sediment, its effectiveness will be diminished. At some point, a greater dosage more equivalent to the initial dosage may be required to re-establish the “blanket”.

C.1.1.5 Zeolites

Zeolites refers to a class of naturally-occurring microporous aluminosilicate minerals which can have a high negative charge on their surface. The negatively charged surface of zeolite particles can be used to attract and bind positively charged cations. A number of different zeolites with variable chemical structures are found in nature; however, the natural structure all zeolites share gives the minerals a large surface area and high negative charge which can allow for cation exchange capacities greater than 100mEq/100g. Zeolites occur in many parts of the world and are mined and used locally for a number of commercial applications including wastewater treatment, animal feed supplements, water and air filtration, odor control, and soil conditioning. Although zeolites have become a commercially available chemical solution for reducing nutrient levels in aquariums and decorative ponds, the use of zeolites in controlling high nutrient concentrations in large, naturally occurring waterbodies has only recently emerged as a potential area of study. A small number of successful trials of Zeolite application for the removal of nutrients from a waterbody have been conducted in recent years in New Zealand, Australia and the European Union. In most cases, the Zeolites used were naturally occurring in the region and were applied after some relatively simple physical and chemical modification of the naturally occurring form.

Zeolite application to lakes and reservoirs is conceptually similar to applying Phoslock and alum, but may offer some distinct advantages. Zeolites are highly efficient at binding both phosphates (P) and ammonia (N) and, depending on the chemical make-up of the specific zeolite used, may require considerably less material per unit of nutrient removal than Phoslock. Adsorption rates for PO4-P and NH4-N in lake studies have been shown to be very high with up to 90 percent of phosphate and 98 percent of the $N4_4$-N being bound to the zeolites and removed from the water column. In addition, zeolites are naturally occurring in many parts of the world and commercial mining operations for zeolites already exist in parts of California, Arizona, and Nevada which could provide a relatively close source of the material for application at Canyon Lake and considerable cost savings over alum and Phoslock applications.

Fine-grained modified zeolite application may have additional positive impacts on water quality in a lake. Beyond the ability to sequester soluble reactive phosphorus and ammonia, the negatively charged zeolite material can also be effective at coagulating and settling suspended dirt particles, bacteria and many microorganisms that possess charged surfaces in natural water. However, zeolite applications performed to date have utilized zeolites at larger particle sizes than Phoslock that settle more quickly, allowing less time for flocculation of particles and binding to phosphate in water column. At sufficient applications rates, zeolites will form a sediment cap similar to that created in a Phoslock application which will prevent nutrient cycling from the sediment back in to the water column. Once in the sediment, zeolite has also been shown to be successful in adsorbing the bioavailable phosphorus in the sediment. A study was conducted in New Zealand (Faithful et. al., 2005) with up to 50 percent of the bioavailable phosphorus in the sediment being adsorbed over 18 months However, the larger particle size of zeolite suggests that sediment capping may remain more permeable, allowing some nutrient cycling to continue.

Some of the most promising investigations and applications have been conducted by Pacific Blue Materials, a company in New Zealand. They have applied a modified zeolite with a aluminum based P-binding agent to block the release of both P and NH_4-N from the sediment and remove them from the overlying water. The product is being marketed as Aqual-P. To date it has only been used in New Zealand but the company is planning an application in Singapore and has indicated an interest in supplying the material to other countries.

There are some additional concerns regarding the safety and practicality of a modified zeolite application to remove nutrients from Canyon Lake. Zeolite application is an emerging technology and few studies have been conducted on the long-term effectiveness, the effectiveness under anoxic conditions, and concentrations at which there is potential for toxicity. There are very few examples in the literature of zeolite application for nutrient removal in lakes worldwide, and no major publications have been identified which examined zeolite applications to lakes in the United States.

Calculating the recommended dose of zeolite and associated costs is difficult based on the current state of the industry and market for zeolite for waterbody applications in the U.S. Although zeolites are mined for other commercial uses in parts of California, Nevada, and Arizona, a proven source of zeolites capable of efficient nutrient removal in lakes and reservoirs has yet to be identified. Furthermore, zeolite field trials to date have typically been conducted with modified zeolite, which has been thermally or chemically processed to improve binding efficiency with phosphates. The process and associated costs of creating a modified zeolite optimized for nutrient adsorption will vary based on the exact chemical makeup of the raw zeolite source material. Therefore, the costs associated with zeolite application at Canyon Lake can only be developed at a very cursory level. Based on the potential for local sourcing and reduced raw material costs and expected dosage requirements as compared to Phoslock, it is possible that zeolite application could provide considerable cost savings over Phoslock application while providing a higher level of effectiveness at removing both P and N from the system.

C.1.1.6 Summary

Preliminary findings indicate that Phoslock and modified zeolites are more likely to be usable in Canyon Lake than alum. Alum has been used extensively for nutrient reduction in lakes and reservoirs in the United States. However, conditions within Canyon Lake and the very large estimated dose of alum required to successfully treat the lake suggest that alum will not provide a safe and effective means of treating the internal nutrient loading in Canyon Lake. Alum treatments at Canyon Lake will not be further evaluated within this report.

Phoslock has been shown to be effective under a variety of water quality conditions and has less potential for adverse affects than alum, particularly at the estimated doses required for successful treatment at Canyon Lake. Phoslock has some advantages over zeolite in that it is a somewhat more intensely studied technology that has been successfully applied in a range of conditions and locations. The first trials of

Phoslock in the U.S. occurred in 2010 on a series of lakes in Orange County, California. However, the costs associated with Phoslock application at Canyon Lake are likely to be high.

Although early indications show that zeolites may provide the most effective means of treatment for the internal nutrient loading in Canyon Lake for both phosphorus and nitrogen, some concerns still exist. Zeolite has only recently gained attention as an in-lake nutrient treatment option, and is still poorly reported in the literature. Especially, few trials or case-studies are available for zeolite application at lakes in the United States, although results from studies in other countries have shown treatment with zeolites to be both safe and effective. The limited use of zeolites in the U.S to date may make it difficult to identify suppliers and may have a higher level of uncertainty as to effectiveness, risks, and costs than the somewhat more commonly used Phoslock application.

C.1.2 Concept Level Evaluation of Potential Treatment Strategies

C.1.2.1 Hypolimnentic Oxygenation System (HOS)

As described in the PACE study identified above, the HOS system is presumed to consist of the facilities described under Option 10b, which includes two onshore oxygenation systems (1,200 lb and 600 lb each), the underwater piping, and all appurtenant facilities, constructed in two phases. CDM reviewed the capital and O & M cost estimates developed in the report. The base construction cost of $1,563,000 for all phases, as shown in the April 18, 2011, report addendum appears reasonable. However, at this conceptual level of design, CDM would recommend a 25 percent contingency factor rather than a 10 percent contingency factor. In addition, CDM recommends that the allowance for non-construction costs, which consist of such activities as design, construction services, environmental compliance, permitting, legal, etc., be increased to 30 percent of construction cost, rather than the approximately 8 percent shown. With these two changes, the total capital cost estimate for both phases would be $2,834,000. CDM also reviewed the O&M costs provided in the report. The labor hours for operation and maintenance (200 hours/year) appeared low, so these were increased to 400 hours per year (essentially 20 percent of a full-time effort), and the rate for power was increased to $0.14/kwh to reflect typical current power rates. These two factors would increase the estimated annual O&M cost to $130,000 vs. the $100,000 shown in the report.

If the full system were installed in the main body and continuously operated through most of the year, and the increased dissolved oxygen in the hypolimnion maintained as projected, it is anticipated that a relatively large reduction in the release of phosphorus and a lesser reduction in the release of ammonia from the sediments could be achieved. Furthermore, it is anticipated that the system would be able to maintain its effectiveness fairly consistently from year to year. For "default" assumptions on the reductions that could be achieved by a HOS system in the main body, CDM used estimates from Anderson, 2007, that indicated the HOS system could effectively reduce the SRP flux from the sediments by 71 percent and the NH4-N flux by 35 percent. As a independent check, CDM also performed a limited evaluation of the potential for sediment flux reduction, using a modeling approach and parameters developed from a recent study for the City of Los Angeles for Machado Lake, the results of which are documented in Appendix A. This model was developed using data from a sediment core study conducted by Alex Horne. While some of the same parameters were not readily available for the Canyon Lake studies, it was believed that this effort could at least provide a check on whether the assumptions were reasonable. As documented in the appendix, when the flux model was applied to the available canyon lake parameters, it suggested that there was the potential to achieve an even larger reduction in sediment flux, approaching 90 percent SRP and 60 percent NH4-N. It was decided to use the estimates developed by Anderson that may reflect a somewhat conservatively low estimate for this phase of implementation planning.

When these values are applied to the estimated flux in the main body of 2,685 kg/year Total-P and 8,578 NH4-N, it suggests that the long term average reduction in nutrient flux from the sediments in the main body would be approximately 1,906 kg/year and 3,001 kg/year, respectively.

Lake aeration systems are very common and have been in place for many years. Pure oxygenation systems targeting the hypolimnion are much less common but have been in place and demonstrated in a number of locations in the U.S. To implement the system would require extensive coordination and permitting efforts with a number of agencies as well as CEQA compliance both for the construction and operation of the system. Areas of potential uncertainty include long-term energy cost trends, actual demonstrated effectiveness over a relatively large water body.

C.1.2.2 Phoslock

The anticipated cost of a Phoslock application is heavily dependent on the calculated dose requirements. As previously discussed, a properly applied dose of Phoslock is expected to have a Phoslock to Biologically Active Phosphorus (BAP) removal ratio of approximately 100:1. Therefore, each 1 kg of BAP in excess of the assimilative capacity of the water body will require approximately 100 kg of Phoslock in order to render the BAP inactive. Discussions with the representatives of Phoslock have suggested that an initial dose of Phoslock be applied to develop a sediment cap of approximately 0.5 mm thick which is expected to tie up phosphorus releases for sediments for a number of years. Subsequently much lower dosages could be re-applied annually following the rainy season to remove new phosphorus in the water column that is brought in from runoff. Estimates of the phosphorus loads in reflux from the sediments were provided in the final TMDL reports as shown in Table 1 and are on the order of 4,625 kg/year expressed as FRP with 2,685 in the main body and 1940 kg/year in the East Bay. In addition, the projected MS4 annual loads (including septic loads), reduced by future land use conversions and program implementation measures, to Canyon Lake indicates a long-term average of approximately 466 kg/year for TP into the lake. Estimates of the ratio of reactive phosphorus to total phosphorus were taken from 2010 monitoring data for both Salt Creek and the San Jacinto River upstream of Canyon Lake.

Table C-1. TP and FRP loads to Canyon Lake

	East Bay		Main Body		Lake Total	
	Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Sediment Reflux (kg/yr)
TP (kg/yr)	142		333		476	
FRP (kg/yr)	57	1,940	50	2,685	78	4,625

Based on these estimates of phosphorus loadings, projections of the amount of Phoslock that would be needed to create an initial sediment "cap" and add additional Phoslock to address the annual phosphorus loads was developed. It was also assumed that after 10 years, an additional "cap" would be needed to replace the initial layer. The estimates were developed for three different scenarios:

- Phoslock applied only to the Main Body of the lake, equivalent to area proposed for the HOS system as an alternative to HOS system
- Phoslock applied only the Salt Creek Arm to reduce Phosphorus in this portion of the lake, in addition to installing the HOS system in the main body
- Phoslock applied throughout the entire lake, with no HOS system installed.

The second and third scenarios will reduce/remove a significantly greater overall load of phosphorus than the first, as noted below. In order to estimate an annual application, the net remaining annual load reduction for phosphorus for Canyon Lake was used as a basis for estimating annual Phoslock applications. This value diminishes over time, and after 2019, the net load reduction is negative; therefore, additional application was not expected to be required (except for the re-application of a blanket after 10 years).

Current costs of a Phoslock application will vary based on a variety of factors which have not yet been fully assessed. The manufacturer and U.S. distributer have a indicated cost estimate of $180-$200 per pound ($396-$440 per kg) of BAP removed from the waterbody, with the cost per pound generally trending lower for larger applications. However, there has not been a Phoslock application in the U.S. at the scale of what would be required in Canyon Lake, and because the cost estimates are programmatic and include all aspects of application, data collection, and monitoring necessary in an application of this nature, it is likely that the cost per unit of BAP removed is likely on the conservatively high side. Applying these values to the Canyon Lake load reduction goals, Tables C-2 to C-4 present the total application requirements and cost estimate by year, and the 20-year total.

In addition to the costs of Phoslock application at Canyon Lake, a number of regulatory issues may be involved in obtaining approval to use the material. Previously published trials of Phoslock in the U.S. are limited. Recently, Phoslock has been applied at reservoirs in Orange County, California As a result, obtaining the appropriate approvals from State and Federal agencies may require considerable effort. The Manufacturer is currently working with the San Diego Regional Water Quality Control Board to obtain a De Minimus Waste Discharge Requirements for the use of Phoslock in lakes within its jurisdiction. To implement use of Phoslock would require extensive coordination and permitting efforts with a number of agencies as well as a potential for CEQA compliance for the application. Areas of potential uncertainty include long-term energy, dosage requirements, and actual demonstrated effectiveness over a relatively large water body.

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Table C-2. Estimates of Phoslock Application for Main Body Application Only

	Existing FRP Load into Main Body of Canyon Lake		FRP Load with Phoslock Treatment						
Year	Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Estimated Sediment Reflux Reduction efficiency	Continued Sediment Reflux (kg/yr)	Treated FRP (kg)	Treated FRP (pounds)	Cost per Pound of Treated P - applied	
1	106.89	2,685	0	90%	269	1,343	2,960	$ 180.00	
2	103.845	2,685	0	90%	269	1,343	2,960	$ 180.00	
3	97.65	2,685	0	90%	269	98	215	$ 198.00	
4	85.365	2,685	0	90%	269	85	188	$ 198.00	
5	70.035	2,685	0	80%	537	70	154	$ 198.00	
6	51.555	2,685	0	80%	537	52	114	$ 198.00	
7	39.165	2,685	0	80%	537	39	86	$ 198.00	
8	23.835	2,685	0	80%	537	24	53	$ 198.00	
9	8.4	2,685	0	70%	806	8	19	$ 198.00	
10	0	2,685	0	70%	806	-	-	$ 198.00	
11	0	2,685	0	90%	269	1,343	2,960	$ 180.00	
12	0	2,685	0	90%	269	1,343	2,960	$ 180.00	
13	0	2,685	0	90%	269	-	-	$ 198.00	.
14	0	2,685	0	90%	269	-	-	$ 198.00	$ -
15	0	2,685	0	80%	537	-	-	$ 198.00	$ -
16	0	2,685	0	80%	537		-	$ 198.00	$ -
17	0	2,685	0	80%	537	-	-	$ 198.00	$ -
18	0	2,685	0	80%	537	-	-	$ 198.00	$ -
19	0	2,685	0	70%	806	-	-	$ 198.00	$ -
20	0	2,685	0	70%	806	-	-	$ 198.00	$ -
Total	**587**	**53,700**			**9,666**				**$ 2,295,096.60**

Total P Removed/Sequestered over 20 years (kg)	**44,621**
Average Annual Cost	**$ 114,754.83**

[1] Based on 2-year sediment capping process recurring every 10 years

Table C-3. Estimates of Phoslock Application for East Bay Application Only

	Existing FRP Load into East Bay of Canyon Lake		FRP Load with Phoslock Treatment						
Year	Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Estimated Sediment Reflux Reduction Efficiency	Continued Sediment Reflux (kg/yr)	Treated FRP (kg)	Treated FRP (pounds)	Cost per Pound of Treated P - Applied	Total Annual Cost Estimate[1]
1	122.16	1,940	0	90%	194	970	2,138	$ 180	$ 384,923
2	118.68	1,940	0	90%	194	970	2,138	$ 180	$ 384,923
3	111.6	1,940	0	90%	194	111.6	246	$ 198	$ 48,715
4	97.56	1,940	0	90%	194	97.56	215	$ 198	$ 42,586
5	80.04	1,940	0	80%	388	80.04	176	$ 198	$ 34,938
6	58.92	1,940	0	80%	388	58.92	130	$ 198	$ 25,719
7	44.76	1,940	0	80%	388	44.76	99	$ 198	$ 19,538
8	27.24	1,940	0	80%	388	27.24	60	$ 198	$ 11,891
9	9.6	1,940	0	70%	582	9.6	21	$ 198	$ 4,191
10	0	1,940	0	70%	582	0	-	$ 198	$ -
11	0	1,940	0	90%	194	970	2,138	$ 180	$ 384,923
12	0	1,940	0	90%	194	970	2,138	$ 180	$ 384,923
13	0	1,940	0	90%	194	0	-	$ 198	$ -
14	0	1,940	0	90%	194	0	-	$ 198	$ -
15	0	1,940	0	80%	388	0	-	$ 198	$ -
16	0	1,940	0	80%	388	0	-	$ 198	$ -
17	0	1,940	0	80%	388	0	-	$ 198	$ -
18	0	1,940	0	80%	388	0	-	$ 198	$ -
19	0	1,940	0	70%	582	0	-	$ 198	$
20	0	1,940	0	70%	582	0	-	$ 198	$
Total	**671**	**38,800**			**6,984**				**$ 1,727,270**

Total P Removed/Sequestered over 20 years (kg)	**32,487**
Average Annual Cost	**$ 86,363.50**

[1] Based on 2-year sediment capping process recurring every 10 years

Table C-4. Estimates of Phoslock Application for Whole Lake Application Scenario

	Existing FRP Load into all of Canyon Lake		FRP Load with Phoslock Treatment						
Year	Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Estimated Sediment Reflux Reduction Efficiency	Continued Sediment Reflux (kg/yr)	Treated FRP (kg)	Treated FRP (pounds)	Cost per Pound of Treated P - Applied	Total Annual Cost Estimate[1]
1	167.97	4,625	0	90%	463	2,313	5,098	$ 180.00	$ 917,664.75
2	163.185	4,625	0	90%	463	2,313	5,098	$ 180.00	$ 917,664.75
3	153.45	4,625	0	90%	463	153	338	$ 198.00	$ 66,982.58
4	134.145	4,625	0	90%	463	134	296	$ 198.00	$ 58,555.74
5	110.055	4,625	0	80%	925	110	243	$ 198.00	$ 48,040.20
6	81.015	4,625	0	80%	925	81	179	$ 198.00	$ 35,363.92
7	61.545	4,625	0	80%	925	62	136	$ 198.00	$ 26,865.06
8	37.455	4,625	0	80%	925	37	83	$ 198.00	$ 16,349.51
9	13.2	4,625	0	70%	1,388	13	29	$ 198.00	$ 5,761.94
10	0	4,625	0	70%	1,388	-	-	$ 198.00	$ -
11	0	4,625	0	90%	463	2,313	5,098	$ 180.00	$ 917,664.75
12	0	4,625	0	90%	463	2,313	5,098	$ 180.00	$ 917,664.75
13	0	4,625	0	90%	463	-	-	$ 198.00	$ -
14	0	4,625	0	90%	463	-	-	$ 198.00	$ -
15	0	4,625	0	80%	925	-	-	$ 198.00	$
16	0	4,625	0	80%	925	-	-	$ 198.00	$ -
17	0	4,625	0	80%	925	-	-	$ 198.00	$
18	0	4,625	0	80%	925	-	-	$ 198.00	$ -
19	0	4,625	0	70%	1,388	-	-	$ 198.00	$ -
20	0	4,625	0	70%	1,388	-	-	$ 198.00	$ -
Total	**922.02**	**92,500**			**16,650**				**$ 3,928,577.95**

Total P Removed/Sequestered over 20 years (kg)	**76,772**
Average Annual Cost	**$ 196,428.90**

[1] Based on 2-year sediment capping process recurring every 10 years

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C.1.2.3 Zeolite

Developing project-specific estimates for the potential costs of zeolite application to treat the condition of excess nutrients in Canyon Lake is difficult based on current information available regarding zeolite applications in large waterbodies in the U.S. Zeolites are a naturally occurring class of minerals which are mined in a variety of locations throughout the world. The exact chemical make-up of a mined zeolite formation will vary from site to site and may vary considerably within a given source area. The relative effectiveness of a given zeolite source at removing specific cations such as $PO4^{+}$ and $NH4^{+}$ from a waterbody will depend on a number of physical and chemical conditions within the zeolite. The relative purity of the zeolite source material will also influence the expected dose calculations.

Calculating dosage requirements for zeolite application is similar to Phoslock dosage estimation and involves an attempt to calculate the relative mass of zeolite which would be required for removal of a given mass of N or P in the waterbody. The result would be an estimate of the kilograms of zeolite required per kilogram of N or P removed from the waterbody. Although little data from field trials is available, one laboratory study conducted on wastewater in New Zealand using a locally sourced and un-modified zeolite, clinoptilolite, showed maximum NH4+ removal rates in water of 5.75 g of NH4-N per kg of zeolite added (Nguyen 1998). Based on these results, it would require approximately 174 kg of clinoptilolite to remove 1 kg of NH4-N from the waterbody. This study did not provide estimates of phosphate removal rates. Based on the internal loading estimates from the Canyon Lake TMDL reports, removal of the full 4,971 kg of NH4-N in the East Bay and 8,578 kg of NH4-N in the main body would require the addition of approximately 865 and 1,492 metric tons of clinoptilolite zeolite, respectively (Table C-5).

There remains a potential need for additional treatments to the lake as external loads of nutrients and sediment continue to enter the lake. Calculations of annual or long-term application scenarios for zeolites similar to those performed for Phoslock treatments are shown in **Table C-5 to C-7.** As described previously for Phoslock, the net remaining annual load was used as a basis for estimating long-term applications. In the use of TN and Ammonia, this value is projected to gradually increase over time. Projections of cost over a 20-year period were estimated for scenarios involving applications of zeolite to the Main Body only, the East Bay only, and the whole lake combined, as shown in **Table C-5 to C-7.** Many of the current assumptions and uncertainties regarding long-term projections of zeolite efficacy at nutrient reduction can be mitigated if an adaptive management strategy is adopted.

Due to the currently undeveloped state of the zeolite industry in regards to in-lake water treatment applications, some information necessary to provide accurate cost information is currently unavailable, and some broad assumptions were made during development of the rough cost estimates in Table C-5, specifically in regard to dosage requirements, material and application costs. Commercial sources of clinoptilolite zeolite are available in the southern California region; however, suitability of the source material for in-lake nutrient removal is currently untested. Procedures for application of zeolite to a waterbody are similar to application of Phoslock, suggesting that similar application costs for both products may be expected. However, there are no known commercial zeolite applications to waterbodies in the U.S. or vendors developing the application, so identifying potential application contractors may be difficult. Very preliminary cost estimates were also received from a company in New Zealand that has been doing pioneering work with zeolite treatment of lakes using material mined and processed in New Zealand. The preliminary unit cost estimates were significantly higher than those used in Table 5, which could potentially make the cost of zeolite treatment much higher than other methods. Considerably more investigation would be needed to refine both the application rates and potential domestic sources and costs to determine if zeolite application is a viable option

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Table C-5. Estimates of Zeolite Application for Main Body Application Only

	Existing NH4-N into Main Body of Canyon Lake		NH4-N Load with Zeolite Treatment									
Year	NH4-N Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Estimated Sediment Reflux Reduction Efficiency	Continued Sediment Reflux (kg/yr)	Treated NH4-N (kg)	Estimated Zeolite mass per kg NH4-N Removal (kg)	Total Zeolite Addition (Metric Tons)	Zeolite Material Costs (Per Metric Ton)	Zeolite Shipping Costs[1] (Per Metric Ton)	Zeolite Application Costs (Per Metric Ton)	Total Annual Cost Estimate[2]
1	571	8,578	0	90%	858	4,289	173.9	745.9	$ 160.00	$ 500.00	$ 100.00	$ 566,851.40
2	573	8,578	0	90%	858	4,289	173.9	745.9	$ 160.00	$ 500.00	$ 100.00	$ 566,851.40
3	577	8,578	0	90%	858	577	173.9	100.4	$ 160.00	$ 500.00	$ 100.00	$ 76,317.68
4	585	8,578	0	90%	858	585	173.9	101.8	$ 160.00	$ 500.00	$ 100.00	$ 77,370.93
5	595	8,578	0	80%	1,716	595	173.9	103.5	$ 160.00	$ 500.00	$ 100.00	$ 78,687.50
6	607	8,578	0	80%	1,716	607	173.9	105.6	$ 160.00	$ 500.00	$ 100.00	$ 80,267.37
7	615	8,578	0	80%	1,716	615	173.9	107.0	$ 160.00	$ 500.00	$ 100.00	$ 81,320.63
8	625	8,578	0	80%	1,716	625	173.9	108.7	$ 160.00	$ 500.00	$ 100.00	$ 82,637.19
9	635	8,578	0	70%	2,573	635	173.9	110.5	$ 160.00	$ 500.00	$ 100.00	$ 83,953.75
10	645	8,578	0	70%	2,573	645	173.9	112.2	$ 160.00	$ 500.00	$ 100.00	$ 85,270.32
11	653	8,578	0	90%	858	4,289	173.9	745.9	$ 160.00	$ 500.00	$ 100.00	$ 566,851.40
12	663	8,578	0	90%	858	4,289	173.9	745.9	$ 160.00	$ 500.00	$ 100.00	$ 566,851.40
13	669	8,578	0	90%	858	669	173.9	116.4	$ 160.00	$ 500.00	$ 100.00	$ 88,430.07
14	679	8,578	0	90%	858	679	173.9	118.1	$ 160.00	$ 500.00	$ 100.00	$ 89,746.63
15	687	8,578	0	80%	1,716	687	173.9	119.5	$ 160.00	$ 500.00	$ 100.00	$ 90,799.89
16	695	8,578	0	80%	1,716	695	173.9	120.9	$ 160.00	$ 500.00	$ 100.00	$ 91,853.14
17	703	8,578	0	80%	1,716	703	173.9	122.2	$ 160.00	$ 500.00	$ 100.00	$ 92,906.39
18	711	8,578	0	80%	1,716	711	173.9	123.6	$ 160.00	$ 500.00	$ 100.00	$ 93,959.64
19	717	8,578	0	70%	2,573	717	173.9	124.7	$ 160.00	$ 500.00	$ 100.00	$ 94,749.58
20	725	8,578	0	70%	2,573	725	173.9	126.1	$ 160.00	$ 500.00	$ 100.00	$ 95,802.83
Total	**12,934**	**171,560**	**-**		**30,881**							**$ 3,651,479.12**

Total NH4-N Removed/Sequestered over 20 years (Kg)	**153,613**
Average Annual Cost	**$ 182,573.96**

[1] Based on 250 Mile Delivery (NV mine to Canyon Lake)

[2] Based on 2-Year Sediment Capping Process Recurring Every 10 Years

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Year	NH4-N Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Estimated Sediment Reflux Reduction Efficiency	Continued Sediment Reflux (kg/yr)	Treated NH4-N (kg)	Estimated Zeolite mass per kg NH4-N Removal (kg)	Total Zeolite Addition (Metric Tons)	Zeolite material costs (Per Metric Ton)	Zeolite Shipping Costs[1] (Per Metric Ton)	Zeolite Application Costs (Per Metric Ton)	Total Annual Cost Estimate[2]
1	135	4,971	0	90%	497	2,486	173.9	432.2	$ 160.00	$ 500.00	$ 100.00	$ 328,493.62
2	136	4,971	0	90%	497	2,486	173.9	432.2	$ 160.00	$ 500.00	$ 100.00	$ 328,493.62
3	137	4,971	0	90%	497	137	173.9	23.7	$ 160.00	$ 500.00	$ 100.00	$ 18,045.56
4	138	4,971	0	90%	497	138	173.9	24.1	$ 160.00	$ 500.00	$ 100.00	$ 18,294.61
5	141	4,971	0	80%	994	141	173.9	24.5	$ 160.00	$ 500.00	$ 100.00	$ 18,605.91
6	144	4,971	0	80%	994	144	173.9	25.0	$ 160.00	$ 500.00	$ 100.00	$ 18,979.48
7	145	4,971	0	80%	994	145	173.9	25.3	$ 160.00	$ 500.00	$ 100.00	$ 19,228.52
8	148	4,971	0	80%	994	148	173.9	25.7	$ 160.00	$ 500.00	$ 100.00	$ 19,539.83
9	150	4,971	0	70%	1,491	150	173.9	26.1	$ 160.00	$ 500.00	$ 100.00	$ 19,851.13
10	153	4,971	0	70%	1,491	153	173.9	26.5	$ 160.00	$ 500.00	$ 100.00	$ 20,162.44
11	154	4,971	0	90%	497	2,486	173.9	432.2	$ 160.00	$ 500.00	$ 100.00	$ 328,493.62
12	157	4,971	0	90%	497	2,486	173.9	432.2	$ 160.00	$ 500.00	$ 100.00	$ 328,493.62
13	158	4,971	0	90%	497	158	173.9	27.5	$ 160.00	$ 500.00	$ 100.00	$ 20,909.57
14	161	4,971	0	90%	497	161	173.9	27.9	$ 160.00	$ 500.00	$ 100.00	$ 21,220.88
15	162	4,971	0	80%	994	162	173.9	28.2	$ 160.00	$ 500.00	$ 100.00	$ 21,469.92
16	164	4,971	0	80%	994	164	173.9	28.6	$ 160.00	$ 500.00	$ 100.00	$ 21,718.97
17	166	4,971	0	80%	994	166	173.9	28.9	$ 160.00	$ 500.00	$ 100.00	$ 21,968.01
18	168	4,971	0	80%	994	168	173.9	29.2	$ 160.00	$ 500.00	$ 100.00	$ 22,217.06
19	170	4,971	0	70%	1,491	170	173.9	29.5	$ 160.00	$ 500.00	$ 100.00	$ 22,403.84
20	171	4,971	0	70%	1,491	171	173.9	29.8	$ 160.00	$ 500.00	$ 100.00	$ 22,652.89
Total	**3,058**	**99,420**	-		**17,896**							**$ 1,641,243.11**

Total NH4-N removed/sequestered over 20 years (kg)	**84,583**
Average annual cost	**$ 82,062.16**

[1] Based on 250 mile delivery (NV mine to Canyon Lake)

[2] Based on 2-year sediment capping process recurring every 10 years

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Table C-7. Estimates of Zeolite Application for Whole Lake Application Only

	Existing NH4-N Load into all of Canyon Lake		NH4-N Load with Zeolite Treatment									
Year	NH4-N Inflow (kg/yr)	Sediment Reflux (kg/yr)	Inflow (kg/yr)	Estimated Sediment Reflux Reduction Efficiency	Continued Sediment Reflux (kg/yr)	Treated NH4-N (kg)	Estimated Zeolite mass per kg NH4-N Removal (kg)	Total Zeolite Addition (Metric Tons)	Zeolite Material Costs (Per Metric Ton)	Zeolite Shipping Costs[1] (Per Metric Ton)	Zeolite Application Costs (Per Metric Ton)	Total Annual Cost Estimate[2]
1	647	13,549	0	90%	1,355	6,775	173.9	1,178.1	$ 160.00	$ 500.00	$ 100.00	$ 895,345.02
2	650	13,549	0	90%	1,355	6,775	173.9	1,178.1	$ 160.00	$ 500.00	$ 100.00	$ 895,345.02
3	654	13,549	0	90%	1,355	654	173.9	113.8	$ 160.00	$ 500.00	$ 100.00	$ 86,468.31
4	663	13,549	0	90%	1,355	663	173.9	115.3	$ 160.00	$ 500.00	$ 100.00	$ 87,661.65
5	675	13,549	0	80%	2,710	675	173.9	117.3	$ 160.00	$ 500.00	$ 100.00	$ 89,153.32
6	688	13,549	0	80%	2,710	688	173.9	119.7	$ 160.00	$ 500.00	$ 100.00	$ 90,943.33
7	697	13,549	0	80%	2,710	697	173.9	121.2	$ 160.00	$ 500.00	$ 100.00	$ 92,136.67
8	708	13,549	0	80%	2,710	708	173.9	123.2	$ 160.00	$ 500.00	$ 100.00	$ 93,628.34
9	720	13,549	0	70%	4,065	720	173.9	125.2	$ 160.00	$ 500.00	$ 100.00	$ 95,120.02
10	731	13,549	0	70%	4,065	731	173.9	127.1	$ 160.00	$ 500.00	$ 100.00	$ 96,611.69
11	740	13,549	0	90%	1,355	6,775	173.9	1,178.1	$ 160.00	$ 500.00	$ 100.00	$ 895,345.02
12	751	13,549	0	90%	1,355	6,775	173.9	1,178.1	$ 160.00	$ 500.00	$ 100.00	$ 895,345.02
13	758	13,549	0	90%	1,355	758	173.9	131.8	$ 160.00	$ 500.00	$ 100.00	$ 100,191.71
14	769	13,549	0	90%	1,355	769	173.9	133.8	$ 160.00	$ 500.00	$ 100.00	$ 101,683.38
15	778	13,549	0	80%	2,710	778	173.9	135.4	$ 160.00	$ 500.00	$ 100.00	$ 102,876.72
16	787	13,549	0	80%	2,710	787	173.9	136.9	$ 160.00	$ 500.00	$ 100.00	$ 104,070.06
17	796	13,549	0	80%	2,710	796	173.9	138.5	$ 160.00	$ 500.00	$ 100.00	$ 105,263.39
18	805	13,549	0	80%	2,710	805	173.9	140.1	$ 160.00	$ 500.00	$ 100.00	$ 106,456.73
19	812	13,549	0	70%	4,065	812	173.9	141.3	$ 160.00	$ 500.00	$ 100.00	$ 107,351.74
20	821	13,549	0	70%	4,065	821	173.9	142.8	$ 160.00	$ 500.00	$ 100.00	$ 108,545.08
Total	**14,654**	**270,980**	-		**48,776**							**$ 5,149,542.20**

Total NH4-N Removed/Sequestered over 20 Years (Kg)	**236,857**
Average Annual Cost	**$ 257,477.11**

[1] Based on 250 Mile Delivery (NV mine to Canyon Lake)

[2] Based on 2-Year Sediment Capping Process Recurring Every 10 Years

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The use of zeolite application as an in-lake nutrient reduction strategy has not been conducted on a large-scale basis in the U.S. and there remain many uncertainties regarding the potential regulatory issues that may arise when considering a zeolite treatment program. The variability in chemical composition of naturally occurring zeolite formations will likely require that chemical analyses and full-scale toxicity testing of the sourced material be conducted prior to consideration for in-lake application. Assessment of the potential long-term effects of zeolite application on the biological and chemical conditions in the sediment and water column will likely need to be performed and documented prior to obtaining regulatory approval for application. Although there appears to be considerable potential for the use of zeolite as a nutrient binding agent in Canyon Lake, the currently undeveloped state of the industry in the U.S. and worldwide provides many uncertainties regarding the cost and timeframe of implementing a zeolite application program in the immediate future. However, if there is sufficient interest shown for application here and/or elsewhere, the Permittees could consider partnering with potential outside vendors to further develop the knowledge, testing and research necessary to accelerate the knowledge and applicability to the lake.

C.1.2.4 Comparison of Potentially Feasible Lake Management Strategies

Table C-8 presents a comparison of the three primary strategies relative to effectiveness, operational duration, experience, potential regulatory issues, other issues and possible hazards, major sources of uncertainty and the potential outlook for possible use at Canyon Lake.

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Table C-8. Comparison of Alternative Lake Management Strategies

		Estimated Percent Removals					Issues/Hazards			Major sources of uncertainty				Outlook	
Alternative	**Targeted Nutrient Source**	**Total -P**	**Total - N**	**Operational Duration**	**In Practice in U.S.?**	**Potential Regulatory Issues**	**Potential WQ/Chemica l Hazards**	**Potential Biological Hazards**	**Other issues**	**Initial Costs**	**On-going Costs**	**Effectiveness**	**Hazards**	**Feasibility of Use at Canyon Lake**	**Major Caveats**
Hypolimnetic Oxygenation System (HOS) - Main Body only	Internal Sediment Flux	71-80% of Annual Internal Load	35-60% of Annual Internal Load	Continual Except During Winter Months	Yes	CEQA Compliance (Possibly MND or EIR). Likely need 404/401 Permit and Certification, 1602 Permit	None Expected	None Expected	Ongoing Costs, Effectiveness	High	Energy costs, liquid oxygen costs, long-term maintenance, lifespan of system components	Will not achieve TMDL targets for entire lake	None	High	Can reduce more than minimum Required POTW WLA Main Body Only; Does not directly manage East Bay; partially meets WLA for TN
Phoslock	Water Column/Internal Cycling (Capping)	Up To 100% of Water Column SRP and Internal Load	None	One-Time	Being Applied in Several Locations. Recent Trial Applications for IRWD In Lakes Receiving Recycled Water.	CEQA Compliance (Possibly MND or EIR). May need Deminimus WDR - Phoslock currently working with SDRWQCB on this Issue.	None Expected	Possible Lanthanum Toxicity at High Doses, not Expected at Prescribed Doses	Recently Adapted Technology, No Reported Use For TMDL Compliance, Limited Documentation	Required dosage and costs	Longevity of treatment, pattern to deal with incoming loads of TSS and nutrients	No effect on N, longevity uncertain	Minimal Documentation of Hazards	Moderate	Potential for high costs if used in entire lake, re-application rates, long-term effectiveness
	Water Colum - Following New Runoff Input	Up to 100% of incoming water column load	None	Annual or Periodic											
Zeolites	Water Column/Internal Cycling (Capping)	Up to 90% of water column PO4-P	Up to 98% of Water Column NO3-N	One-Time	No	Similar to Phoslock but greater potential effort as no demonstrated use in US and minimal full scale testing available	Unknown, but Likely Low	Poorly Studied Chronic/Acute Toxicity (Likely Low)	Emerging Technology, No Reported Use in the US, No Documented Safety Information	Source of material, applicator, material costs, application costs, zeolite modification costs, required dosage	Longevity of Treatment, Incoming Loads of TSS and Nutrients	Longevity uncertain	No Documentation of Hazard, Poorly Studied	Moderate/High pending further investigation.	Sourcing, unknown costs, unknown long-term effectiveness, potential regulatory issues
	Water Colum - Following New Runoff Input			Periodic											

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C.1.3 Potential Combinations and Summary Comparison of Alternatives

Based on the above discussions, several specific alternative approaches were developed based on using one or more of the three methods for nutrient compliance. Some alternatives focus on the Main body of Canyon Lake only, others address the whole lake. In order to bracket the entire range of combinations, these include:

- Alternatives that address the main body only:
- HOS system
- Phoslock application
- Zeolites application
- Alternatives that address the entire lake:
- HOS system in main body, Phoslock in East Bay
- Phoslock in entire lake
- HOS system in main body, Zeolites in East Bay
- Zeolites in entire lake

Each of these alternatives has different degrees of effectiveness for reducing both phosphorus and nitrogen in the lake as well as a range of costs.

Table C-9 presents a summary comparison on the three major strategies with respect to nutrient removal effectiveness and costs. For each alternative, the table presents an estimate of capital cost (applies to HOS system only), and average O&M costs, which includes the power, labor and maintenance for the HOS system, and cost of chemicals and application for the Phoslock and Zeolite. In order to compare the alternatives, particularly when some are more capital intensive while others are solely annual operating costs, these approaches were used including: (1) a life cycle cost estimate (capital plus net present worth of annual costs); and (2) an equivalent annual cost estimate (annual costs plus a capital recovery amount) both approaches are based on 5 percent interest rate and a 20-year period. Estimated removal rates for both P and N (where applicable) are expressed as both a 20-year total and annual average value; and the relative cost per kg removed by dividing the projected 20-year load reduction by the life cycle cost. The costs and load reductions are based on installing the full HOS system in the Main Body and/or applying sufficient additives to address the loadings for either portion of the lake, or the lake as a whole.

Table C-9. Canyon Lake In-Lake Costs

Alternative	Capital Cost, $	Average O&M cost over 20 years, $/yr	Life Cycle Cost[1]	Equivalent Annual Cost[2]	P Removed or Sequestered			N Removed or Sequestered		
					Total over 20 years, kg	Life Cycle Cost, $/kg	Average kg/yr	Total over 20 years, kg	Life Cycle Cost, $/kg	Average kg/yr
HOS system only in Main Body	$ 2,834,000	$ 130,000	$ 4,454,060	$ 356,720	37590	118	1880	60046	74	3002
Phoslock only in Main Body	$ -	$ 114,800	$ 1,729,000	$ 114,800	44600	39	2230	0	n/a	0
Phoslock in entire lake	$ -	$ 196,000	$ 2,958,000	$ 196,000	76800	39	3840	0	n/a	0
HOS system in Main Body, Phoslock in Salt Creek	$ 2,834,000	$ 216,000	$ 5,758,060	$ 442,720	70090	82	3505	60046	96	3002
Zeolite in Main Body only	$ -	$ 183,000	$ 2,504,000	$ 183,000	48330	52	2417	153600	16	7680
Zeolite in entire lake	$ -	$ 257,000	$ 3,596,000	$ 257,000	83250	43	4163	236900	15	11845
HOS system in Main Body, Zeolite in Salt Creek	$ 2,834,000	$ 212,000	$ 5,629,800	$ 438,720	72510	78	3626	144629	39	7231

1. Capital Cost Plus Net Present Worth of Annual O&M Costs Over 20 Years @ 5%

2. Average Annual O&M Cost Plus Equivalent Annual Cost of Capital @ 5% and 20 Years

In many cases, this would result in a greater load reduction than that needed to meet the load allocation for MS4 runoff to meet after accounting for other program implementation and land use conversion factors, particularly for phosphorus.

Assumptions and information used to compile the information in the table include:

1. HOS system costs based on Pace study Option 10b as updated by CDM
2. Phoslock and Zeolite costs assume a full blanket applied to stated area twice in 20 years, and in remaining years apply sufficient quantity to address incoming annual load.
3. Phoslock application rate and unit costs provided by Phoslock vendor based on phosphorus loads only.
4. Zeolite application rate roughly estimated from one published study based on nitrogen loads.
5. Zeolite unit costs are tentative – estimated dosages taken from uses for other purposes, very high level estimates of transportation and application costs developed by CDM. No commercial vendor is currently supplying zeolites formulated for this purpose.

The following observations can be drawn from the table:

1. All alternatives can theoretically achieve more than the MS4 load reduction target for Phosphorus of 580 kg/year (after accounting for watershed based program implementation BMPs and land use conversions).
2. All of the alternatives can theoretically achieve equal to or greater than the load reduction target for nitrogen (after accounting for watershed based program implementation BMPs and land use conversions) of nitrogen except those that rely solely on the use of Phoslock.
3. The lowest apparent annual cost option would be to apply Phoslock only in the Main Body. This would more than achieve the MS4 load reduction for Phosphorus, but would provide no quantifiable nitrogen reduction benefit. If algal growth in Canyon Lake is primarily phosphorus limited, Phoslock could potentially be an appropriate management technique. However, if reduction of nitrogen is also necessary, then installation of a HOS system in the main body, possibly supplemented by the use of zeolites in the East Bay may be a more effective option.
4. Further investigation of the use of zeolites is warranted due to their potential for reducing both phosphorus and nitrogen. Due to the limited demonstration and testing to date, the lack of any developed domestic sources for this purpose, and uncertainty in costs, this will require significant additional investigation and development.
5. Zeolite application in the entire lake may have the highest rates of phosphorus and nitrogen removal or sequestering of any of the alternatives over the 20 year period.

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Appendix A – Sediment Flux Modeling Summary

Numerical modeling was used to investigate the potential impact of a hypolimnion oxygenation system (HOS) on sediment internal nutrient fluxes in Canyon Lake. The modeling approach was based largely on a previous CDM study of Machado Lake in Los Angeles [CDM 2009; Cox 2010]. In the Machado Lake study, site specific sediment laboratory incubations [Horne 2009] were used to parameterize a lake water quality model that included mechanistic representation of sediment nutrient flux dynamics. A simple 2-layer model of the incubation chambers was fit to incubation data to quantify adsorption and desorption/mineralization rate constants for both nitrogen (N) and phosphorus (P). These rate constants were then used directly in the Machado Lake water quality model to simulate water column nutrient concentration dynamics.

In the investigation presented here, the same rate constants parameterized for the Machado Lake incubations were used in a simple 2-layer model of Canyon Lake to quantify relative differences in simulated nutrient fluxes under two different levels of oxygenation (aerobic and anaerobic). Results show that full oxygenation of the hypolimnion is predicted to decrease sediment N releases by approximately 60 percent and sediment P releases by approximately 90 percent. These results compare reasonably well to rates quantified with independent laboratory incubation tests [Anderson 2007] (35 percent reduction in N flux and 71 percent reduction in P flux with oxygenation).

The modeling approach described here was designed to isolate the calculation of internal sediment nutrient fluxes for relative comparisons of simulated flux rates with and without hypolimnion oxygenation. The analysis is not intended to capture all of the dynamics at play in lake nutrient processing and, in fact, relies on assumptions of steady and uniform lake water column and sediment nutrient concentrations. While it is known that neither water column nor sediment nutrient concentrations are steady or uniform, these are useful and valid assumptions for the analysis presented here. It is also important to note that the modeling performed here was based on incubation chamber experiments that were *not* specific to Canyon Lake. Results presented therefore should be considered to have a high degree of associated uncertainty. The analysis would benefit greatly from more site specific model calibration.

A.1 Model Construction and Parameterization

A.1.1 Simple Model of Lake Sediment Nutrient Fluxes

A simple 2-layer lake model was constructed to simulate sediment nutrient fluxes under varying levels of hypolimnion oxygen. In this model, water column N and P concentrations (layer 1) are assumed uniform and constant and set according to recent measured data. Releases of nutrient from the shallow sediment porewater (layer 2) to the water column are calculated according to Fickian diffusion as a function of the gradient between porewater and water column nutrient concentrations. The rate of transport between these two layers is defined by user-specified diffusion coefficient (D). The size of the well-mixed sediment porewater layer is defined by a user-specified depth (d_2) and porosity (ρ). Within a portion of the sediment layer, the following sediment nutrient dynamics are simulated:

- Lumped nutrient mineralization (of organic particulate nutrients) and desorption (of sediment-bound nutrients)

- Nutrient adsorption (from pore water to sediments).

The model assumes that these dynamics only occur in a thin biologically active sub-layer at the top of the sediment layer, the depth is which is user-input (d_3). The net flux of nutrient from the sediment layer to the water column is calculated as:

$$L_{internal} = \frac{dM}{dt} = D(C_2 - C_1)\frac{A}{z}n \qquad (1)$$

where:

$L_{internal}$ = nutrient load released from sediments to water column ($g\ d^{-1}$)

D = vertical diffusion coefficient ($m^2\ d^{-1}$)

C_1 = water column dissolved nutrient concentration ($g\ m^{-3}$)

C_2 = porewater dissolved nutrient concentration ($g\ m^{-3}$)

A = area of lake sediments (m^2)

z = vertical mixing length (m) = 0.5 * d_1

d_1 = depth of lake hypolimnion during critical conditions (m).

The governing equation for the sediment porewater calculations can be written as:

$$\frac{dC_2}{dt} = D(C_{1d} - C_2)\frac{A}{z*V_2} + k_{d2}C_3\frac{M_{sed}}{V_2} - k_{d3}C_2$$

$$\frac{dC_2}{dt} = D(C_1 - C_2)\frac{An}{z*V_2} + k_{d2}C_3\frac{M_{sed}}{V_2} - k_{d3}C_2 \qquad (2)$$

where:

C_2 = porewater dissolved nutrient concentration ($g\ m^{-3}$)

V_1 = water column volume (m^3)

V_2 = sediment layer porewater volume (d_2 * A * n, m_3)

d_2 = depth of well-mixed porewater layer

n = sediment layer porosity

k_{d2} = lumped first order mineralization/desorption rate constant (d^{-1}) (different values for oxic vs. anoxic conditions)

C_3 = sediment nutrient concentration ($mg\ g^{-1}$)

M_{sed} = total mass of biologically active sediment sub-layer (d_3 * A * (1- n) * ρ, g)

d_3 = depth of biologically active sediment sub-layer (m^3)

ρ= sediment particle density ($g\ m^{-3}$)

k_{d3} = 1st order adsorption rate constant (d^{-1}) (different values for oxic vs. anoxic conditions)

Equations 2 and 1 are solved numerically and sequentially in the model. Final results are reported in terms of mean annual sediment nutrient loads ($L_{internal}$) for both N and P. A summary of model parameterization is provided in Table A-1.

Table A-1. Model Parameterization

Parameter	Value	Units	Source
Water column:			
mean hypolimnion depth (d_1)	3	m	PACE (2011) @ WS 1375'
hypolimnion surface area, main body of lake (A)	7.9 x 10^5	m^2	TMDL report (Li, 2004)
hypolimnion dissolved P concentration (C_1)	1.0	mg/L	TMDL Data for Sites CL07 and CL08 (Mar-Nov)
hypolimnion dissolved N concentration (C_1)	3.4	mg/L	TMDL Data for Sites CL07 and CL08 (Mar-Nov)
fully mixed dissolved P concentration (C_1)	0.2	mg/L	assumed ½ of total concentration; TMDL report (Li, 2004)
fully mixed dissolved N concentration (C_1)	0.8	mg/L	assumed ½ of total concentration; TMDL report (Li, 2004)
period of stratification	Mar - Nov	-	PACE (2011)
Sediment porewater:			
sediment-bound P concentration (C_3)	1.7	mg/g	Anderson (2007)
sediment-bound N concentration (C_3)	4.0	mg/g	Anderson (2007)
vertical diffusion coefficient (D)	*0.004*	$m^2\ d^{-1}$	Chapra, 1998
surface sediment porosity (n)	*0.9*	unitless	general knowledge for silt/clay
vertical mixing length (z)	*1.5*	m	set to ½ of mean lake depth
Depth of well-mixed porewater layer (d_2)	*0.02 (P), 0.15 (N)*	m	Calibrated, using reported porewater concentrations (Anderson, 2001)
depth of biologically active sub-layer (d_3)	*0.02*	m	Cox (2010)
sediment particle density (ρ)	*1.5*	$g\ cm^{-3}$	general knowledge for silt/clay
N mineralization rate (kd_2) (oxic, anoxic)	*0.03, 0.09*	d^{-1}	independently parameterized, see Cox (2010)
P mineralization rate (kd_2) (oxic, anoxic)	*0.002, 0.01*	d^{-1}	independently parameterized, see Cox (2010)
N adsorption rate (kd_3) (oxic, anoxic)	*0.9, 0.5*	d^{-1}	independently parameterized, see Cox (2010)
P adsorption rate (kd_3) (oxic, anoxic)	*1.1, 1.1*	d^{-1}	independently parameterized, see Cox (2010)
Assumed anoxia fraction during stratification, existing lake	*1.0*	unitless	estimated
Assumed anoxia fraction during stratification, after HOS	*0.3*	unitless	Visual observation of PACE 2011 results for Option 10

A.1.2 Parameterization of Sediment-Nutrient Rate Constants

A simplified model was developed to simulate the dynamics of the sediment core incubation studies conducted in 2009 for the City of Los Angeles [Horne 2009]. The objective was to quantify the sediment flux parameters, to be used in the lake model described above (k_{d2} and k_{d3}), for both oxic and anoxic sediment conditions based on the experimental data. The simple 2-layer incubation chamber model is depicted in Figure A-1. The numerical formulation of the model closely follows that of the porewater nutrient flux module of the lake model described above. A major difference, however, is that the water column of the incubation chamber model is essentially stagnant (no flushing flows) and is only impacted by the diffusive exchanges with the sediment (we assume no internal water column dynamics). Additionally, the sediment nutrient concentrations (C_3) are assumed to be steady in the chamber model. This assumption is believed to be appropriate for the timescales of the incubation studies. The governing equations for this model are therefore:

(4) $$\frac{dC_1}{dt} = D(C_2 - C_1)\frac{A\rho}{z * V_1}$$

(5) $$\frac{dC_2}{dt} = D(C_{1d} - C_2)\frac{An}{z * V_2} + k_{d2}C_3\frac{M_{sed}}{V_2} - k_{d3}C_2$$

$C_3 = constant$ (6)

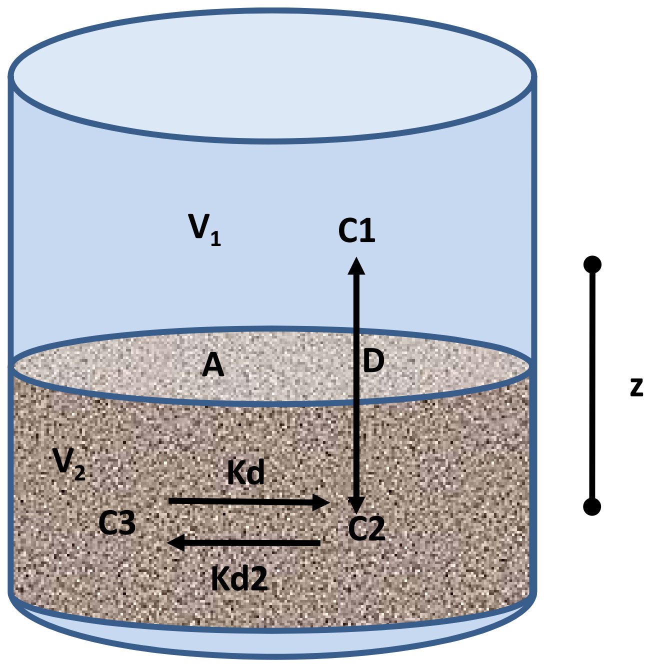

Figure A-1. Incubation Chamber Model

These equations are solved numerically for C_1 and C_2. For each incubation, Microsoft *Excel*'s "Solver" add-in program was used to calibrate k_{d2} and k_{d3} values to best match the reported water column concentration versus time profiles. Solver's nonlinear optimization code was used to minimize the sum of squares error of modeled versus measured concentration data, by varying oxic and anoxic k_{d2} and k_{d3} values. Each of the incubations involved both an oxic period and an anoxic period and therefore allowed for the determination of both types of rate constants for each incubation. A value of 10^{-4} cm^2 s^{-1} was assumed for the diffusion coefficient (D) (high end of molecular diffusion, per Chapra 1998) for all incubations. Oxic and anoxic calibrated rate constants were then averaged across all of the incubations to arrive at the final values used in the lake model (described above). Example incubation calibration profiles are provided in Figure A-2. Results of the rate constant parameterization are summarized in Table A-1.

A.2 Analysis Results

Analysis results are summarized in Table A-2. Model simulations indicate that full oxygenation of the hypolimnion may decrease N sediment fluxes by approximately 60 percent and may decrease P sediment fluxes by approximately 90 percent compared to the assumed existing condition. Similar, albeit lower, levels of reduction were quantified previously with independent laboratory chamber incubations (35 percent reduction in NH_4 flux and 71 percent reduction in SRP flux) [Anderson 2007].

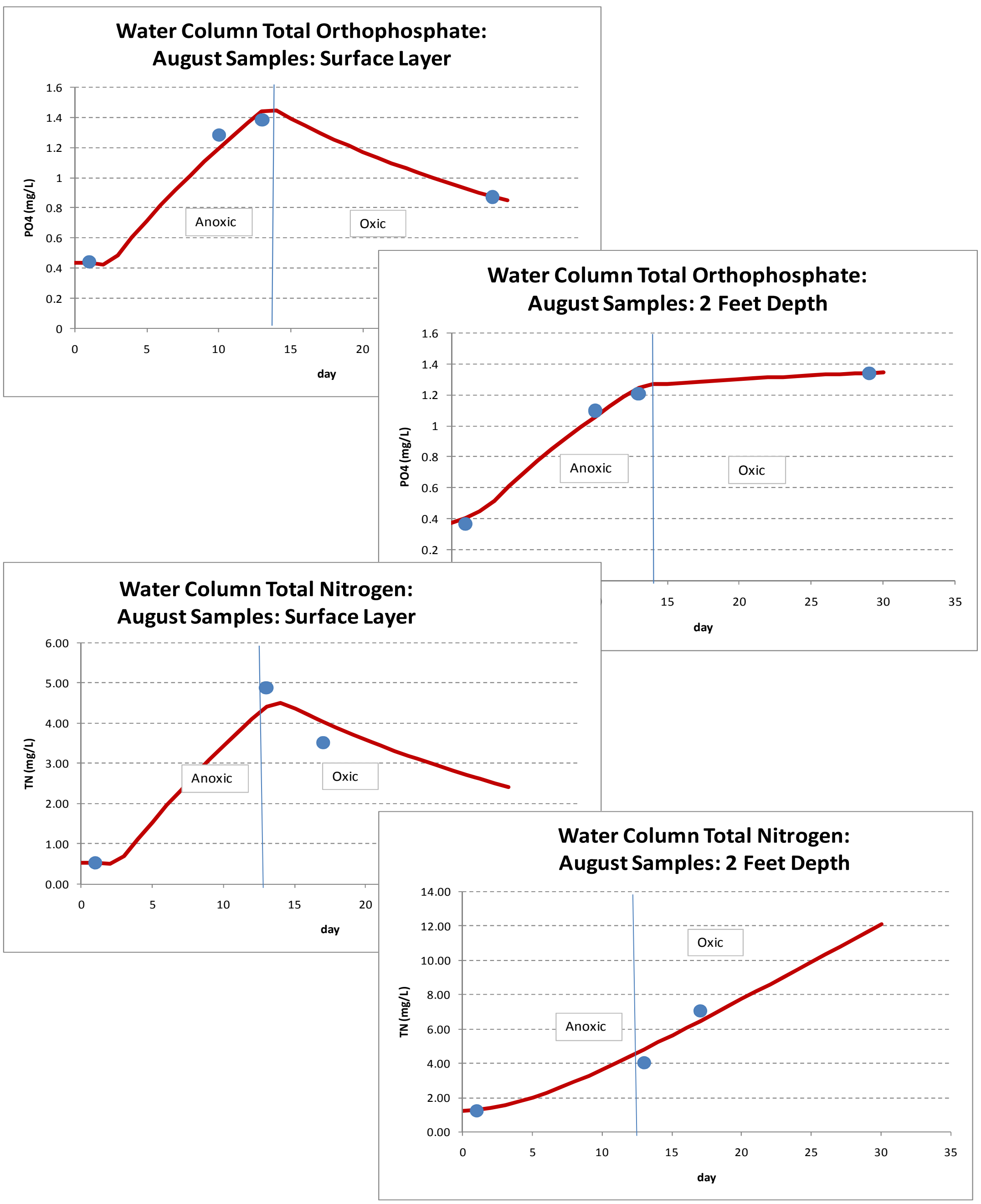

Figure A-2. Example Incubation Model Calibration Results: Modeled vs. Measured

Table A-2. Summary of Results

	Mean N areal flux (mg m^{-2} d^{-1})	Mean P areal flux (mg m^{-2} d^{-1})	Annual N internal loading[1] (kg-N yr^{-1})	Annual P internal loading[1] (kg-P yr^{-1})
Existing system	33	3	9400	750
Fully oxygenated system	12	0.2	3500	60
% change	60%	90%	60%	90%

[1] = internal loading

Equations 2 and 1 are solved numerically and sequentially in the model. Final results are reported in terms of mean annual sediment nutrient loads ($L_{internal}$) for both N and P. A summary of model parameterization is provided in Table A-1.

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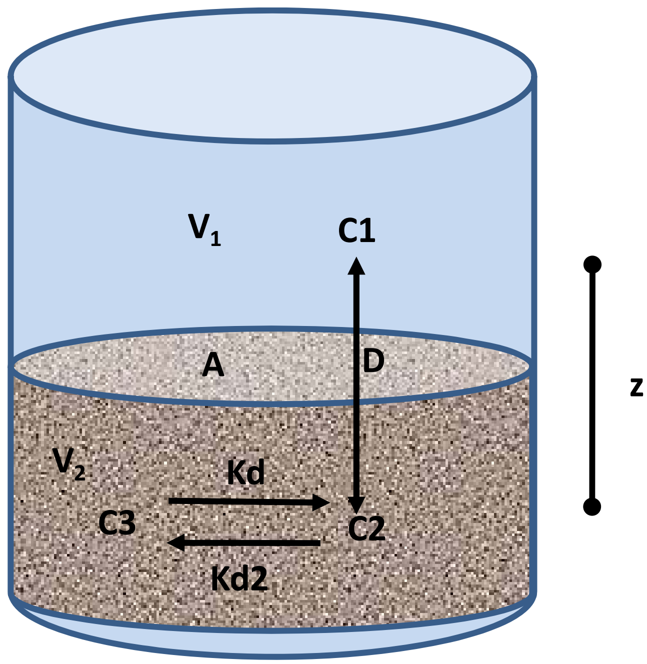

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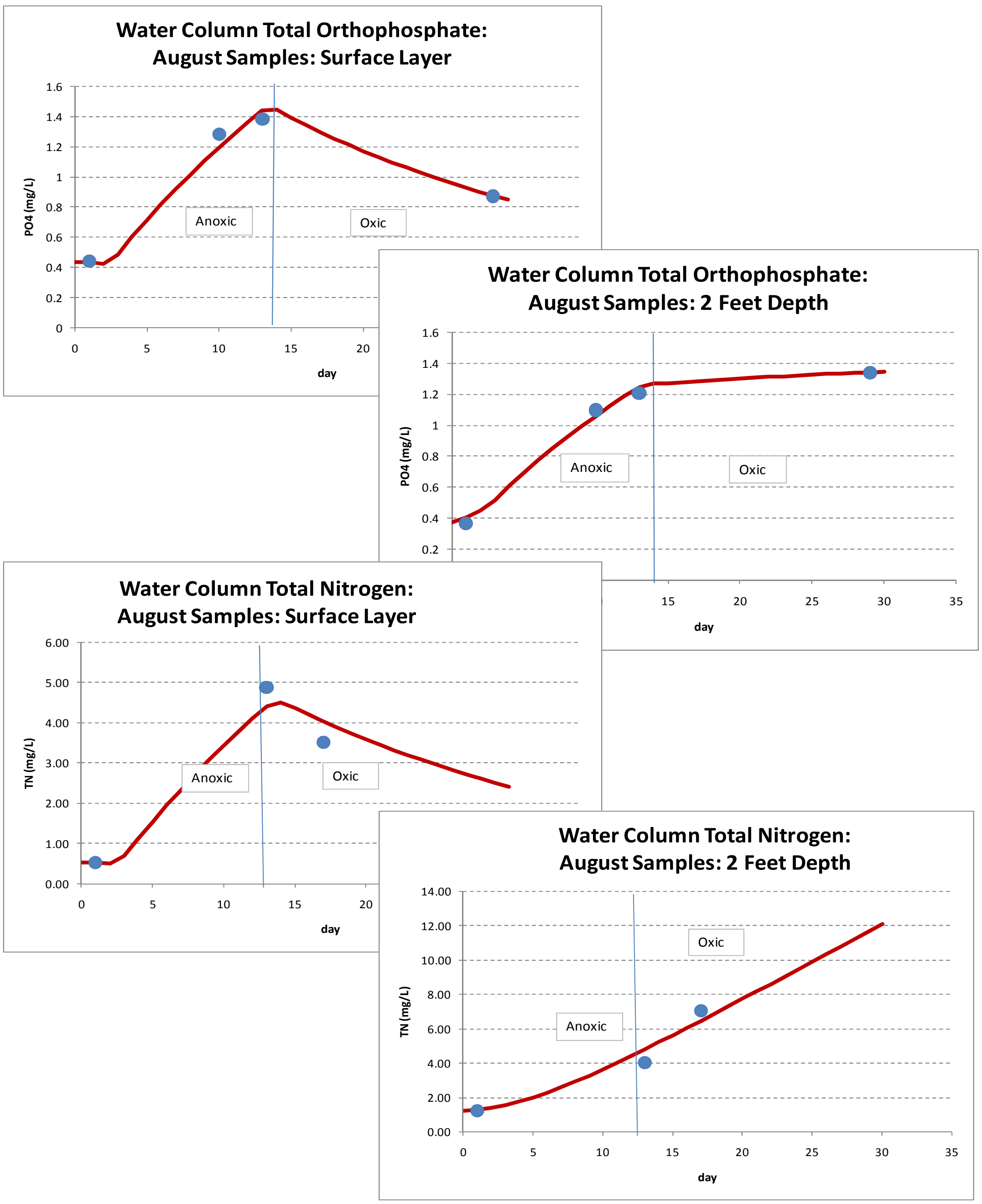

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Fully oxygenated system	12	0.2	3500	60
% change	60%	90%	60%	90%

[1] = internal loading

Attachment D
Table of Contents

Tables

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Attachment D
Existing Nutrient Source Control Programs

D.1 Introduction

The MS4 permittees within the watersheds draining to Canyon Lake and Lake Elsinore are in compliance with the MS4 permit requirements applicable to this area of Riverside County. Compliance activities include implementation of both non-structural and structural BMPs. This section documents permit-related activities implemented by the MS4 permittees since January 1, 2005, essentially the time period since adoption of the Nutrient TMDLs (adopted December 20, 2004). Implementation of these activities has supported efforts to reduce the runoff of nutrients from urban areas covered by the MS4 permit, thus providing water quality benefits to the area.

D.2 Non-Structural BMPs

Non-structural BMPs that can reduce the presence of nutrients in urban runoff include:

- Public Education and Outreach
- Ordinance Adoption
- Inspection and Enforcement Activities
- Street Sweeping
- MS4 Facility Inspection and Cleaning Programs
- Septic System Management
- Fertilizer Application Management

The following sections describe each of the above BMPs. Where it is possible to quantify water quality benefits, this information has been included in the CNRP compliance analysis (see Section 3). Where it is not possible to quantify the benefits, the expected water quality benefits are considered qualitatively as part of the margin of safety that is implicit in the compliance analysis calculations.

D.2.1 Public Education and Outreach

The MS4 permittees collectively participate in public education and outreach efforts that promote stormwater pollution prevention. Although outreach events may not specifically focus on reducing nutrient levels, events which highlight the elimination or reduction of debris or pollutants from entering the MS4 or runoff have the potential to reduce nutrient loads. Emphasis of BMPs is on management of pet waste, fertilizer use, proper operation and maintenance of septic systems, and prevention of sedimentation. Example public education BMPs and outreach activities in the watershed that reduce nutrients in urban runoff include (see MS4 Program Annual Reports for more details regarding ongoing public education and outreach activities):

- *What's the Scoop* and *After the Storm* brochures address the need to pick up animal waste and to dispose of it properly.
- *After the Storm* brochure addresses the need to pick up pet wastes and minimize sedimentation.
- RCFC&WCD, in partnership with San Bernardino County, sponsored a 1-hour episode of a PBS show for kids called *Curiosity Quest*. The episode focused on the impacts residential activities can have on stormwater, e.g., improper pet waste disposal.
- A school activity book and "Fancy Fin" presentation discuss proper disposal of pet waste.
- The *Keep Our Water Clean* video focuses on the proper disposal of pet waste and proper uses of fertilizers and avoiding excess runoff from sprinklers.
- The adult-focused presentation, *Only Rain Down the Storm Drain*, discusses various pollutant concerns associated with stormwater. The Agricultural Commissioner, University of California Riverside Cooperative Extension and local nurseries assist with distribution of materials. Mission Resource Conservation District presentations discuss the effects fertilizers can have on local waters.
- Construction, municipal, industrial/commercial and new development training activities focus on the need to address pollutant sources, including nutrients, erosion control and sedimentation, in the watershed. A specific section of the municipal employee training focuses on the need to manage nutrients in the watershed.
- RCFC&WCD contracts with S. Groner and Associates to distribute pet waste information in pet stores, veterinarian clinics, kennels and pet grooming facilities.
- The MS4 program coordinates with the Riverside County Animal Control Department and private "no kill" pet shelters to distribute *What's the Scoop* and *After the Storm* brochures to families adopting pets at these shelters.
- The MS4 program distributes a variety of materials that promote reduction of pollutants at the source. Distributed materials include:
- Landscape and Gardening brochures;
- Tips for Maintaining a Septic Tank System brochure *(information is also included in the County*'s Septic Tank Guide Booklet);
- *Tips for Horse Care* brochure that addresses equestrian care and management; and

CDM Smith

- Dust pans featuring the Only Rain Down the Storm Drain message to promote dry cleaning of driveways and impervious surfaces.
- An Earth Day flyer (April), offers user-friendly suggestions for reducing the use of chemicals, considering integrated pest management in gardening, and understanding problems with unrecovered pet waste.
- The County's *Environmental Calendar* includes a variety of information regarding stormwater management and promotes the "Only Rain Down the Storm Drain" message and provides the stormwater program's 800 hotline number to report water quality concerns.
- RCFC&WCD does not allow the disposal of pet waste or other trash within its facilities. Signage has been installed at access gates to discourage illegal dumping and encourage the reporting thereof. At the start of the program, RCFC&WCD purchased "Dogipots" (containers that hold pet waste bags) and installed them in County Parks. Upkeep and additional purchases of Dogipots are the responsibility of County Park staff.

It is not possible to directly quantify reductions in nutrient loads in urban runoff to specific public education and outreach activities. Accordingly, the water quality benefits that occur as a result of these activities are considered qualitatively as part of the margin of safety associated with implementation of the CNRP.

D.2.2 Ordinance Adoption

The MS4 permittees in the Santa Ana Region have adopted ordinances which provide legal authority to control non-permitted discharges from entering MS4 facilities. These ordinances prevent the following types of discharges to MS4 facilities:

- Sewage to MS4 facilities
- Wash water resulting from hosing or cleaning of gas stations and other types of automobile stations
- Discharges resulting from the cleaning, repair, or maintenance of equipment, machinery or facilities, including motor vehicles, concrete mixing equipment, and portable toilet servicing
- Wash water from mobile auto detailing and washing, steam and pressure cleaning, and carpet cleaning
- Water from cleaning of municipal, industrial, and commercial areas including parking lots, streets, sidewalks, driveways, patios, plazas, work yards and outdoor eating or drinking areas, containing chemicals or detergents and without prior sweeping
- Runoff from material storage areas or uncovered receptacles that contain chemicals, fuels, grease, oil or other hazardous materials
- Discharges of runoff from the washing of toxic materials from paved or unpaved areas
- Discharges from pool or fountain water containing chlorine, biocides, or other chemicals; pool filter backwash containing debris and chlorine
- Pet waste, yard waste, debris, and sediment

- Restaurant or food processing facility wastes such as grease, floor mat and trash bin wash water, and food waste

Table D-1 summarizes the ordinances adopted by jurisdiction. Most ordinance updates in recent years have focused on landscape water use efficiency. Of particular note in Table D-1 are the ordinances adopted by (a) City of Canyon Lake (Ordinance No. 134U), which prohibits animal and human waste and illegal dumping in Bureau of Land Management lands in the vicinity of Canyon Lake and Ordinance No. 138U which requires proper disposal of pet waste by owners; and (b) Riverside County Ordinance, which prohibits septic tanks in specified areas in Quail Valley (now incorporated as part of City of Menifee) and requiring connection to existing septic systems to sewer systems.

It is not possible to directly quantify reductions in nutrient loads in urban runoff to ordinance adoption. Accordingly, the water quality benefits that occur as a result of the adoption and implementation of ordinances are not included in the set of BMPs used to demonstrate compliance.

D.2.3 Inspection and Enforcement Activities

MS4 permittees conduct inspections of commercial and industrial facilities as part of municipal NPDES programs to assess compliance of facilities with local stormwater ordinances and, where applicable, potential noncompliance with California's General Permit for Storm Water Discharges Associated with Industrial Activities. In evaluation of these programs for water quality benefits, restaurant inspections are of particular interest since restaurant activities are potential sources of nutrients.

Riverside County MS4 permittees implement a Commercial/Industrial Compliance Assistance Program (CAP) to conduct focused outreach to restaurants, automotive repair shops and certain other commercial and industrial establishments to encourage implementation of stormwater BMPs and facilitate consistent and coordinated enforcement of local stormwater quality ordinances. This program is conducted regionally through the County Department of Environmental Health. Site visits include use of survey checklists to document stormwater management practices for each facility.

In Riverside County, there are approximately 6,750 retail food facilities. Inspections are conducted one to three times per year. In addition, CAP has a specific compliance survey for food facilities to verify that:

- Oil and grease wastes are not discharged onto a parking lot, street or adjacent catch basin
- Trash bin areas are clean; bin lids are closed, not filled with liquid, and bins have not been washed out into the MS4
- Floor mats, filters and garbage containers are not washed in adjacent parking lots, alleys, sidewalks, or streets and that no wash water is discharged to MS4s
- Parking lot areas are cleaned by sweeping, not by hosing down, and that facility operators use dry methods for spill cleanup

Table D-1. Existing Ordinances Adopted by MS4 Permittees in the San Jacinto River Watershed

Jurisdiction	Ordinance Name	Key Provisions
Beaumont		▪ No data /info submitted
Canyon Lake	Landscape Water Use Efficiency	▪ Establishes landscape water use efficiency requirements
	Ordinance No. 107	▪ City permit required for all commencing projects that can lead to illegal discharge to Canyon Lake
	Ordinance No. 123	▪ Adopts 2007 California Plumbing Code, prevent leaks and spillage within City of Canyon Lake
	Ordinance No. 134U	▪ Prohibit animal, human waste, and illegal dumping in undeveloped City jurisdiction - Bureau of Land Management (BLM) lands in vicinity of Canyon Lake
	Ordinance No. 138U	▪ Establishes in municipal code requirements for proper disposal of animal waste by a pet owner/keeper from any public or private property regardless of property ownership or possession
Hemet	Water Efficient Landscape Ordinance	▪ Promote water conservation through efficient irrigation and climate appropriate plant material
Lake Elsinore	Water Efficient Ordinance No. 19.08	▪ Reduce water demand from landscapes; attain water efficient landscape goals
Menifee	Landscape Water Use Efficiency Ordinance	▪ Purpose of ordinance is to eliminate irrigation overspray and runoff
Moreno Valley	Ordinance No. 826	▪ Establishes landscape and irrigation design standards
	Ordinance No. 827	▪ Repeal and reenact stormwater urban runoff management & discharge control
Murrieta	Ordinance No. 335-05	▪ NPDES stormwater runoff quality
City of Riverside	Water Conservation	▪ Addresses irrigation water leaving the property
County of Riverside	Water Efficient Landscaping – Ordinance 859	▪ Addresses irrigation water leaving the property with greater than 1 acre of landscaping
	Ordinance 427	▪ Regulates land application of manure
	Ordinance 856	▪ Prohibits septic tanks in specified areas in Quail Valley, requiring connection to existing septic systems to sewer
	Ordinance 650	▪ Regulates discharge of sewage in unincorporated areas
San Jacinto	Water Conservation – Ordinance 09-16	▪ Prohibits excessive water flow or runoff onto sidewalks, driveways, streets, alleys, and gutters
Wildomar	Ordinance adoption at incorporation	▪ City adopted County of Riverside ordinances as they existed on July 1, 2008 (date of City incorporation); includes septic system management

Each Permittee also develops an inventory of commercial facilities that include industries such as nurseries and greenhouses as well as landscape and hardscape installation. Having a list of these types of businesses is critical when conducting inspections and training regarding practices which may be sources of nutrients.

Additional inspections conducted by individual jurisdictions since January 1, 2005 that provide benefits to water quality include:

- City of Canyon Lake conducted 3 commercial inspections in 2011 calendar year and inspected a Property Owners Association-owned campground, which has close proximity to Canyon Lake.
- In addition to the commercial and industrial facility programs, Menifee conducts 120 inspections yearly. The increase in inspections provides increased public and business awareness of stormwater pollution which in turn reduces the potential for pollutants to enter the storm drain system.

It is not possible to directly quantify reductions in nutrient loads in urban runoff to inspection and enforcement programs. Accordingly, the water quality benefits that occur as a result of these activities are considered qualitatively as part of the margin of safety associated with implementation of the CNRP.

D.2.4 Construction Site Inspections

MS4 permittees conduct construction site inspections as part of their permit requirements. Reducing sediment and other pollutants in discharges from a construction site is particularly important when reducing nutrient loading to the MS4. This inspection program involves maintaining an inventory database of construction sites 1-acre or larger which are issued a building or grading permits by the permittee. This inventory of construction projects is inspected and reported as part of the Annual Progress Report. Permittees inspect all inventoried constructions sites for compliance with local stormwater ordinances and WQMP requirements. Projects within the San Jacinto watershed are verified to have submitted a Notice of Intent (NOI) with the Regional Board for a Construction General Permit and issued a Waste Discharge Identification (WDID) Number. The inspector also verifies that a Stormwater Pollution Prevention Plan (SWPPP) is on-site and checks that construction BMPs are being implemented. Inspector training is also part of the construction inspection program. Permittee staff inspectors receive annual training in the requirements of the MS4 permits, Construction General Permit, and local stormwater ordinances and enforcement policy.

D.2.5 Street Sweeping and Other Debris Removal Programs

Street sweeping removes debris, which contains nutrients that may potentially be mobilized in urban runoff. The benefits of street sweeping are most closely associated with wet weather runoff which has the greatest capacity to flush unswept and accumulated debris into the storm drain. Table D-2 summarizes the quantity of debris collected by street sweeping programs for each jurisdiction from 2005 through 2010.

The MS4 permittees implement MS4 facility inspection and cleaning programs to satisfy minimum facility maintenance requirements contained in their MS4 permits. The debris that builds up in MS4 facilities has the potential to be a nutrient source that can be mobilized particularly by wet weather flows. The Riverside County permittees annually document the length and percent of pipeline and channel facilities inspected in the Annual Progress Report (Tables D-3 and D-4). Table D-5 summarizes the amount of debris removed annually from MS4 facilities from 2005 to 2010.

Relationships between the volume of debris removed (through street sweeping or MS4 facility cleaning activities) and nutrient load reductions have been established by various studies (CWP, 2008). This information was used to quantify benefits expected from implementation of street sweeping and debris removal programs under the CNRP.

Table D-2. Debris Collected (metric tons) as a Result of Street Sweeping in San Jacinto Watershed, 2005-2010

Jurisdiction	2005	2006	2007	2008	2009	2010
Beaumont[1]	-	-	23	23	23	23
Canyon Lake	-	-	1	2	2	25
Hemet[1]	-	-	1591	909	909	909
Lake Elsinore	-	-	NR	NR	NR	350
Menifee	NA	NA	NA	NA	36	36
Moreno Valley	-	-	1050	1010	706	805
Murrieta	-	-	-	5	5	5
Perris	-	-	588	600	342	495
Riverside[2]	30	30	30	30	28	28
County of Riverside[1]	-	-	797	55	760	540
RCFC&WCD[3]	-	-	-	-	-	-
San Jacinto[1]	-	-	205	189	59	59
Wildomar	NA	NA	NA	NA	25	25

Source: Riverside County Annual Progress Reports, 2005 to 2010
(-): In 2005, 2006, 2007 not all jurisdictions reported this measurement
NA; Wildomar and Menifee incorporated as cities in 2008.
NR; Not reported
[1] Values include debris removal from sweeping performed upstream of Mystic Lake.
[2] City of Riverside data based on reported average removal rate of 0.07 tons/curb mile swept in San Jacinto Watershed portion of City.
[3] RCFC&WCD does not own or maintain streets.

Table D-3. Linear Feet of Pipe and Percent of Pipe Inspected in San Jacinto Watershed, 2005 - 2010

Jurisdiction	Linear Feet or Miles (mi) of Pipe Inspected						Percent Pipe Inspected					
	2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009	2010
Beaumont	1,000	1,000	1,000	250	250	250	50	50	50	10	10	10
Canyon Lake	900	900	900	900	900	NR	100	100	100	100	100	100
Hemet	0	0	15,600	0	0	0	0	0	0	0	0	0
Lake Elsinore	ND	ND	ND	4,600	0	0	ND	100	100	100	0	100
Menifee	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
Moreno Valley	100,000	100,000	100,000	100,000	100,000	100,000	100	100	100	100	100	100
Murrieta	0	ND	ND	0	110	0	0	ND	ND	0	0	0
Perris	3,955	402	26,094	28,041	3,013	67,346	4	0.3	17	16	2	36
City of Riverside[1]	0	ND	ND	ND	ND	ND	0	ND	10	10	10	10
County of Riverside[1]	ND	ND	ND	All[2]	6,150	6,150	ND	80	80	100	82	82
RCFC&WCD[1]	ND	ND	All[2]	300 mi	All[2]	All[2]	100	100	100	100	100	100
San Jacinto	12,000	12,000	12,000	9,000	800	1,500	76	76	75	50	5	9
Wildomar	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND

[1] Data reflects inspections conducted over entire jurisdiction
[2] All components that can be visually inspected
[3] Data reflects inspections conducted over entire jurisdiction
ND: No data shown
NA: Menifee and Wildomar incorporated as cities in 2008.
Source: Riverside County Annual Progress Reports, 2005 to 2010

Table D-4. Linear Feet of Channel and Percent of Channel Inspected in San Jacinto Watershed, 2005 - 2010

Jurisdiction	Linear Feet or Miles (mi) of Channel Inspected						Percent Channel Inspected					
	2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009	2010
Beaumont	2,000	2,000	2,000	2,000	2,000	2,000	100	100	100	100	100	100
Canyon Lake	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	100
Hemet	15,600	15,600	ND	15,600	15,600	15,600	100	100	100	100	100	100
Lake Elsinore	ND	ND	ND	1,000	1,000	0	ND	100	100	100	100	100
Menifee	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
Moreno Valley	950	950	950	950	950	950	100	100	100	100	100	100
Murrieta	0	ND	ND	7,969	7,969	8,268	0	ND	ND	100	100	100
Perris	16,476	18,181	12,500	10,320	6,557	5,320	78	86	58	48	29	29
City of Riverside[1]	199,000	199,000	ND	ND	ND	ND	100	100	100	100	100	ND
County of Riverside[1]	ND	ND	ND	ND	57,855	60,900	ND	92	92	100	95	100
RCFC&WCD[1]	133 mi	59 mi	160 mi	103 mi	95 mi	230 mi	100	100	100	100	100	100
San Jacinto	16,000	16,000	16,000	19,000	12,000	12,000	94	94	94	100	100	67
Wildomar	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND

[1] Data reflect inspections conducted over entire jurisdiction

ND: No data shown

NA: Menifee and Wildomar incorporated as cities in 2008.

Source: Riverside County Annual Progress Reports, 2005 to 2010

Table D-5. Debris (tons) Collected from MS4 Facilities in San Jacinto Watershed, 2005-2010

Jurisdiction	2005	2006	2007	2008	2009	2010
Beaumont	-	-	50	50	50	50
Canyon Lake	-	-	2	1.5	1	1.5
Hemet	-	-	6	5.4	4.9	5
Lake Elsinore	-	-	NR	NR	NR	NR
Menifee	NA	NA	NA	NA	NA	79
Moreno Valley[1]	-	-	1,620	753	408	429
Murrieta[2]	-	-	NR	40	40	42
Perris	-	-	NR	16	113	31
Riverside	-	-	NR	NR	NR	NR
County of Riverside	-	-	15	125	24	25
RCFC&WCD	433	101	263	523	535	260
	11,605	4,331	31,064	5,688	1,840	10,979
San Jacinto	-	-	4	NR	19	19
Wildomar	NA	NA	NA	NA	NR	NR

(-): In 2005 and 2006, not all jurisdictions reported this measurement since Annual Report format did not include this metric.
NA: Wildomar and Menifee incorporated as cities in 2008.
[1]: Reported in cubic feet
[2]: Reported in cubic yards
NR: Not reported
Source: Riverside County Annual Progress Reports, 2005 to 2010

D.2.6 Septic System Management

The Riverside County MS4 permit requires permittees to develop an inventory of septic systems within their jurisdictions to be added to a database managed by County Environmental Health. Poorly operating septic systems can potentially lead to the discharge of pollutants to surface waters. The County Department of Health (DEH) is conducting the following actions in response to MS4 permit requirements for septic systems:

- *Develop a septic system inventory* - Inventories are maintained for any new septic systems which are being installed. Historical data are being captured as resources are available.
- *Evaluate potential water quality impacts* - DEH is considering how to incorporate a GIS/mapping system overlay with current database programs to facilitate septic system evaluations.
- *Conduct public health education* - DEH currently provides both written and electronic information to septic system owners to inform and educate owners to understand proper routine maintenance activities.
- *Conduct inspections & initiate enforcement* - DEH currently responds to all notifications of surfacing sewage in areas within the County served by septic systems. Appropriate enforcement is initiated to ensure any system failures are remedied correctly and promptly.

Additionally, the County of Riverside Environmental Health Division, MS4 Permittees, RCFC&WCD and other stakeholders in the San Jacinto watershed participated in the development of the San Jacinto Septic System Management Plan (SSMP) in 2007. The SSMP includes the following key components and recommendations:

- *Public Education* – Include general public awareness, system owner education, and targeted outreach in critical management zones using a variety of media outlets, workshops, meetings, and direct consultations.
- *Planning* – Include an inventory of the community's wastewater treatment systems, as well as an onsite wastewater plan, to assess onsite wastewater treatment system alternatives.
- *Operation and Maintenance* – Establish maintenance rules, based upon system manufacturers' requirements and qualified septic system experts, and require maintenance contracts with qualified private service providers for systems of a certain size, type, and location. Regular inspection requirements and plumbing frequency recommendations are included in the operation and maintenance component.
- *Reporting and Tracking* – System owners should maintain operation and maintenance records and provide inspection reports to the Regional Board. The management program also recommends developing an online tracking and reporting system where information can be stored and easily retrieved.
- *Site Evaluation, System Design, Installation, Construction* – Site specific observations and characterization shall be performed by a qualified professional when the seasonal high groundwater level is unknown or known to be greater than 10 feet below the ground surface. New and replacement septic tanks installation shall meet California standards.
- *Performance Requirements* – Pollutants of concern should be targeted to reduce bacteria and nutrient loading using performance standards. Supplemental treatment systems will be required for new and replacement septic tanks systems in the critical management zones as well as existing systems that are suspected to be contributing to surface water and groundwater impairment.
- *Monitoring* – Include regular inspections during installation and operation to help identify performance problems quickly.
- *Enforcement and Compliance* – The wastewater management program should be enforced by a regulatory agency such as DEH using appropriate enforcement tools for compliance.

The State Water Resources Control Board (State Board) is in the process of adopting new regulations for septic systems to meet the legal mandate of Assembly Bill (AB) 885[1]. When the new regulations are adopted, the Permittees in the San Jacinto watershed will evaluate the SSMP and revise the SSMP as required.

The conversion of septic systems to a sewer system connection can provide significant water quality benefits. These benefits, in terms of expected nutrient load reductions can be quantified. As a consequence, this information was used to quantify benefits expected from septic system conversions that may occur under the CNRP.

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1 AB 885 was passed by the California State Legislature in 2000 requiring the State Board to adopt regulations or standards by January 1, 2004.

D.2.7 Fertilizer Application Management

The MS4 permittees provide Fertilizer Applicator Training on an annual basis. As required by the 2002 MS4 permit, staff responsible for fertilizer application attended at least three training sessions during a permit term. Permittees continue to provide training for public agency staff and contract field operations staff on fertilizer management and model maintenance procedures under the existing MS4 permit. Training includes emphasis on applying fertilizers according to manufacturer specifications, rates, and ratios. Specific fertilizer management practices implemented by MS4 Permittees in the San Jacinto Watershed include:

- *Lake Elsinore* - Staff apply fertilizer to park landscapes at manufacturer specifications, rates, and ratios so as to not over fertilize or under fertilize. Staff ensures excess fertilizer is blown, swept, or removed from the environment.
- *Murrieta* – Staff use organic phosphorus-free fertilizer.
- *Riverside* – Park maintenance staff conduct bi-weekly meetings which include fertilizer application topics. Two City staff are certified Fertilizer/Pesticide Applicators.
- *San Jacinto* – The city requires contract vendors to apply fertilizer three times per year and specifies that the vendor notify City staff prior to each application.

It is not possible to directly quantify reductions in nutrient loads in urban runoff to fertilizer application and training activities. Accordingly, the water quality benefits that occur as a result of these activities are considered qualitatively as part of the margin of safety associated with implementation of the CNRP.

D.3 Structural BMPs

The MS4 Permittees have been implementing structural BMPs in the watershed to fulfill new development and significant redevelopment requirements incorporated into the 2002 MS4 permit adopted for the Santa Ana Region within Riverside County and as required by Watershed-wide Waste Discharge Requirements for Discharges of Stormwater runoff Associated with New Developments in the San Jacinto Watershed (Regional Board Order 01-34). These structural BMP requirements have been implemented through the development of Water Quality Management Plans for development projects. Table D-6 summarizes the number of projects and number of acres of runoff impacted by the implementation of WQMPs since January 1, 2005, shortly after adoption of the Nutrient TMDLs.

CDM Smith

Table D-6. Summary of Structural BMPs Implemented as Required by Implementation of WQMP Requirements for New Development or Significant Redevelopment Activities

Jurisdiction	No. of Projects	Total Acres	Description
Beaumont			
Canyon Lake	-	-	
Hemet	22	108	Infiltration basins, extended detention, bioretention basins, grass swales, underground chamber infiltration
Lake Elsinore	38	2,710	Water quality basins, swales, bio-retention
Menifee	12	75	Extended detention basins
Moreno Valley	20	1,220	Extended detention basins, vegetated swales, media filter
Murrieta	2	34	Infiltration basin, swale
Perris	73	2,233	Extended detention, infiltration basins, bioswales, and media filters
Riverside	-	511	
Riverside County	6	25	Extended detention basins. County did not have a tracking mechanism for San Jacinto Construction Permit SWPPP projects that deployed BMPs. As they could not be accounted for, they are not tracked here. The numbers here represent only projects subject to WQMP requirements that have been constructed within the unincorporated County. These numbers also do not include additional WQMP projects originally constructed within the County that have since been incorporated into cities.
San Jacinto			
Wildomar	-	-	
Total	**176**	**6,916**	

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Attachment E
CNRP Implementation Plan

E.1 Introduction

As noted in Section 2.4, the MS4 permit requires that the CNRP include a detailed schedule includes the following:

- Discrete milestones, decision points and alternative analyses necessary to assess satisfactory progress toward meeting the urban WLAs for nutrient by December 31, 2020.
- Agency or agencies are responsible for meeting each milestone.
- Specific metric(s) that demonstrate the effectiveness of the CNRP and acceptable progress toward meeting the urban WLAs for nutrient by December 31, 2020

Section 2.4 provided an illustration of the key CNRP elements in a timeline. In this attachment, Table E-1 provides the detailed information required above for each CNRP task, specifically:

- *CNRP Activity* – Programmatic area to be implemented;
- *Milestones* – Discrete actions associated with the completion of each CNRP activity;
- *Metrics* – Specific outcomes to demonstrate completion of each milestone;
- *Lead Agency* – Assignment of the activity to the appropriate jurisdiction or group of stakeholders; and
- *Completion Date* – Completion dates for the CNRP activities.

E.2 CNRP Activities

The following sections provide a brief summary of the activities that will be completed under each key CNRP element.

E.2.1 Watershed-based BMPs

Three BMPs will be evaluated by the permittees to determine if modifications or enhancements can be made that will provide additional reduction of nutrient sources within their jurisdictions:

- Ordinances
- Street Sweeping
- Debris Removal

The implementation schedule includes milestones for the evaluation of these BMPs and, if appropriate, completion of program modifications.

Two BMPs will continue to be implemented as currently designed. Public education and outreach activities that target nutrients are already routinely implemented. The MS4 program will continue to regularly evaluate these activities and update PEO programs as needed. Septic system management will continue as described by the approved San Jacinto Onsite Wastewater Management Program.

Future development in the watershed is subject to recently revised WQMP requirements that require implementation of LID-based BMPs. The revised WQMP requirements are currently under Regional Board review. Once approved, the revised WQMP will be fully implemented within six months, likely prior to the expected CNRP approval date.

E.2.2 In-lake Remediation Projects

Lake Elsinore

The Lake Elsinore aeration system, incorporated into the CNRP, is already being implemented. During CNRP implementation the MS4 permittees will support the continued operation of this system as needed to comply with urban WLAs. However, as noted in Section 2.2.2., the permittees will continue to evaluate alternative compliance approaches including use of chemical additives such as alum. If it is determined that an alternative approach is more cost effective for achieving compliance with the urban WLAs and septic LAs, the Permittees will recommend revision to the CNRP.

Canyon Lake

The permittees have preliminarily committed to the design, construction and long-term operation and maintenance of the HOS, consistent with Alternative 10b (see Section 2, footnote 6). However, as noted in Section 2.2.2., the Permittees will continue to evaluate alternative approaches including use of chemical additives such as alum. If it is determined that an alternative approach is more cost effective for achieving compliance with the urban WLAs and septic LAs, the Permittees will recommend revision to the CNRP. If HOS is ultimately implemented, this project will have to follow the CIP process, as described in Section 2.2 (see Figure 2-1). Based on the preliminary commitment to HOS, the CNRP schedule anticipates that HOS will begin construction by the end of 2014. This date should allow sufficient time to secure funding, finalize the engineering design (currently at about 10 percent), receive CEQA approval, obtain all required permits and approvals, enter into ownership and operation agreements, and, with city manager and Permittee approval, complete construction.

E.2.3 Monitoring Program

Watershed-based monitoring will continue at current levels through fiscal year 2014-2015. The Permittees propose to eliminate existing in-lake monitoring programs through the same period to ensure that resources are dedicated to facilitating and constructing the Canyon Lake HOS. By December 31, 2014, the permittees will propose a revised comprehensive watershed and in-lake monitoring program for implementation beginning in fiscal year 2015-2016. The level of effort associated with this revised program will be sufficient to provide data to assess compliance with the 2015 interim and 2020 final TMDL compliance requirements. These compliance assessments will provide the basis for determining whether the CNRP requires revision to ensure compliance with TMDL requirements. Annual monitoring reports will be submitted to the Regional Board by November 30th of each year, at the same time that the MS4 Annual Report is submitted to the Regional Board.

E.2.4 Special Studies (optional)

The CNRP identifies several special studies that may be completed during implementation. Their primary purpose is to develop new data or information that could provide the basis for revisions to the Nutrient TMDLs or CNRP. The three studies listed in Table E-1 (land use updates, TMDL model update and use of chemical additives, e.g., alum, Zeolite, or Phoslock application) may be implemented by the MS4 Permittees, but only if it is determined that the expenditure of resources on these efforts would yield appropriate outcomes. For that reason, Table E-1 notes that these tasks are optional and only lists general milestones and metrics. If the studies were to be implemented, the efforts would be coordinated with other stakeholders to the extent necessary. Currently, given the TMDL triennial review schedule, which provides periodic opportunity to revise the TMDL, these studies would be completed in a timely manner to inform the triennial review process.

E.2.5 Adaptive Implementation

This CNRP element covers activities associate with continued participation in the Task Force, the development of a PTP, and the need, where appropriate, for revisions to the CNRP or Nutrient TMDLs. The development of the PTP is currently occurring under the direction of the Task Force. The Permittees will collaborate on the development of this plan, its approval by the Regional Board, and implementation through continued participation in the Task Force.

The need for modification of the CNRP will be determined by the findings of any special studies (if implemented) and the results of ongoing monitoring efforts which provide the basis for assessments of compliance with TMDL requirements. This assessment will include completion of a trend analysis for the response targets and nutrient levels in Lake Elsinore and Canyon Lake by November 30, 2018. This analysis will be included in the fiscal year 2017-2018 MS4 Annual Report. Based on the outcome of this analysis, the permittees may make recommendations for additional BMPs and a schedule for deployment of those BMPs for incorporation into a revised CNRP by June 30, 2019.

Adaptive implementation also includes a provision for providing support to the TMDL revision process. Recommendations for revisions to the TMDL would be made by the Permittees working in collaboration with other TMDL stakeholders. Any recommendations made would be based on the findings of special studies or the data obtained from the monitoring program. The schedule for TMDL revisions is based on the TMDL review schedule that anticipates opportunity for TMDL revisions every three years.

Table E-1. CNRP Implementation Plan

CNRP Activity	CNRP Element	Milestones	Metrics	Lead	Complete by
Watershed-based BMPs	Ordinances Development	Evaluate need to revise existing or establish new ordinances to reduce sources of nutrients in the watershed	Complete ordinance evaluation	Permittees	March 31, 2013
			Establish revised or new ordinances	Permittees	December 31, 2013
	Street Sweeping & Debris Removal	Street Sweeping & Debris Removal	Evaluate existing street sweeping and debris removal programs to identify opportunities to enhance program	Permittees	March 31, 2013
			Implement program enhancements, where identified, and as approved in local jurisdiction	Permittees	December 31, 2013
			Annual reporting of regular street sweeping and debris removal outcomes in Annual Report, with emphasis on TMDL benefits	Permittees/MS4 Program	November 30, each year
	Inspection & Enforcement	Continued implementation of inspection and enforcement program	Update inspection and enforcement program if needed based on outcome of ordinance evaluation	Permittees	March 31, 2014
			Annual reporting of regular inspection and enforcement activities in Annual Report, with emphasis on TMDL benefits	Permittees/MS4 Program	November 30, each year
	Septic System Management	Continued implementation of Septic System Management Plan for the watershed; modify implementation as needed to comply with State OWTS Policy	Annual reporting of septic system management activities in Annual Report, with emphasis on TMDL benefits	Permittees	November 30, each year
	Public Education & Outreach	Continued implementation of PEO program	As part of Annual Report preparation evaluate PEO program to determine need to modify or expand PEO activities that target nutrient sources	Permittees/MS4 Program	November 30, each year
			Update PEO materials, as needed; implement PEO program	Permittees/MS4 Program	Annually, as needed

Table E-1. CNRP Implementation Plan

CNRP Activity	CNRP Element	Milestones	Metrics	Lead	Complete by
	WQMP Implementation	Implement approved LID-based WQMP following Regional Board approval	Prepare final WQMP, obtain Regional Board approval, and implement in watershed	Permittees/MS4 Program	Within 6 months of Regional Board approval of WQMP
In-Lake Remediation Projects	Lake Elsinore	Support implementation of existing lake aeration system	Establish necessary agreements among aeration system participants	MS4 Program in collaboration with stakeholders	December 31, 2012
	Canyon Lake	Complete alternatives analysis of in-lake remediation project(s) for Canyon Lake	Select in-lake remediation project(s) for Canyon Lake	MS4 Program in collaboration with stakeholders	June 30, 2014
		Prepare preliminary design for HOS	Preliminary HOS design to support CEQA process	MS4 Program in collaboration with stakeholders	June 30, 2014
		Implement CEQA process	Obtain CEQA approval of HOS	MS4 Program in collaboration with stakeholders	December 31, 2014
		Prepare final design for HOS	Finalize HOS design; complete bid and award process	MS4 Program in collaboration with stakeholders	December 31, 2014
		Implement process to obtain all permits and approvals	Secure permits and approvals to operate HOS	MS4 Program in collaboration with stakeholders	December 31, 2014
		Implement HOS construction	Complete construct and testing of HOS	MS4 Program in collaboration with stakeholders	December 31, 2015
		Establish operation and maintenance agreement	Operation of properly maintained HOS	MS4 Program in collaboration with stakeholders	January 1, 2016 and following
Monitoring Program	In-Lake Monitoring	Implement reduced monitoring program	Completion of annual monitoring as required by current approved monitoring program	MS4 Program in collaboration with stakeholders	June 30, 2015
		Prepare revised comprehensive monitoring program	Submit revised comprehensive monitoring program to the Regional Board for approval	MS4 Program in collaboration with stakeholders	December 31, 2014
		Implement Regional Board-approved revised comprehensive monitoring program	Completion of annual monitoring as required by revised program	MS4 Program in collaboration with stakeholders	December 31, 2020
	Watershed-based Monitoring	Continue implementation of Phase I watershed monitoring program	Completion of annual monitoring as required by current approved monitoring program	MS4 Program in collaboration with stakeholders	June 30, 2015
		Prepare revised comprehensive monitoring program	Submit revised comprehensive monitoring program to the Regional Board for approval	MS4 Program in collaboration with stakeholders	December 31, 2014
		Implement Regional Board-approved revised comprehensive monitoring program	Completion of annual monitoring as required by revised program	MS4 Program in collaboration with stakeholders	December 31, 2020
	Annual Reports	Complete annual reports to assess effectiveness of CNRP	Submittal of annual reports to Regional Board by August 15	MS4 Program in collaboration with stakeholders	November 30, annually

Table E-1. CNRP Implementation Plan

CNRP Activity	CNRP Element	Milestones	Metrics	Lead	Complete by
	Interim Compliance Assessment	Demonstrate compliance with interim TMDL requirements	Submittal of assessment of compliance with interim TMDL requirements	MS4 Program in collaboration with stakeholders	December 31, 2015
	Final Compliance Assessment	Demonstrate compliance with WLAs	Submittal of assessment of expected compliance with final TMDL requirements including any recommended supplemental actions.	MS4 Program in collaboration with stakeholders	November 30, 2019
Special Studies (Optional)	Use of Chemical Additives	Evaluate potential to use chemical additives, e.g., alum, Zeolite or Phoslock, as an in-lake remediation strategy alternative	Complete studies, as appropriate, to evaluate potential for use of chemical additives	MS4 Program in collaboration with stakeholders	June 30, 2013
	Land Use Updates	Update watershed urban land use based on 2010 data	Submit land use revision to the Regional Board	MS4 Program in collaboration with stakeholders	June 30, 2018
	TMDL Model Update	Revise/update TMDL models for Canyon Lake/ Lake Elsinore based on new data (e.g., land use, water quality)	Submit TMDL models to the Regional Board	MS4 Program in collaboration with stakeholders	December 31, 2018
Adaptive Implementation	Task Force	Participate in Task Force process	Regular attendance at Task Force meetings	MS4 Program in collaboration with stakeholders	Ongoing
	Pollutant Trading Plan (PTP)	Provide input to the development of the PTP	Final PTP submitted to the Regional Board	MS4 Program in collaboration with stakeholders	Prior to December 31, 2012 (in coordination with CNRP)
	CNRP Revisions	Review progress towards achieving TMDL requirements based on compliance assessments; modify CNRP as needed	Prepare compliance assessment; if needed, submit revised CNRP to the Regional Board	MS4 Program/Permittees	November 30, 2015
		Review progress towards achieving final TMDL requirements based on compliance assessments; modify CNRP as needed	Prepare compliance assessment; if needed, submit revised CNRP to the Regional Board	MS4 Program/Permittees	November 30, 2019
	TMDL Revision	Based on degree of Regional Board support, prepare materials to support revision to the TMDL as part of the Triennial Review process, if revision is appropriate	Submit recommendations and supporting material for revisions to the TMDL to the Regional Board	MS4 Program in collaboration with stakeholders	Prior to potential triennial review dates in 2015 and 2019

Attachment F
Other Supporting Documents

Supporting documents provided in this attachment include:

- *Canyon Lake Hypolimnetic Oxygenation System, Preliminary Design Phase 1 Report*, prepared for LESJWA by PACE, April 2011.
- Pollutant Trading Plan (Task 12 – TMDL Implementation Plan) – *currently being completed by Task Force*
- Operations & Management Agreement for Aeration and Mixing Systems, December 2010

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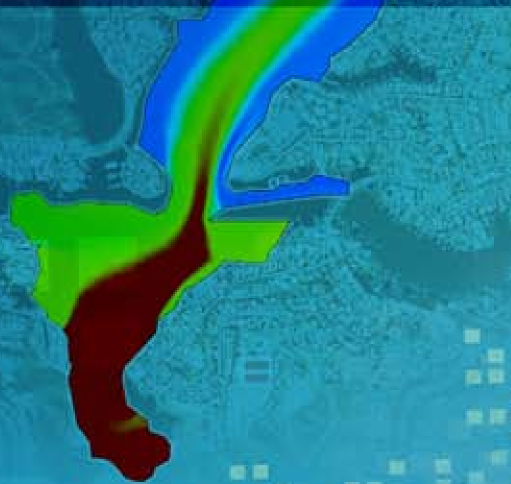
CANYON LAKE HYPOLIMNETIC OXYGENATION SYSTEM PRELIMINARY DESIGN PHASE I REPORT



Prepared for:

Lake Elsinore & San Jacinto Watersheds Authority

PACE

17520 Newhope Street, Suite 200
Fountain Valley, CA 92708
174.481.7300 | www.pacewater.com

Job #: 9653E | April 2011
(February 2011) - Revised

Addendum #1

PACE
Advanced Water Engineering

Addendum #1

PACE
Advanced Water Engineering

REPORT ADDENDUM #1

Date: April 18, 2011

To: Rick Whetsel, Senior Watershed Planner
Santa Ana Watershed Project Authority (SAWPA)
Direct: (951) 354-4222
Email: rwhetsel@sawpa.org

From: Andy Komor, MS, PE

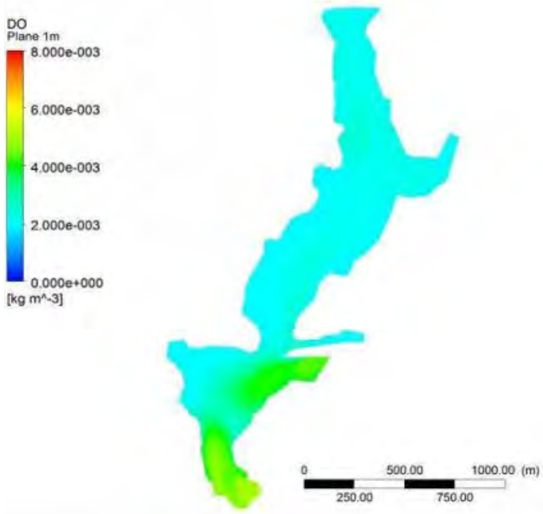
Re: Report Addendum #1 # 9653E

After completion of the preliminary design report dated February 2011, this report addendum was created to provide supplemental information and to re-examine a variant of the preferred alternative for the project. Based on 40 comments received from the project stakeholders, with the comments and responses included at the end of this addendum, it was understood that a smaller treatment system, constructed in phases, was desired to reduce life cycle costs and allow for slow long-term improvement in lake water quality. The originally recommended treatment alternative was #10, and this variant is referred to as alternative #10b. Because alternative #10 and #10b are dual-zone systems, they can be easily phased to include only one of the treatment skids to provide treatment to only a portion of the lake in the first phase. Phase one includes supplying the treatment skid for zones 2 and 3 only, and phase two includes waiting to include the zone 1 treatment skid.

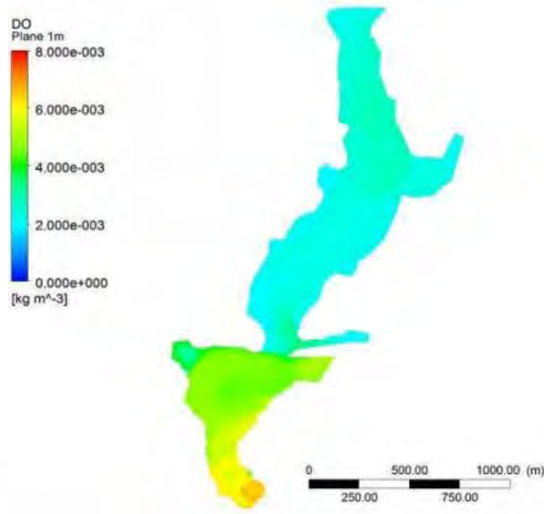
Alternative #10b includes 1,700 lbs of total oxygen supply at 3,200 gpm water flow to zones 2 and 3 using a 1.2 times safety factor for the oxygen depletion rates; whereas, alternative #10 included 3,000 lbs/day of total oxygen supply at 4,100 gpm water flow to zones 2 and 3 with a 1.5 times safety factor for the oxygen depletion rates. The lake was computer modeled using the alternative #10b design criteria, and the model results is shown in Exhibit 1 in the Report Addendum. The preliminary system layout is shown in Exhibit 2 in the Report Addendum. As discussed in response comment 37, the level of design certainty for success of the original alternative #10 was essentially 100% based on a higher safety factor and higher margin of safety. Alternative #10b includes about a 50-80% certainty of achieving 5 mg/L dissolved oxygen along the hypolimnion. Using the first phase of Alternative #10b would include about a 30-40% certainty in the first year, but higher in subsequent years as the sediment layer becomes more oxidized.

Capital, operation and maintenance, life cycle, and annualized bond re-payments at 5% interest are shown in Tables A1 and A2 for the entire Alternative #10b and the first phase of Alternative #10b.

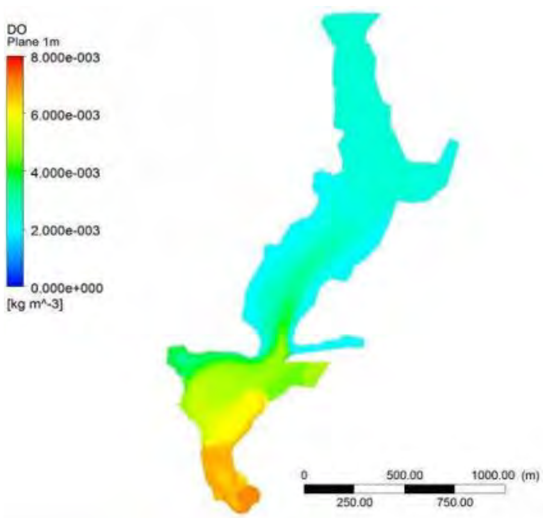
Exhibit 1: 1,700 lbs O_2/day delivered by 4,800 gpm (1.2X Safety Factor)



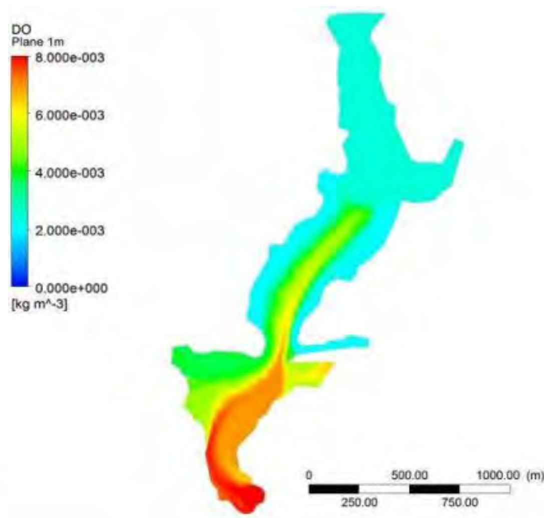
20 Days of Operation



50 Days of Operation



70 Days of Operation



100 Days of Operation

PACE

W:\9653E\6-GIS\Mxds\Reports\Report_20110405\9653E_ProposedPipeAlignment_Modeled_LandscapePC1_20110405.mxd

FIGURE	PACE Advanced Water Engineering	SCALE 1" = 657.490516774236	JOB	TITLE
		DESIGNED PC	CANYON LAKE AERATION PROJECT	PROPOSED PIPE LAYOUT MODELED
		DRAWING PC		
		CHECKED JP		
		DATE 04/05/11		
		JOB NO. 9653-E	Riverside CA	

Shoreline Installation 2 SDOX Units
All Phases

Capital Cost - Shoreline Installation, 2 Units (1,200 lbs/day Zone 2/3 + 600 lb/day Zone 1, LOX				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Intake Suction Cans Rehab			-	$50,000
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
LOX Facility Civil Improvements	-		-	$25,000
SUBTOTAL				**$150,000**
Underwater Civil				
Dredging Equipment	15	cy	$250	$3,750
Underwater Concrete Cassions Materials and Equipment	15	cy	$750	$11,250
SUBTOTAL				**$15,000**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$80	$216,000
Concrete Ballast for 18" Pipe Installed	18	cy	$1,200	$21,600
14" HDPE Piping	4,150	LF	$65	$269,750
Concrete Ballast for 14" Pipe Installed	16	cy	$1,200	$19,200
10" HDPE Piping	1,400	LF	$40	$56,000
Concrete Ballast for 10" and 6" Pipe Installed	4	cy	$1,500	$6,000
6" HDPE Pipe for Zone I	200	LF	$25	$5,000
16" Onshore Piping	350	LF	$90	$31,500
SUBTOTAL				**$625,050**
Equipment				
Onshore 1200 lb Oxygenation System Skid	1		$150,000	$150,000
Onshore 600 lb Oxygenation System Skid	1		$110,000	$110,000
Submersible Pumps (3,200 gpm and 800 @ 25')	2		$35,000	$70,000
Misc Valves / Instrumentation				$30,000
Mechanical Piping / Hosing / Supports / Misc.				$40,000
SUBTOTAL				**$400,000**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$20,000
Motor Control Center				$40,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$40,000
Lighting				$5,000
SUBTOTAL				**$195,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	200	man days	$440	$88,000
Divers	15	crew days	$5,000	$75,000
Per Diem	200	man days	$75	$15,000
SUBTOTAL				**$178,000**
SUM SUBTOTAL				**$1,563,050**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$46,892
FINAL SUBTOTAL				**$1,729,942**
Contingency 10%				$172,994
Contractor Overhead 15%				$259,491
TOTAL				**$2,162,427**

O&M Cost - Shoreline Installation, 2 Units (1,800 lbs/day, LOX)				
Electrical	33	kW-hr	$0.12	$25,661
Maintenance	200	hr	$50	$10,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	7	refills/year	$4,059	$28,412
Equipment Replacement				$15,000
Yearly O&M Cost				**$100,073**
20 Yr Life Cycle Cost (5% Discount Rate)				**$3,409,557**
20 Yr Annual Payment (5% Interest Rate)				**$273,592**

Shoreline Installation 2 SDOX Units
Phase I

Capital Cost - Shoreline Installation, 1 of 2 Units (1,200 lbs/day Zone 2/3, LOX)	quantity	units	cost/unit	total cost
Site Civil and Building				
Intake Suction Cans Rehab			-	$30,000
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
LOX Facility Civil Improvements	-		-	$25,000
SUBTOTAL				**$130,000**
Underwater Civil				
Dredging Equipment	15	cy	$250	$3,750
Underwater Concrete Cassions Materials and Equipment	15	cy	$750	$11,250
SUBTOTAL				**$15,000**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$80	$216,000
Concrete Ballast for 18" Pipe Installed	18	cy	$1,200	$21,600
14" HDPE Piping	4,150	LF	$65	$269,750
Concrete Ballast for 14" Pipe Installed	16	cy	$1,200	$19,200
10" HDPE Piping	1,400	LF	$40	$56,000
Concrete Ballast for 10" Pipe Installed	3	cy	$1,500	$4,500
16" Onshore Piping	350	LF	$90	$31,500
SUBTOTAL				**$618,550**
Equipment				
Onshore 1200 lb Oxygenation System Skid	1		$150,000	$150,000
Submersible Pump (3,200 gpm @ 25')	1		$50,000	$50,000
Misc Valves / Instrumentation				$25,000
Mechanical Piping / Hosing / Supports / Misc.				$30,000
SUBTOTAL				**$255,000**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$20,000
Motor Control Center				$30,000
Control Panel and Programming				$25,000
Conduit / Wiring / Disconnects				$30,000
Lighting				$5,000
SUBTOTAL				**$165,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	150	man days	$440	$66,000
Divers	12	crew days	$5,000	$60,000
Per Diem	150	man days	$75	$11,250
SUBTOTAL				**$137,250**
SUM SUBTOTAL				**$1,320,800**
Design, Engineering, Startup				$100,000
Bonding and Insurance 3%				$39,624
FINAL SUBTOTAL				**$1,460,424**
Contingency 10%				$146,042
Contractor Overhead 15%				$219,064
TOTAL				**$1,825,530**

O&M Cost - Shoreline Installation, 2 Units (1,800 lbs/day, LOX)				
Electrical	22	kW-hr	$0.12	$17,107
Maintenance	130	hr	$50	$6,500
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	5	refills/year	$4,059	$20,294
Equipment Replacement				$10,000
Yearly O&M Cost				**$74,902**
20 Yr Life Cycle Cost (5% Discount Rate)				**$2,758,969**
20 Yr Annual Payment (5% Interest Rate)				**$221,387**

PACE
Advanced Water Engineering

Technical Memorandum

Date: March 30, 2011

To: Rick Whetsel, SAWPA Senior Watershed Planner

From: Andy Komor, MS, PE

Re: **Preliminary Response to HOS Comments** # 9653E

PACE RESPONSE TO COMMENTS

(From James Grimm, 3/9/11)

Design:

1. Sampling showed that the December rates of oxygen depletion are six times lower than the September rates. Why does the system size remain approximately the same as it was before the December sampling data was available?

The revised system size is approximately the same as the previously estimated system size, despite a six times reduction in oxygen depletion, for two reasons:

1) **the volume to be treated approximately doubles by using a lake level four feet below the top of the dam instead of 10 feet below the top of the dam**

2) **only a portion of the oxygen depletion rate was used in the previously estimated system size for several reasons outlined in the December, 2010 powerpoint presentation, but the entire rate was used in the revised system size**

2. The preliminary design needs to include a “Instrumentation and Piping Drawing” (P&ID) that shows all valves, instruments, pumps, interconnecting piping, special equipment, etc.

An instrumentation and piping diagram was not included in this preliminary design scope. We expect it to be created as a first step in the next design phase.

3. The preliminary design also needs to identify all equipment (valves, instruments, pumps, special equipment, etc) by manufacture and part number. It should also show how the pipes would be secured to the bottom of the lake.

Identification of all equipment and securing pipes to the bottom of the lake was not included in this preliminary design scope. We expect it to be designed in the next design phase.

4. Page E-4, 2nd Para and page 7-54, 4th Para:
Does the term “modified side-stream” mean that the output of the BlueinGreen system is mixed with non-oxygenated lake water by a mixing valve system as shown in fig 21 on page 5-27 to produce a lower oxygen concentration ? If so, how are these valves controlled: automatically or by the operator ? If automatically, what does that control system look like, if by operator, how does he know where to position the valves ?

To clarify, the modified side-stream includes mixing of the two water sources described. The mixing is achieved using a carefully designed orifice nozzle which controls the discharge of high oxygen water from the oxygenation equipment into the large pipe containing lower oxygen water. The nozzle shall be sized by the manufacturer, and verified by the engineer, to achieve proper back pressure for optimal oxygenation equipment operation. The nozzle is not adjustable.

5. "Pump speed can be perfectly regulated to optimize oxygen dissolution in the water". Will the pump speed be automatically controlled or controlled by the operator. If automatically, what does that control system look like ? If controlled by the operator how does the operator know when the system has optimum oxygen dissolution in the water ? "This is achieved by maintaining a constant water level in the tank ……." Is this done by automatic control or by the operator ? If automatically, what does that control system look like ? If by operator, how does the operator know if there is a constant water level in the tank ? Is there a tank water level sight glass or other device ?

The pump will contain a variable frequency drive (VFD) which allows automatic change in speed to achieve a desired flow. The flow will be directly dependent on the feedback from a level instrument located in the oxygenation tank.

6. Page 3-14, para 1, last sentence:
I don't the typical water surface level is maintained at 1375. The lake level max is 1382 controlled by the dam height. The lake level min is 1372 controlled by a lease agreement between Canyon Lake POA and EVMWD. EVMWD keeps historic lake level elevations. This data could be use to determine the nominal lake level over the years for the months of April through November to determine what lake level should be used to determine the volume of the hypolimnion to be used in sizing the system.

For clarity, a full lake makes the oxygenation system larger. Since the lake is often full at the end of the spring, and evaporation will only decrease the lake by four feet throughout the summer, it seems reasonable to use the dam height minus four feet as a good design criteria.

7. Page 3-19, 1st Para: "……… lake level was 5 ft below dam spillway". 5 ft below the dam spillway is 1377 but the text and table use 1378 and 1358. This is only a difference of one foot but it makes a significant difference in the volume of the hypolimnion and thus system sizing. What lake level and hypolimnion volume were used for sizing?

Table 3 presents information based on 10 feet below the dam or a water surface of 1372 feet, and Table 4 presents information based on four feet below the dam or a water surface of 1378. The text preceding both tables in inaccurate.

8. Page 4-20, last Para, and last sentence: says layers are 6 meters below the top of the hypolimnion. Should that be below top of the lake ?

The sentence shall be corrected to say 6 meters above the bottom of the lake.

9. Page 4-21 to 4-24:
All 4 options shown achieve more than 5 mg/l in some areas with option 10 having the greatest area with more than 5 mg/l and a significant area of over 8 mg/l. This appears to be a distribution problem. Can the distribution be improved resulting in a smaller size system ?

The distribution of oxygen appears reasonably good to PACE, for example the distribution of high oxygen is achieved to all three zones in 100 days. To improve the distribution, additional mixing flow is required, but additional mixing flow will greatly increase the capital cost considering the piping accounts for 40+% of the capital cost.

10. Page 5-29, last Para: "……..and alarm problems in the system operation". Does the BlueInGreen system have an alarm system and if so what does it look like ? The last line says"……. and is further described in section 6". I do not see that in section 6, where is it ?

Sentence should be revised to say:

The BlueInGreen system has advantages over the speece cone in that the oxygen saturation into the water column is tightly controlled with a variable speed pump to optimize efficiency. When oxygen is not properly dissolved or other problems occur in system operation, the BlueInGreen system automatically reacts to adjust its operation or has a system shutdown and alarms operations staff; whereas, the Speece Cone system does not provide these real time adjustments or safety shutdown functions.

The BlueInGreen system is further described in Section 7, not Section 6.

10. Page 7-55, fig 29: What is the cylindrical object between the 2 BIGSDOX units ?

The cylindrical object is no longer necessary. It shall be omitted.

11. Page 7-56, fig 30: upper view,
a. what does "from treatment location" mean ?
b. What are the yellow circles in the upper and lower views trying to show ?
c. What are the 2 "Dissolved Oxygen" gages trying to show ?

a. In the case of Canyon Lake, the treatment location is the low-oxygen bottom lake waters that require treatment.

b. The yellow circles indicate areas where oxygen is dissolving into the water (top schematic) or diffusing into the water column (bottom schematic).

c. The dissolved oxygen gauges are showing the theoretical standard BlueInGreen design oxygen concentrations in the treatment reactor and in a reservoir.

12. We need to try to keep the size of the system down and thus the cost down, but we do not want to undersize it. Toward that end, we should consider the following:

a. Does the entire vertical height of the hypolimnion need to be the greater than 5 mg/l or is it just the lower level near the water/sediment interface that is critical ?

b. A safety factor of 1.5 seems high. What is the rational for that number ?

c. Was wind mixing taken into consideration for sizing the system ?

a. In our experience the hypolimnion oxygen concentration is similar vertically, so the bottom of the hypolimnion and the top of the hypoliminion have similar concentrations, and it is difficult to trap high oxygen near the sediments as a means of reducing the

overall system size. We will rerun the model examining the oxygen concentration nearer the sediments.

b. **This safety factor is based on our experience with other reservoir system treatment designs for inefficient diffusion and dispersion, and includes standard inefficiencies used by ECO2 Speece Cone for oxygen bubbles that come out of solution (about 10% of applied oxygen). We can consider a lower safety factor, with the understanding that a level of design safety will not be provided.**

c. **Wind mixing historically mixes the top 20 feet of Canyon Lake and does not change the hypolimnion layer volume.**

Editorial:

13. Page E-1, 1st para, next to last sentence: “Central Body”. I am not sure if there is an official name, but it is commonly referred to as the “Main Body” or “Main Lake”.

14. Page E-2, Fig ES2: a reference to where these zones are may be helpful (i.e. “see page 2-12 for zone location”).

15. Page E-4, define WTP, LOX & EVMWD. Provide a reference as to where locations A, B & C are (i.e. see fig 25, page 5-33).

16. Page E-4, 1st para, 5th sentence: “he LOX” should be “the LOX”.

17. Page 3-15, 1st line: CL was divided into 3 zones for purpose of design but fig 12 shows 4 zones.

18. Page 5-26, last Para, next to last sentence: “……….. while diluting the water that will be pumped to zones I and II……..”. Should be zones II and III.

19. Page 5-27, fig 21: it is difficulty to see the 3 different colors on the schematic.

20. Page 5-33, Para 5.3: “……. As seen in fig 252.” Should be fig 25.

21. The tabs for appendix A and B are reversed.

All editorial corrections noted.

(from Tim Moore, 3/14/11)

22. It appears that the HOS is designed to assure compliance with the DO objective by oxygenating the water directly. Such an approach is both straight forward and conservative. However, it also requires a much larger and more costly system than previously anticipated.
In retrospect, much of the added cost may be due to the fact that the system is designed to achieve the DO objective less than 100 days after it begins operation. There may be another way to spec the system. Dr. Anderson's previous research shows there is a significant "feedback loop" governing the nutrient cycle in Canyon Lake. Sequestering nutrients in the sediment, via oxygenation, is expected to produce a cumulative compound benefit. Thus, in addition to assuming that the HOS can meet the DO objective directly, it is also appropriate to consider the indirect benefits associated with reducing phosphorus releases from the sediment and thereby interrupting the nutrient cycle.

Because every winter the bottom sediments are oxygenated for several months, the current winter oxygen depletion rates are in our opinion somewhat similar to the anticipated summer oxygen depletion rates of future years with the oxygenation system running. They both represent an aerobic depletion rate. We understand Dr. Anderson has shown slight improvement year to year with continued oxygen supply to create an almost 100% aerobic condition in the sediments, but an aerobic depletion rate is an aerobic depletion rate and it won't change drastically in our opinion. We agree that creating oxygen in 100 days starting from zero oxygen is really irrelevant, and we intend on re-running the models starting with saturated spring oxygen conditions and maintaining oxygen throughout the summer.

23. If a smaller HOS were built and begin operation by 2014, we would have at least two full years to meet the interim DO targets and nearly seven years to meet the final targets. Dr. Anderson should be able to calculate the incremental and cumulative indirect benefits associated with building such a HOS in Canyon Lake.

Since the proposed Option 10 dual zone system contains two independent treatment systems, it seems reasonable to install the zone 2/3 system first prior to installing the zone 1 system to monitor its effectiveness over a two-year period prior to expanding. The zone 2/3 system contains the critical mixing energy to distribute the oxygen properly.

24. The omission of indirect, long term, cumulative benefits and the addition of a substantial safety factor likely account for the large difference between Dr. Anderson's initial cost estimate (<$1 million) and Pace's more recent estimate (>$4 million). We need a more sophisticated modeling analysis of the type that Dr. Anderson did for Lake Elsinore in his report of March, 2006.

Doubling the treatment volume from Dr. Anderson's initial cost estimate to account for higher lake levels would increase the original cost estimates. Assuming it doubled, Dr. Anderson's estimate could be nearly $2M. In Table 32 the capital cost estimate for Option 10 for LOX was $2.56M, not >$4M. Thus, the two cost estimates are similar. Considering the doubling of cost of oil-based plastic pipe in eight years from when Dr. Anderson's estimate was provided, these estimates are even more comparable.

(from Dr. Anderson 3/18/11)

The report summarizes results from measurements conducted at the lake and in the laboratory, with hydrodynamic modeling of dissolved oxygen (DO) distribution to develop and evaluate several hypolimnetic oxygenation design alternatives. The approach adopted is sound and the report is well-written. The sediment oxygen demand and water oxygen demand rates measured by PACE in December 2010 are encouragingly similar to those that we found in 2007 (Anderson et al., 2007). The higher lake level and thicker hypolimnion than used in our previous work appears to be a principal reason for total DO demands that are higher than those reported in our study. PACE properly also included a safety factor in their design recommendations. Hydrodynamic modeling was a very useful tool for optimizing delivery of DO across the main basin of the lake. Modeling results suggest that option 10 provides efficient distribution of DO, with sufficient capacity to meet most any likely lake water quality condition. PACE also makes a strong case for use of liquid oxygen and the BlueInGreen system over the Speece Cone.

(from LESJWA Staff 3/21/11)

Executive Summary

25. Page E-1, Fig ES1, right hand legend for water depth missing.

26. Page E-4, 1st para, 5th sentence: "he LOX" should be "the LOX".

Section 1

27. Pages 1-5, Fig 4, right hand legend for water depth missing.

28. Pages 1-6, Fig 5, right hand legend for water depth missing.

29. Pages 1-7, Fig 6, right hand legend for water depth missing.

Section 3

30. Pages 3-13, Fig 11, top legend for DO concentration missing.

Section 5

31. Page 5-33, 1st para, 2nd sentence, replace Figure 252 with Figure 25.

All editorial corrections noted.

(from Ron Young, 3/29/11)

32. There was concern about the design trying to create a 'high' DO throughout the hypolimniom and not just the sediment layer where the recycling of nutrients takes place under anaerobic conditions as the anaerobic bacteria are in the sediment and not in the water column. This may cause the O2 demand to be way too large for the actual needs of the deep sediment area.

In our experience the hypolimnion oxygen concentration is similar vertically, so the bottom of the hypolimnion and the top of the hypoliminion have similar concentrations, and it is difficult to trap high oxygen near the sediments as a means of reducing the overall system size. We will rerun the model examining the oxygen concentration nearer the sediments.

33. Another area of concern is the escalating cost from the first Anderson estimate of $0.5 to 1 MM, then Pace initial estimate at $2MM, and now at $3MM. With the loss of WLA and possible participants above Mystic Lake a more lean design may be needed. If generation is reduced then capital will also reduce making costs more possible for agency participation.

Doubling the treatment volume from Dr. Anderson's initial cost estimate to account for higher lake levels would increase the original cost estimates. Assuming it doubled, Dr. Anderson's estimate could be nearly $2M. In Table 32 the capital cost estimate for Option 10 for LOX was $2.56M, not >$4M. Thus, the two cost estimates are similar. Considering the doubling of cost of oil-based plastic pipe in eight years from when Dr. Anderson's estimate was provided, these estimates are even more comparable.

The 1.5X safety factor used in the design was based on our experience with other reservoir system treatment designs. We can consider a lower safety factor, with the understanding that a

level of design safety will not be provided. We also recommend consideration of proceeding with installation of only one of the two Option 10 dual-zone oxygenation systems as described in comment 23.

34. With all the interest in cost, the life cycle costs should be more detailed with a breakdown of assumptions so costs can be allocated based on WLA of agencies above Canyon Lake.

Life-cycle cost is not detailed Section 6 because it is calculated simply as the capital cost plus the 20-year present worth O&M cost at 8% discount rate. The O&M cost is based on nine months of operation per year.

35. The TAC with input from Anderson and Komor should take a look at the hybrid of Phosloc and HOS. Maybe HOS is only a fraction of the size and cost.

The oxygen depletion rate will be dependent on the quantity of organic material in the water column and sediments, consisting of many things including natural debris and dead algae. Assuming phosphorus was decreased, dead algae could decrease, which would decrease the organic material, and would decrease the oxygen depletion rate. It is difficult to quantify this potential benefit at this time. It seems reasonable in an effort to take advantage of these benefits to install the HOS system in a phased approach as described in comment 23 to allow time for a smaller system to operate and monitor the lake oxygen improvement.

36. PACE should do a payback calc on O2 generation vs. LOX based on the number of days per year that the systems operate, which might be about 1/2 of the year.

Using Option 10 O&M cost estimates with an oxygen generator in Table 30 and with LOX in Table 33, the difference in annual O&M is approximately $21,000 per year, with LOX being more expensive. The difference in capital cost, comparing Table 29 with Table 32, shows a difference in capital cost of approximately $370,000, with LOX being less expensive. Thus, assuming no discount rate, the payback would be approximately 18 years.

37. PACE should add a discussion on how the system will meet the TMDL requirements. I'd like to see some probabilities if possible on reducing the nutrient recycling so the pollutant credits can be calculated and costed out for trading.

The TMDL Targets are shown in Table 1 of the report (NOTE: the DO limits were stated incorrectly in the report but have been revised herein):

Table 1: Basin Plan Resolution No. R8-2004-0037 TMDL Targets for Canyon Lake

Indicator	TMDL Targets
Total Phosphorus Concentration	≤ 0.1 mg/L in 2020
Total Nitrogen Concentration	≤ 0.75 mg/L in 2020
NH3-Nitrogen Concentration	CMC and CCC limits per formula
Chlorophyll a Concentration	≤ 40 ug/L in 2015
Chlorophyll a Concentration	≤ 40 ug/L in 2015

Epilimnion DO Concentration	≥ 5 mg/L in 2015*
Hypolimnion DO Concentration	≥ 5 mg/L in 2020*

The scope of work we have provided is to meet the DO concentration hypolimnion objective of the TMDL. We believe the probability of meeting this DO concentration objective is essentially 100% if Option 10 was installed. By installing the first phase of Option 10, we believe the probability decreases to 50-80%. The benefit to the other three parameters was not part of our scope, but it is reasonable that the phosphorus and ammonia will decrease with oxidized sediments. Decreased dissolution of phosphorus and ammonia will decrease algae, which decreases chlorophyll. The exact quantity of decrease is difficult to predict, but based on experience could be on the order of 25-50% reduction after five years of operation.

38. Can we get some expectations on the hybrid systems discussed by Tim to see how much different they may be from pure HOS?

We are not sure of which hybrid systems are described, whether it is hybrid Phosloc/HOS or phased HOS or something else. Response 35 describes information related to the hybrid Phosloc approach and response 23 describes information related to the phased HOS approach.

39. Should there be some recognition of the value for siting the facilities on EVMWD property so we are seem as adding value to the solution to reduce requests for paying to get intangible benefits due to HOS. The water treatment plant operation schedule won't be the same as the HOS operation but there will be some overlap. The WTP only operates about 5 months / yr. and can start and stop during spring and fall turnover when there is mixing to bring iron and manganese water to the surface.

Assumed that this question was directed at staff.

40. Does HOS operation guarantee no FE or MN during turnover events?

In an oxidized condition iron and manganese will not dissolve into the water column in the hypolimnion during a stratified summer condition. Thus, instead of seeing elevated iron and manganese rise to the surface after a turnover, the epilimnion background iron and manganese concentrations shall also be present at the bottom of the reservoir before, during, and after turnover.

PACE

Lake Elsinore & San Jacinto Watersheds Authority

Canyon Lake Hypolimnetic Oxygenation System

April 2011
(February 2011) – Revised

Prepared For:

Lake Elsinore and San Jacinto Watersheds Authority
11615 Sterling Avenue.
Riverside, CA 92503

Prepared By:

Pacific Advanced Civil Engineering, Inc.
17520 Newhope Street, Suite 200
Fountain Valley, CA 92708
714-481-7300

Contact Person:

Andy Komor, MS, PE

PACE JN 9653E

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<u>Tables</u>

Figures

Appendices

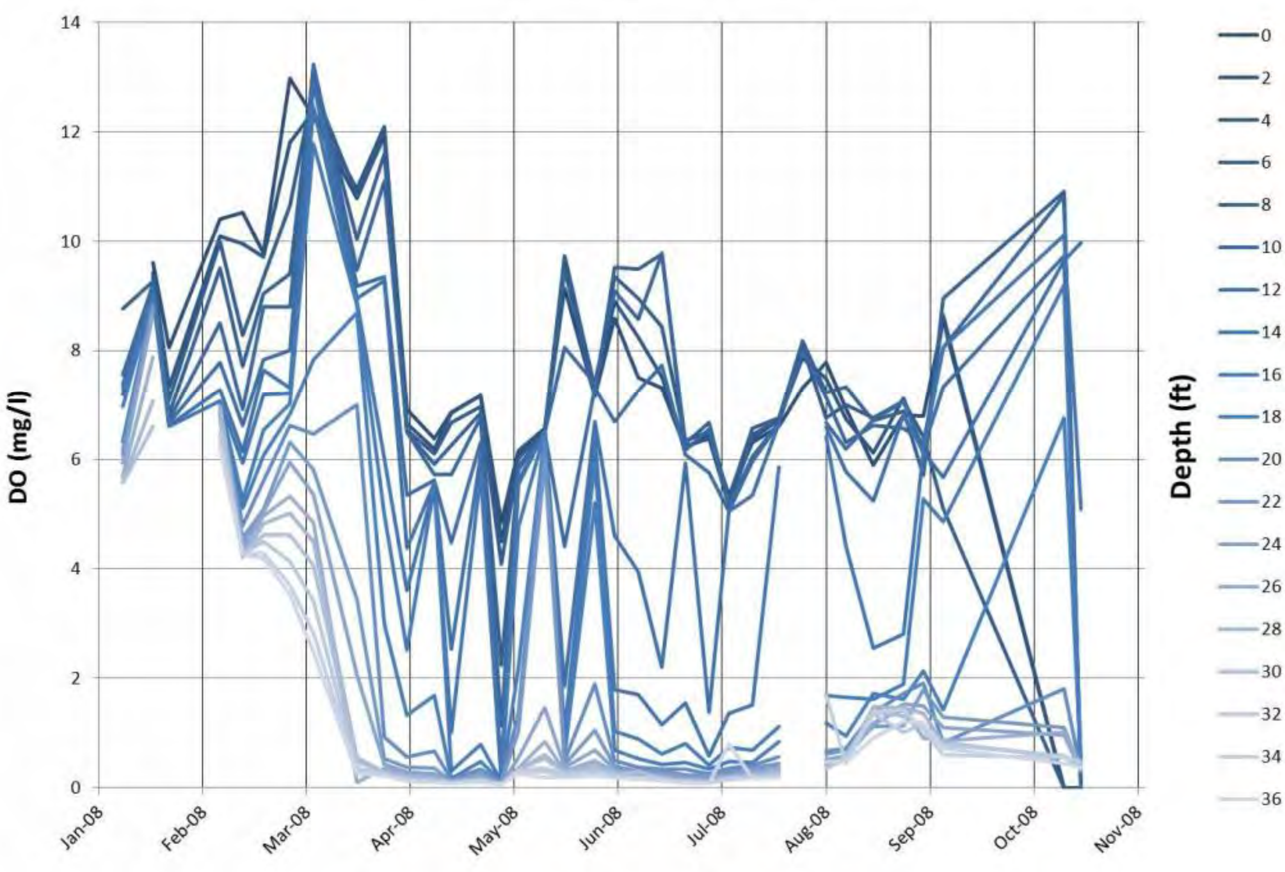
Advanced Water Engineering

Executive Summary

Executive Summary

Canyon Lake is listed on the Clean Water Act Section 303(d) list as impaired for excessive nutrients and high bacteria. The Regional Water Quality Control Board identified numeric water quality targets for total phosphorus, total nitrogen, ammonia, chlorophyll a, and dissolved oxygen. The primary in-lake treatment strategy recommended by the project stakeholders was a deep water, or hypolimnetic, oxygenation system. This report describes the preliminary design of this oxygenation system for the Main Lake of Canyon Lake. Figure ES1 shows Canyon Lake's low oxygen concentrations at water depths below 20 feet throughout the summer.

Figure ES1: 2008 Canyon Lake Oxygen versus Time at Various Depths

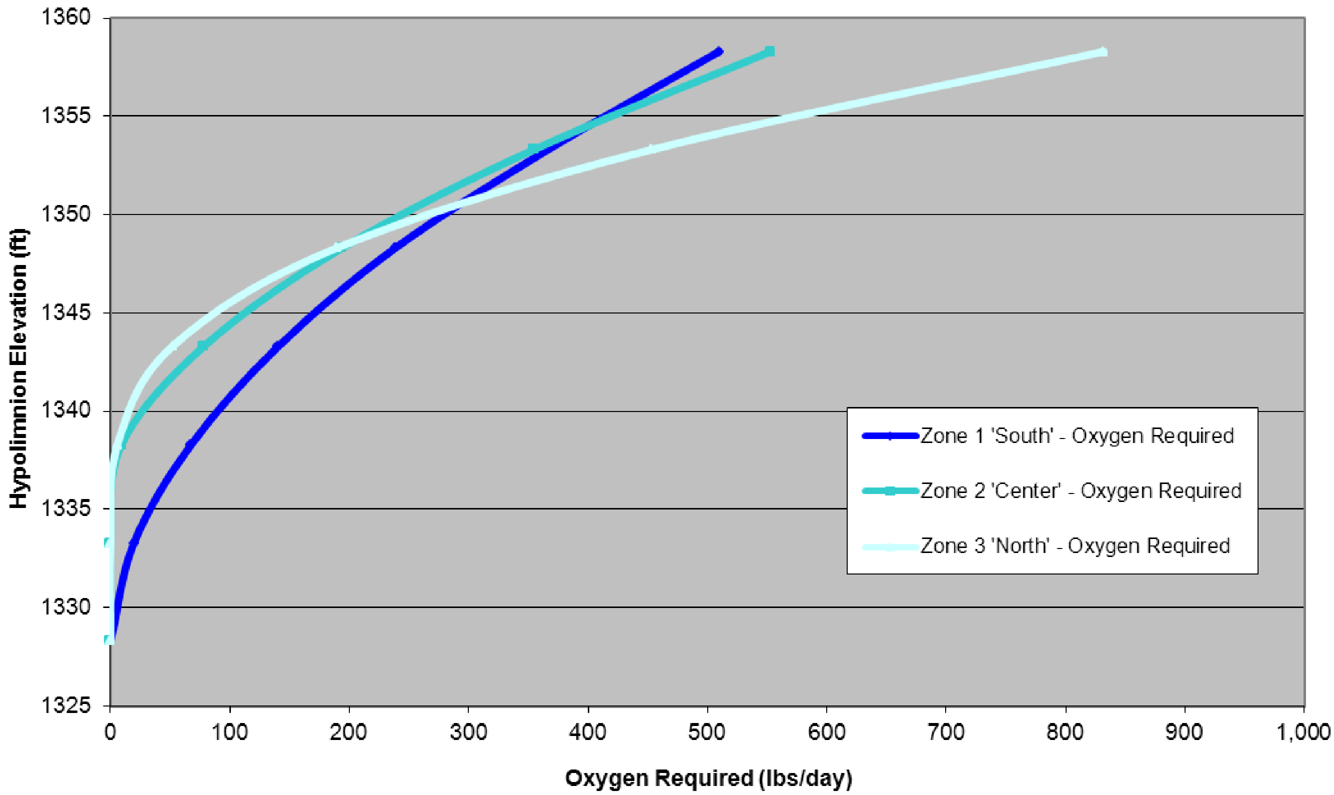


The following new data was collected as part of the preliminary design report evaluation:

1. Depth measurements to augment and clarify the existing bathymetry
2. Bottom of lake organic muck layer depth and characteristics near the dam
3. Location of deep and flat location suitable for submerged equipment (buoy installed)
4. Temperature, pH, and oxygen profiles during three periods of 2010
5. September collection of samples and experimentation of oxygen depletion rates from six sites including soil, bottom water, and top water at three different temperatures
6. December collection of samples and experimentation of oxygen depletion rates from three sites including soil and bottom water at a temperature of 15°C

Oxygen requirements for the Canyon Lake hypolimnetic oxygenation system were calculated using results from the oxygen depletion tests in conjunction with bathymetric data of the lake showing volume versus depth. Oxygen depletion rates of water (mg/L/day) and soil (g/m^2/day) were multiplied by the total volume of water and area of soil to be treated.

Figure ES2: Combined Soil and Water Hypolimnion Oxygen Depletion versus Hypolimnion Level



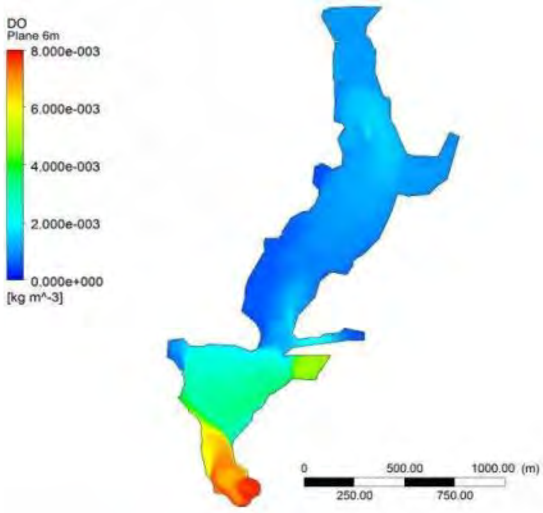
A modeling analysis was performed to evaluate the effectiveness of supplying the suggested oxygen quantities to Canyon Lake at various flows and oxygen concentrations. Ten different options were created and modeled. A 3D Computational Fluid Dynamic (CFD) model was developed for the main reservoir using bathymetric data provided. The experimental oxygen demands were used to determine the rate of oxygen depletion throughout the lake. The level of the lake was 1378 feet above sea level in order to evaluate a condition with a higher oxygen demand as compared to a lower lake elevation. Each system was run for a 100 day time duration at a 10 day time step interval.

Of the ten options listed, four options in particular were chosen to present in this report because they display well the effectiveness of increased water flow and oxygen output:

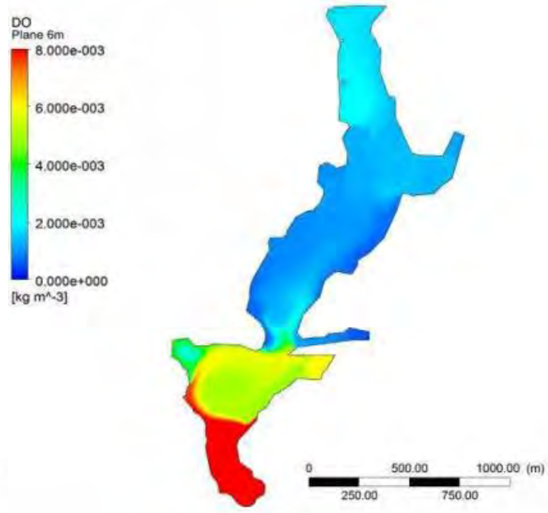
- Option 1 - 2,000 lbs O_2/day, 3,650 gpm of water at [O_2] of 60 and 40 mg/L
- Option 3 - 2,000 lbs O_2/day, 6,000 gpm of water at [O_2] of 30 mg/L
- Option 8 - 3,000 lbs O_2/day, 9,000 gpm of water at [O_2] of 30 mg/L
- Option 10 - 3,000 lbs O_2/day, 5,000 gpm of water at [O_2] of 150 and 40 mg/L

Figures ES3a, ES3b, ES3c, and ES3d show model results from option 10. The images are of Canyon Lake at a depth of 6 meters (20 feet) below the top of the hypolimnion layer.

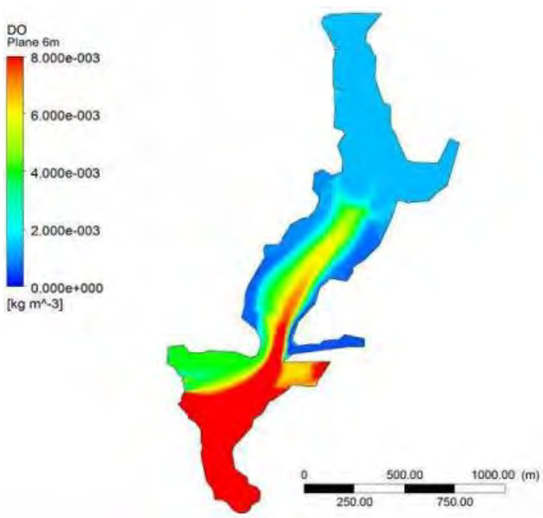
Figure ES3: - Option 10: 3,000 lbs O2/day delivered by 5,000 gpm



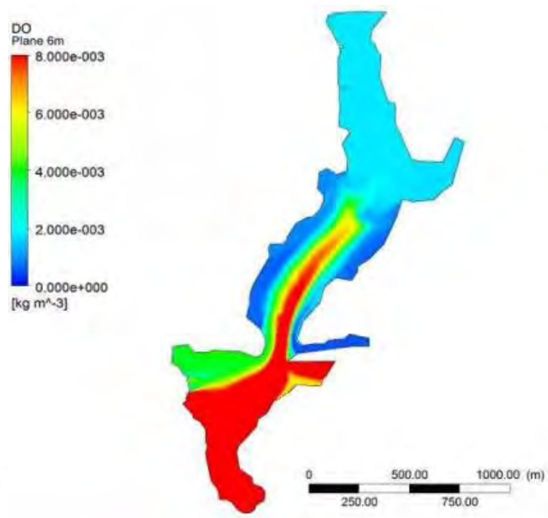
20 Days of Operation



50 Days of Operation



70 Days of Operation



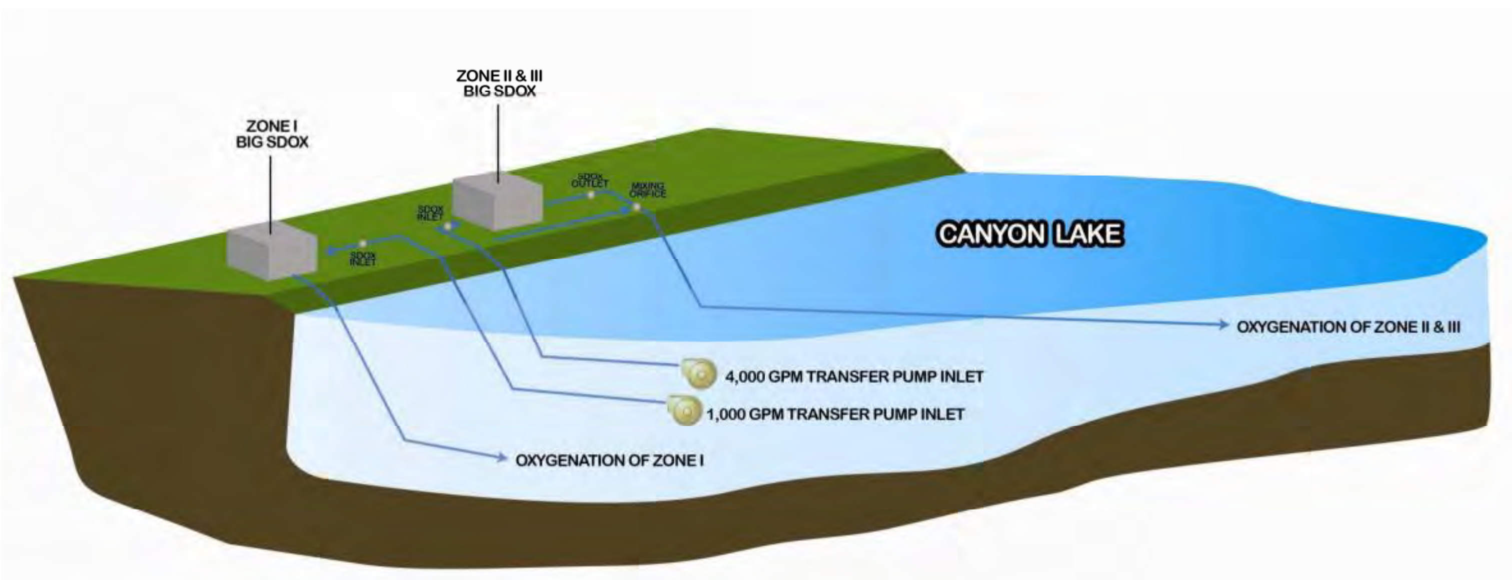
100 Days of Operation

After review of the information presented, after meetings with operations staff from EVMWD (Elsinore Valley Municipal Water District), and after careful evaluation of model results and cost estimates, PACE recommends proceeding with option 10 (3,000 lb/day at 5,000 gpm system) using two on-shore oxygenation systems: one high oxygen concentration system for zone 1, and one low oxygen concentration, high flowrate system for zones 2 and 3. When considering onsite oxygen generation or LOX (Liquid Oxygen) for oxygen production, the LOX system seems to be more advantageous because: 1) electrical upgrades will be costly and LOX does not require new electrical, 2) LOX is very quiet and requires very little maintenance, 3) LOX is better at delivering peak oxygen when necessary, 4) there is ample space and good access for LOX in Location A. Equipment locations can be found in Figure 25 on page 5-33.

PACE recommends the following: use a standard high pressure/high oxygen concentration BlueInGreen system for zone 1 and a modified side-stream low pressure/low oxygen concentration BlueInGreen system for zones 2 and 3. BlueInGreen's SDOX system is lower capital cost, smaller size, and unlike the Speece Cone, the BlueInGreen system is easier to operate because the pump speed can be perfectly regulated to optimize oxygen dissolution in the water. This is achieved by maintaining a constant water level in the tank, and water is sprayed through the headspace.

The systems could be located at the Canyon Lake WTP (Water Treatment Plant) as follows: Location B can be outfitted with new submersible pumps using the existing intake structure, Location A parking lot can be used for a new dual tank LOX facility, and Location C can be used to install two new BlueInGreen SDOX skids. The anticipated costs for this proposed system are as follows: capital cost $2.6M, annual operation and maintenance cost $0.14M, and 30 year life cycle cost $4.0M.

Figure ES4: Conceptual Schematic of Canyon Lake Dual On-Shore Oxygenation System



Main Report

Main Report

1 Background to Canyon Lake Oxygen Deficiency

Canyon Lake is listed on the Clean Water Act Section 303(d) list as impaired for excessive nutrients and high bacteria. The Regional Water Quality Control Board, Santa Ana Region, adopted a resolution in 2004 to amend the Basin Plan to incorporate total maximum daily loads (TMDLs) for Canyon Lake to control nutrients, specifically identifying numeric water quality targets for total phosphorus, total nitrogen, ammonia, chlorophyll a, and dissolved oxygen. This TMDL was subsequently approved by the State Water Resources Control Board and by the U.S. Environmental Protection Agency.

As part of the TMDL, an In-lake Sediment Nutrient Treatment Plan was prepared and strategies were initiated to prevent the release of excess nutrients from lake sediments. The plan was completed and submitted to the Regional Board in July 2007. This study was followed-up with additional analysis, the "Predicted Effects of External Load Reductions and In-Lake Treatment on Water Quality in Canyon Lake – a Supplemental Simulation Study" was completed in December 2008. This report prepared by Dr. Michael Anderson demonstrates that in-lake oxygenation treatment will enhance oxygen and phosphorus, but both in-lake oxygenation treatment and a large reduction in external nutrient sources from the watershed are required to approach meeting agency goals.

Table 1: Basin Plan Resolution No. R8-2004-0037 TMDL Targets for Canyon Lake

Indicator	TMDL Targets
Total Phosphorus Concentration	≤ 0.1 mg/L in 2020
Total Nitrogen Concentration	≤ 0.75 mg/L in 2020
NH3-Nitrogen Concentration	CMC and CCC limits per formula
Chlorophyll a Concentration	≤ 40 ug/L in 2015
Chlorophyll a Concentration	≤ 40 ug/L in 2015
Epilimnion DO* Concentration	≥ 5 ug/L in 2015
Hypolimnion DO* Concentration	≥ 40 ug/L in 2015

* - dissolved oxygen abbreviated by DO

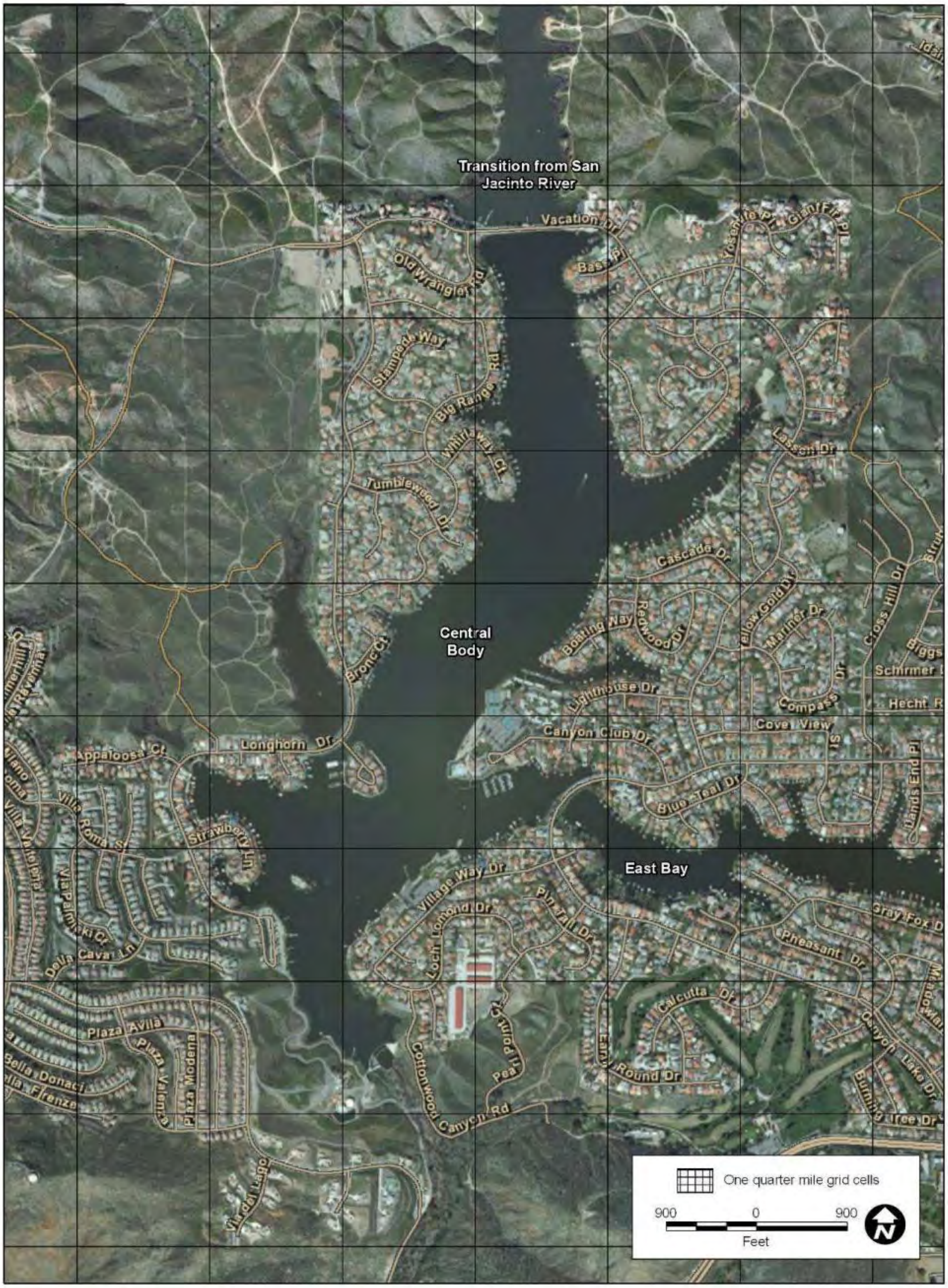
The primary in-lake treatment strategy recommended by the project stakeholders was a deep water, or hypolimnetic, oxygenation system. This report describes the preliminary design of this oxygenation system for the Central Body of Canyon Lake.

Canyon Lake was formed in 1928 when the Canyon Lake / Railroad Canyon Dam was constructed. The lake has three main sections – the relatively shallow East Bay (depths generally less than 10 ft), the deeper Central Body of the lake (depths in excess of 40 ft), and the area north of the causeway that connects with the San Jacinto River. Elsinore Valley Municipal Water District (EVMWD) has used the reservoir as a potable water source since 1957 when the Canyon Lake water treatment plant began operation. Allowable recreational activities on Canyon Lake are defined in the lease agreement between EVMWD and the Canyon Lake POA and include swimming, boating, fishing and water sports.

The Central Body of Canyon Lake is a monomictic, eutrophic lake that typically stratifies from about late-February/early-March through late-November/early-December each year. Maximum depth of the main body of the lake is about 50 feet, with a mean depth of approximately 20 feet. In the Central Body of the lake the water column is divided into three depth zones, with the deep-water layer starting at about the 20 to 25 foot depths by mid-summer, with oxygen depletions at or near zero at 16 to 18 feet. The deep water becomes anaerobic and devoid of dissolved oxygen by early summer each year. This low oxygen condition causes the release of dissolved iron, manganese, ammonia, hydrogen sulfide, phosphorus and other substances that degrade potable water quality. Phosphorus release from sediments under anaerobic conditions may increase eutrophication through internal phosphorus loading.

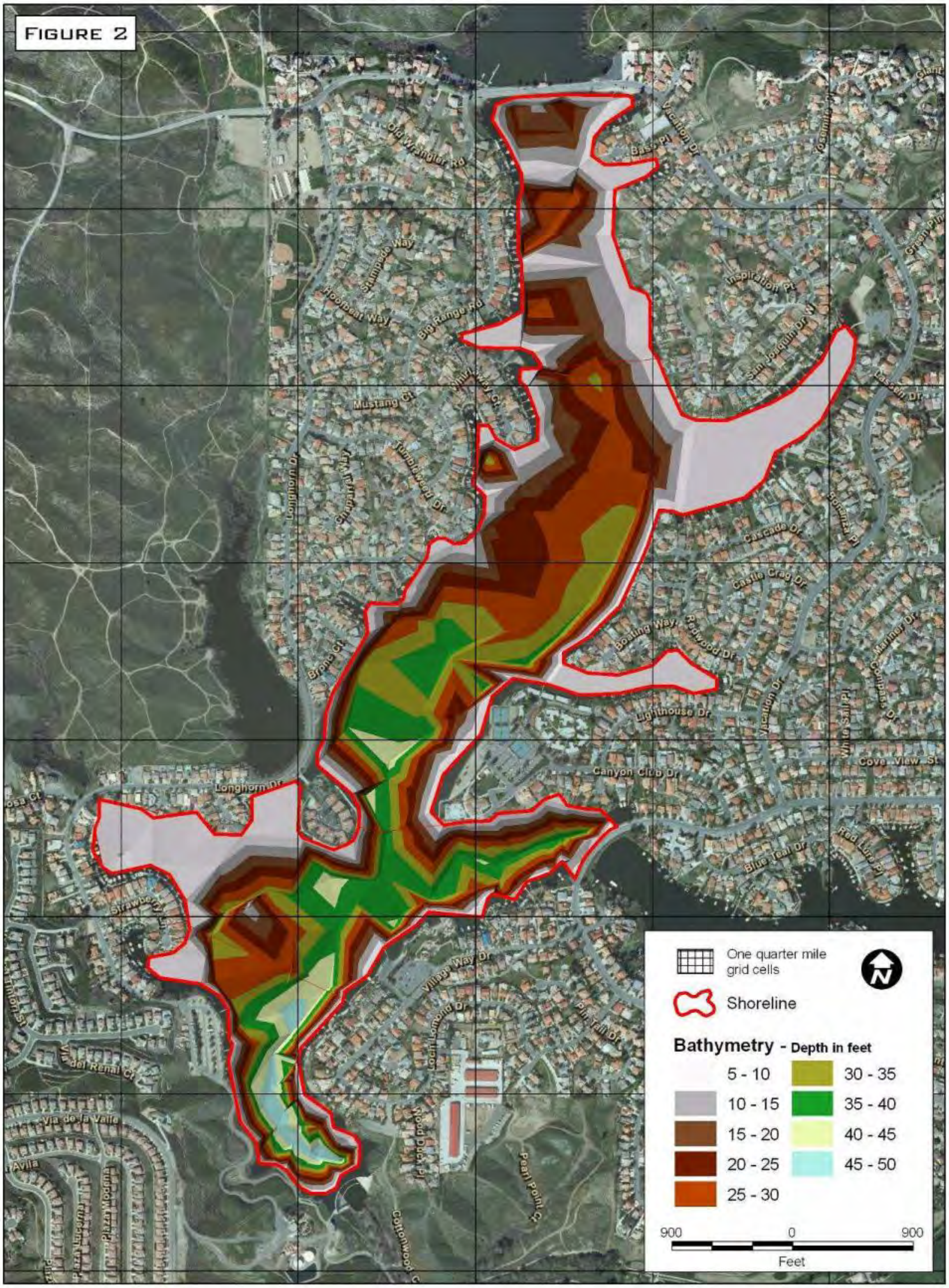
Figure 1 shows a vicinity map including the three main sections of Canyon Lake, and Figure 2 shows a bathymetry map of the Central Body.

Figure 1: Vicinity Map of Canyon Lake



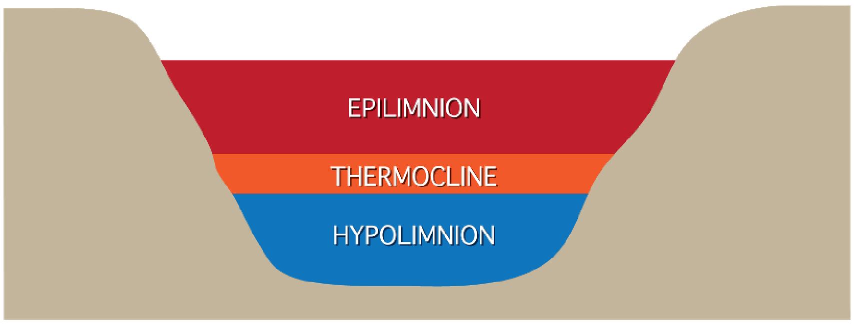
PACE

Figure 2: Bathymetry Map of Central Body of Canyon Lake



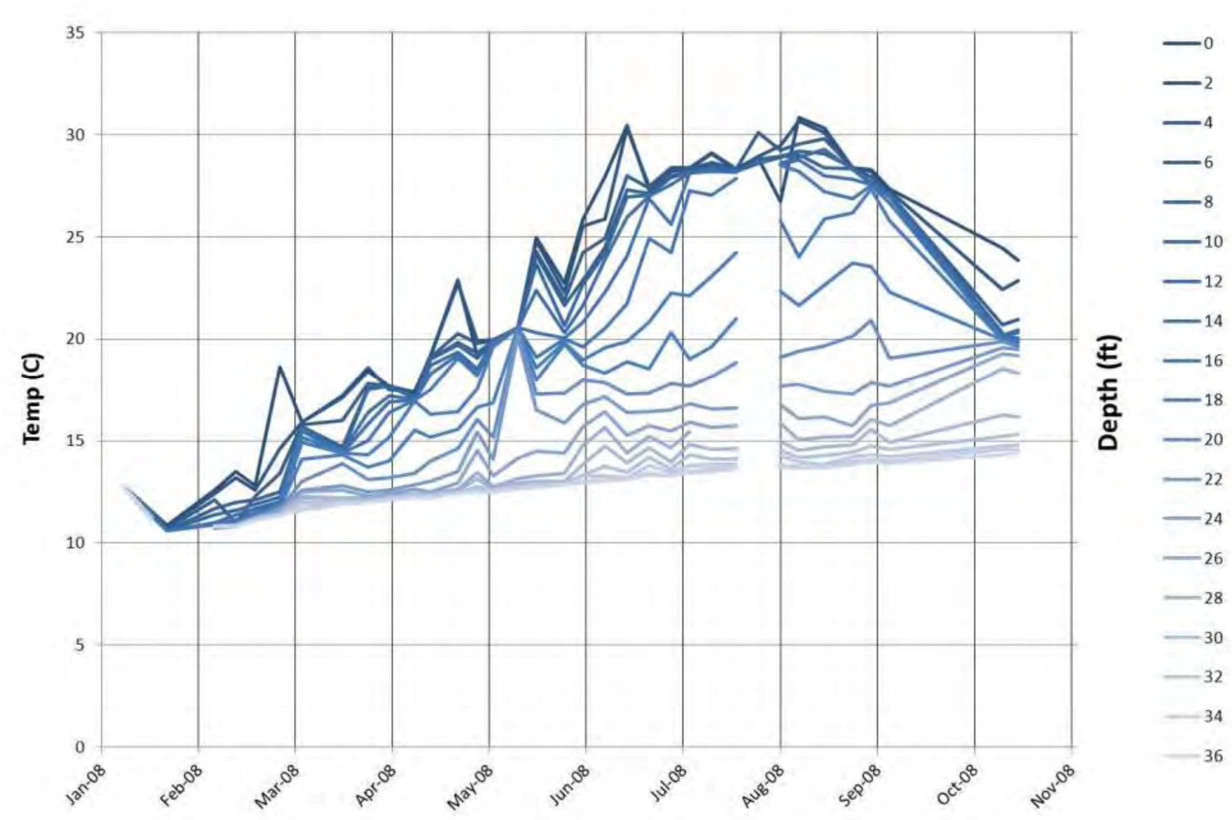
For purposes of discussion, the top layer of lake water is referred to as the epilimnion, which is typically the warm, low-density water present at the top of a lake. The bottom layer of lake water is the hypoliminion, which consists of cool, high-density water. The layer in-between the epilimnion and hypolimnion is the thermocline, which is the layer of water with transitioning temperature

Figure 3: Lake Layer Terminology



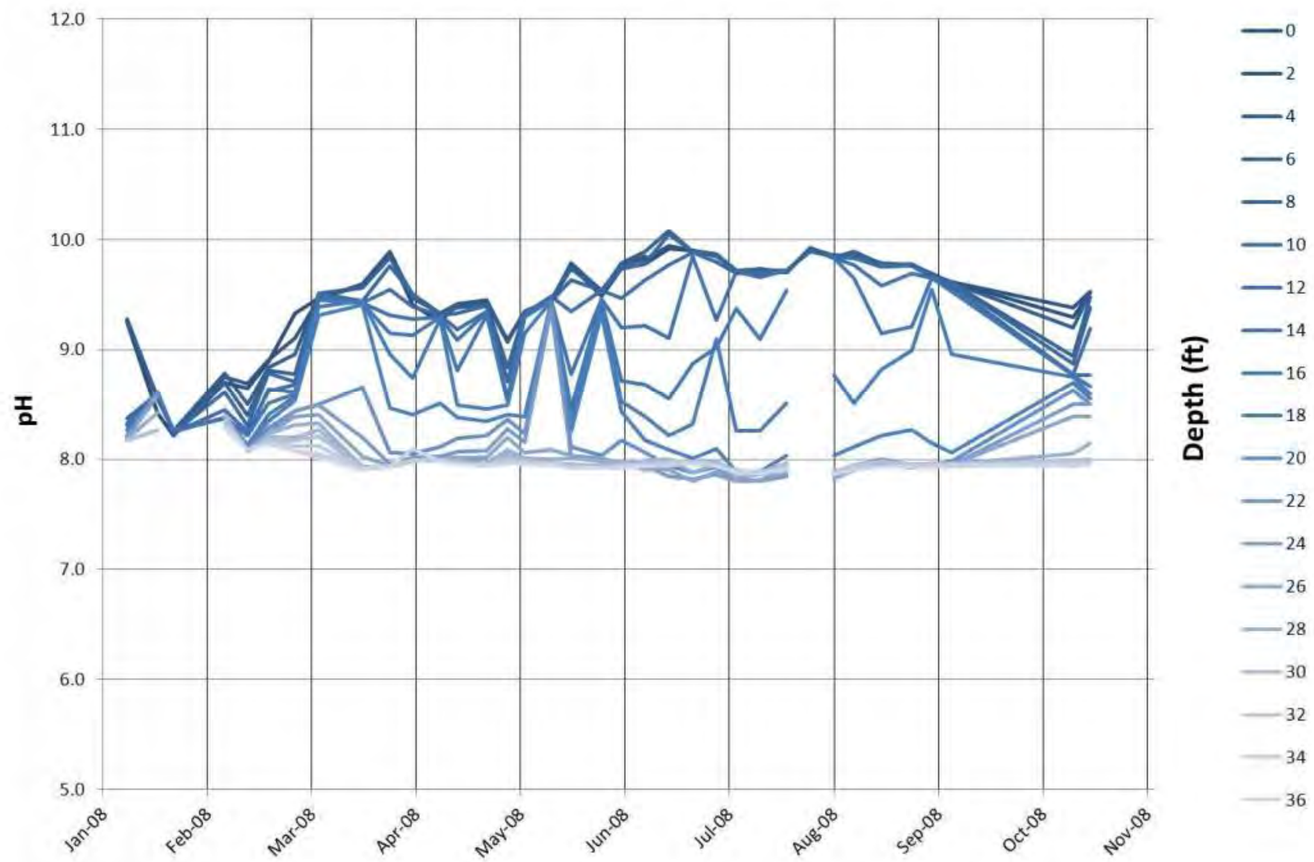
EVMWD has been collecting weekly temperature, pH, and dissolved oxygen measurements from Canyon Lake near the Canyon Lake Water Treatment Plant for the past seven years. 2008 had one of the best data records available, and the data is shown in Figures 4, 5, and 6. As shown in Figure 4, the hypolimnion was thermally separated from the upper layers of water by a density difference, and atmospheric oxygen was not able to penetrate to the lower depths (see Figure 6).

Figure 4: 2008 Canyon Lake Temperature versus Time at Various Depths



The lack of photosynthetic activity and the presence of bacterial respiration in the hypolimnion are indicated by lower pH as shown in Figure 5. The epilimnion had higher pH due to high algae and other photosynthetic organisms including cyanobacteria.

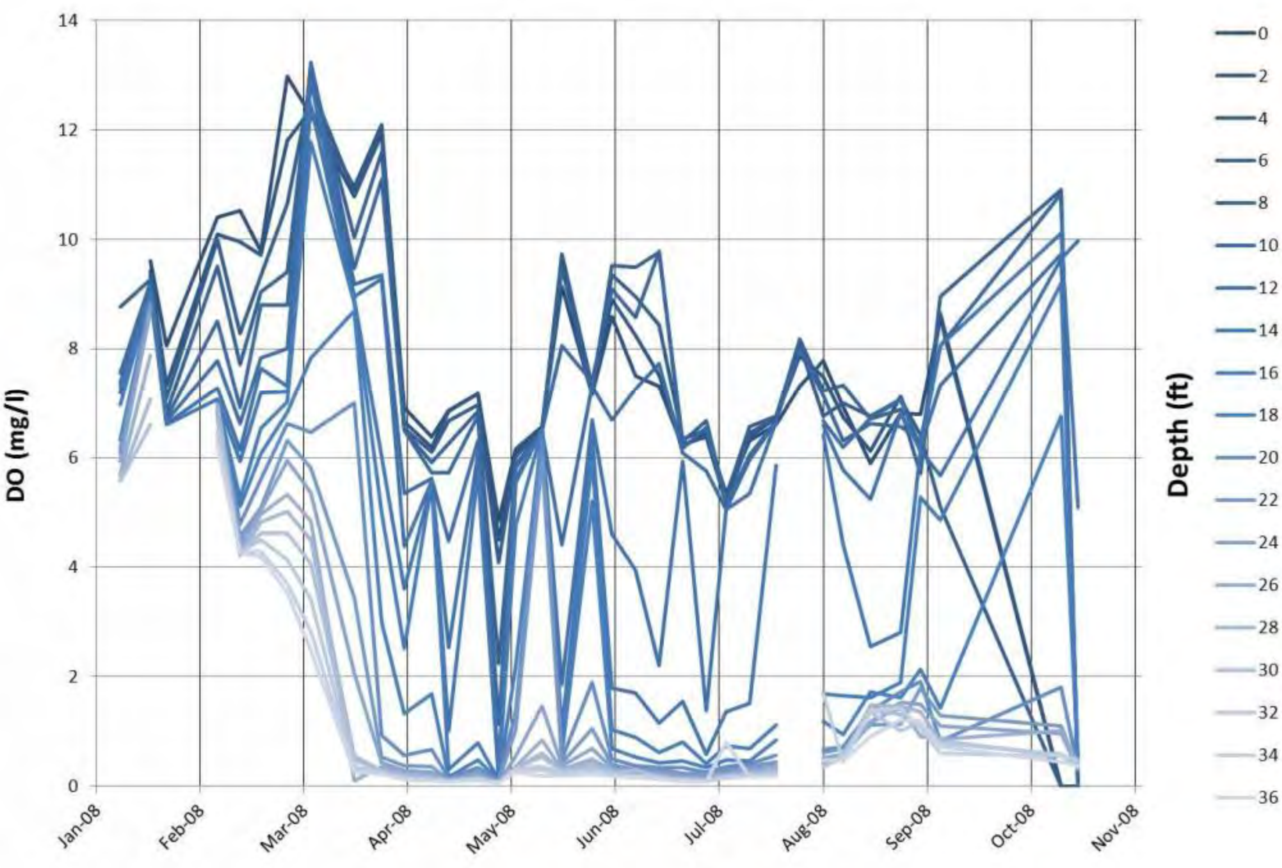
Figure 5: 2008 Canyon Lake pH versus Time at Various Depths



As shown in Figure 6, starting in early April through November, Canyon Lake has zero oxygen in the hypolimnion. This is typical of deep reservoirs such as Canyon Lake without mechanical mixing or oxygen injection systems. The disadvantage of having low oxygen in bottom waters is that it causes reduced constituents such as iron, manganese, phosphorus, ammonia, and sulfide to dissolve into the water column. The dissolution of these constituents then causes immediate bacterial respiration of oxygen, but also high quantities of algal growth, and the decaying algae is ultimately consumed by bacteria and respired. The high rates of respiration cause additional oxygen depletion and additional nutrient dissolution.

The reversal of this process is similar in that in theory it is exponentially beneficial: increases bottom water oxygen will reduce nutrient dissolution, which decreases algal growth, which decreases bacterial respiration. The other benefit of hypolimnetic oxygen injection without mixing is that the cool temperatures shown in Figure 6 reduce metabolic activity which reduces oxygen consumption.

Figure 6: 2008 Canyon Lake Oxygen versus Time at Various Depths



2 New Data Collection Performed

The following new data was collected as part of the preliminary design report evaluation:

1. Depth measurements to augment and clarify the existing bathymetry
2. Bottom of lake organic muck layer depth and characteristics near the dam
3. Location of deep and flat location suitable for submerged equipment (buoy installed)
4. Temperature, pH, and oxygen profiles during three periods of 2010
5. September collection of samples and experimentation of oxygen depletion rates from six sites including soil, bottom water, and top water at three different temperatures
6. December collection of samples and experimentation of oxygen depletion rates from three sites including soil and bottom water at a temperature of 15°C

2.1 Depth Measurements

Bathymetric data provided to PACE showed a large mound in the topography of the lake on the border of Zone I and Zone II. It was unclear whether this mound was actually present or caused by interpolating between the points surrounding the area of concern. PACE performed a site visit in November 2010 to clarify the results. Depth measurements were taken where the mound was supposedly located and it was determined that the mound did not exist. The removal of this mound from the bottom of the lake increased the volume of the hypolimnion.

2.2 Muck Layer Depth

In October 2010 a diver investigation was performed on the Canyon Lake bottom near the southern dam. The diver was to measure the muck layer depth during the investigation using a six foot retractable rod. It was found that the diver could not reach solid lake bottom through the muck layer using the six foot rod. The muck was then measured from the surface using 10' galvanized pipe segments. It was found that the area near the dam had a consistent muck depth of 8 – 10 feet.

Muck measurements were taken for Zone II and Zone III during the November 2010 site visit. Muck depth in the main body of Zone II and the southern area of Zone III remained similar to that found near the dam: between 8 – 10 feet thick. The northern half of Zone III had a thinner muck thickness of 4 – 5 feet.

2.3 Submerged Equipment Location

During the October 2010 diver investigation a suitable location for a submerged oxygenation skid and intake pumps was to be determined. A suitable location was defined as a flat expanse of lake bottom, clear of obstructions, with a thin muck layer, preferably near the treatment plant shore.

It was discovered using sonar attached to the boat and trolling the dam area that the area is relatively flat. The diver performed two dives to ensure the area was clear of obstructions. Obstructions were found near the intake structure to the treatment plant, but north of the intake there were no obstructions. A buoy was placed at a location deemed suitable for the submerged equipment. The location of this buoy can be seen in the following figure.

Figure 7: Buoy Location for Submerged Equipment

2.4 Temperature and Oxygen Profiles

Temperature, oxygen, conductivity, pH, and ORP measurements were collected from six sampling sites at Canyon Lake in September 2010, two sites in October 2010, and two sites in December 2010. Measurements were taken using a YSI 650 MDS with a Model 600 Sonde.

2.5 September Oxygen Depletion Test – Summer Period

On September 9, 2010 PACE conducted a site visit to Canyon Lake to collect samples for testing. Six sites were selected throughout the lake to provide a comprehensive representation of the system. These sites are shown in Figure 8. Water samples were collected from the top (surface) and bottom (2' from the bottom) using a Wildco® Horizontal Alpha™ water sampler with a capacity of 3.2 L. Core soil samples were collected from all six sites using a Wildco® 196-F65 Tall Ekman Bottom Grab (6" x 6" x 9"). To contain core samples, 2.5" x 12"clear plastic tubes were used. Two soil samples, two bottom water samples, and two top water samples were collected from each site except for site 40 which only had one top water sample due to available space for testing. Water and sediment samples were transported in coolers to the PACE Environmental Water Laboratories (Fountain Valley, CA) where oxygen depletion tests were performed. The samples collected on September 9, 2010 were tested for oxygen depletion rates from September 10 – September 22, 2010. The samples were placed in a water bath that could maintain constant temperature for the tests. The three temperatures used for this test were 15°C, 22°C, and 27°C. The setup for these tests are shown in Figure 8.

Figure 8: Six Sampling Site Locations for September 9, 2010 Oxygen Testing

PACE

Figure 9: Water and Sediment Oxygen Depletion Testing Setup

Every sample was aerated, and re-aerated, prior to each depletion test so that the dissolved oxygen would be at measurable concentrations. Dissolved oxygen concentrations were measured with a Hach LBOD101 Luminescent Dissolved Oxygen Probe. Dissolved oxygen would be measured every hour for the first three hours, and then every 8-16 hours afterward until depletion rates were determined to be zero. After every measuring interval each tube was purged of excess air space using nitrogen and then sealed to prevent introducing new oxygen to the test.

2.6 December Oxygen Depletion Test – Winter Period

A second round of sampling was performed on December 17, 2010 in order to determine oxygen depletion rates after destratification had occurred. Three points were chosen for this round of sampling, one location per oxygenation zone as decided by PACE during previous design steps. The sampling locations for this round can be seen in Figure 10. Three bottom water samples and three core soil samples were taken from each site using the same equipment as had been used during the September 9th visit. Samples were transported to the PACE Environmental Water Laboratories where oxygen depletion tests were once again performed at varying temperatures for the following week.

The samples collected on December 17, 2010 were tested for oxygen depletion rates from December 19 – December 21, 2010. The samples were placed in a water bath that could maintain constant temperature for the tests. Since it had been determined that the hypolimnion water temperature is consistently around 15°C, the test was only run at this one temperature. Every sample was aerated, and re-aerated, prior to the test so that the dissolved oxygen would be at measurable concentrations. Dissolved oxygen concentrations were measured with a Hach LBOD101 Luminescent Dissolved Oxygen Probe. Dissolved oxygen would be measured every hour for the first two hours, and then every 8-16 hours afterward until depletion rates were determined to be zero. After every measuring interval each tube was purged of excess air space using nitrogen and then sealed to prevent introducing new oxygen to the test.

Figure 10: Three Sampling Site Locations for December 17, 2010 Oxygen Testing

PACE

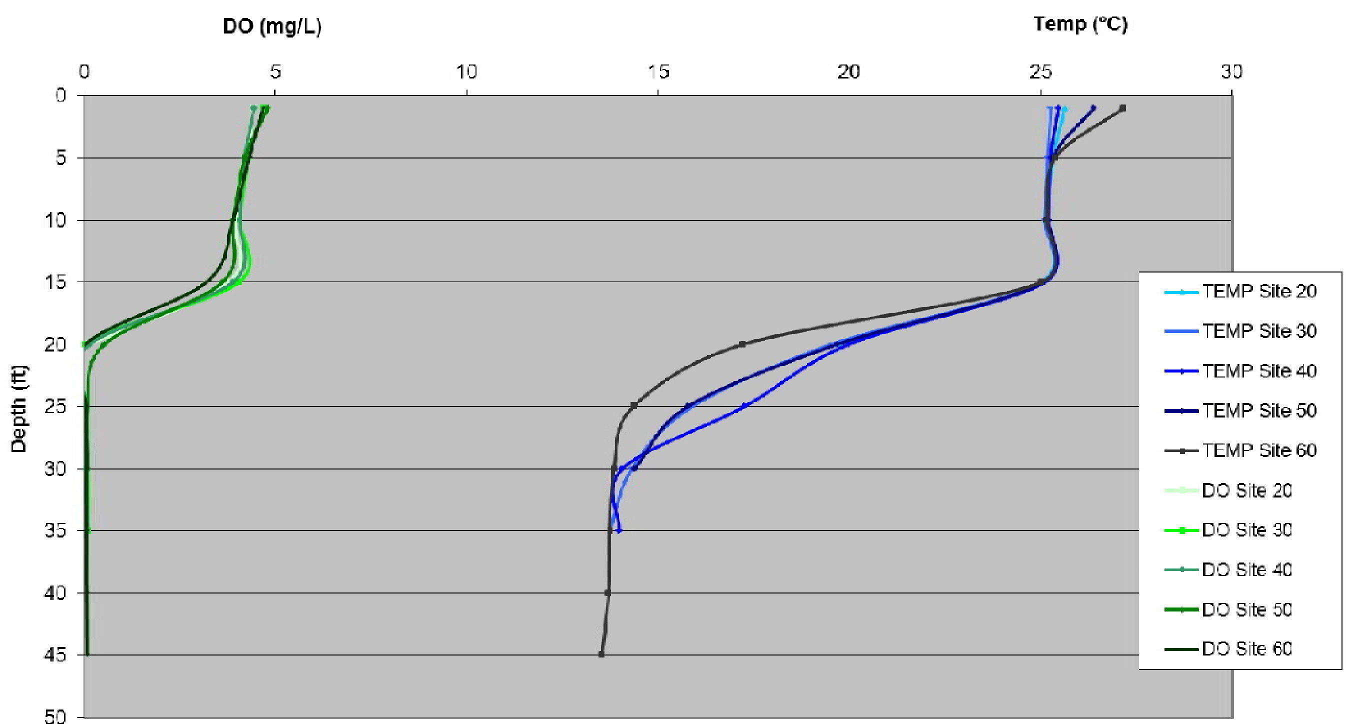
3 Calculated Oxygen Requirements

Oxygen requirements for the Canyon Lake hypolimnetic oxygenation system were calculated using results from the oxygen depletion tests in conjunction with bathymetric data of the lake showing volume versus depth. Oxygen depletion rates of water (mg/L/day) and soil (g/m^2/day) were multiplied by the total volume of water and area of soil to be treated.

3.1 Size of Hypolimnion

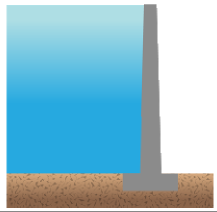
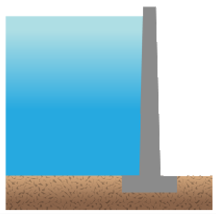
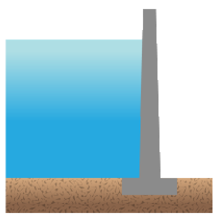
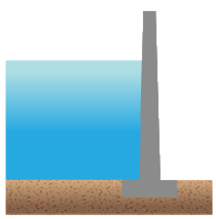
Historical temperature and dissolved oxygen data as shown in Section 1 shows the hypolimnion layer begins at approximately 20 feet deep. The 2010 profiling data supports this conclusion. As shown in Figure 11, stratification can be seen during the September site visit. The epilimnion was warmed throughout the spring and summer while the hypolimnion remained cold, preventing the two layers from mixing, and causing oxygen concentrations to reduce to essentially zero milligrams per liter.

Figure 11: 9/9/2010 Canyon Lake Dissolved Oxygen (Green) & Temp (Blue) at Varying Depth



The volume of water to be treated was therefore calculated as all hypolimnetic water located 20 feet or deeper in the lake. The volume and area to be treated are shown in Table 2. Canyon Lake has a maximum water surface elevation of 1,382 feet above sea level, where spill over occurs downstream of the dam on the south end of the lake. The storage volume of the lake at this water elevation is approximately 6,000 acre-feet, or nearly 2 billion gallons of water. Typical water surface elevation is maintained at 1,375 feet.

Table 2: Canyon Lake Area and Volume and Area and Volume of Hypolimnion

Lake Elevation *(ft)*		Total Lake Area *(ac)*	Total Lake Vol *(ac-ft)*	Hypolimnion Area *(ac)*	Hypolimnion Vol *(ac-ft)*
1382		~230	5,924	152	1,874
1378		~230	5,055	130	1,340
1375		~230	4,368	110	962
1372		~220	3,707	99	768

* - NOTE: Bathymetric data obtained from LESJWA on 8/10/10 from City of Canyon Lake (undated) was used for the first round of calculations, but due to extrapolation showed a large underwater mound in the south end of Zone II. PACE conducted a survey of the mound on November 17, 2010, and discovered the mound was not present. The new survey data points were implemented into the calculation and the hypolimnion volume was increased by 51,000,000 gallons, and the data in Table 2 reflects this adjustment.

Canyon Lake was divided into three oxygenation zones (Zones I – III) and one zone that does not require treatment (Zone IV) for the purposes of design:

Figure 12: Three Zones Used for Oxygenation Design

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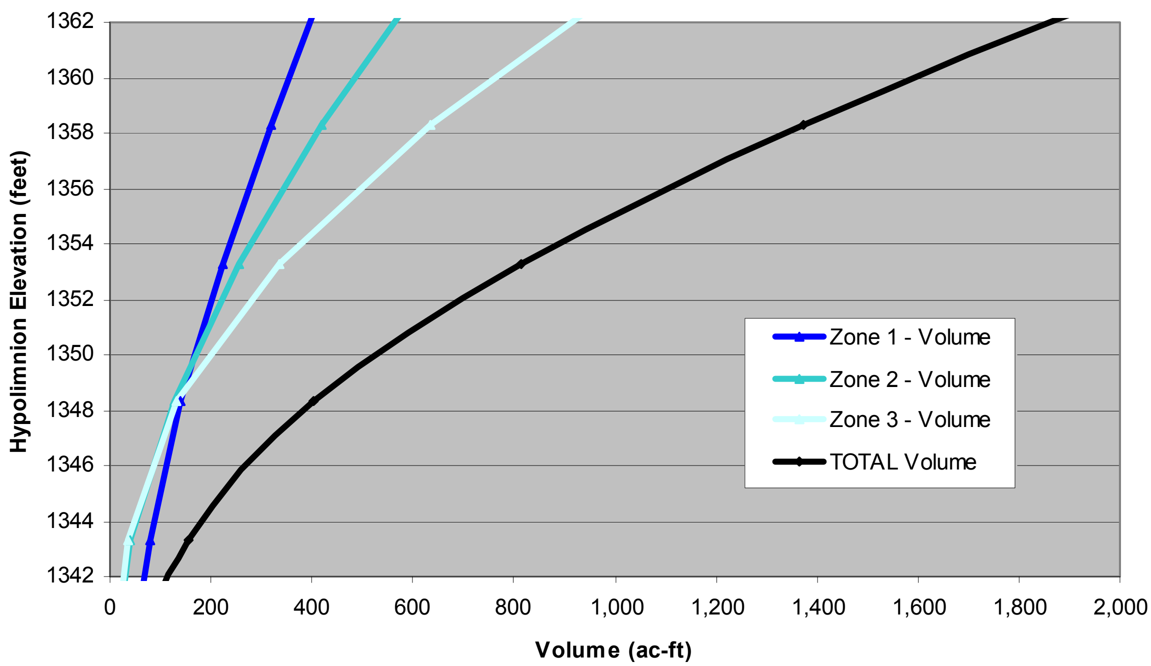
Figure 13: Elevation of the Hypolimnion (20 Ft below Water Surface) versus Hypolimnion Volume



As shown in Figure 13, the three zones have similar volumes of hypolimnetic water that requires oxygenation, however, zones 2 and 3 expand in volume at a faster rate with increasing depth as compared to zone 1.

3.2 Oxygen Depletion Rates in Hypolimnion

Results from the water and sediment oxygen depletion testing in September (summer condition) and December (winter condition) were widely varying, with water oxygen demands in the summer being approximately seven times higher than winter rates. September (summer) results showed extremely high oxygen depletion in both the water and sediments, even after multiple re-aeration steps, likely due to the long duration of anaerobic conditions and buildup of reduced constituents such as sulfide, manganese, iron, and ammonia. It was accepted that the high rates of summer condition oxygen depletion was mostly irrelevant to the oxygenation system design, because the proposed oxygenation system would never allow accumulation of reduced constituents which create excessive oxygen demands. Thus, the December results were thought to be more representative of the oxygen demand requirements from an aerobic system such as Canyon Lake with an oxygenation injection system.

Thus, for the purposes of this report, only the December winter period results are presented. Soil and water oxygen depletion rates are shown in Figures 14 and 15. Oxygen depletion due to soil bacteria respiration was linear, with site 25 in zone 2 and site 35 in zone 1 having similar rates of oxygen reduction, but site 15 in zone 3 had nearly half the rate of depletion as compared to zones 2 and 3. In general, zone 3 is located in a shallower portion of the lake, and is believed to be subject to lower duration anaerobic conditions. Also, during muck depth measurement, zone 3 had a shallower muck depth, which represents a lower quantity of high-respiration organic bacteria.

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Figure 14: Canyon Lake Soil Oxygen Depletion Test Results from Winter Period (December 17, 2010)

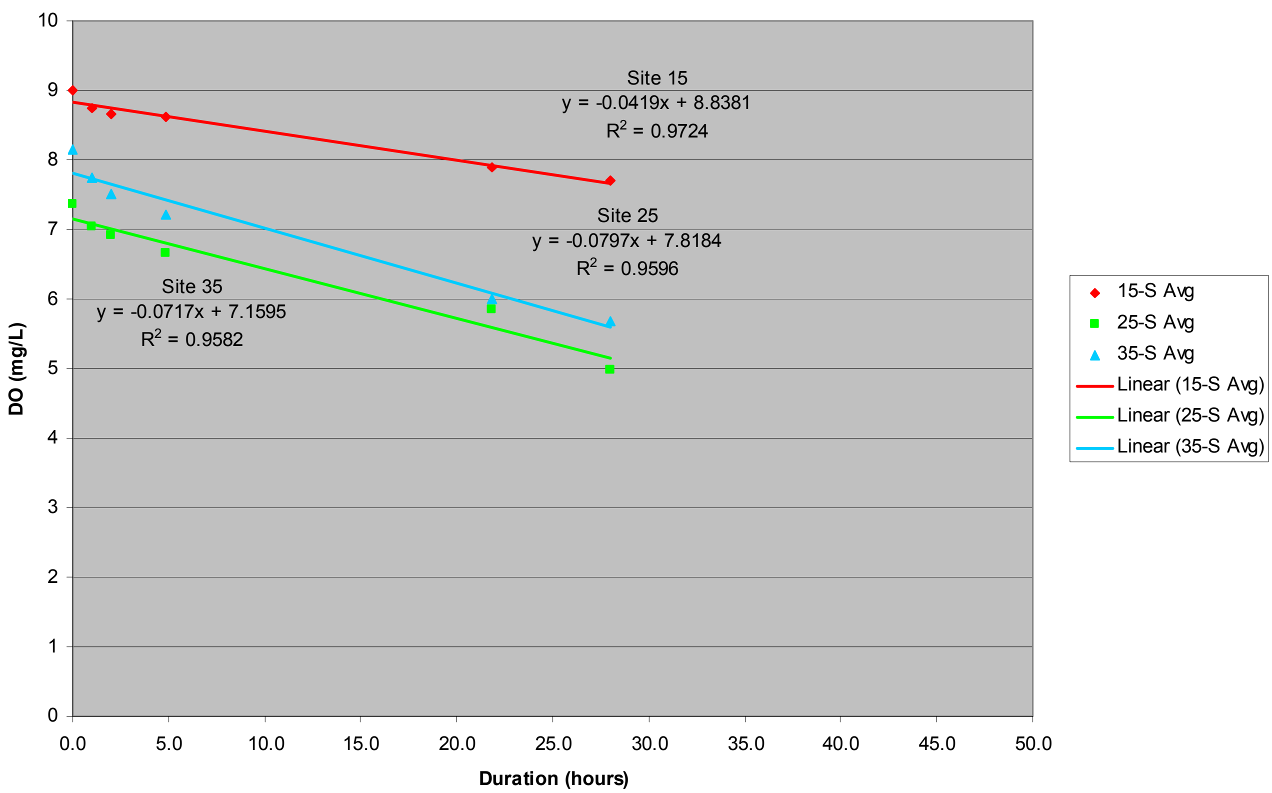
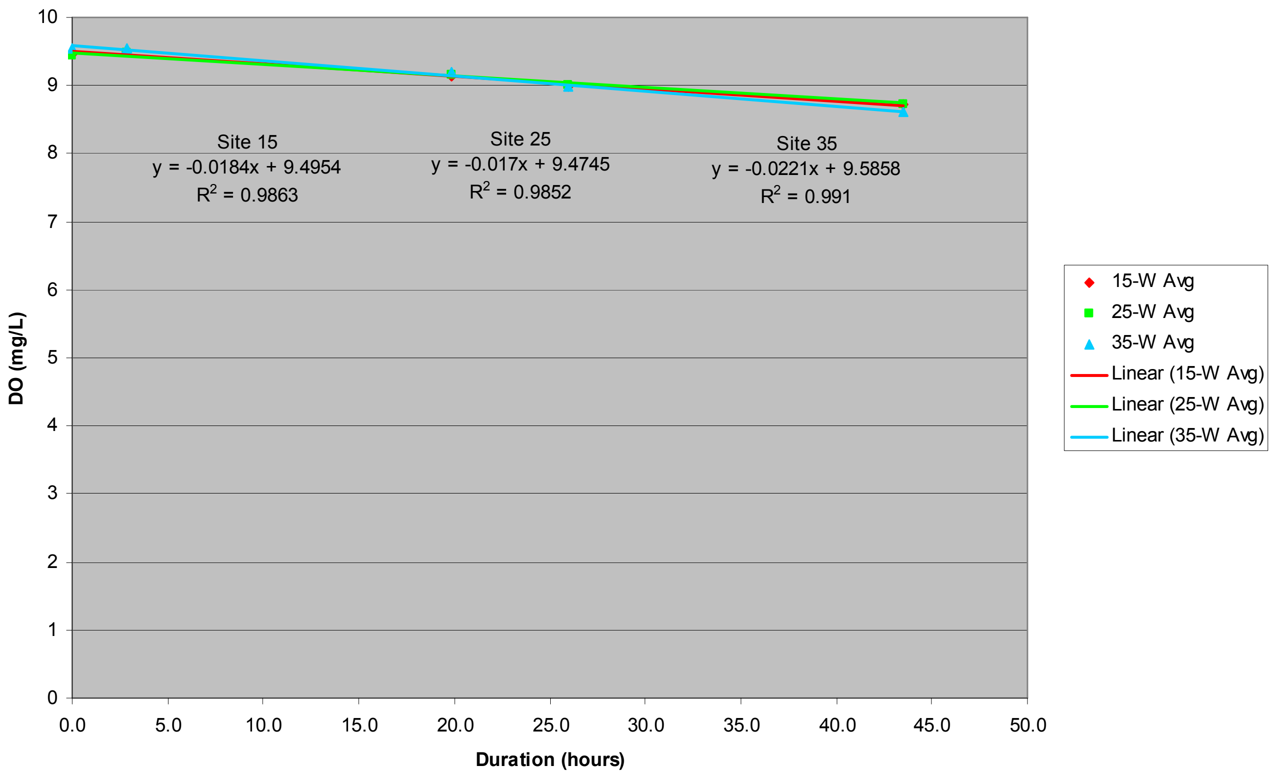


Figure 15: Canyon Lake Water Oxygen Depletion Test Results from Winter Period (December 17, 2010)



3.3 Combined Oxygen Demand Calculations for Hypolimnion

The December 2010 water oxygen demands from lake zones 1-3 were multiplied by the hypolimnetic volume and the soil oxygen demands from lake zones 1-3 were multiplied by the hypolimnetic soil area to determine the total oxygen demand of Canyon Lake. The first set of calculations was performed assuming the hypolimnion began 20 feet below the water surface during the original bathymetric survey, or the hypolimnion starting below 1,352 feet above sea level, as shown in Table 3.

Table 3: Canyon Lake Combined Soil and Water Oxygen Demand at 1,372 Lake Elevation

	Zone I		Zone II		Zone III	
Soil Conditions	0.281	$g/m^2/d$	0.267	$g/m^2/d$	0.115	$g/m^2/d$
Soil Area	801,000	ft^2	1,284,000	ft^2	2,239,000	ft^2
Soil Demand	46	lbs/d	70	lbs/d	53	lbs/d
Water Conditions	0.531	mg/L/d	0.409	mg/L/d	0.441	mg/L/d
Water Volume	72,386,000	gallons	83,394,000	gallons	108,916,000	gallons
Water Demand	320	lbs/d	284	lbs/d	400	lbs/d
Soil and Water Demand	366	lbs/d	354	lbs/d	453	lbs/d
				Total Demand	**1,172**	**lbs/d**
				Safety Factor	1.5	
				Design Demand	**1,758**	**lbs/d**

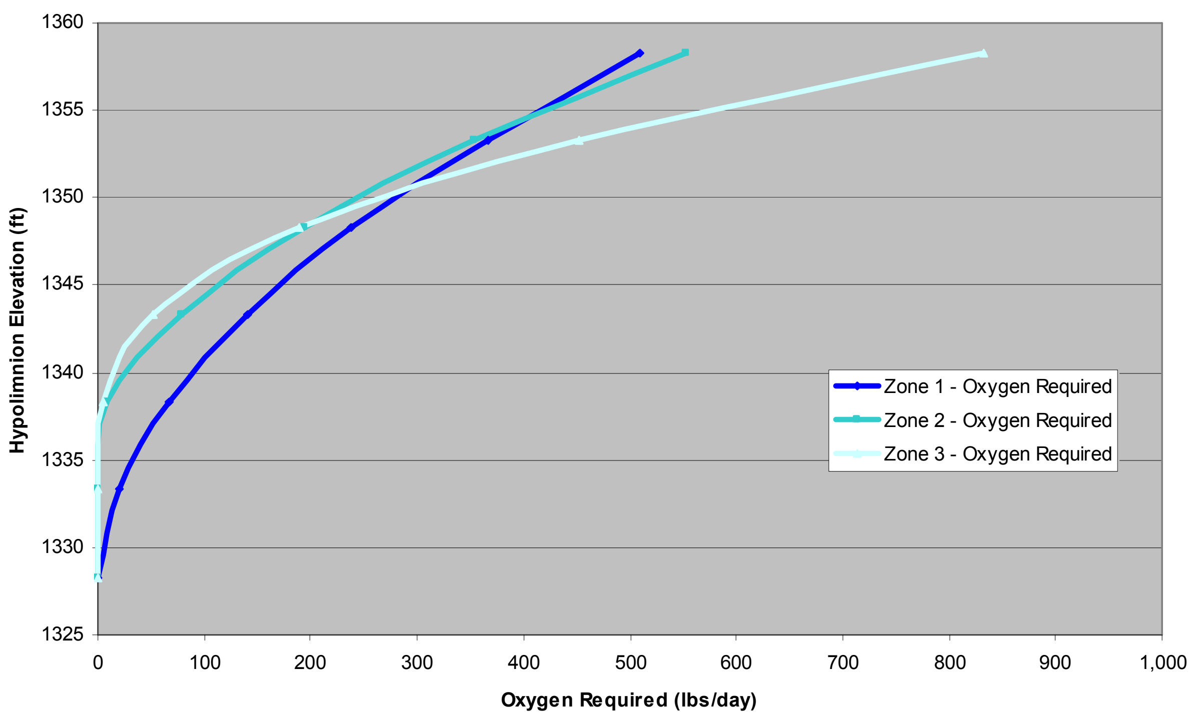
The oxygen demand for Canyon Lake was also calculated assuming the lake elevation was four feet below the dam spillway. In this condition the hypolimnion elevation would include water and soil below an elevation of 1,358 feet as shown in Table 4. The increase of hypolimnion thickness by six feet will increase the oxygen demand by over 60% due to the large increase in area and available volume over the six feet.

Table 4: Canyon Lake Combined Soil and Water Oxygen Demand at 1,378 ft Lake Elevation

	Zone I		Zone II		Zone III	
Soil Conditions	0.281	$g/m^2/d$	0.267	$g/m^2/d$	0.115	$g/m^2/d$
Soil Area	881,000	ft^2	1,581,000	ft^2	3,018,000	ft^2
Soil Demand	51	lbs/d	86	lbs/d	71	lbs/d
Water Conditions	0.531	mg/L/d	0.409	mg/L/d	0.441	mg/L/d
Water Volume	103,835,000	gallons	136,967,000	gallons	207,221,000	gallons
Water Demand	459	lbs/d	466	lbs/d	761	lbs/d
Soil and Water Demand	510	lbs/d	552	lbs/d	832	lbs/d
				Total Demand	**1,894**	**lbs/d**
				Safety Factor	1.5	
				Design Demand	**2,841**	**lbs/d**

Figure 16 shows total combined oxygen demand versus hypolimnion elevation, which demonstrates the large increase in oxygen demand with increases in lake level.

Figure 16: Combined Soil and Water Hypolimnion Oxygen Depletion Versus Hypolimnion Level



4 Model Results & Alternative Discussion

A modeling analysis was performed to evaluate the effectiveness of supplying the suggested oxygen quantities to Canyon Lake at various flows and oxygen concentrations. Ten different options were created and modeled as shown in Table 5. Appendix A shows a plan-view layout of these ten options.

Table 5: 10 Oxygen Delivery Options Considered and Modeled

Option	Total O2 Delivered	Total Water Flow	Zone 2/3 Flow	Submerged?
	(lb/day)	*(gpm)*	*(gpm)*	
1	**2,000**	**3,700**	**2,150**	**Yes**
2	4,000	7,400	4,300	No
3	**2,000**	**6,000**	**4,550**	**Yes**
4	4,000	12,000	6,000	No
5	3,700	1,400	950	No
6	2,000	gas	gas	NA
7	2,000	2,100 + gas	2,100	No
8	**3,000**	**9,000**	**6,100**	**No**
9	3,000	6,000 + gas	6,000	No
10	**3,000**	**5,000**	**4,100**	**No**

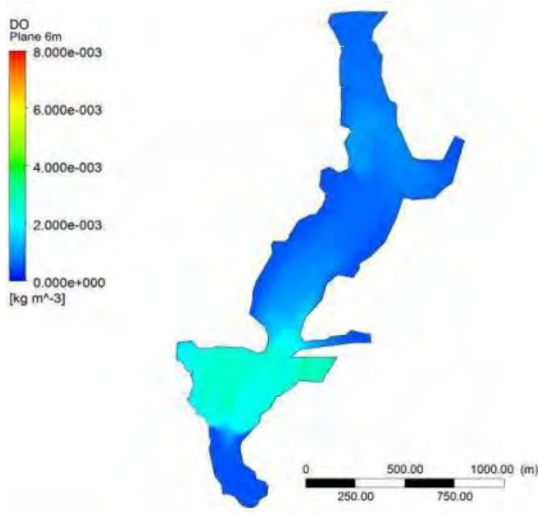
A 3D Computational Fluid Dynamic (CFD) model was developed for the main reservoir using bathymetric data provided. The experimental oxygen demands were used to determine the rate of oxygen depletion throughout the lake. The level of the lake was 1378 feet above sea level in order to evaluate a condition with a higher oxygen demand as compared to a lower lake elevation. Each system was run for a 100 day time duration at a 10 day time step interval.

Of the ten options listed in Table 4, four options in particular were chosen to present in this report because they display well the effectiveness of increased water flow and oxygen output:

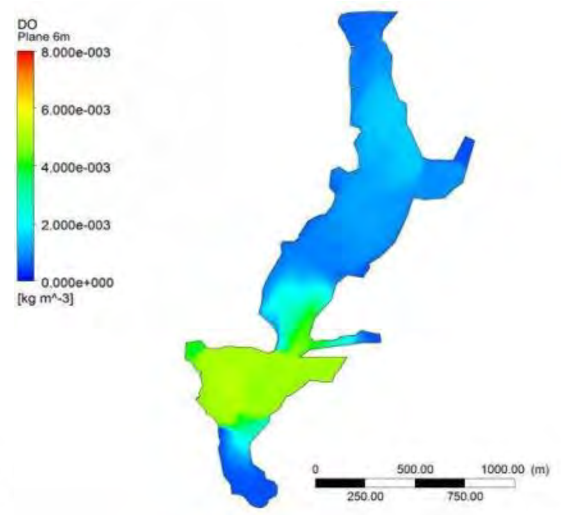
- Option 1 - 2,000 lbs O_2/day, 3,650 gpm of water at [O_2] of 60 and 40 mg/L
- Option 3 - 2,000 lbs O_2/day, 6,000 gpm of water at [O_2] of 30 mg/L
- Option 8 - 3,000 lbs O_2/day, 9,000 gpm of water at [O_2] of 30 mg/L
- Option 10 - 3,000 lbs O_2/day, 5,000 gpm of water at [O_2] of 150 and 40 mg/L

Figures 17 show model results from option 1, figure 18 shows model results from option 3, figure 19 shows model results from option 8, and figure 20 shows model results from option 10. The images are of Canyon Lake at a depth of 6 meters (20 feet) above the lake bottom.

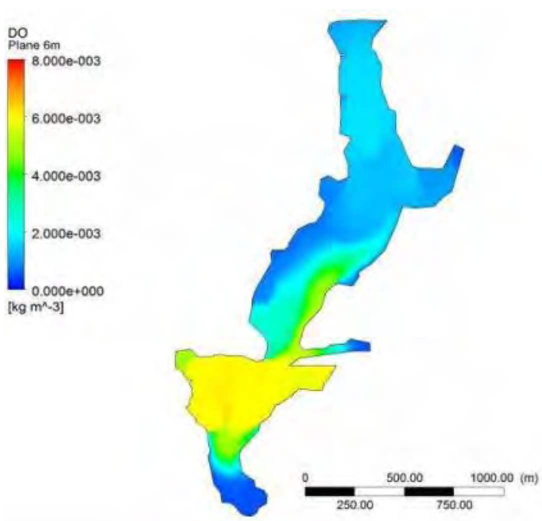
Figure 17: - Option 1: 2,000 lbs O_2/day delivered by 3,650 gpm



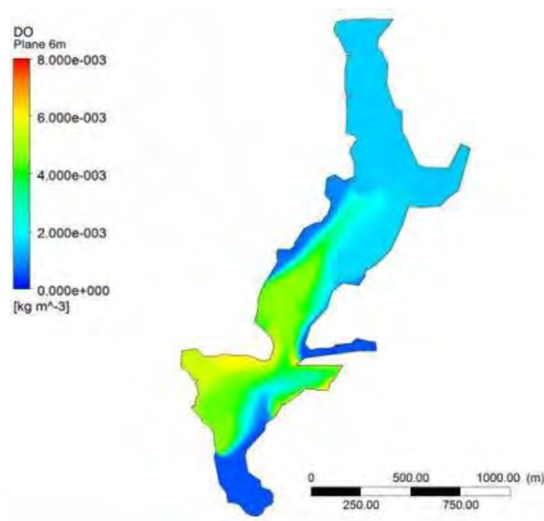
20 Days of Operation



50 Days of Operation

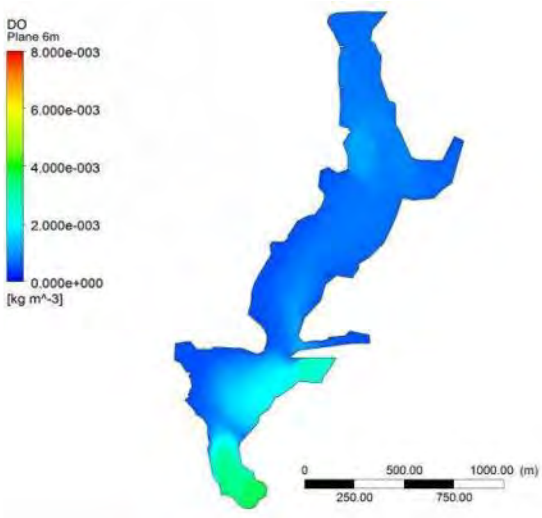


70 Days of Operation

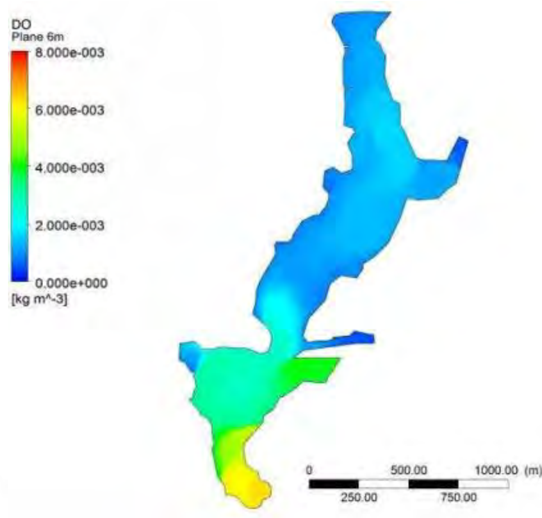


100 Days of Operation

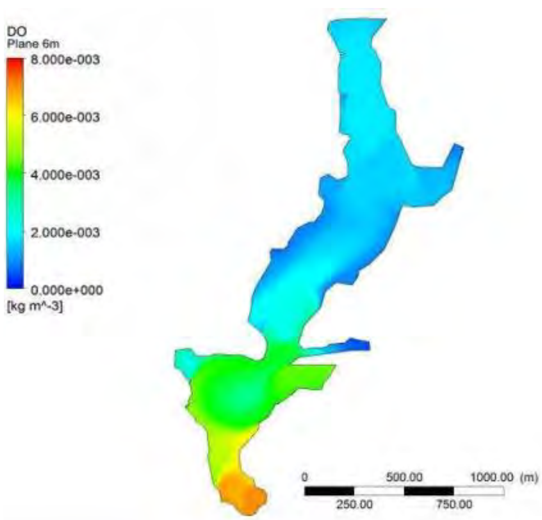
Figure 18: - Option 3: 2,000 lbs O_2/day delivered by 6,000 gpm



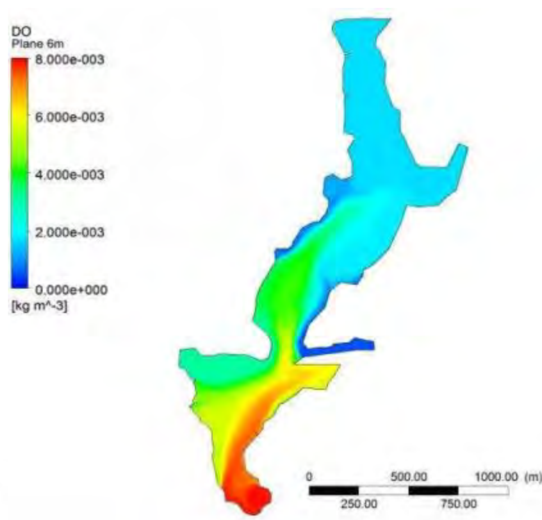
20 Days of Operation



50 Days of Operation

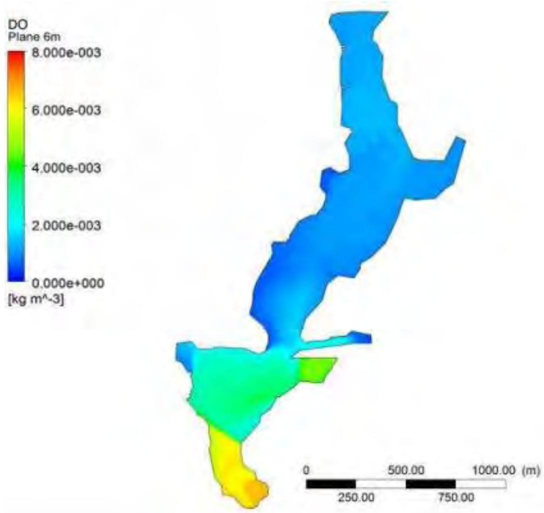


70 Days of Operation

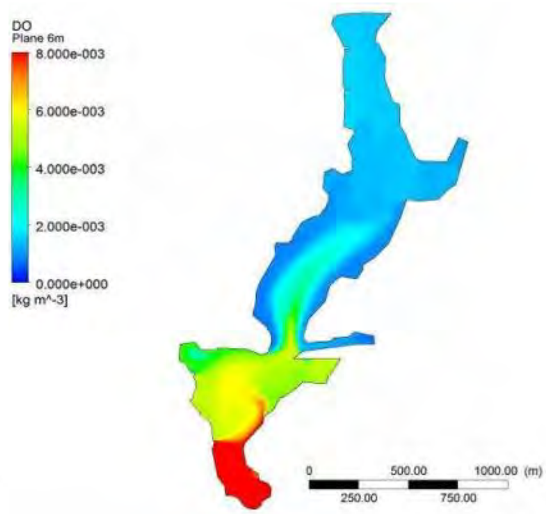


100 Days of Operation

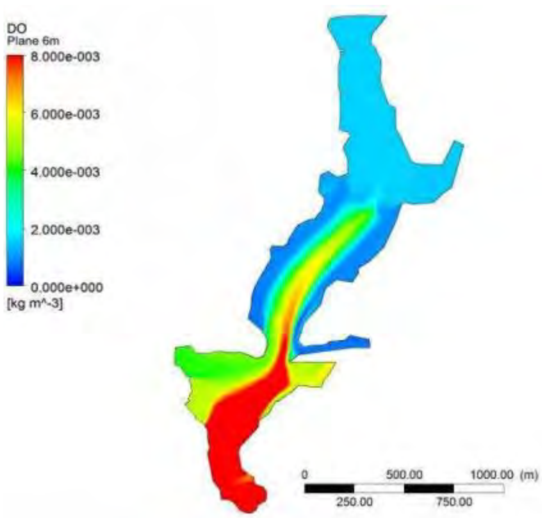
Figure 19: - Option 8: 3,000 lbs O_2/day delivered by 9,000 gpm



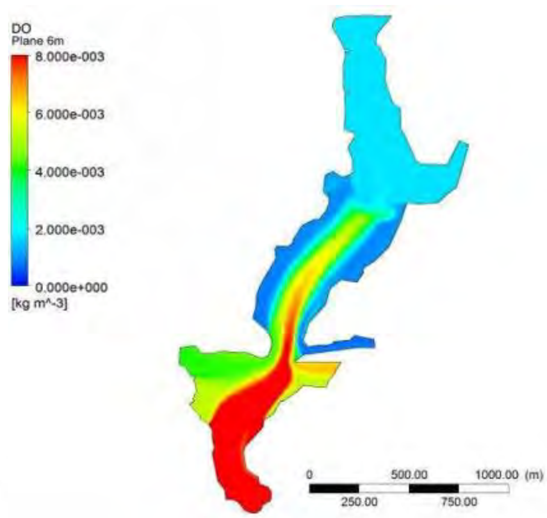
20 Days of Operation



50 Days of Operation

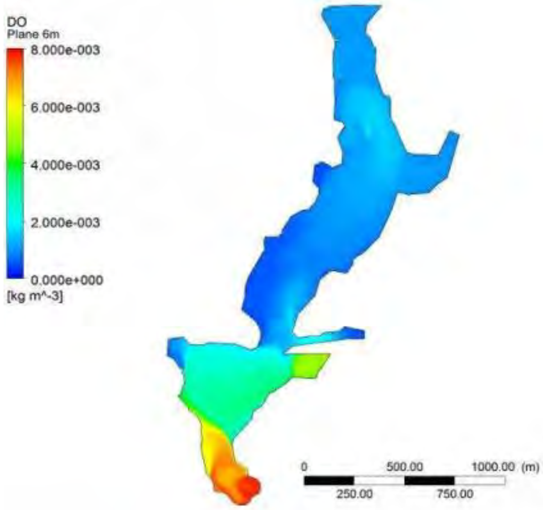


70 Days of Operation

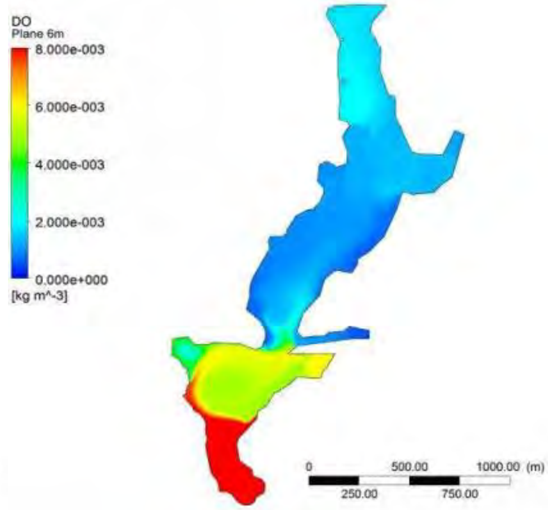


100 Days of Operation

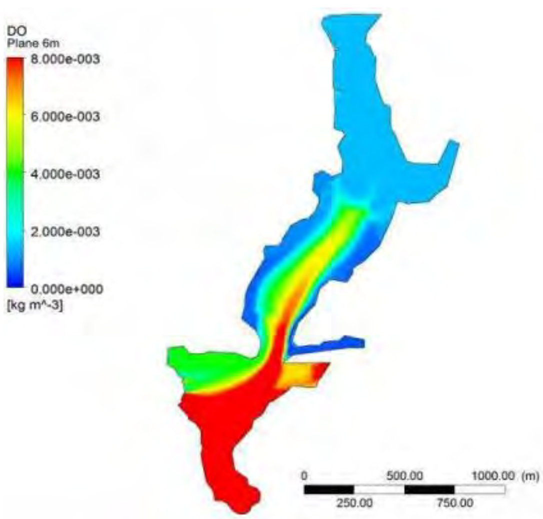
Figure 20: - Option 10: 3,000 lbs O_2/day delivered by 5,000 gpm



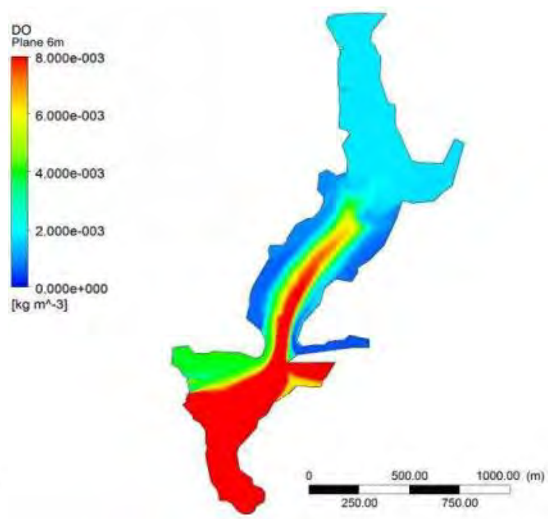
20 Days of Operation



50 Days of Operation



70 Days of Operation



100 Days of Operation

As shown in Figures 17, 18, 19 and 20, in 100 days of operation the oxygen concentration in the hypolimnion is greatly improved in all scenarios compared to existing observed oxygen concentrations. The first major observation from the model results is that a certain quantity of water flow rate is important to distribute the oxygen both horizontally and vertically, which is demonstrated in the better oxygen content and distribution in Figure 18 (option 3) versus Figure 17 (option 1). Figure 18 (option 3) had 60% higher water flow (6,000 gpm compared to 3,700 gpm) to the whole lake and nearly double the water flow to zones 2 and 3 as compared to option 1. Secondly, the modeled 2,000 lb/day oxygen supply in Figure 18 (option 3) results in only a small portion of hypolimnion having an oxygen concentration above 5 mg/L, but the modeled 3,000 lb/day oxygen supply in Figure 19 (option 8) achieves a very high percentage of the hypoliminion having an oxygen concentration above 5 mg/L in 100 days of operation. Thus, the 1.5 times safety factor, which is included in the 3,000 lb/day design discussed in Section 3, appears to be very important to meeting the project objectives for oxygen content. Finally, it appears that using a higher concentration with a lower flow into zone 1 (option 10) produces comparable results to option 8, even though these two options supply the same mass of oxygen to the system, although it takes about 30 extra days to get the desired mixing to zones 2 and 3.

5 Oxygenation Systems Considered

5.1 Three Methods of Oxygenation Delivery

5.1.1 ECO$_2$ Speece Cone

The ECO$_2$ speece cone system operates by pumping water through a conical shaped oxygen transfer reactor. Inside the cone pure oxygen is introduced to the water stream and creates super-oxygenated water that is then pumped throughout the lake. The system will operate at a pressure of approximately 30 psi when submerged at the bottom of the lake or approximately 15 psi if installed on the shore. The saturation point of oxygen in water is directly related to the pressure of the water. Since the pressure of the submerged speece cone is double that of the shoreline speece cone, the dissolved oxygen concentration in the water can also be doubled. The submerged and shoreline DO concentrations can be seen in Table 6.

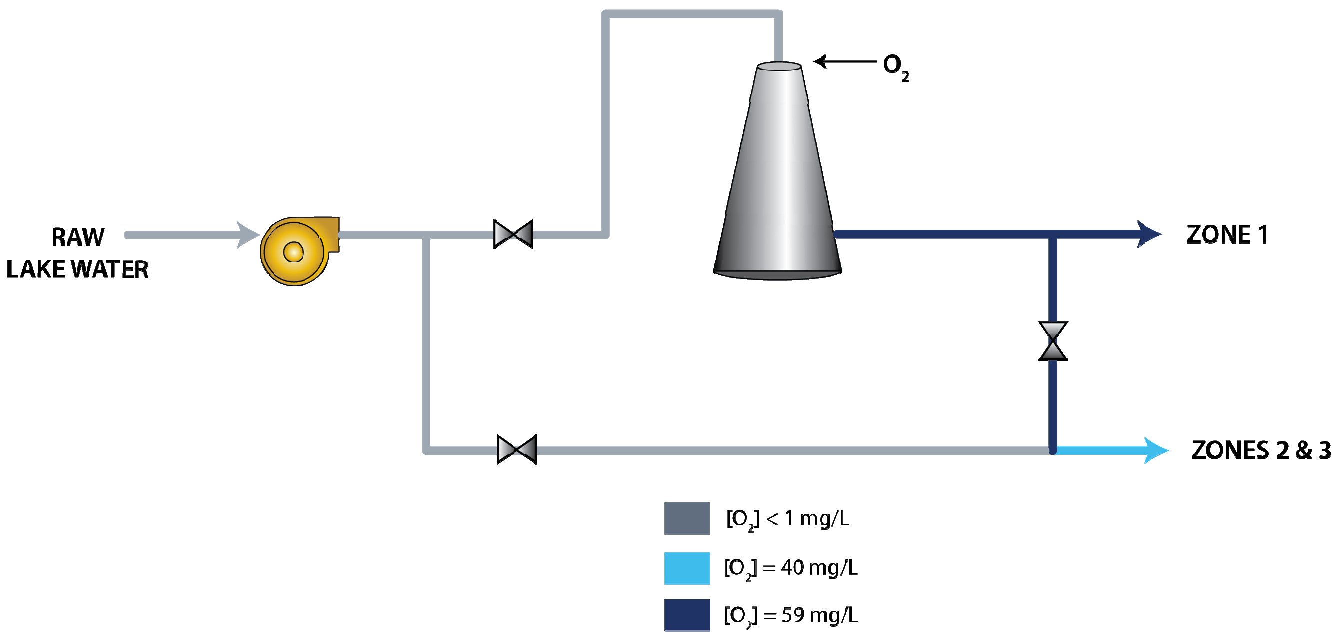
Table 6: ECO2 Speece Cone Design O2 Concentrations

	Submerged Cone	Shoreline Cone
Pressure (atm)	>2	~1
Theoretical O_2 Sat (mg/L)	100	50
Absorption Efficiency (%)	~70	~70
Design Discharge [O_2] (mg/L)	60	30

5.1.1.1 Submerged Speece Cone

The higher concentration of oxygen achieved by the submerged cone allows for a lower flow rate than that required by the shoreline option. In this case a flow rate of nearly 3,700 gpm is required to pass through the speece cone to deliver 2,000 lbs of O_2/day required by the lake's hypolimnion in option 1. The natural slope of the lake causes the depths of water to become shallower in the north. Where the cone discharge pipe terminates in the north, the water depth is no longer sufficient to create enough pressure to keep the 60 mg/L of oxygen dissolved in the water. In this case a side stream system would be used to deliver the high concentration of oxygenated water to the deep area by the dam while diluting the water that will be pumped to Zones II and III to prevent the oxygen from coming out of solution. The diluted concentration to the northern zones would be 40 mg/L. This increases the required flow rate to the north. A schematic for this dilution process can be seen in Figure 21.

Figure 21: Submerged Speece Cone Conceptual Flow Schematic



A summary of the submerged cone option can be seen in Table 6.

Table 7: Submerged Speece Cone Design Parameters (Option 1 of 10 System Design)

Flow Rate	3,650	gpm		
Head Required	32.5	ft		
Speece Cone Size	6	ft		
Piping	10	in dia	2,600	ft
	12	in dia	4,150	ft
	18	in dia	2,700	ft
Pump Power	45	hp	55	A

5.1.1.2 Shoreline Speece Cone

The limited saturation point of oxygen in water for the shoreline speece cone installation requires a higher flow rate for this option compared to the submerged option. Using the concentration of 30 mg/L, 6,000 gpm needs to pass through the speece cone to achieve the 2,000 lbs of O_2/day required by the lake's hypolimnion as shown in option 3. The lake is deep enough in the north to keep the 30 mg/L of oxygen dissolved in the water. The flow rate is still substantially larger than the submerged option, requiring larger piping and pumping requirements. A summary of the shoreline cone option can be seen in Table 8.

Table 8: Shoreline Speece Cone Design Parameters (Option 3 of 10 System Design)

Flow Rate	6,000	gpm		
Head Required	32.5	ft		
Speece Cone Size	10	ft		
Piping	12	in dia	1,400	ft
	16	in dia	4,150	ft
	20	in dia	1,500	ft
	24	in dia	1,200	ft
Pump Power	75	hp	89	A

The higher flow rate required by the shoreline option compared to the submerged option causes an increase in required pipe sizes, speece cone size, pump size, and power. This causes the capital cost for equipment to be greater. However, divers are not needed to install the shoreline speece cone or maintain it. Divers will only be needed to install and maintain the pipeline. This reduces the manpower cost of compared to the submerged option which requires divers to install and maintain the speece cone and pipelines. There is also an added advantage to the increase flow rate as shown in Section 4. By increasing the flow rate from 3,650 gpm to 6,000 gpm, the hydraulic retention time is decreased from 85 days to 52 days at lake elevation 1378 feet, which means it will take less time for the super oxygenated water to travel throughout the lake.

In order to accommodate an increased oxygen supply up to 3,000 lb/day in option 8, a shoreline designed system would pump 9,000 gpm of water with a DO concentration of 30 mg/L. The hydraulic retention time of this system would be further reduced to 35 days. A summary of the shoreline cone option to deliver 3,000 lbs/day can be seen in Table 9.

Table 9: Shoreline Speece Cone Design Parameters (Option 8 of 10 System Design)

Flow Rate	9,000	gpm		
Head Required	34.5	ft		
Speece Cone Size	12	ft		
Piping	16	in dia	1,400	ft
	20	in dia	4,150	ft
	24	in dia	1,500	ft
	30	in dia	1,200	ft
Pump Power	102	hp	89	A

5.1.2 BlueInGreen's Supersaturated Dissolved Oxygen (SDOX)

BlueInGreen's SDOX system works in a similar manner as ECO_2's speece cone. Water is pumped into a pressurized tank instead of a cone where oxygen is transferred into the water under pressure. However, the SDOX system generally has a much higher back-pressure to allow for a higher saturation point of oxygen in the water. Under BlueInGreen's standard system design, the equipment operates at a pressure of nearly 90 psi, allowing a concentration of 230 mg/L of dissolved oxygen and reducing the pumping flow rate of the system. This design concentration requires a flow rate of only 700 gpm to deliver nearly 2,000 lbs of O_2/day, or 1,400 gpm to deliver nearly 4,000 lbs of O_2/day (option 5). The hydraulic retention time for the 2,000 lb/day system design would be 400 days.

The high oxygen concentrations of this design require the super saturated water to remain pressurized in the pipelines or else the oxygen would come out of solution. If the oxygen does come out of solution, gas will accumulate at the high points of the pipeline, causing restriction of flow and improper operation. Gas relief holes drilled into the discharge piping, common for the speece cone design, are not generally used for the SDOX system since the pipeline must remain highly pressurized. The end of the pipelines will be capped to create a back pressure in the pipe and all of the saturated water will be delivered to the hypolimnion through small holes drilled at given intervals. Once the saturated water is mixed with the lake water, the concentration of oxygen is dispersed into the lake to prevent oxygen from coming out of solution. An image of a BlueInGreen SDOX pressurized vessel can be seen in Figure 22.

Figure 22: BlueInGreen SDOX Installation at Lake Thunderbird, OK

Various modifications to the standard BlueInGreen system design can be considered to work more effectively in Canyon Lake. The BlueInGreen system has advantages over the speece cone in that the oxygen saturation into the water column is tightly controlled with a variable speed pump to optimize efficiency. When oxygen is not properly dissolved or other problems occur in system operation, the BlueInGreen system automatically reacts to adjust its operation or has a system shutdown and alarms operations staff; whereas, the Speece Cone system does not provide these real time adjustments or safety shutdown functions.

5.1.3 *Gas Diffuser System (Soaker Hose)*

Instead of dissolving oxygen in a water column and delivering the oxygenated water to the lake, pure gaseous oxygen could alternatively be delivered. The challenge with gas diffusers is two-fold: 1) the gas has a tendency to mix the lake which removes the advantages of stratification and 2) the diffusers become a maintenance problem due to biofouling, pressure differences along the lines, and damage from fish hooks and other submerged objects. Plastic and ceramic membranes are capable of gas diffusion but typically require high flux rates that could cause unwanted mixing. A coarse bubble diffuser, such as a soaker hose system, is another type of diffuser feasible for Canyon Lake. Soaker hoses are typically used in gardening as a way to allow water to seep out the entire length of the hose. When the hose is pressurized, it expands, opening pores that allow the contents of the hose to exit. A network of these hoses could theoretically be placed on the bottom of the lake and connected to an oxygen supply. Pressurized oxygen in the hose will expand the hose and transfer the oxygen to the hypolimnion layer. An image of a soaker hose that is oxygenating a water bath can be seen in Figure 23.

Figure 23: Soaker Hose Oxygenating a Water Bath in PACE Laboratory

The benefit to using a gas diffuser a relative inexpense of the system when compared to the other two oxygenation systems described. Equipment for this option would include an oxygen supply and a piping system that can deliver the oxygen to the network of hoses. There are several disadvantages associated with using a soaker hose to oxygenate the hypolimnion: 1) 50% or more of the delivered oxygen may be lost to atmosphere, 2) water circulation is not created since there is no pumping and redistribution of oxygenated water throughout the lake, 3) durability of the diffusers may be low.

5.2 Two Methods of Oxygen Generation

Two systems are available to supply oxygen for the proposed equipment. These two options each have benefits and drawbacks which are described below. The two systems are: 1) onsite oxygen generation via mechanical gas separation process and 2) offsite generation and bi-monthly delivery of liquid oxygen (LOX) and onsite storage in steel tanks.

5.2.1 Oxygen Generator

Onsite oxygen generators create pure oxygen by mechanically separating the oxygen from air which is approximately 20% oxygen and 80% nitrogen. The generator will pull air into the system through a sieve that will separate the oxygen from the nitrogen. The generator operates on a cycle of pulling air in to separate the oxygen and nitrogen, the expelling the nitrogen from the system and pushing oxygen into the oxygen transfer vessel.

Figure 24: Oxygen Generator Installation at Oso Reservoir in Mission Viejo, CA

Oxygen generators can create substantial noise for surrounding properties. Past installations have required sound attenuation to be installed on buildings housing oxygen generators to prevent the sound nuisance to local residents. Oxygen generators have a set oxygen supply that can be attained. The system can be turned down to deliver less oxygen than the design limit, but there is a maximum oxygen supply that can be achieved unlike LOX, which has higher peak output capacity. PCI, a leading vacuum swing oxygen generator manufacturer, makes oxygen generators up to only 1,750 lbs/day in one unit, so potentially multiple units would be required. Oxygen generators also require electrical power, although relatively the same power as the pumping equipment,

Oxygen generators will incur a substantial capital cost for the project: 2 units at $115,000 each. This does not include extra costs caused by doubling the required power upgrade to the Canyon Lake Water Treatment Plant service entrance. There will also be extra costs in upgrading wiring and conduits to the proposed generator location and installation of electrical panels.

The electrical cost to supply oxygen at a rate of 3,000 lbs/day using oxygen generators is approximately $105/day assuming power can be supplied at a rate of $0.12 / kW-hr.

5.2.2 Liquid Oxygen

Liquid oxygen (LOX) as the supply for the oxygenation system is the alternative to oxygen generators. Liquid oxygen is a cryogenic fluid that is maintained at a temperature of approximately -300°F. The low temperature causes the oxygen to remain in liquid form which is stored in an onsite vacuum insulated tank. LOX becomes a gas by passing through an ambient vaporizer that heats up the liquid, causing it to boil. The pressure created by this boiling process is sufficient to push the oxygen into the oxygenation system so that no compressors are needed.

There is no capital cost for a liquid oxygen system as they are leased from suppliers for a monthly fee between $1,500 and $2,000. The supplier also maintains the system so operators will not be required to perform any maintenance on the tanks or vaporizers.

Liquid oxygen must be shipped in periodically to refill the tanks. 18 wheel trucks are the method of shipment of liquid oxygen and must pass through the local neighborhood streets to access the Canyon Lake Water Treatment Plant. Delivery of LOX is expected occur every 3 – 4 weeks, depending on the oxygen consumption of the system. 18 wheel trucks currently travel to the treatment plant on a bi-monthly basis to deliver a variety of consumable chemicals.

Liquid oxygen costs $0.42 / 100 cubic feet delivered. Each delivery has 40 tons of oxygen, which equates to a cost of $4,060/delivery. If the rate of oxygen consumption is 3,000 lbs/day, a delivery must be made every 27 days. This deliver cost, along with a monthly lease of $1,750, means the daily operating cost for a 3,000 lbs/day system would be $210, or double the daily operating cost of the oxygen generator option.

5.3 Equipment Location

Five areas have been considered for equipment installation for the oxygenation system equipment including oxygen generation and storage. The five areas can be seen in Figure 25.

Figure 25: Canyon Lake Proposed Equipment Locations

Not every location identified can house all of the required equipment. Table 10 shows which equipment can be located at each location.

Table 10: Proposed Equipment Locations Based on Figure 22

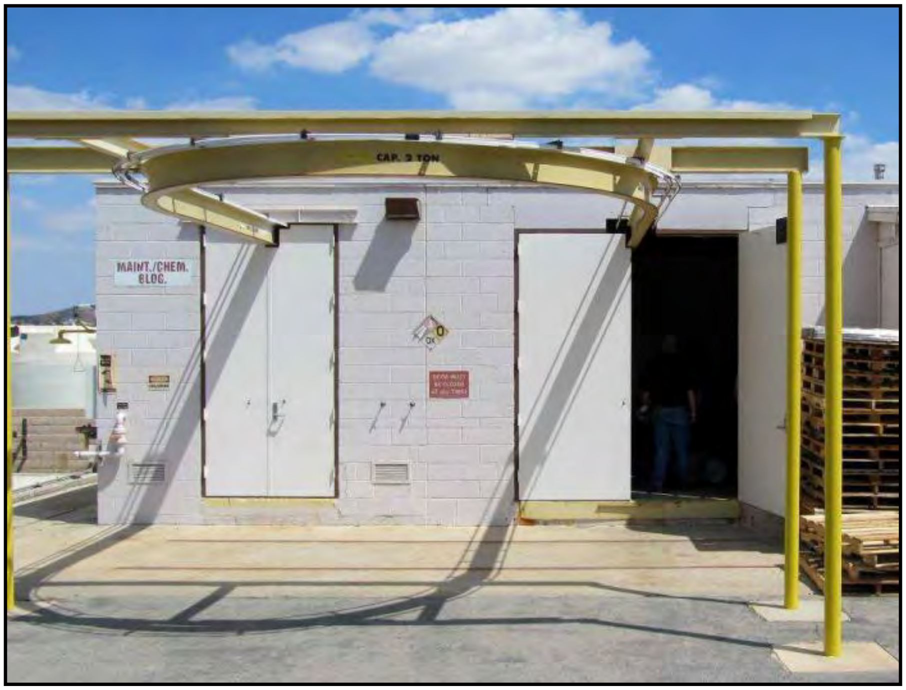
Location	Intake Pumps	Speece Cone	LOX Tank	O_2 Generator
A			X	X
B	X			
C	X	X		
D	X	X	X	
E	X	X		

Note: “X” used to signify equipment can be installed at location.

5.3.1 *Location A: Upper Parking Lot*

The upper parking lot of the treatment plant has been identified as suitable location for the oxygen generators or the liquid oxygen tanks. The oxygen generators can be installed in the old chemical storage building. The building is constructed using concrete masonry units (CMU). It consists of two rooms, one is 19 ft x 18 ft, the other is 12 ft x 19 ft. This is large enough to house both oxygen generators required to meet the oxygen demand of the system. Required improvements to the building include new electrical wiring, sound attenuation, HVAC system. A picture of the old chemical storage building can be seen in Figure 26.

Figure 26: Proposed Oxygen Generator Building (Location A)



The parking lot area near this building would also be a good location to install liquid oxygen tanks. The area has space for installation and setbacks required for a liquid oxygen system. The large parking lot and proximity to the treatment plant entrance also provide easy access for the refilling trucks.

5.3.2 Location B: Abandoned Intake Structure

North of the dam on the western shore are four 36" diameter pipes that were once used as the intake structure for the Canyon Lake Water Treatment Plant. These pipes are currently abandoned and could be used as the water intake site for the oxygenation system. The pipes would be fitted with a rail system allowing submersible pumps to be lowered to the bottom of the lake. Since the pipes go all the way to the bottom of the dam area, the water would be ideal for the oxygenation system.

Figure 27: Abandoned Intake Structure and Pipes (Location B)

5.3.3 Location C: Boat Dock Access Road

EVMWD has a boat dock north of the Canyon Lake Water Treatment Plant that is accessed by a road running along the shoreline from the dam. The area near the boat dock has open space near the access road that could be leveled to allow for installation of an onshore oxygenation system. The intake pumps could be localized with onshore oxygenation equipment at this location with the construction of an intake structure. The oxygenation equipment could also be provided with water from Location B if it is desirable to use the abandoned intake structure.

5.3.4 Location D: Flat Protected Area

A large, flat area is located near the shore of the lake on the northwest side of the Canyon Lake Water Treatment Plant. The area sits at the bottom of the hill and is protected on three sides by the hill; the fourth side being open to the lake. This location would be ideal for locating all the required equipment at one site. It is large enough to install a speece cone, liquid oxygen system, and allow room for LOX refill trucks room to turn around. The road to the site is likely suitable to allow trucks access for refilling the LOX tank. The proximity to the water makes an intake structure at this site feasible. However, the intakes would need to be longer than the other two viable locations to reach the deep, cold water necessary for the oxygenation system. Location D can be seen in Figure 28.

Figure 28: Flat Protected Area Northwest of Canyon Lake WTP (Location D)

5.3.5 Location E: Submerged Location

A submerged speece cone and intake pumps could be installed on the lake bottom instead of on the shore. This option allows the speece cone to take advantage of the pressure of the lake water to increase the DO saturation point and reduce pumping requirements. PACE conducted a diver survey on October 21, 2010 to find a suitable area for an underwater installation. Location E was found to be a flat, obstruction free area that was in the deeper area of the lake making it an attractive site for the underwater equipment.

6 Capital, O&M, and Life Cycle Costs

Options 1, 3, 8, and 10, which were modeled in Section 5, have estimated costs as shown in the following tables.

Option 1 - 2,000 lbs O_2/day, 3,650 gpm of water at [O_2] of 60 and 40 mg/L
Tables 10a, 10b, and 10c – Option 1 with Oxygen Generation
Tables 11a, 11b, and 11c – Option 1 with LOX

Option 3 - 2,000 lbs O_2/day, 6,000 gpm of water at [O_2] of 30 mg/L
Tables 12a, 12b, and 12c – Option 3 with Oxygen Generation
Tables 13a, 13b, and 13c – Option 3 with LOX

Option 8 - 3,000 lbs O_2/day, 9,000 gpm of water at [O_2] of 30 mg/L
Tables 14a, 14b, and 14c – Option 8 with Oxygen Generation
Tables 15a, 15b, and 15c – Option 8 with LOX

Option 10 - 3,000 lbs O_2/day, 5,000 gpm of water at [O_2] of 150 and 40 mg/L
Tables 16a, 16b, and 16c – Option 10 with Oxygen Generation
Tables 17a, 17b, and 17c – Option 10 with LOX

Table 11: Capital Cost of Option 1 with Oxygen Generator

Capital Cost - Submerged Installation (2,000 lbs/day, O_2 Generator)	quantity	units	cost/unit	total cost
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$0
SUBTOTAL				**$20,000**
Underwater Civil				
Dredging	170	cy	$125	$21,250
Concrete Pads	170	cy	$250	$42,500
SUBTOTAL				**$63,750**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$64	$172,800
Concrete Ballast for 18" Pipe	49.6	cy	$1,000	$49,600
12" HDPE Piping	4,150	LF	$45	$186,750
Concrete Ballast for 12" Pipe	38.2	cy	$1,000	$38,200
10" HDPE Piping	1,400	LF	$33	$46,200
Concrete Ballast for 10" Pipe	9.2	cy	$1,000	$9,200
10" HDPE Piping	1,200	LF	$33	$39,600
Concrete Ballast for 10" Pipe	7.9	cy	$1,000	$7,900
SUBTOTAL				**$550,250**
Equipment				
6' Speece Cone	1		$190,735	$190,735
DOCS 500 Oxygen Generator	1		$115,000	$115,000
Pump (3,000 gpm @ 33')	2		$45,000	$90,000
Submersible Cable for pumps	100	LF	$250	$25,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$50,000
SUBTOTAL				**$500,735**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$15,000
Motor Control Center				$50,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$40,000
Lighting				$5,000
SUBTOTAL				**$200,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	280	man days	$440	$123,200
Divers	80	man days	$2,000	$160,000
Per Diem	360	man days	$75	$27,000
SUBTOTAL				**$310,200**
SUM SUBTOTAL				**$1,644,935**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$49,348
FINAL SUBTOTAL				**$1,814,283**
Contingency 10%				$181,428
Overhead and Profit 15%				$272,142
TOTAL				**$2,267,854**

Table 12: Operations and Maintenance Cost of Option 1 with Oxygen Generator

O&M Cost - Submerged Installation (2,000 lbs/day, O_2 Generator)				
Electrical	60	kW-hr	$0.12	$46,656
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$25,037
Yearly O&M Cost				**$86,693**

Table 13: 20-Year Life Cycle Cost of Option 1 with Oxygen Generator

20 Yr Life Cycle Cost	**$3,348,237**

Table 14: Capital Cost of Option 1 with LOX

Capital Cost - Submerged Installation (2,000 lbs/day, LOX)	quantity	units	cost/unit	total cost
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$60,000
SUBTOTAL				**$65,000**
Underwater Civil				
Dredging	170	cy	$125	$21,250
Concrete Pads	170	cy	$250	$42,500
SUBTOTAL				**$63,750**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$64	$172,800
Concrete Ballast for 18" Pipe	49.6	cy	$1,000	$49,600
12" HDPE Piping	4,150	LF	$45	$186,750
Concrete Ballast for 12" Pipe	38.2	cy	$1,000	$38,200
10" HDPE Piping	1,400	LF	$33	$46,200
Concrete Ballast for 10" Pipe	9.2	cy	$1,000	$9,200
10" HDPE Piping	1,200	LF	$33	$39,600
Concrete Ballast for 10" Pipe	7.9	cy	$1,000	$7,900
SUBTOTAL				**$550,250**
Equipment				
6' Speece Cone	1		$190,735	$190,735
Pump (3,000 gpm @ 33')	2		$45,000	$90,000
Submersible Cable for pumps	100	LF	$250	$25,000
Valves / Instrumentation				$25,000
Mechanical Piping / Supports / Misc.				$50,000
SUBTOTAL				**$380,735**
Electrical Systems				
New Service Entrance				$45,000
Power Distribution Section				$15,000
Motor Control Center				$35,000
Control Panel and Programming				$25,000
Conduit / Wiring / Disconnects				$30,000
Lighting				$5,000
SUBTOTAL				**$155,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	220	man days	$440	$96,800
Divers	80	man days	$2,000	$160,000
Per Diem	300	man days	$75	$22,500
SUBTOTAL				**$279,300**
SUM SUBTOTAL				**$1,494,035**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$44,821
FINAL SUBTOTAL				**$1,658,856**
Contingency 10%				$165,886
Overhead and Profit 15%				$248,828
TOTAL				**$2,073,570**

Table 15: Operations and Maintenance Cost of Option 1 with LOX

O&M Cost - Submerged Installation (2,000 lbs/day, LOX)				
Electrical	35	kW-hr	$0.12	$27,216
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	6	refills/year	$5,307	$31,841
Equipment Replacement				$19,037
Yearly O&M Cost				**$114,094**

Table 16: 20-Year Life Cycle Cost of Option 1 with LOX

20 Yr Life Cycle Cost	**$3,495,432**

Table 17: Capital Cost of Option 3 with Oxygen Generator

Capital Cost - Shoreline Installation (2,000 lbs/day, O_2 Generator)	quantity	units	cost/unit	total cost
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$15,000
SUBTOTAL				**$35,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	1,200	LF	$114	$136,800
Concrete Ballast for 24" Pipe	39.2	cy	$1,000	$39,200
20" HDPE Piping	1,500	LF	$90	$135,000
Concrete Ballast for 20" Pipe	34.0	cy	$1,000	$34,000
16" HDPE Piping	4,150	LF	$60	$249,000
Concrete Ballast for 16" Pipe	60.2	cy	$1,000	$60,200
12" HDPE Piping	1,400	LF	$45	$63,000
Concrete Ballast for 12" Pipe	12.9	cy	$1,000	$12,900
24" Suction Pipe	200	LF	$114	$22,800
SUBTOTAL				**$752,900**
Equipment				
SDOX System	1		$165,000	$165,000
DOCS 500 Oxygen Generator	1		$115,000	$115,000
Pump (6,000 gpm @ 33')	2		$55,000	$110,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$445,000**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$15,000
Motor Control Center				$50,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$45,000
Lighting				$5,000
SUBTOTAL				**$205,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	295	man days	$440	$129,800
Divers	70	man days	$2,000	$140,000
Per Diem	365	man days	$75	$27,375
SUBTOTAL				**$297,175**
SUM SUBTOTAL				**$1,740,325**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$52,210
FINAL SUBTOTAL				**$1,912,535**
Contingency 10%				$191,253
Overhead and Profit 15%				$286,880
TOTAL				**$2,390,668**

Table 18: Operations and Maintenance Cost of Option 3 with Oxygen Generator

O&M Cost - Shoreline Installation (2,000 lbs/day, O_2 Generator)				
Electrical	80	kW-hr	$0.12	$62,208
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$22,250
Yearly O&M Cost				**$99,458**

Table 19: 20-Year Life Cycle Cost of Option 3 with Oxygen Generator

20 Yr Life Cycle Cost	**$3,367,162**

Table 20: Capital Cost of Option 3 with LOX

Capital Cost - Shoreline Installation (2,000 lbs/day, LOX)				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
SUBTOTAL				**$80,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	1,200	LF	$114	$136,800
Concrete Ballast for 24" Pipe	39.2	cy	$1,000	$39,200
20" HDPE Piping	1,500	LF	$90	$135,000
Concrete Ballast for 20" Pipe	34.0	cy	$1,000	$34,000
16" HDPE Piping	4,150	LF	$60	$249,000
Concrete Ballast for 16" Pipe	60.2	cy	$1,000	$60,200
12" HDPE Piping	1,400	LF	$45	$63,000
Concrete Ballast for 12" Pipe	12.9	cy	$1,000	$12,900
24" Suction Pipe	200	LF	$114	$22,800
SUBTOTAL				**$752,900**
Equipment				
SDOX System	1		$165,000	$165,000
Pump (6,000 gpm @ 33')	2		$55,000	$110,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$330,000**
Electrical Systems				
New Service Entrance				$45,000
Power Distribution Section				$15,000
Motor Control Center				$35,000
Control Panel and Programming				$30,000
Conduit / Wiring / Disconnects				$35,000
Lighting				$5,000
SUBTOTAL				**$165,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	235	man days	$440	$103,400
Divers	70	man days	$2,000	$140,000
Per Diem	305	man days	$75	$22,875
SUBTOTAL				**$266,275**
SUM SUBTOTAL				**$1,599,425**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$47,983
FINAL SUBTOTAL				**$1,767,408**
Contingency 10%				$176,741
Overhead and Profit 15%				$265,111
TOTAL				**$2,209,260**

Table 21: Operations and Maintenance Cost of Option 3 with LOX

O&M Cost - Shoreline Installation (2,000 lbs/day, LOX)				
Electrical	55	kW-hr	$0.12	$42,768
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	6	refills/year	$5,307	$31,841
Equipment Replacement				$16,500
Yearly O&M Cost				**$127,109**

Table 22: 20-Year Life Cycle Cost of Option 3 with LOX

20 Yr Life Cycle Cost	**$3,457,236**

Table 23: Capital Cost of Option 8 with Oxygen Generator

Capital Cost - ShorelineInstallation (3,000 lbs/day, O_2 Generator)				
	quantity	*units*	*cost/unit*	*total cost*
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$15,000
SUBTOTAL				**$35,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
30" HDPE Piping	1,200	LF	$175	$210,000
Concrete Ballast for 30" Pipe	61.2	cy	$1,000	$61,200
24" HDPE Piping	1,500	LF	$114	$171,000
Concrete Ballast for 24" Pipe	49.0	cy	$1,000	$49,000
20" HDPE Piping	4,150	LF	$90	$373,500
Concrete Ballast for 20" Pipe	94.0	cy	$1,000	$94,000
16" HDPE Piping	1,400	LF	$60	$84,000
Concrete Ballast for 16" Pipe	20.3	cy	$1,000	$20,300
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$1,098,000**
Equipment				
SDOX Unit	1		$345,000	$345,000
DOCS 500 Oxygen Generator	2		$115,000	$230,000
Pump (9,000 gpm @ 33')	2		$90,000	$180,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$810,000**
Electrical Systems				
New Service Entrance				$70,000
Power Distribution Section				$25,000
Motor Control Center				$60,000
Control Panel and Programming				$50,000
Conduit / Wiring / Disconnects				$55,000
Lighting				$5,000
SUBTOTAL				**$265,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	305	man days	$440	$134,200
Divers	75	man days	$2,000	$150,000
Per Diem	380	man days	$75	$28,500
SUBTOTAL				**$312,700**
SUM SUBTOTAL				**$2,525,950**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$75,779
FINAL SUBTOTAL				**$2,721,729**
Contingency 10%				$272,173
Overhead and Profit 15%				$408,259
TOTAL				**$3,402,161**

Table 24: Operations and Maintenance Cost of Option 8 with Oxygen Generator

O&M Cost - Shoreline Installation (3,000 lbs/day, O_2 Generator)				
Electrical	120	kW-hr	$0.12	$93,312
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$40,500
Yearly O&M Cost				**$148,812**

Table 25: 20-Year Life Cycle Cost of Option 8 with Oxygen Generator

20 Yr Life Cycle Cost	**$4,825,046**

Table 26: Capital Cost of Option 8 with LOX

Capital Cost - Shoreline Installation (3,000 lbs/day, LOX)				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
SUBTOTAL				**$80,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
30" HDPE Piping	1,200	LF	$175	$210,000
Concrete Ballast for 30" Pipe	61.2	cy	$1,000	$61,200
24" HDPE Piping	1,500	LF	$114	$171,000
Concrete Ballast for 24" Pipe	49.0	cy	$1,000	$49,000
20" HDPE Piping	4,150	LF	$90	$373,500
Concrete Ballast for 20" Pipe	94.0	cy	$1,000	$94,000
16" HDPE Piping	1,400	LF	$60	$84,000
Concrete Ballast for 16" Pipe	20.3	cy	$1,000	$20,300
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$1,098,000**
Equipment				
SDOX Unit	1		$345,000	$345,000
Pump (9,000 gpm @ 33')	2		$90,000	$180,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$580,000**
Electrical Systems				
New Service Entrance				$60,000
Power Distribution Section				$20,000
Motor Control Center				$50,000
Control Panel and Programming				$40,000
Conduit / Wiring / Disconnects				$35,000
Lighting				$5,000
SUBTOTAL				**$210,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	245	man days	$440	$107,800
Divers	75	man days	$2,000	$150,000
Per Diem	320	man days	$75	$24,000
SUBTOTAL				**$281,800**
SUM SUBTOTAL				**$2,255,050**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$67,652
FINAL SUBTOTAL				**$2,442,702**
Contingency 10%				$244,270
Overhead and Profit 15%				$366,405
TOTAL				**$3,053,377**

Table 27: Operations and Maintenance Cost of Option 8 with LOX

O&M Cost - Shoreline Installation (3,000 lbs/day, LOX)				
Electrical	75	kW-hr	$0.12	$58,320
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	11	refills/year	$4,059	$44,648
Equipment Replacement				$29,000
Yearly O&M Cost				**$167,968**

Table 28: 20-Year Life Cycle Cost of Option 8 with LOX

20 Yr Life Cycle Cost	**$4,702,508**

Table 29: Capital Cost of Option 10 with Oxygen Generator

Capital Cost - Shoreline Installation, 2 Units (3,000 lbs/day, O_2 Generator)				
	quantity	*units*	*cost/unit*	*total cost*
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$15,000
SUBTOTAL				**$35,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	2,700	LF	$114	$307,800
Concrete Ballast for 24" Pipe	88.1	cy	$1,000	$88,100
18" HDPE Piping	4,150	LF	$70	$290,500
Concrete Ballast for 18" Pipe	76.2	cy	$1,000	$76,200
14" HDPE Piping	1,400	LF	$50	$70,000
Concrete Ballast for 14" Pipe	15.6	cy	$1,000	$15,600
8" HDPE Pipe for Zone I	200	LF	$25	$5,000
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$888,200**
Equipment				
SDOX Unit for Zone I	1		$129,950	$129,950
SDOX Unit for Zone II and III	1		$165,000	$165,000
DOCS 500 Oxygen Generator	2		$115,000	$230,000
Pump (5,000 gpm @ 33')	2		$50,000	$100,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$679,950**
Electrical Systems				
New Service Entrance				$65,000
Power Distribution Section				$20,000
Motor Control Center				$55,000
Control Panel and Programming				$40,000
Conduit / Wiring / Disconnects				$50,000
Lighting				$5,000
SUBTOTAL				**$235,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	305	man days	$440	$134,200
Divers	75	man days	$2,000	$150,000
Per Diem	380	man days	$75	$28,500
SUBTOTAL				**$312,700**
SUM SUBTOTAL				**$2,156,100**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$64,683
FINAL SUBTOTAL				**$2,340,783**
Contingency 10%				$234,078
Overhead and Profit 15%				$351,117
TOTAL				**$2,925,979**

Table 30: Operations and Maintenance Cost of Option 10 with Oxygen Generator

O&M Cost - Shoreline Installation, 2 Unts (3,000 lbs/day, O_2 Generator)				
Electrical	95	kW-hr	$0.12	$73,872
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$33,998
Yearly O&M Cost				**$122,870**

Table 31: 20-Year Life Cycle Cost of Option 10 with Oxygen Generator

20 Yr Life Cycle Cost	**$4,132,330**

Table 32: Capital Cost of Option 10 with LOX

Capital Cost - Shoreline Installation, 2 Units (3,000 lbs/day, LOX)				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
SUBTOTAL				**$80,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	2,700	LF	$114	$307,800
Concrete Ballast for 24" Pipe	88.1	cy	$1,000	$88,100
18" HDPE Piping	4,150	LF	$70	$290,500
Concrete Ballast for 18" Pipe	76.2	cy	$1,000	$76,200
14" HDPE Piping	1,400	LF	$50	$70,000
Concrete Ballast for 14" Pipe	15.6	cy	$1,000	$15,600
8" HDPE Pipe for Zone I	200	LF	$25	$5,000
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$888,200**
Equipment				
SDOX Unit for Zone I	1		$129,950	$129,950
SDOX Unit for Zone II and III	1		$129,950	$129,950
Pump (5,000 gpm @ 33')	2		$50,000	$100,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$414,900**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$20,000
Motor Control Center				$45,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$40,000
Lighting				$5,000
SUBTOTAL				**$200,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	245	man days	$440	$107,800
Divers	75	man days	$2,000	$150,000
Per Diem	320	man days	$75	$24,000
SUBTOTAL				**$281,800**
SUM SUBTOTAL				**$1,870,150**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$56,105
FINAL SUBTOTAL				**$2,046,255**
Contingency 10%				$204,625
Overhead and Profit 15%				$306,938
TOTAL				**$2,557,818**

Table 33: Operations and Maintenance Cost of Option 10 with LOX

O&M Cost - Shoreline Installation, 2 Units (3,000 lbs/day, LOX)				
Electrical	55	kW-hr	$0.12	$42,768
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	11	refills/year	$4,059	$44,648
Equipment Replacement				$20,745
Yearly O&M Cost				**$144,161**

Table 34: 20-Year Life Cycle Cost of Option 10 with LOX

20 Yr Life Cycle Cost	**$3,973,209**

7 Recommendations and Next Steps

After review of the information presented, after meetings with operations staff from EVMWD, and after careful evaluation of model results and cost estimates, PACE recommends proceeding with option 10 using two on-shore oxygenation systems: one high oxygen concentration system for zone 1, and one low oxygen concentration, high flowrate system for zones 2 and 3. It is recommended to use a liquid transfer oxygenation system such as a Speece Cone or BlueInGreen system instead of a gaseous oxygen system such as the soaker hose concept because of the perceived reliability problems of gas diffusers, the loss of nearly 50% of the oxygen delivered, and the lack of mixing.

The reason for using an on-shore system instead of a submerged system is three fold: 1) the bottom of the lake contains a very high quantity of organic muck which will increase a submerged system installation cost and delay permitting, 2) the submerged system is more difficult to maintain because divers are required, and 3) long-term leveling of equipment is more challenging which can cause gas accumulation and potential damage to equipment.

When considering onsite oxygen generation or LOX for oxygen production, both systems or a combination of systems may be considered. At first glance the LOX system seems to be more advantageous because: 1) electrical upgrades will be costly and LOX does not require new electrical, 2) LOX is very quiet and requires very little maintenance, 3) LOX is better at delivering peak oxygen when necessary, 4) there is ample space and good access for LOX in Location A. The LOX system has more daily operation cost for oxygen supply by nearly 2:1, but does not have maintenance cost, and the estimated life-cycle cost for LOX is lower for a 3,000 lb/day system. The biggest drawback to the LOX system will be the need for large liquid-oxygen-carrying trucks coming to the site multiple times per month.

When considering whether to use an onshore Speece Cone or the BlueInGreen system for the proposed option 10 design, although both systems appear to work effectively, PACE recommends the following: use a standard high pressure/high oxygen concentration BlueInGreen system for zone 1 and a modified side-stream low pressure/low oxygen concentration BlueInGreen system for zones 2 and 3. BlueInGreen's SDOX system is lower capital cost, smaller size, and unlike the Speece Cone, the BlueInGreen system is easier to operate because the pump speed can be perfectly regulated to optimize oxygen dissolution in the water. This is achieved by maintaining a constant water level in the tank, and water is sprayed through the headspace. The Speece Cone does not have a spray, but rather water is pumped through a pipe with a gaseous cloud, which cannot be easily regulated. Thus, the Speece Cone controls require a higher safety factor for inefficiencies to avoid over gassing the cone (and floating it if submerged).

The systems could be located at the Canyon Lake WTP as follows: Location B can be outfitted with new submersible pumps using the existing intake structure, Location A parking lot can be used for a new dual tank LOX facility, and Location C can be used to install two new BlueInGreen SDOX skids. The next step to installation would include a site survey for the locations described and preparation of plans and specifications for bid by qualified contractors.

A schematic of the proposed setup is shown in Figure 29. Graphics of the BlueInGreen SDOX units are shown in Figure 30.

Figure 29: Conceptual Schematic of Proposed Dual BlueInGreen (BIG) On Shore System

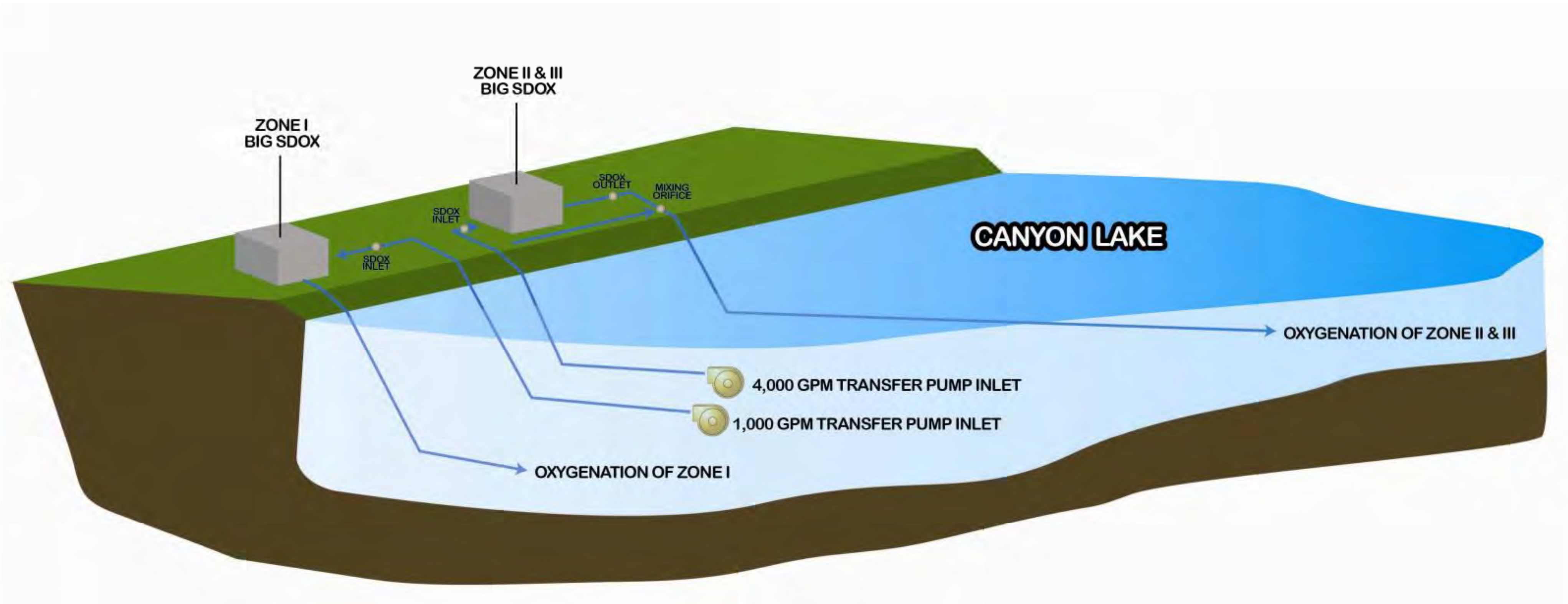
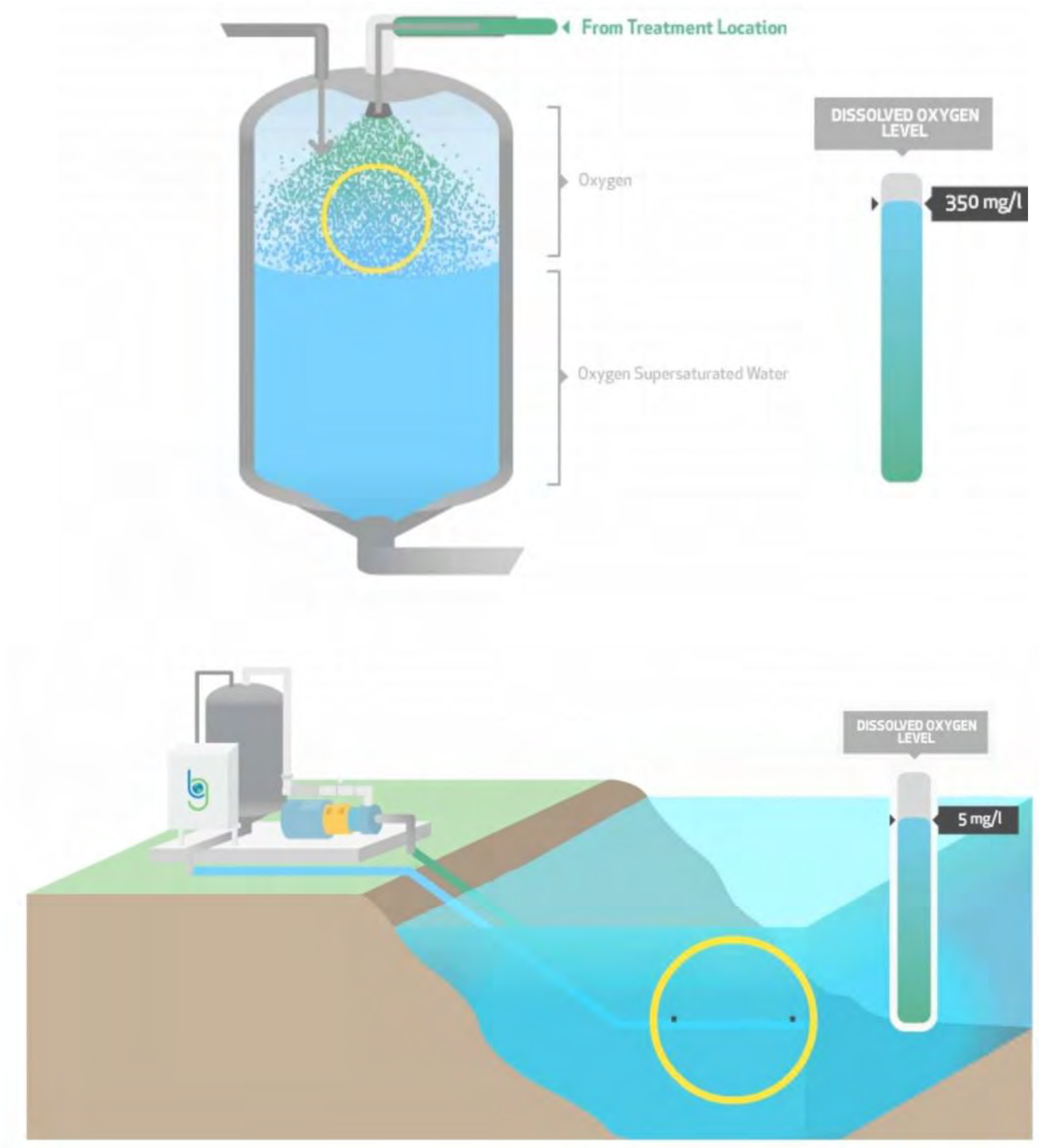


Figure 30: **Schematic of Standard BlueInGreen (BIG) On Shore System**



8 Permitting and Scheduling

Table 35: Anticipated Biological and Regulatory Permitting Project Schedule

Task	Dates
Notice to Proceed from with complete project description, project plans, CAD files, and other required project data.	10/04/11
Biological survey field work completed (within a week of receipt of Notice to Proceed)	10/11/11
Draft Biological Report completed (One week following completion of field work)	10/25/11
Contact USACE, CDFG, and RWQCB to discuss project and possible site visit. (Within five days working days of Notice to Proceed)	10/08/11
Complete field work for Jurisdictional Delineation Report if required by USACE (within one week from receipt of the Notice to Proceed).	10/11/11
Meet to discuss appropriate CEQA documentation (within 10 days of receipt of the Notice to Proceed). If Agency agrees to authorize the project under a Categorical Exemption (CE), the CE will be prepared. If a Mitigated Negative Declaration is determined to be appropriate, an Initial Study/Mitigated Negative Declaration (IS/MND) will be prepared.	10/14/11
Prepare draft application package that includes: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation (previously prepared), NOD, CDFG fee receipts, revises JD report, and Approved Jurisdictional Determination Form for Review (three days)	11/01/11
Prepare final Permit Application Package including: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation, NOD, CDFG fee receipts, revises JD report if one is required, prepares an Approved Jurisdictional Determination Form, and proposed mitigation strategy if required by the agencies. Obtains application signatures and filing fees for CDFG 1602 and RWQCB 401 applications and submits application package to USACE, RWQCB and CDFG. (One week)	11/15/11
Contact agencies to discuss applications to determine if additional information for a complete application. (Three weeks from date of application submittal to agencies)	11/22/11
Date agencies must determine if applications are complete. (30 days from date of application submittal)	12/ 01/11
Permit processing. Anticipated permit approvals (3 months)	1/04/12

Appendix B provides a sample permitting proposal from Bonterra for a submerged speece cone oxygenation system option with onsite oxygen generators.

Appendix A

Appendix A


Proposed Pipe
Option I
Submerged Equipment
2,000 lb O_2/Day
Zone IV
Treatment
Not Necessary
Zone III
460 lbs O_2
22% O_2
Length = 4150'
Diameter = 12"
Material = HDPE
[O_2] = 40 mg/L
Q = 970 gpm
Length = 1400'
Diameter = 10"
Material = HDPE
[O_2] = 40 mg/L
Zone II
500 lbs O_2
24% O_2
Q = 915 gpm
Length = 2700'
Diameter = 18"
Material = HDPE
[O_2] = 40 mg/L
Q = 1,500 gpm
Q = 2,150 gpm
Length = 1200'
Diameter = 10"
Material = HDPE
[O_2] = 59 mg/L
Zone I
1,115 lbs O_2
54% O_2
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 32.5'. This includes friction losses and losses through speece cone.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.
Oxygen Reactor
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
N

PROPOSED PIPE
OPTION II
SUBMERGED EQUIPMENT
4,000 LB O2/DAY
Zone IV
Treatment
Not Necessary
Zone III
955 lbs O2
23% O2
Length = 4150'
Diameter = 18"
Material = HDPE
[O2] = 40 mg/L
Q = 1,850 gpm
Length = 1400'
Diameter = 14"
Material = HDPE
[O2] = 40 mg/L
Zone II
950 lbs O2
23% O2
Q = 1,490 gpm
Length = 2700'
Diameter = 24"
Material = HDPE
[O2] = 40 mg/L
Q = 3,000 gpm
Q = 4,300 gpm
Length = 1200'
Diameter = 16"
Material = HDPE
[O2] = 59 mg/L
Zone I
2,240 lbs O2
54% O2
Oxygen Reactor
& Water Intake
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 29'. This includes friction losses and losses through speece cone.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.


Proposed Pipe
Option III
Shoreline Equipment
2,000 lb O_2/Day
Zone IV
Treatment
Not Necessary
Length = 4150'
Diameter = 16"
Material = HDPE
[O_2] = 29 mg/L
Zone III
540 lbs O_2
25% O_2
Q = 1,780 gpm
Length = 1400'
Diameter = 12"
Material = HDPE
[O_2] = 29 mg/L
Length = 1500'
Diameter = 20"
Material = HDPE
[O_2] = 29 mg/L
Q = 1,530 gpm
Zone II
650 lbs O_2
31% O_2
Zone I
920 lbs O_2
44% O_2
Q = 1,450 gpm
Q = 6,000 gpm
Length = 1200'
Diameter = 24"
Material = HDPE
[O_2] = 29 mg/L
Oxygen reactor
Water Intake
Transition to 20" HDPE
with 2 - 4" outlets.
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 32.5'. This includes friction losses and losses through speece cone. Does not include head required to pump up to the shore.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Proposed Pipe
Option IV
Shoreline Equipment
4,000 lb O_2/Day
Zone IV
Treatment
Not Necessary
Zone III
990 lbs O_2
23% O_2
Length = 4150'
Diameter = 24"
Material = HDPE
$[O_2]$ = 29 mg/L
Q = 2,800 gpm
Length = 1400'
Diameter = 18"
Material = HDPE
$[O_2]$ = 29 mg/L
Zone II
1,170 lbs O_2
28% O_2
Length = 1500'
Diameter = 30"
Material = HDPE
$[O_2]$ = 29 mg/L
Q = 2,800 gpm
Zone I
2,070 lbs O_2
49% O_2
Q = 5,435 gpm
Q = 12,000 gpm
Length = 1200'
Diameter = 30"
Material = HDPE
$[O_2]$ = 29 mg/L
Oxygen Reactor
Water Intake
2 - 8" outlets.
Proposed Pipes Option 4
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 28'. This includes friction losses and losses through speece cone. Does not include head required to pump up to the shore.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Proposed Pipe
Option V
Shoreline Equipment
2,000 lb O_2/Day
Zone IV
Treatment
Not Necessary
Length = 4150'
Diameter = 8"
Material = HDPE
[O_2] = 200 mg/L
1/16" diameter
holes every 35'
Zone III
725 lbs O_2
36% O_2
Q = 190 gpm
Length = 1400'
Diameter = 8"
Material = HDPE
[O_2] = 200 mg/L
1/16" diameter
holes every 20'
Zone II
900 lbs O_2
45% O_2
Q = 190 gpm
Length = 2700'
Diameter = 10"
Material = HDPE
[O_2] = 200 mg/L
1/16" diameter
holes every 20'
Q = 800 gpm
Zone I
370 lbs O_2
19% O_2
Note:
Head required 325'. This is head required to keep O_2 from coming out of solution.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.
Oxygen Reactor
Water Intake
Proposed Pipes Option 5
Oxygenation Zones
600 300 0 600
Feet

Proposed Pipe
Option VII
Hybrid - Fine
Bubbles/Oxygen Reactor
2,000 lb O2/Day
Zone IV
Treatment
Not Necessary
Zone III
415 lbs O2
21% O2
Length = 4150'
Diameter = 20"
Material = HDPE
[O2] = 29 mg/L
Q = 865 gpm
Length = 1400'
Diameter = 16"
Material = HDPE
[O2] = 29 mg/L
Zone II
480 lbs O2
24% O2
Q = 865 gpm
Length = 2700'
Diameter = 24"
Material = HDPE
[O2] = 29 mg/L
Zone I
1,105 lbs O2
55% O2
Q = 2,100 gpm
Array of ceramic fine
bubble diffusers delivering
1,000 lbs O2/day
Oxygen Reactor
& Water Intake
Proposed Pipes
Oxygenation Zones
600
300
0
600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 32.5'. This includes friction losses and losses through speece cone.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

PROPOSED PIPE
OPTION VIII
SHORELINE EQUIPMENT
3,000 LB O_2/DAY
Zone IV
Treatment
Not Necessary
Length = 4150'
Diameter = 20"
Material = HDPE
$[O_2]$ = 29 mg/L
Zone III
965 lbs O_2
32% O_2
Q = 2,875 gpm
Length = 1400'
Diameter = 16"
Material = HDPE
$[O_2]$ = 29 mg/L
Length = 1500'
Diameter = 24"
Material = HDPE
$[O_2]$ = 29 mg/L
Zone II
1,075 lbs O_2
36% O_2
Q = 2,575 gpm
Q = 6,100 gpm
Zone I
980 lbs O_2
32% O_2
Q = 9,000 gpm
Length = 1200'
Diameter = 30"
Material = HDPE
$[O_2]$ = 29 mg/L
Oxygen reactor
Water Intake
Transition to 24" HDPE with 2 - 4" outlets
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 36'. This includes friction losses and losses through speece cone. Does not include head required to pump up to the shore.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.

Head required 38'. This includes friction losses and losses through speece cone.

Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.

Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Proposed Pipe
Option X
Two Reactor System
3,000 lb O_2/Day
Zone IV
Treatment
Not Necessary
Zone III
1,000 lbs O_2
34% O_2
Length = 4150'
Diameter = 18"
Material = HDPE
[O_2] = 40 mg/L
Q = 2,100 gpm
Length = 1400'
Diameter = 14"
Material = HDPE
[O_2] = 40 mg/L
Zone II
900 lbs O_2
30% O_2
Q = 1,750gpm
Length = 2700'
Diameter = 24"
Material = HDPE
[O_2] = 40 mg/L
Q = 4,100 gpm
Zone I
1,050 lbs O_2
36% O_2
Q = TBD
Oxygen Reactor Location
Water Intake
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Numbers for Zone I include 1,000 lb O_2 injected by second system
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Appendix B

Appendix B

ATTACHMENT A

SCOPE OF WORK AND FEES
CANYON LAKE AERATOR PROJECT
BIOLOGICAL RESOURCES, ENVIRONMENTAL, AND REGULATORY PERMITTING SERVICES

September 21, 2010

PROJECT UNDERSTANDING

The proposed Canyon Lake Aerator project includes the following project components:

- The project will occur at the very southern tip of the lake. An oxygen generator will be installed at the existing water treatment plant on a slab about 13' x 13'. Since the oxygen generator is noisy and ramps up and down continuously, it will be installed indoors. The residents of the private Canyon Lake Community are very sensitive to noise.

- The piping from the oxygen generator and the electrical lines will be run overland in an existing chemical feed conduit box that extends partially into the lake. There may be some trenching across the road to access the conduit box where it goes underground. In the lake, the lines will lie on the lake bottom in a conduit and no trenching will be required.

- A concrete pad, approximately 10' x 30', will be constructed at the bottom of the lake for the speece cone foundation. Some dredging of muck will be required and will likely be around 30 CY more or less. We will be doing some coring in the area to determine the actual depth. The pad will likely be poured in place as an underwater installation with marine grade concrete. Depth is approximately 45 feet.

- Divers will be utilized to bolt the speece cone to the slab and attach the piping and electrical to the submersible pumps. Once installed, the speece cone will not be seen or heard above the water. The fish will be able to hear the underwater pumps though.

As we discussed, the project is very small and will not likely result in significant impacts to the biological resources within or near the lake or the residents living in close proximately to the lake. The following tasks assume minimal impacts but address both alternative environmental and regulatory permitting strategies.

TASK 1 ENVIRONMENTAL DOCUMENTATION

Task 1.1 Project Initiation

BonTerra Consulting will attend a kickoff meeting with Elsinore Valley Municipal Water District (EVMWD) staff, Pacific Advanced Civil Engineering, Inc. (PACE) and other team members to discuss the proposed scope of work and to coordinate and identify data gaps and potential issues of concern and to obtain relevant supporting technical documents, planning documents, and other existing pertinent information. The appropriate level of environmental documentation (Categorical Exemption [CE] vs. Initial Study/Mitigated Negative Declaration [ISI/MND]) will be discussed. This coordination effort is intended to ensure that EVMWD and PACE concur with the scope of work, studies to be completed, and appropriate environmental documentation for the project. The project schedule will also be discussed at this meeting. Attendance at one project meeting is assumed for this task.

Task 1.1 Deliverable: 1. Attendance at one project meeting

Task 2.2 Preparation of Environmental Documentation

Once the appropriate level of environmental documentation has been determined, BonTerra Consulting will prepare the environmental document. At the request of the PACE/EVMWD, this section of the scope of work has been organized to address preparation of a CE as Option A and an IS/MND as Option B.

Option A: Categorical Exemption (CE)

Preparation of CEQA Categorical Exemption/NEPA Categorical Exclusion

In compliance with Section 15062 of the CEQA Guidelines and Code of Federal Regulations, Title 40, Chapter 1, Part 6, Section 6.107, BonTerra Consulting will prepare a Notice of Exemption for the project. The Notice of Exemption will follow the format provided as Appendix E to the CEQA Guidelines. This notice will include a description of the project, the location of the project including a vicinity map, a finding that the project is exempt from CEQA and NEPA, and a statement substantiating this finding. A brief statement will also be included identifying how the notice conforms to the required elements set forth in CEQA and NEPA.

This scope of work assumes that EVMWD/PACE will provide BonTerra with necessary information to prepare the project description, including any available structural elevations. BonTerra Consulting will conduct a site evaluation to substantiate the findings of no environmental impacts. The site evaluation will include a description of the site's existing conditions related to land use, biological resources, aesthetics, recreational resources, and any other relevant information.

Filing of the CE/CE

Following approval of the CE/CE, the Notice of Exemption shall be filed with the Governor's Office of Planning and Research State Clearinghouse and the EPA. BonTerra will coordinate the necessary filings on behalf of EVMWD.

Option A (CE) Deliverables: 1. Three copies of Notice of Exemption

Option B: Initial Study/Mitigated Negative Declaration (IS/MND)

Preparation of CEQA Initial Study

In compliance with Section 15063 of the State CEQA Guidelines, the IS will contain a Project Description, including its location; a discussion of the environmental setting; and identification of the Project's potential environmental effects. This Scope of Work assumes that PACE will provide BonTerra Consulting with the necessary information to prepare the Project Description for the IS including the specific location of the project, limits of grading, quantities of earthwork, and interface of the proposed facilities with other District facilities. The discussion of the environmental setting will be based on a review of existing literature and a site visit. The discussion of the environmental effects will follow the environmental checklist form included in Appendix G of the State CEQA Guidelines unless another format is requested by EVMWD. An explanation for all checklist answers will be included to provide an understanding of how the IS conclusions were reached. Mitigation measures will be clearly identified to facilitate the development of the mitigation monitoring program. Following is a description of the work effort for assessing potential environmental effects relative to each topical issue.

- Aesthetics – The proposed project would occur largely underground; however, an oxygen generator and housing unit would be installed aboveground. BonTerra Consulting will assess potential visual changes resulting from these aboveground appurtenances. Mitigation will be recommended, as necessary.

- Agriculture and Forestry Resources – Although no impacts to agriculture and forestry resources are anticipated with the proposed project, BonTerra Consulting will prepare a qualitative discussion related to agriculture and forestry resources.

- Air Quality – Based on preliminary reviews, construction and operational emissions would be well below the South Coast Air Quality Management District's (SCAQMD) emission thresholds. BonTerra Consulting will qualitatively discuss air quality impacts from the Project's short-term construction and long-term operations, and recommend mitigation measures that may be appropriate.

- Biological Resources – BonTerra Consulting will prepare a biological constraints report that will incorporate an underwater survey, as indicated in Task 2.7, Biological Survey, below. The IS/MND will summarize the findings of the biological survey, including the existing conditions, potential impacts, and mitigation measures, The potential direct, indirect, and cumulative impacts on biological resources, as a result of construction of the project, will be identified.

- Cultural Resources – BonTerra Consulting will prepare a CEQA-compliant, Phase I Cultural Resources technical letter report which will include literature reviews, complete a field survey, and applicable Native American consultation. The IS/MND will summarize the findings of the study and provide recommendations for management of any cultural resources documents within the project site.

- Geology and Soils– BonTerra Consulting will summarize geotechnical information to be provided by EVMWD and information previously prepared for the site vicinity. This scope of work assumes that the existing documentation will provide sufficient information to address the questions in the CEQA checklist. Mitigation measures will be identified, as necessary.

- Greenhouse Gas Emissions - Preliminary reviews indicate that proposed project's greenhouse gas emissions would be considerably less than any screening level for small Projects. BonTerra Consulting will qualitatively address greenhouse gas (GHG) emissions from the proposed Project.

- Hazards and Hazardous Materials - BonTerra Consulting will prepare a qualitative discussion of potential hazards associated with construction and operation of the project.

- Hydrology and Water Quality - BonTerra Consulting will summarize technical information to be provided by the EVMWD/PACE. This scope of work assumes that the information available will be sufficient to address the questions identified in the CEQA checklist.

- Land Use and Planning – BonTerra Consulting will conduct a site visit to document existing land uses surrounding the project site and will review existing planning documents relevant to the project area. A discussion of the compatibility of the project with surrounding land uses and consistency with applicable planning documents will be provided. Mitigation measures will be provided, as necessary.

- Mineral Resources - Although no impacts to mineral resources are anticipated with the proposed project, BonTerra Consulting will prepare a qualitative discussion related to mineral resources.

- Noise – BonTerra Consulting will qualitatively discuss potential short-term construction-related noise and operations noise impacts. Mitigation measures will be identified, as necessary.

- Population and Housing – Although no impacts to population and housing are anticipated with the proposed project, BonTerra Consulting will prepare a qualitative discussion related to population and housing.

- Public Services and Utilities – The proposed project would not affect public services or utilities. Appropriate documentation will be provided to confirm this assumption. Mitigation will be provided, as necessary.

- Recreation – BonTerra Consulting will assess potential direct and indirect impacts to existing and proposed recreational facilities from the project. Mitigation will be provided, as necessary.

- Transportation/Traffic – BonTerra Consulting will describe the construction-related, operations, and maintenance trips from the proposed project to address the questions in the CEQA checklist.

Preparation of IS/MND for Distribution

Following EVMWD/PACE review of the IS, BonTerra Consulting will revise the IS, if necessary, to address comments and suggested revisions provided by EVMWD/PACE that are within the scope of work. Should comments require additional technical studies or the description of the project be substantially modified, an amendment would be required. Concurrent with preparation of the revised IS, BonTerra Consulting will prepare the necessary documentation for the MND, including a proposed finding that the project will not have a significant effect on the environment, with implementation of mitigation measures. This will be submitted to the EVMWD/PACE for review with the revised IS.

Following receipt of comments from EVMWD/PACE on the IS/MND, the document will be finalized and submitted to the EVMWD for signature. A draft distribution list will be developed and submitted to the EVMWD for review and approval. BonTerra Consulting will reproduce and distribute the IS/MND to a public distribution list of up to 20 individuals and agencies. A notice that the lead agency proposes to adopt an MND needs to be provided to the public, prior to adoption of the MND. This notice should be published in a local newspaper or, at a minimum, posted at the project site. It is assumed that BonTerra Consulting would prepare the notice, but that the SMWD will submit the notice to the newspaper and/ or post it at the project site.

The IS/MND will be submitted to the State Clearinghouse and will be distributed for a 30-day public review period.

Response to Comments

Once the 30-day MND review period has ended, BonTerra Consulting will review the comments received and develop an approach to responding to these comments. Responses to comments are not required, but they are recommended to assist the lead agency in the decision making process. Topical responses, with a brief summary of the response and reference back to the larger response, will be used if multiple comments are received on the same issue. This will allow a more complete response without undue repetition. The draft responses to comments will be submitted to the EVMWD/PACE for review. In compliance with Section 15074 of the CEQA Guidelines, the decision-making body of the lead agency must consider the proposed MND together with any comments received during the public review process.

Notice of Determination

Following adoption of the MND by EVMWD, BonTerra Consulting will prepare the Notice of Determination (NOD) to be filed with the County Clerk and State Clearinghouse. BonTerra Consulting will coordinate the necessary NOD filings on behalf of EVMWD. Assuming the MND finds that the project would have an impact on biological resources, the project would require the payment of fees to the CDFG with the NOD. BonTerra Consulting will file on behalf of the EVMWD; however, the EVMWD would submit the check for the required fees.

Mitigation Monitoring

To comply with Public Resources Code 21081.6, BonTerra Consulting will prepare a mitigation monitoring program (MMP) for adoption with the MND. The MMP is required to ensure compliance with adopted mitigation requirements during project implementation. The program will be prepared in matrix format and will provide the timing and responsibility for each mitigation measure. A draft copy will be submitted for review by EVMWD/PACE. Revisions will be made accordingly.

Option B (IS/MND) Deliverables:

1. Attendance at one meeting
2. Three copies each of the screencheck IS
3. Three copies of the IS/draft MND
4. 30 copies of the IS/MND (20 for distribution, 10 for EVMWD staff and board use)
5. Three copies of draft responses to comments
6. Ten copies of final responses to comments
7. Notice of Determination
8. Five copies of the draft MMP
9. Ten copies of the final MMP

Project Management and Meetings

BonTerra Consulting will coordinate with PACE/EVMWD, as necessary, throughout the CEQA documentation process to ensure compliance with the scope and schedule. In addition to the two meetings previously identified, this scope of work assumes the need for two additional coordination meetings with EVMWD/PACE personnel. Additionally, BonTerra Consulting's principal-in-charge and/or project manager will attend one public hearing, if requested by the EVMWD.

Project Management and Meetings Deliverables:

1. Attendance at up to two team meetings. These meetings will be attended by BonTerra Consulting's project manager
2. Attendance at one public hearing. This meeting will be attended by BonTerra Consulting's principal-in-charge and/or project manager

TASK 2 REGULATORY PERMITTING SCOPE OF WORK

Task 2.1 Jurisdictional Delineation Report (Optional)

A Nationwide Permit No. 18 (Minor Discharges) requires a jurisdictional delineation if more than 10 cubic yards of discharge is proposed below the plain of the defined Ordinary High Water Mark (OHWM) or below the surface of the lake. BonTerra Consulting will contact the U.S. Army Corps of Engineers (USACE) to determine if a jurisdictional delineation is necessary. If one is, BonTerra Consulting will perform a jurisdictional delineation to map jurisdictional "waters of the U.S.," including wetlands (if present), and/or "waters of the State" for the construction of the Canyon Lake Project. The proposed project is defined as the ultimate limits of project disturbance including grading and any other construction-related activity that involve temporary and/or permanent ground/vegetation disturbances that can be characterized as dredge or fill within "waters of the U.S.," including wetlands, and/or "waters of the State". The delineation will result in the identification of the jurisdictional boundaries based on the ordinary high water mark(s) (OHWM) on the project site and indicate the presence of any adjacent wetlands not within the jurisdictional OHWM. The actual presence or absence of wetlands on site will be verified through the presence of wetlands hydrologic conditions, hydrophytic vegetation, and hydric soils pursuant to the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (USACE 2008) and the 1987 Corps Manual. Any special status species observed will be reported to the CNDDB. Waters of the State will be identified based on the presence of bed, bank, stream and riparian vegetation.

The PACE/EVMWD will provide BonTerra Consulting with existing topographic contour data at 2-foot intervals in a CAD or GIS file. This data will be used in conjunction with digital color aerial photography for recording the U.S. Army Corps of Engineers (USACE) and CDFG jurisdictional limits. The PACE/EVMWD will also provide digital files of the proposed project to be used for impact assessment, specifically the limits of permanent structural and temporary construction disturbance limits including haul routes and equipment and materials staging areas. The PACE/EVMWD will also provide BonTerra Consulting with the hydrology report as well as a list of Best Management Practices (BMPs) that would be used to avoid and/or minimize impacts to water quality during construction.

The Jurisdictional Delineation Report (JD Report) would be used to: (1) assess jurisdictional impacts to state and federal jurisdictional waters; (2) prepare an individual or nationwide permit (NWP) if project impacts fit within the established threshold for a NWP authorization; (3) provide the jurisdictional information necessary for the supporting documentation; and (3) support the request for subsequent USACE, CDFG, and RWQCB permits.

This scope includes one revision to the draft JD Report based on comments received by the PACE/EVMWD.

Task 2.2 A Preliminary Jurisdictional Determination Form (Optional)

If a jurisdictional delineation is required by the USACE, BonTerra Consulting will prepare and process a “Preliminary Jurisdictional Determination Form” through the USACE. The process for obtaining a “Preliminary Jurisdictional Delineation” for the project involves the following actions: 1) Submittal of the JD Report and a completed “Preliminary Jurisdictional Delineation Form” to the USACE. The Preliminary Jurisdictional Determination does not require review by USACE Headquarters or the Environmental Protection Agency and is generally processed within 30 days of receipt by the USACE.

Task 2.3 USACE Clean Water Act Section 404 Permit Water Quality Certification

The project is very small and would likely be authorized under Nationwide Permits 18 (Minor Discharges). BonTerra Consulting will prepare and submit a permit application to the USACE, following review and approval of the application by the PACE/EVMWD, to satisfy the requirements of Section 404(b) (1) of the Clean Water Act. The project engineer will provide a PDF of the entire project will all project components. The permit application package will include the Regional Water Quality Control Board (RWQCB) Clean Water Act Section 401 Water Quality Certification and California Fish and Game Code Section 1602 Streambed Alteration Agreement notification which will be completed under Tasks No. 4 and 5. This task includes one revision in response to comments by the PACE/EVMWD.

Please note that if the USACE determines that the project must be authorized under a Letter of Permission, a budget augment would be required to prepare the application and obtain the necessary notification information.

Task 2.4 RWQCB Clean Water Act Section 401 Water Quality Certification

A Section 401 Water Quality Certification application will be prepared and submitted to the Santa Ana RWQCB (SARWQCB) following review and approval of the application by the PACE/EVMWD. This task will include a consistency review of the Basin Plan that includes: 1.) Beneficial Uses - uses of water for drinking, agriculture, navigation, recreation, and fish and wildlife habitat; 2.) Objectives - numeric and narrative limits on water characteristics or bans on substances, which affect water quality; and 3.) Anti-Degradation Policy - which requires that existing high-quality waters be protected and maintained. This certification is necessary prior to the USACE concurring with discharges of fill material under the USACE permit process. This task includes one revision following PACE/EVMWD review. The PACE/EVMWD will also provide written descriptions and graphics (if available) of the proposed construction and post-construction Best Management Practices (BMPs). This task does not include the permit filing fees.

Task 2.5 CDFG Fish And Game Code Section 1602 Agreement Streambed Alteration Application/Notification

A California Department of Fish and Game (CDFG) Section 1602 Lake or Streambed Notification application for a Streambed Alteration Agreement will be prepared and submitted to the CDFG following review and approval of the application by the PACE/EVMWD. The submittal package will include: (1) Form FG 2023; (2) vicinity map; (3) project description; (4) jurisdictional delineation map; and (5) site photos. The application filing fees are based on total construction costs and will be provided by PACE/EVMWD prior to the submittal of the application. A check from PACE/EVMWD in the amount specified by the CDFG fee schedule shall be provided by the PACE/EVMWD to BonTerra Consulting prior to the submittal of the application. The check shall be payable to the California Department of Fish and Game. This task does not include the development of a Habitat Mitigation and Monitoring Plan (HMMP)/mitigation plan. If an HMMP is required by CDFG, the concept HMMP/mitigation plan must be completed prior to the submittal of this application and would be need to be completed under a separate task.

Task 2.6 Permit Processing and Management

Following submittal of the application packages to the affected regulatory agencies, BonTerra Consulting will contact designated agency staff to confirm receipt of the application submittal packages. BonTerra Consulting, in coordination with PACE/EVMWD, will contact the appropriate USACE, CDFG, and RWQCB staff to: (1) provide an overview of the proposed project; (2) the extent of existing jurisdictional and biological resources as defined by the JD Report; (3) identify anticipated project impacts to these resources; (4) identify proposed mitigation (if required) to address the type and value of riparian habitat impacted by the project and mitigation ratios established by USACE-accepted habitat assessment methodologies; and (5) verification of the type of regulatory permit/authorization required and schedule for permit issuance. This would typically occur as part of a pre-application meeting However, if agency staff cannot attend a pre-application meeting due to current and future state budget constraints and/or state-mandated furlough days, BonTerra Consulting will schedule meetings at these agency at their respective office(s) to provide project information identified above and obtain comments from the assigned state and/or federal staff person(s), and recommendations concerning the appropriate regulatory permit authorization(s).

BonTerra Consulting will process the USACE Section 404 permit, CDFG Section 1602 Streambed Alteration Agreement notification, and SARWQCB Section 401 WQC permit including preparation of correspondence, and participation in telephone calls between agency staff assigned to process the permits. These services also include up to two meetings with assigned regulatory agency staff during the permit application review process. BonTerra Consulting will provide regulatory permit status reports to the PACE/EVMWD each month until the permits are issued. It is difficult to anticipate all of the processing requirements associated with this task. As a result, if the proposed coordination budget exceeds the amount identified in this task, BonTerra Consulting will request a contract budget augment to complete the regulatory process.

Task 2.7 Biological Survey

A survey will be conducted in the vicinity of the proposed approximately 10' x 30' concrete base and speece cone. The biological investigators will conduct dive field survey to check for invasive mussels and other aquatic life. Two divers, and a support skipper. The survey will be conducted over field day with vessel. A biological constraints letter report will be prepared and will include existing conditions, an impact analysis, and mitigation plan (if required). This task also includes project management and up to two meetings at 3 hours each.

ATTACHMENT B

TABLE 1
BIOLOIGCAL AND REGULATORY PERMITTING
PROJECT SCHEDULE

Task	Dates
Notice to Proceed from PACE with complete project description, project plans, CAD files, and other required project data.	10/04/10
Biological survey field work completed (within a week of receipt of Notice to Proceed)	10/11/10
Draft Biological Report completed (One week following completion of field work)	10/25/10
BonTerra contacts USACE, CDFG, and RWQCB to discuss project and possible site visit. (Within five days working days of Notice to Proceed)	10/08/10
BonTerra completes field work for Jurisdictional Delineation Report if required by USACE (within one week from receipt of the Notice to Proceed).	10/11/10
BonTerra meeting with PACE and Water District to discuss appropriate CEQA documentation (within 10 days of receipt of the Notice to Proceed). If the District agrees to authorize the project under a Categorical Exemption (CE), the CE will be prepared. If a Mitigated Negative Declaration is determined to be appropriate, an Initial Study/Mitigated Negative Declaration (IS/MND) will be prepared. **Refer to Table 2 below for environmental documentation schedule**	10/14/10
BonTerra prepares draft the application package that includes: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation (previously prepared), NOD, CDFG fee receipts, revises JD report, and Approved Jurisdictional Determination Form for PACE and District Review (three days)	11/01/10
BonTerra prepares the final Permit Application Package including: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation, NOD, CDFG fee receipts, revises JD report if one is required, prepares an Approved Jurisdictional Determination Form, and proposed mitigation strategy if required by the agencies. BonTerra obtains application signatures and filing fees for CDFG 1602 and RWQCB 401 applications and submits application package to USACE, RWQCB and CDFG. (One week)	11/15/10
BonTerra contacts agencies to discuss applications to determine if additional information for a complete application. (Three weeks from date of application submittal to agencies)	11/22/10
Date agencies must determine if applications are complete. (30 days from date of application submittal)	12/ 01/10
Permit processing. Anticipated permit approvals (3 months)	1/04/11

TABLE 2
ENVIRONMENTAL DOCUMENTATION SCHEUDLE (OPTIONS A AND B)
PROJECT SCHEDULE

Task	Dates
OPTION A – CATEGORICAL EXEMPTION	
BonTerra prepares screencheck CE/CE	10/15/10-10/29/10
PACE/EVMWD reviews screencheck CE/CE	11/1/10-11/5/10
BonTerra prepares final CE/CE	11/8/10-11/19/10
EVMWD Board of Directors Meeting	TBD
OPTION B – INITIAL STUDY/MITIGATED NEGATIVE DECLARATION	
BonTerra prepares screencheck draft IS/MND	10/15/10-11/19/10
PACE/EVMWD reviews screencheck draft IS/MND	11/22/10-11/29/10
BonTerra prepares Approval Draft IS/MND	11/30/10-12/7/10
PACE/EVMWD reviews Approval Draft IS/MND	12/8/10-12/10/10
BonTerra prepares Draft IS/MND	12/13/10-12/17/10
Public Review Period	12/20/10-1/18/11
BonTerra submits draft Responses to Comments	1/24/11
1. PACE/EVMWD reviews Responses to Comments	1/25/11-1/28/11
2 BonTerra submits final Responses to Comments	2/3/11
3. BonTerra prepares Mitigation Monitoring Program	2/3/11
Public Hearings	TBD
BonTerra files Notice of Determination (within five days of project approval)	TBD

FEE ESTIMATE

September 21, 2010

TASK			FEE
BonTerra Consulting Professional Fees			
Task 1	Environmental Documentation		
	Task 1.1	Project Initiation	
	Task 1.2	Preparation of Environmental Documentation	
		(Option A – Categorical Exemption)	$6,010.00
		(Option B – Initial Study/Mitigated Negative Declaration)	$23,785.00
Task 2	Regulatory Permitting		
	Task 2.1	Jurisdictional Delineation Report (Optional)	$5,601.00
	Task 2.2	A Preliminary Jurisdictional Determination (Optional)	$1,305.00
	Task 2.3	USACE Section 404 Permit Water Quality Certification	$4,121.00
	Task 2.4	RWQCB Section 401 Water Quality Certification	$5,421.00
	Task 2.5	CDFG Fish and Game Code Section 1602 Agreement	$4,988.00
	Task 2.6	Permit Processing and Management	$11,608.00
	Task 2.7	Biological Survey	$8,160.00
		Labor Fees (Option A)	**$40,308.00**
		Labor Fees (Option B)	**$57,083.00**
		Optional Tasks	**$6,906.00**
Other Direct Costs			
Reproduction			$ .00
Deliveries			100.00
Mileage			355.00
Other			200.00
		Other Direct Costs	**$ .00**
		TOTAL FEE ESTIMATE (OPTION A)	***$41,536.00***
		TOTAL FEE ESTIMATE (OPTION B)	***$58,538.00***

PACE
17520 Newhope St., Suite 200
Fountain Valley, CA 92708
www.pacewater.com

Attachment G
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CDM Smith

cdmsmith.com