Final Report

San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan






City of San Diego

May 2014

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Prepared for

City of San Diego

May 2014

Prepared by

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This Salt and Nutrient Management Plan incorporates stakeholder input, including contributions from the ***San Pasqual Lake Hodges (SPLH) Planning Group***, the ***San Pasqual Land Task Force*** subcommittee, and the following ***San Pasqual SNMP subcommittee members***:

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Executive Summary

In conjunction with and on behalf of the City of San Diego (City), CH2M HILL prepared a Salt and Nutrient Management Plan (SNMP) for the San Pasqual Valley Groundwater Basin (Basin). The City owns most of the land in the San Pasqual Valley (Valley), and groundwater is an important asset and resource in the Valley.

The San Pasqual Vision Plan (Council Policy 600-45) reinforces the City's commitment to comprehensively protect the water, agricultural, biological, and cultural resources in the Valley. This SNMP was prepared in accordance with the San Pasqual Vision Plan and for two primary reasons. First, the City, as a major landowner and water rights holder, has a strong commitment to protect water quality in the Basin. Second, the Recycled Water Policy requires that SNMPs be prepared for each California groundwater basin or subbasin by May 2014 (State Board, 2009). Although the Basin is not currently used as a municipal water supply, it has been identified as a Tier A basin, indicating that it is of high priority for salt and nutrient management, having both significant groundwater storage capacity and significant potential for municipal groundwater use.

It is important to manage salts and nutrients in the Basin because excessive amounts of salts or nutrients in groundwater reduce its quality, which potentially impacts the beneficial uses of groundwater. High salt content in groundwater can adversely affect the vigor and health of vegetation, as well as crop yield supported by natural groundwater sources, and by irrigation of pumped groundwater. Groundwater with excessively high salt or nitrate concentrations also threatens the suitability of groundwater as a source of domestic supply. It is a combination of human activities (e.g., groundwater pumping for irrigation, synthetic fertilizer applications, and manure management) and natural processes (e.g., plant transpiration, precipitation, and groundwater movement) that, together, affect salt and nutrient concentrations in the Basin. For this reason, a comprehensive approach is needed that can address major contributing salt and nutrient sources and processes.

Groundwater quality in the Basin is regulated by the California Regional Water Quality Control Board, San Diego Region (Regional Board). The *Water Quality Control Plan for the San Diego Basin* (Basin Plan) designates beneficial uses for the groundwater in the Basin and establishes groundwater water quality objectives (WQOs) to support beneficial uses (Regional Board, 1994).

This SNMP includes characterization of the Basin and an evaluation of existing groundwater quality relative to the groundwater WQOs to evaluate the assimilative capacity for total dissolved solids (TDS) and nitrate. Existing groundwater quality in some areas of the Basin is poorer than WQOs, whereas groundwater quality meets or exceeds groundwater WQOs in other portions of the Basin. The appropriateness of existing Basin Plan groundwater WQOs was assessed in the SNMP, and groundwater WQOs are protective of beneficial uses that are consistent with the Basin management objectives and Basin utilization goals of the City. No revisions to the groundwater WQOs are proposed at this time.

Land and water use practices required to sustain beneficial uses in the Basin were evaluated. A detailed assessment of sources and loads for salts and nutrients was performed, which heavily relied on data and information provided by stakeholders. The assessment revealed the following:

- More salts are currently entering the aquifer than are being removed, which has resulted in an overall increase in groundwater concentrations of TDS over time. Based on current land uses and land management practices, the approximate net increase in TDS mass that is stored in water-bearing formations is approximately 8,000 United States (U.S.) tons annually, according to computer models developed to support the preparation of this report. Evapoconcentration of groundwater salts from irrigation pumping and passive use by riparian vegetation is a significant factor contributing to elevated groundwater TDS concentrations.

- The single largest contributing source of nitrogen is commercial crop fertilizer use at 56 percent of the Basin total, followed by landscape fertilizer use at 14 percent. Nitrogen, managed through in-Basin manure applications at the Konyn Dairy and San Diego Zoo Safari Park, represents a combined 21 percent of the Basin total, with other nonregulated small animal facilities comprising 2 percent of the Basin total. With more than 90 percent of the total nitrogen contributions to the Basin coming from fertilizer and manure use, and given the historical elevated nitrate levels in groundwater, these data suggest that ensuring effective nutrient management across agricultural and urban landscapes should be an important component of Basin water quality management.

The Basin has been studied extensively, and sufficient data were available to support the development of this SNMP. In areas where monitoring data were not available, enough information was available to make reasonable estimates of salt and nutrient loads and Basin processes to support the development of potential management strategies. However, additional monitoring will be required to support SNMP implementation. Supplemental monitoring recommendations are summarized in Table ES-1.

TABLE ES-1
San Pasqual Valley Supplemental Monitoring Recommendations
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Monitoring Item	Brief Description	Lead Entity	Target Schedule
Groundwater level and quality monitoring	Continue groundwater monitoring and data collection/archiving	City	Groundwater monitoring is ongoing.
Groundwater well metering	Phased implementation of installing flowmeters on production wells on agricultural leases	City	Initiate first phase by 2017.
Surface water flow and quality monitoring	Ongoing surface water monitoring plus a revised monitoring plan, which might include additional gaging stations	City	Surface water monitoring is ongoing. Update surface water monitoring plan by 2017.

An analytical, quantitative approach, including the development of a numerical groundwater flow model and solute transport models, was developed to assess salt and nutrient loading. Key findings from these analyses are summarized as follows:

- If salt and nutrient loading rates to groundwater remain similar to those under current conditions, it is likely that TDS and nitrate concentrations in groundwater will increase and the overall assimilative capacity for these constituents will decrease over time, according to available data and numerical models. Thus, implementing salt and nutrient management strategies to mitigate elevated TDS and nitrate concentrations is recommended.
- Data suggest that more nutrients are currently entering the aquifer than are being removed. Based on current land uses and land management practices, the forecast net increase in nitrate mass stored in water-bearing formations is approximately 520 U.S. tons annually.
- The most promising nutrient management strategy involves reducing nitrate loading to groundwater through improved nutrient management of fertilizer and manure applications. Reducing the net nitrate loading to the groundwater system by 25 percent from current levels is projected to curb the trend of increasing groundwater nitrate concentrations across the Basin and result in an overall reduction in groundwater nitrate concentrations over time, although groundwater quality response times may take 5 to 25 years depending on a variety of physical factors.
- Reductions in TDS levels may be more difficult to achieve than reductions in nitrate levels in the Basin. This is partially due to the limited flushing of groundwater and salts through the downstream end of the Basin through the San Pasqual Narrows relative to the amount of salts that enter the Basin or are

further concentrated within the Basin on an annual basis. The most effective salt management strategy that was evaluated in this report was removal of salts from the Basin by a conjunctive use project involving pumping and desalinization of groundwater extracted from high-TDS locations in the Basin and replacement of current irrigation water sources from groundwater pumping with the desalinated water. Implementing this project with 2,470 acre-feet per year of groundwater pumping and desalination is projected to decrease the total TDS mass in the alluvial aquifer by approximately 7 percent over the next 50 years. Projects such as this, potentially combined with conjunctive use projects for seasonal groundwater storage and extraction, could be further optimized for both water supply and water quality benefits.

- Groundwater modeling suggests that it takes more than a decade in some areas of the Basin for surface constituents to reach the water table, and lateral groundwater movement of constituents through the aquifer occurs over multiple decades. Site-specific flow dynamics in the Basin cause some subareas to transmit groundwater and constituents more readily than in other subareas. Consequently, it may take several years to decades after implementing salt and nutrient management strategies before there would be noticeable changes in TDS and nitrate concentrations in groundwater in some portions of the Basin.
- According to the groundwater model presented in this report, the annual nitrate mass flux from the Basin alluvial aquifer to Lake Hodges could increase by up to 20 percent over the next 50 years. This increase might occur regardless of reasonable reductions in nitrogen loading to the groundwater system over the next 50 years. The model suggests that most of the nitrate mass that is already present in the groundwater system near the downstream end of the Basin and in the San Pasqual Narrows will eventually flow into Lake Hodges, unless intercepted/consumed by vegetation or mitigated by a physical project.
- Uncertainty in salt and nutrient loading rates and transport processes, compounded by slow groundwater quality responses to land management changes, complicates forecasting the impacts of current and potential future management practices. Although predictive uncertainty is part of any numerical model forecast, this uncertainty should not prevent stakeholders from gaining insight into the Basin hydrologic processes and expected outcomes from potential projects or management actions. Thus, use of the salt and nutrient source assessment and groundwater model results presented here to help guide the overall recommendations for future salt and nutrient management efforts within the Basin is reasonable and appropriate.
- Groundwater quality varies spatially, both horizontally and vertically. Groundwater quality also varies temporally, depending on the quantity of water being stored in the aquifer and by constituent transport through the aquifer. A qualitative analysis of TDS and nitrate concentration trends indicates that groundwater quality may have improved at certain locations, particularly for nitrate, during the last 5 years. However, TDS and nitrate concentration trends at other locations indicate that groundwater quality may be declining, which is shown by the groundwater model forecasts. A statistical trend analysis has not been conducted to confirm any actual trends that can be separated from natural variations; however, trend analysis of groundwater constituent concentrations should be included as part of future efforts to track water quality changes and to assess the effectiveness of salt and nutrient management strategies.

This SNMP concludes that groundwater quality associated with salinity and nutrients is expected to degrade unless management strategies are implemented. Therefore, the SNMP identifies and evaluates salt and nutrient management strategies for water quality protection and enhancement in the Basin. It is unlikely that implementation of any single management strategy will effectively mitigate elevated TDS and nitrate concentrations at all locations within the Basin. Effective resource management will likely require implementing a combination of management strategies, including additional monitoring and reporting, refining and expanding upon existing studies, and potentially implementing focused nutrient and salinity management projects. A series of potential management strategies is presented in the SNMP, some of which require further analysis or stakeholder input. SNMP management strategies that have been selected for implementation are summarized in Table ES-2.

TABLE ES-2
Implementation Plan Summary
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Selected Management Strategy	Brief Description	Lead Entity	Target Completion Schedule
Nutrient Management Plans	Site-specific nutrient management plans and annual reporting for certain qualifying City-leased lands. Develop program and incorporate requirements into leases at the time of renewal.	City	Define a nutrient management planning approach by mid-2016. Annual reporting by qualifying lessees each year thereafter.
Nutrient Management Outreach	Promote the adoption of nutrient management best management practices on stakeholder and private lands throughout the subcatchment.	City	Complete the first phase of outreach by mid-2016.
Stormwater Management	Evaluate leases for stormwater management on agricultural lands and promote efforts to use natural treatment systems for nutrient treatment.	City	Evaluate leases by mid-2016. Present a status of natural treatment system projects in the Basin in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.
Septic System Evaluations	Develop procedures to evaluate septic system condition when renewing City leases and coordinate with lessees to perform regular septic system maintenance.	City	Coordinate with the City Real Estate Assets Department and develop lease terms related to septic system evaluations and maintenance by July 2016.
Riparian Area Management	Continue supporting and cooperating with other entities to promote on-the-ground projects for control of invasive non-native species in the Basin.	City	Update on progress in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.
Conjunctive Use	Expand upon previous studies and projects to further evaluate conjunctive use project(s) aimed at reducing salt accumulation in the aquifer	City	Present findings in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.
Groundwater Resource Protection	Proceed with recommendations for well construction, abandonment, and deconstruction, and for protecting recharge areas as described in the *San Pasqual Groundwater Management Plan* (City of San Diego Water Department, 2007). Include the actions of wellhead condition assessments and backflow prevention program.	City	Present findings in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.

The City intends to evaluate management strategy effectiveness approximately every 2 years in conjunction with the San Pasqual State of the Basin updates. Management strategy effectiveness reviews will include determining whether amending or adding management strategies should be evaluated further. The City intends to conduct SNMP audits every 10 years. SNMP audits will be conducted by the City in coordination with other Basin stakeholders every 10 years to determine whether comprehensive updates to the SNMP are needed.

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Acronyms and Abbreviations

ac-ft	acre-feet
AFO	animal feeding operation
AFY	acre-feet per year
ASR	aquifer storage and recovery
B	boron
Basin Plan	*Water Quality Control Plan for the San Diego Basin* (Regional Board, 1994)
Basin	San Pasqual Valley Groundwater Basin
bgs	below ground surface
BMO	Basin Management Objective
BMP	best management practice
CEC	constituent of emerging concern
CEQA	California Environmental Quality Act
City	City of San Diego
Cl	chlorine
CNMP	Comprehensive Nutrient Management Plan
CWA	County Water Authority
DO	dissolved oxygen
DWR	California Department of Water Resources
EC	electrical conductivity
ELAP	Environmental Laboratory Approval Program
ESA	environmentally sensitive area
ET	evapotranspiration
Fe	iron
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act of 1972
GFM	groundwater flow model
GMP	*San Pasqual Groundwater Management Plan* (City of San Diego Water Department, 2007)
gpm	gallons per minute
IWMP	Irrigation Water Management Plan
lb	pounds
lb/yr	pounds per year
MBAS	methylene-blue active substance
MCL	maximum contaminant level
mg/L	milligrams per liter
mgd	million gallons per day
mi^2	square mile
mL	milliliters

Mn	manganese
MS4	municipal separate storm sewer system
MSCP	Multiple-Species Conservation Program
Na	sodium
NADP	National Atmospheric Deposition Program
NDVI	Normalized Difference Vegetation Index
NH_3	un-ionized ammonia
NIR	near infrared
NMP	Nutrient Management Plan
NO_3	nitrate
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTN	National Trends Network
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
QA/QC	quality assurance/quality control
Regional Board	California Regional Water Quality Control Board, San Diego Region
Safari Park	San Diego Zoo Safari Park
SMB	Soil Moisture Budget
SNMP	Salt and Nutrient Management Plan
SO_4	sulfate
SOP	standard operating procedure
State Board	State Water Resources Control Board
SUSMP	Standard Urban Stormwater Mitigation Plan
SWPPP	Stormwater Pollution Protection Plan
TDS	total dissolved solids
TN	total nitrogen
U.S.	United States
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
Valley	San Pasqual Valley
WDRs	waste discharge requirements
WQO	water quality objective

SECTION 1

Introduction

1.1 Basin Overview

The San Pasqual Valley Groundwater Basin (Basin) is an alluvial aquifer that underlies the San Pasqual Valley (Valley) and significant portions of Cloverdale Canyon, Rockwell Canyon, and Bandy Canyon in north San Diego County. As shown in Figure 1-1, the Basin is located upstream from Hodges Reservoir (colloquially known and referred to as Lake Hodges) and downstream from Sutherland Reservoir. The City of San Diego (City) owns the land and water rights to a 7.1-square-mile (mi^2) area of the Basin. The City leases much of this land for agricultural and residential uses, for which groundwater from the Basin serves as the primary source of water supply.

1.2 State of California Recycled Water Policy

Groundwater quality in the Basin is regulated by the California Regional Water Quality Control Board, San Diego Region (Regional Board). The *Water Quality Control Plan for the San Diego Basin* (Basin Plan) designates beneficial uses for the groundwater in the Basin and establishes groundwater quality concentration objectives to support beneficial uses (Regional Board, 1994). Beneficial uses of the Basin are summarized in Section 2.3.

The State of California Recycled Water Policy was established in February 2009 with the State Water Resources Control Board (State Board) adoption of Resolution No. 2009-011. The Recycled Water Policy requires the State Board and the nine Regional Water Quality Control Boards to exercise their authority to the fullest extent possible to encourage the use of recycled water, consistent with state and federal water quality regulations and water quality protection needs.

Although the State of California Porter-Cologne Act empowers Regional Boards to develop and enforce water quality objectives (WQOs) for groundwaters and surface waters of the state, the Regional Boards' jurisdiction for permitting and enforcement is limited to the regulation of wastewater and recycled water. The Recycled Water Policy recognizes that wastewater and recycled water projects might represent only a portion of the overall salt and nutrient loads within a watershed or groundwater basin. To address this, the Recycled Water Policy requires that Regional Boards identify and manage salt and nutrient loads on a basinwide or watershed basis. The Recycled Water Policy identifies stakeholder-driven Salt and Nutrient Management Plans (SNMPs) as the appropriate means for identifying and managing salt and nutrient loads.

When completed, SNMPs could trigger the need to modify the Basin Plan groundwater WQOs if the SNMP concludes that (1) existing Basin Plan groundwater WQOs are outdated or inappropriate, or (2) basin-specific salt and nutrient management strategies are required to ensure conformance with existing Basin Plan WQOs. In this latter event, the SNMP must present a plan for implementing the required salt and nutrient management strategies. The Regional Board can then consider incorporating the SNMP into a revised Basin Plan.

1.3 Purpose of Report

The State Board adopted a Recycled Water Policy in February 2009. The Recycled Water Policy requires that SNMPs be prepared for each California groundwater basin or subbasin by May 2014, but the policy does not define what constitutes a groundwater basin. The Regional Board has determined that SNMPs are required for groundwater basins, as published in *California's Groundwater Bulletin 118* (DWR, 2003). In that same document, California Department of Water Resources (DWR) designated the Basin as Groundwater Basin No. 9-10. Additionally, *Proposed Guidelines for the Salinity/Nutrient Management Planning in the San Diego*

Region (SNMP Guidelines) classifies San Diego region aquifers and presents prioritizations for SNMP development (Welch, 2010). The Regional Board endorsed the SNMP Guidelines in 2010.

The City is using these SNMP Guidelines to conduct citywide SNMP planning. The Basin is listed as a Tier A Basin in the SNMP Guidelines (see Section 1.4.2 for additional discussion of Basin categorization).

The purpose of this report is to present a stakeholder-driven SNMP for the Basin with the following objectives:

- Identify water quality constituents of interest in the Basin that are relevant to the SNMP.
- Assess sources and loads for the identified constituents.
- Identify land and water use practices required to sustain beneficial uses in the Basin and, if necessary, identify mitigation measures.
- Assess the appropriateness of existing Basin Plan groundwater WQOs.
- Identify and evaluate salt and nutrient management strategies for water quality protection and enhancement in the Basin.
- Develop a plan, if applicable, for implementing potential salt and nutrient management strategies aimed at achieving compliance with Basin Plan groundwater WQOs.

1.4 Work Plan

The framework, approach, and content of this SNMP follows recommendations presented in *Proposed Guidelines for Salinity and Nutrient Management Planning in the San Diego Region* (SNMP Guidelines) that the Regional Board endorsed in 2010 (Welch, 2010). In accordance with the adopted guidelines, the SNMP for the Basin is tailored to reflect the significant prior groundwater assessment and management studies in the Basin that the City has completed (see Section 2).

1.4.1 San Diego Region SNMP Guidelines

To achieve the Recycled Water Policy goal of promoting recycled water use in a manner consistent with protecting existing and potential groundwater use, the Regional Board in 2009 and 2010 coordinated with the San Diego County Water Authority and Southern California Salinity Coalition to provide local agencies with guidance in developing SNMPs in the San Diego Region. As part of this effort, a series of stakeholder workshops were conducted to identify regional SNMP needs and to develop a set of guidelines for agency use in developing SNMPs. On the basis of this input, the SNMP Guidelines document was finalized (Welch, 2010) with the following goals:

1. Establish a framework under which SNMPs can be developed by interested agencies and stakeholders.
2. Assess the Region's aquifers and identify those that are suitable for the development of SNMPs.
3. Categorize the Region's groundwater basins for the development of SNMPs and present "tiered" SNMP work scopes for each basin category.
4. Identify roles of agencies and categories of potential stakeholders.
5. Identify suggested approaches and the expected level of effort for completing the required SNMP tasks for each of the required SNMP phases.
6. Provide guidance on which SNMP constituents should be addressed.
7. Identify strategies to be considered in managing salt and nutrient sources and loads.
8. Outline the process for regulatory review and approval of developed SNMPs.

The Regional Board formally endorsed the SNMP Guidelines on November 10, 2010, with the adoption of Resolution R9-2010-0125.

1.4.2 Basin Categorization

The SNMP Guidelines include tiered SNMP scopes of work that are based on groundwater basin capacity, potential yield, hydrogeologic complexity, water quality, existing and potential groundwater use, and recycled water compatibility factors. Basin categories range from Tier A through Tier E, with Tier A basins being the largest (storage capacities likely in excess of 60,000 acre-feet [ac-ft]) and having significant existing or proposed municipal groundwater use. Basin categories Tier B through Tier E generally represent basins with gradually smaller storage capacities and having gradually less complexities for the categorization factors listed above. The SNMP Guidelines indicate that the Basin described herein is one of five Tier A basins recommended as warranting the most detailed level of SNMP assessment (Welch, 2010).

1.4.3 SNMP Work Plan Elements

The approach used for the Basin SNMP is based on recommendations presented in the SNMP Guidelines for Tier A basins, encouraging the implementation of a five-step approach for completing SNMPs, as follows:

1. **Initial Basin Characterization**. The SNMP Guidelines recognize that significant groundwater studies previously have been conducted within Tier A basins and recommend making use of this existing information where available for the initial Basin characterization. The City has completed a number of comprehensive groundwater investigations in the Basin, which have been used in completing an initial characterization of the Basin in this SNMP. Information from these studies, along with stakeholder input, is used to finalize the SNMP study area and to identify water quality constituents of interest. Section 2 of this SNMP presents the initial characterization for the Basin.
2. **Identify and Quantify Salt and Nutrient Loads**. Existing groundwater studies, stakeholder input, and evaluations as part of this SNMP effort are used to identify and quantify salt and nutrient loads associated with constituents of interest in the Basin. In accordance with recommendations presented in the SNMP Guidelines, numerical groundwater models of the Basin have been developed to assess how the salt and nutrient loads might affect groundwater quality. Section 3 of this SNMP presents the identification/ quantification of salt and nutrient loads for the Basin and provides an overview of the numerical groundwater models developed to evaluate these loads.
3. **Identify Supplemental Monitoring Needs**. In accordance with the SNMP Guidelines for Tier A basins, Section 4 of this SNMP evaluates existing Basin data and assesses whether additional data are required to support SNMP management strategies. Future monitoring needed to support SNMP implementation is also presented in Section 4.
4. **Identify and Evaluate Management Strategies**. For Tier A basins, the SNMP Guidelines encourage agencies to (1) identify potential strategies for management of salt and nutrient loads; (2) utilize computer modeling to evaluate how the strategies might influence water quality and compliance with the Basin Plan; (3) select appropriate management strategies for implementation in accordance with stakeholder input; (4) assess Basin Plan compliance and identify, if applicable, Basin Plan modification recommendations that would be presented to the Regional Board; and (5) identify, if applicable, recommended action plans for implementing the recommended management strategies. Section 5 of this SNMP was developed using information from prior studies and stakeholder input to identify potential salt/nutrient management strategies for the Basin. Computer modeling is then used to evaluate how the identified strategies could potentially influence groundwater quality and Basin Plan compliance. Stakeholder input is also incorporated into the selection of recommended salt and nutrient management strategies for the Basin. Section 5 also evaluates existing Basin Plan WQOs and identifies recommended salt and nutrient implementation actions.

5. **Plan Effectiveness**. In accordance with the SNMP Guidelines for Tier A basins, Section 6 of this SNMP identifies an approach for assessing SNMP effectiveness and presents a proposed implementation plan for evaluating SNMP effectiveness.

1.5 Stakeholder Outreach

SNMP Guidelines for Tier A basins in the San Diego Region stress the importance of stakeholder input in completing SNMPs. Additionally, the Regional Board issued waste discharge requirements (WDRs) for the San Pasqual Valley Academy, specifying that the Academy is a stakeholder in the SNMP development process. Other WDRs issued for the operation of facilities in the Basin predate the SNMP process; however, these entities are also considered stakeholders in the process. The SNMP presented herein implements stakeholder outreach recommendations from the SNMP Guidelines and Recycled Water Policy into each of the SNMP Work Plan elements.

The SNMP stakeholder outreach program for the Basin SNMP is modeled after a comprehensive stakeholder outreach program conducted by the City of San Diego in the Basin in 2007 as part of development of the City's *San Pasqual Groundwater Basin Management Plan* (GMP) (City of San Diego Water Department, 2007). As part of the GMP, the City identified government agencies, regulatory agencies, nongovernment entities, and other commercial and private entities (including Valley leaseholders) that may have an interest in Basin groundwater. The GMP is recognized by the State as being compliant with standards established by Assembly Bill 3030. Since completing the GMP in 2007, the City has periodically reviewed and updated the list of stakeholders that might have interest in Basin groundwater.

Because the City owns almost all of the land overlying the Basin, the City has taken the lead on this SNMP and the stakeholder process. An initial stakeholder meeting was conducted in August 2013 to introduce the SNMP process to the stakeholder group. In this meeting, the SNMP process and implementation schedule, SNMP goals, SNMP study area boundaries and water quality constituents of interest. In addition, monitoring information or potential data gaps were presented.

Subsequently, a presentation was given to stakeholders in November 2013 where stakeholders were invited to comment on a preliminary work-in-progress draft SNMP completed in October 2013. Additional SNMP comments, along with input on salt and nutrient loading, were provided during December 2013 through February 2014. A presentation of the draft final SNMP findings and selected management was subsequently delivered on April 3, 2014, at a San Pasqual Land Use Task Force meeting. Responses to stakeholder comments are presented in Appendix A.

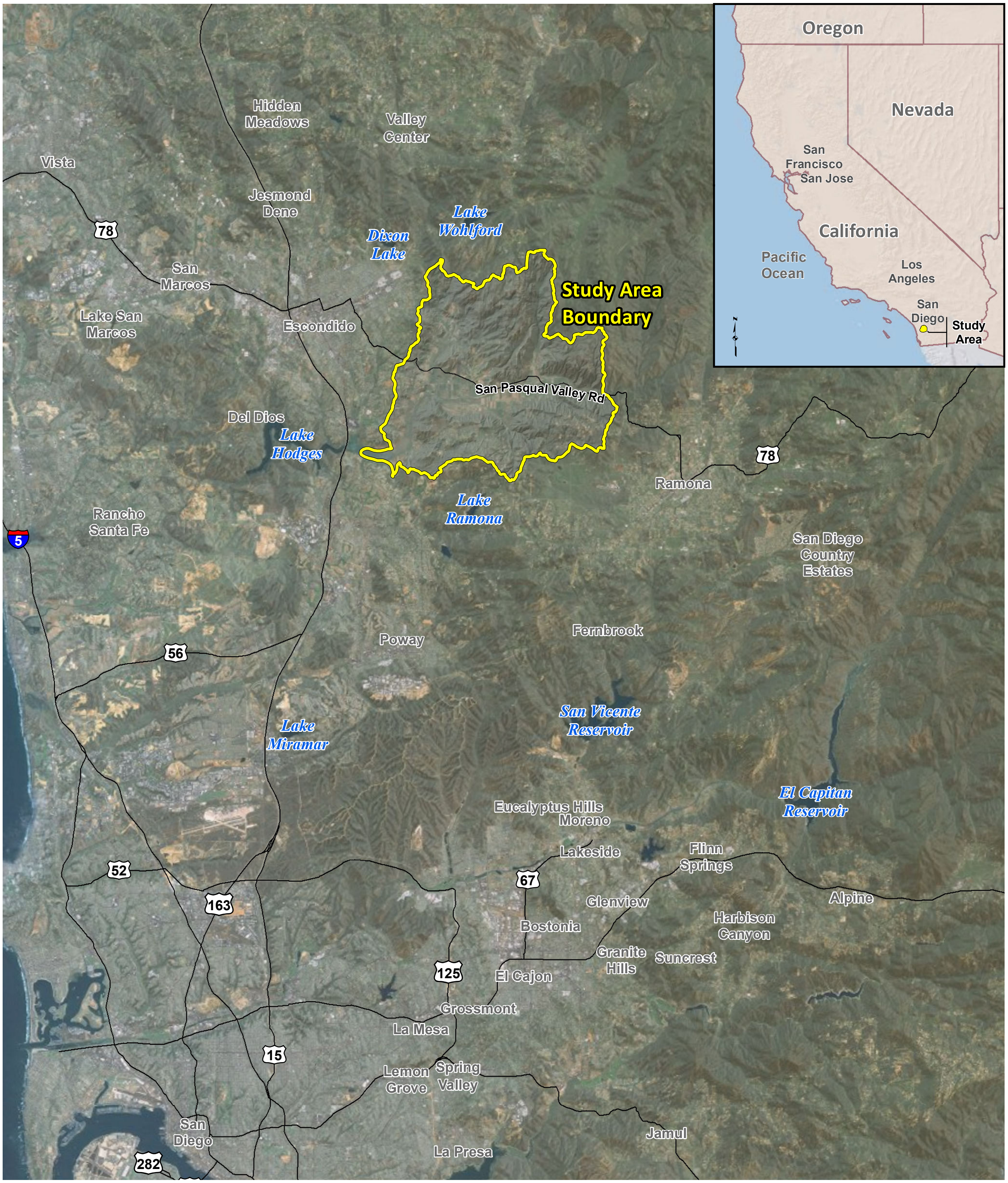

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FIGURE 1-1
Regional Location Map
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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SECTION 2

Initial Basin Characterization

2.1 Study Area

The Basin is located near the southern coast of California, approximately 25 miles north of downtown San Diego and approximately 5 miles southwest of the city of Escondido (Figure 1-1). The Basin is located in the South Coast Hydrologic Region within the San Dieguito Drainage Basin, which is the fourth largest drainage basin in San Diego County (City of San Diego Water Department, 2007). The San Dieguito Drainage Basin starts in the Laguna Mountains, flows west-southwest, and ultimately terminates at the Pacific Ocean (Figure 2-1). The Basin is bounded by Lake Hodges to the southwest and by nonwater-bearing rocks of the Peninsular Ranges to the northeast (DWR, 2003). The basinwide estimate of groundwater storage capacity in the existing Basin is approximately 58,000 acre-feet (Izbicki, 1983).

The Basin encompasses two main drainages—Santa Ysabel Creek and San Dieguito River. Santa Ysabel Creek starts at Sutherland Reservoir and flows west-southwest through the middle of the Basin before merging with Cloverdale Creek. The San Dieguito River begins at the confluence of Santa Ysabel Creek and Santa Maria Creek before flowing into Lake Hodges and resuming flow downstream from Lake Hodges Dam. The Sutherland Reservoir Watershed is approximately 34,470 acres of forested mountains but is not contained in the Lake Hodges Watershed. The Lake Hodges Watershed encompasses the entire Basin and is approximately 158,420 acres of mostly forested mountain landscape. The Lake Hodges Watershed includes the city of Ramona, a portion of the cities of Escondido and Rancho Bernardo, and the Pamo Valley and Santa Maria Valley groundwater basins. The study area also includes areas served by the Rincon Del Diablo, Escondido, Poway, and Ramona Water Districts.

2.2 Basin Boundary

DWR originally defined the Basin as underlying the Valley and Cloverdale, Rockwood, and Bandy canyons in central San Diego County. The City of San Diego and DWR have reevaluated this boundary based on hydrologic and geologic conditions of the Basin. Recently, DWR staff re-assessed the areal extents of the alluvial aquifer, and these changes will likely appear in a future revision of Bulletin 118. DWR found that much of the previous Basin boundary included areas of bedrock outcrops and very thin alluvial “fingers,” and that wells in those areas likely would not be drawing water from the alluvium. Figure 2-2 shows the former Basin boundaries derived from a previously developed groundwater flow model (MWH, 2009) and the current Basin boundaries.

The City owns most of the land in and around the Basin, and much of this property is leased to individuals for various agricultural and commercial land uses (Figure 2-3). Many of the leases, such as the San Diego Zoo Safari Park to the north, have long-term leases with little to no turnover of lessees. Because the City owns most of the Basin property, it has the ability to promote sustainable practices to improve and maintain groundwater quality.

2.3 Beneficial Uses

The City manages the Basin for multiple uses, which must be considered when making programmatic changes to the management of any single resource in the Basin. Basin utilization objectives and actions must be consistent with the following San Pasqual guiding policy documents:

- *City of San Diego General Plan, Conservation Element* (City of San Diego, 2008)
- *San Pasqual Valley Community Plan* (City of San Diego Planning Department, 2006)
- *City of San Diego San Pasqual Vision Plan* (City of San Diego, 1995)

- *San Diego Multiple-Species Conservation Program (MSCP) Subarea Plan* (County of San Diego, 1998)
- Council Policy 700-14, "Management of City-Owned Properties within the Focused Planning Area of the San Dieguito River Park"
- Council Policy 600-45, "Protection of Water, Agricultural, Biological, and Cultural Resources within the San Pasqual Valley"

Many of the valued resources in the Valley are water dependent and are considered beneficial uses of the water resources. One such example is groundwater-dependent habitat and natural vegetation. The remainder of this section describes those beneficial uses of water currently recognized by the Regional Board.

The Basin (designated as Hydrologic Unit 905.3 by the Regional Board) is under the regulatory jurisdiction of the San Diego Regional Board.[1] San Diego Regional Board policies and requirements are established in the Basin Plan, which identifies specific designated beneficial uses of water within each watershed and groundwater basin in the San Diego Region. Knowing how the water will be used is the first step in establishing the objectives of water quality in the Basin Plan. These objectives are discussed in Section 2.7 of this report. Table 2-1 presents designated beneficial uses of groundwater and surface water in the Basin.

TABLE 2-1
Designated Beneficial Uses in the San Pasqual Hydrologic Unit (Hydrologic Unit 905.3)
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Body of Water	Existing Beneficial Use	Potential Beneficial Use
Surface Water: San Dieguito River	Municipal Supply (MUN)	Contact Water Recreation (REC-1)
	Agricultural Supply (AGR)	
	Industrial Service Supply (IND)	
	Industrial Process Supply (PROC)	
	Non-Contact Water Recreation (REC-2)	
	Warm Freshwater Habitat (WARM)	
	Wildlife Habitat (WILD)	
	Rare, Endangered or Threatened Species (RARE)	
Groundwater: Basin	Municipal Supply (MUN)	
	Agricultural Supply (AGR)	
	Industrial Service Supply (IND)	

[1] The San Diego Region includes the portion of San Diego County that is tributary to the Pacific Ocean, along with the southern portions of Orange and Riverside counties.

2.4 Prior Groundwater Studies and Analyses

The Basin has been studied comprehensively for groundwater supply development numerous times during the last 40 years. Some of the recent studies identified the potential for:

- Developing potable supply without the need for demineralization treatment in the eastern portion of the Basin
- Developing potable supply with demineralization treatment in the western portion of the Basin
- Using imported water, Sutherland Reservoir releases, or recycled water for artificial aquifer recharge

Recent changes in California Department of Public Health groundwater recharge guidelines (proposed regulations) enhance the potential feasibility of such future projects in the Basin. In addition to these potential future water uses, several existing uses of groundwater have been studied extensively.

The following reports establish the state of current knowledge of the Basin's groundwater resources:

- **Metcalf & Eddy, September 1997, *San Pasqual Valley Water Resources Management Plan.*** This report presented a recommended plan for the development and management of resources in the Valley. Items in the report that are particularly relevant to this SNMP include an overview of the history of the Valley and descriptions of the San Pasqual Watershed Management Project and San Pasqual Groundwater Management Project.
- **CH2M HILL, April 2001. *Groundwater Asset Development and Protection Program, Characterization of Assets, San Pasqual Groundwater Basin.*** This report summarized groundwater in the Valley, including information such as historical groundwater elevations, water budget, sources of recharge, and Basin characterization.
- **City of San Diego Water Department, November 2007, *San Pasqual Groundwater Management Plan* (GMP).** This report was identified as an adaptive management plan for understanding how to best manage groundwater the Basin. The report includes a preliminary summary of proposed management actions for Basin groundwater management.
- **CDM, October 2008. *Well Construction Report.*** This report provides useful monitoring well information that was used to identify groundwater parameters and model calibration targets presented in this SNMP.
- **MWH, April 2009, *San Pasqual Groundwater Basin Conjunctive Use Study –Task 3.1 Groundwater Model Documentation.* Technical Memorandum.** This study evaluated various potential alternatives for combined aquifer storage and recovery (ASR) using imported water for the primary purpose of developing a supplemental municipal water supply.
- **CDM, May 2010, *San Pasqual Groundwater Conjunctive Use Study Final Report.*** This study presented findings of predesign facility plans, cost estimates, and economic analyses for conjunctive use alternatives. A groundwater flow model was developed to support this effort.
- **MWH, June 2010, *Salinity Study Memorandum: San Pasqual Agricultural Water and Salinity Budget.*** A salinity assessment was conducted, including the development of a salt budget for the Basin. Existing confined animal operations were also documented. Potential on-farm management strategies were presented.
- **MWH, June 2011a, *2010 Groundwater Management State of the Basin Report.*** The report documents groundwater management activities performed by the City between January 2008 and June 2010. The report also documents the ongoing implementation of the GMP and recommends future implementation activities.

- **MWH, September 2011b, *San Pasqual Surface Water Monitoring.*** Alternatives and recommendations to improve surface water flow estimating or monitoring in the Basin were presented in this technical memorandum.
- **RBF Consulting, November 2011, *San Pasqual Brackish Groundwater Desalination Demonstration Project*.**
- **California Regional Water Quality Control Board, San Diego Region, 1994, *Water Quality Control Plan for the San Diego Basin (9)*. Inclusive of all Amendments Effective on or before April 4, 2011.** Referred to as the Basin Plan, this document presents the plan for preserving and enhancing the quality of water resources in the San Diego Region, including WQOs for the Basin.

The primary existing plan that establishes current and planned groundwater management strategies in the Basin is the GMP (City of San Diego Water Department, 2007). Progress toward achieving the Basin Management Objectives established in the GMP is reported biennially in the State of the Basin updates, the last of which was the *2010 Groundwater Management State of the Basin Report* (MWH, 2011a). This SNMP builds upon the groundwork that was established during development the GMP.

2.5 Existing Monitoring Programs

Existing surface water and groundwater monitoring programs are presented in this section. The Basin is not currently used as a source of municipal agency water supply. As a result, monitoring for constituents of emerging concern (CECs) is not currently required by the California Department of Public Health.

2.5.1 Surface Water

Surface water inflows have previously been estimated to contribute up to 80 percent of the Basin groundwater recharge. Tributaries to the Valley include Santa Maria Creek, Santa Ysabel Creek, Cloverdale Creek, Guejito Creek, and Sycamore Creek (Figure 2-4). Surface water monitoring of these creeks is discussed in the following subsection.

The confluence of Kit Carson Creek is downstream from the Basin boundary. Del Dios, Felicita, Green Valley, and Moonsong Creeks flow directly into Lake Hodges. Del Dios and Felicita Creeks are entirely west of Interstate 15, and the confluence of Green Valley Creek is west of Interstate 15. These creeks do not have an effect on groundwater in the Valley, but they do influence water quality in Lake Hodges.

2.5.1.1 City of San Diego Surface Water Monitoring

City personnel have monitored surface water quality on a monthly basis from the year 2000 through present day at Santa Maria Creek, Santa Ysabel Creek, Cloverdale Creek, Guejito Creek, Sycamore Creek, and Kit Carson Creek (Figure 2-4). The goal of City personnel is to monitor surface water quality monthly when the streams in the Valley are flowing. The basic water quality data are measured in the field with a Hydrolab® sonde; water quality data include temperature, dissolved oxygen (DO), pH, electrical conductivity (EC), and oxidation-reduction potential (ORP). Nutrient data are collected as grab samples that are analyzed in the City's Water Quality Laboratory. The laboratory is certified through the Environmental Laboratory Approval Program (ELAP). Fieldwork and laboratory work described herein are completed following quality assurance/quality control (QA/QC) protocols using the standard operating procedures (SOPs) established by the Water Quality Laboratory. A hand-held flowmeter and tape measure are used to measure width, depth, and velocity of streams of interest.

These parameters inform stream flow computations, as do the parameters associated with streambed gradient and roughness. A continuous record of stream flow into the Basin is not currently collected; however, City personnel measure instantaneous stream flows during surface water quality sampling events. Because of the intermittent nature of the stream flow data collection, accurate estimates of stream inflow are not possible. For this reason, it is important to develop a continuous record of stream flow for the watershed areas that are not currently monitored (MWH, 2011b).

2.5.1.2 USGS Surface Water Monitoring

Currently, three active U.S. Geological Survey (USGS) stream gages record daily flows in the study area (Figure 2-4). These include gages on Santa Ysabel Creek near Ramona at Station 11025500, on Guejito Creek near San Pasqual at Station 11027000, and on Santa Maria Creek near Ramona at Station 11028500. Real-time stream discharge data are typically recorded every 15 to 60 minutes. Table 2-2 lists drainage area and gaging status by watershed. Current USGS monitoring covers approximately 85 percent of the total drainage area. The stream flow from Basin and the Cloverdale, Sycamore, and Kit Carson drainages are not monitored; although the Cloverdale, Sycamore, and Kit Carson drainages are important because of land use changes within these drainages. They now likely contribute more surface water and groundwater because of more irrigation returns and urban runoff than they have had previously (MWH, 2011b).

TABLE 2-2
Summary of Drainage Areas and Gaging Status
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Watershed	Drainage Area (mi^2)	Flow Rate/Stage Currently Monitored (Gage ID Number)	Notes
San Dieguito River	250	No	Basin outlet
Santa Ysabel	128	Yes (11025500)	Large area
Santa Maria	58	Yes (11028500)	Large area
Guejito	25	Yes (11027000)	Large area
Cloverdale	18	No	Small area, irrigation returns
Sycamore	less than 10	No	Small area, irrigation returns
Kit Carson	less than 10	No	Small area, irrigation returns

mi^2 square mile

2.5.2 Groundwater

As described in the GMP (City of San Diego Water Department, 2007), groundwater quality data within the Basin have been collected and reported periodically since 1950 (DWR, 1993; Izbicki, 1983; Greeley and Hansen, 1993; CH2M HILL, 2001).

2.5.2.1 City of San Diego Groundwater Monitoring

Three sets of monitoring wells are in the Basin—USGS groundwater level monitoring wells, City of San Diego groundwater level monitoring wells, and City of San Diego water quality monitoring wells (Figure 2-5).The City measures groundwater levels from a network of 10 monitoring wells in the Basin each month. In addition, three USGS groundwater wells are monitored daily at three different depths. The City attempts to collect and analyze groundwater samples quarterly from a network of 11 wells throughout the Basin; however, the recent sampling frequency has fluctuated with only two sampling events in some years. The City analyzes samples for a broad suite of organic and inorganic compounds (MWH, 2011a). USGS collects one water quality sample after completion of new wells.

2.5.2.2 USGS Groundwater Monitoring

USGS tracks groundwater levels at three wells in the Valley—SDSY (Santa Ysabel), SDLH (Lake Hodges), and SDCD (Cloverdale), as shown in Figure 2-5. Water levels for SDSY have been measured daily since April 29, 2011; the total depth of SDSY is 355 feet. Water levels for SDLH have been measured daily since February 14, 2013; the total depth of SDLH is 280 feet. Water levels for SDCD were taken on March 13, 2013; the total depth of SDCD is 287 feet. USGS typically takes water quality samples for analysis once after completion of the wells, prior to installing water level monitoring equipment. Groundwater quality summaries can be found in Tables 2-6 and 2-7 in Section 2.7.2.2.

2.6 Basin Hydrology and Hydrogeology

This section describes a framework for the movement of water in the Basin and its immediate vicinity. It also describes how the four main streams in the Basin are connected to the underlying groundwater system and to Lake Hodges.

2.6.1 Precipitation

The climate of the Basin is characteristic of a Mediterranean-type climate. The 1971 to 2000 average precipitation is approximately 14.7 inches per year.

2.6.2 Anthropogenic Water Movement

Human activity such as groundwater pumping, conveyance, and irrigation alters the natural inflows and outflows of hydrologic systems. Much of the Basin's irrigation water use is satisfied by pumping from groundwater wells described in Section 2.6.4. However, the city of Escondido and other water districts in the Basin use water that is imported primarily from the First San Diego Aqueduct. These water districts service the majority of residential customers in the Basin plus a substantial fraction of the irrigation use in areas without access to Basin groundwater. The First San Diego Aqueduct, which is owned and operated by the San Diego County Water Authority (CWA), runs to the west of the Basin, near the east end of Lake Hodges (CDM, 2010). The City's Public Utilities Department provides municipal water supply to its service customers. The current source of water is imported supplies via the San Diego CWA aqueducts, as well as from nine reservoirs fed from local runoff (City of San Diego Water Department, 2007).

2.6.3 Surface Water Hydrology

Surface water in and around the Basin includes Sutherland Reservoir to the northeast, Lake Hodges to the southwest, and a series of streams draining off the Peninsular Mountain Ranges to the northeast. Sutherland Reservoir is located upstream from Santa Ysabel Creek in the eastern portion of the San Dieguito Drainage Basin. Its 29,680-acre-foot capacity has been used to regulate flows in Santa Ysabel Creek since 1954 (MWH, 2011b). The water from Sutherland Reservoir is used primarily as water supply. The major streams feed into Santa Ysabel Creek and San Dieguito River, and then ultimately into Lake Hodges. The San Dieguito River begins at the confluence of Santa Ysabel Creek and Santa Maria Creek and is impounded in Lake Hodges. San Dieguito River then begins again downstream from Lake Hodges Dam, which regulates the downstream flow (MWH, 2011b).

Figure 2-6 shows the measured streamflows from the City for Santa Ysabel Creek (YSA8), Cloverdale Creek (CDC4), Guejito Creek (GJC4), Kit Carson Creek (KCC3), Santa Maria Creek (SMC4), Sycamore Creek (SYC2), and Temescal Creek (TEM1). Cloverdale Creek (CDC4), Kit Carson Creek (KCC3), and Sycamore Creek (SYC2) were measured sporadically in 2006 and 2007 and at least monthly from January 2008 to September 2010. Santa Ysabel Creek (YSA8) and Guejito Creek (GJC4) were measured monthly from February 2009 until October 2010, with a few measurements taken during 2006 when these streams were flowing. Many of the streams are seasonal and have the highest flows during winter and spring months, with little to no streamflow during summer and fall months.

Santa Ysabel Creek is the largest creek running through the Basin and carries approximately 45 percent of the gaged inflow into the Basin (Izbicki, 1983). The creek drains approximately 128 square miles of mostly forest and Native American reserve. It flows approximately 102 days of the year and is monitored by USGS at Station 11025500. Average annual total stream flow is approximately 7,600 acre-feet. Sutherland Reservoir impounds Santa Ysabel flow. Since the dam was built in 1954, no water has been released from the dam to the creek. All of the creek flow in the Valley reach is due to watershed runoff downstream from the Sutherland Reservoir.

Guejito Creek drains an undeveloped watershed approximately 22 square miles for approximately 148 days per year, a total of approximately 2,110 acre-feet per year (AFY) (Izbicki, 1983). Once this flow reaches the floor of the Valley, most of the flow infiltrates the streambed (MWH, 2011b).

Santa Maria Creek drains approximately 58 square miles and is estimated to flow an estimated 53 days per year, with some years not having any streamflow. This stream is gaged by USGS at Station 110290000. Average annual total streamflow is approximately 4,300 AFY, as determined from USGS stream-gage data. Streamflow from Santa Maria Creek is intermittent because of losses to groundwater that occur in Santa Maria Valley upstream from the Basin (MWH, 2011b).

Cloverdale, Kit Carson, and Sycamore creeks are much smaller and drain approximately 18 square miles in total. Cloverdale and Sycamore creeks experience peaks during the spring season but have little flow the rest of the year. Cloverdale Creek average annual streamflow is approximately 1,160 AFY, as determined from USGS stream-gage data. Of all the creeks measured, Kit Carson Creek is the only stream that flows consistently throughout the year, in turn providing consistent flow into Lake Hodges. Most of Kit Carson Creek flow originates as urban runoff. Although Kit Carson Creek is downstream of the Basin, it is still important to monitor, not only to understand the urban drainage impacts on surface water but also to provide an overall picture of the movement of water in the Lake Hodges watershed.

2.6.4 Hydrogeology

This subsection provides a description of general groundwater conditions within the study area. The groundwater conditions of the Basin have been investigated in a limited number of studies (DWR, 1993; Izbicki, 1983; Greeley and Hansen, 1993; CH2M HILL, 2001).

In general, the Basin receives water from river infiltration, deep percolation of precipitation, and subsurface inflows from tributary stream valleys. Irrigation deep percolation and agricultural return flow from land adjacent to the Basin also contribute to groundwater storage. Outflows include groundwater discharge to streams, subsurface outflow, shallow groundwater evapotranspiration (ET), and discharge to pumping wells. Generally, the eastern end of the Basin is a recharge area where streams enter the Basin, and the western end is the discharge area with discharge to streams and Lake Hodges, and ET by phreatophytes.

Deep percolation of precipitation and applied water along with groundwater recharge from Cloverdale, Santa Maria, Guejito, and Santa Ysabel Creeks are the primary sources of groundwater inflow to the Basin. These streams are ephemeral, and their infiltration rates vary seasonally.

The depth to groundwater has been measured by City personnel monthly since 2008, continuing through the present. Depths have ranged from approximately 52 feet below ground surface (bgs) toward the eastern portion of the Basin to approximately 6 feet bgs in the western portion on May 18, 2010. The depths early in the year were evaluated because groundwater pumping typically increases in the spring to meet agricultural and domestic water demands for the summer months (MWH, 2011a). The seasonal decline in groundwater levels is largely due to agricultural irrigation systems using water from nearby groundwater production wells (Figure 2-5). The groundwater production wells within the Basin range from a total depth of approximately 80 to 750 feet bgs and are used for domestic and irrigation purposes. Seasonal groundwater pumping is distributed throughout the Basin and is considered to be greatest in the eastern portion of the Basin.

Six of the actively pumped wells are metered; other pumping well rates are estimated. The volume of water pumped from the metered wells ranges from approximately 0 to 1,000 gallons per minute (gpm). Because so few pumping wells are metered, estimates of the groundwater pumping rate for irrigation purposes have varied in past reports that incorporated different estimation methods, irrigated areas, and Basin boundaries. Groundwater pumping was estimated at 8,170 to 11,200 AFY with net groundwater consumption (consumptive use of applied water) of 6,000 to 6,300 AFY in 2001 (CH2M HILL, 2001). Later estimates reported groundwater pumping of 11,980 AFY on average, with 8,700 AFY net groundwater consumption (MWH, 2010). However, the groundwater model indicates net groundwater consumption from irrigation pumping of 6,494 AFY based on estimates from California Polytechnic State University Irrigation Training and Research Center (MWH, 2009). Current numerical groundwater modeling indicates approximately 6,000 AFY of groundwater pumping in the Basin (see Appendix B). Further study into actual groundwater pumping and consumptive use rates of groundwater is warranted because this is an important factor in Basin groundwater quantity and quality management.

2.6.5 Sensitive Species

The San Pasqual Valley Community Plan and Multiple Species Conservation Program each contain policies to protect biological resources in the area. The policies that pertain to biological resources target preservation and provide general objectives for habitat protection, restoration, flood control, and removal of exotic plants and cowbirds. Environmentally sensitive areas (ESAs) designate certain plots of land that are used to protect biological resources. ESAs are areas that include but are not limited to all Clean Water Act Section 303(d)-impaired bodies of water, areas designated as Areas of Special Biological Significance (Regional Board, 1994), bodies of water designated as being of rare beneficial use (Regional Board, 1994), areas designated as preserves or their equivalent under the Multiple-Species Conservation Program, and any other equivalent ESAs that have been identified by San Diego County (County of San Diego, 2011a).

As shown in Figure 2-7, the majority of the ESAs are located immediately outside the Basin boundary. ESAs inside the Basin boundary are located primarily along streams, such as in the northeast panhandle by Guejito Creek and in the middle of the Basin along Santa Ysabel Creek. With the exception of the northeast panhandle, most of the ESAs are in native vegetation or riparian zones.

2.7 Water Quality

2.7.1 Basin Plan Water Quality Objectives

Section 13050(h) of the California Water Code defines WQOs as:

> *The limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.*

The specific objectives and limits for each body of water vary, depending on the use for which that body of water is designated (see Section 2.3). According to the Basin Plan, objectives must be more stringent than the water quality criteria and must be based on scientific water quality data (Regional Board, 1994).

The Basin Plan contains the following general antidegradation WQO:

> *Wherever the existing quality of water is better than the quality of water established herein as objectives, such existing quality shall be maintained unless otherwise provided by the provisions of the State Water Resources Control Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California," including any revisions thereto, or the federal Anti-degradation Policy, 40 CFR 131.12 (for surface waters only).*

Additionally, for inland surface waters and groundwater, the Basin Plan designates the following objectives:

- ***WQO for Agricultural Supply****: Water designated for use as agricultural supply (AGR) shall not contain concentrations of chemical constituents in amounts that adversely affect such beneficial use.*
- ***WQO for Un-ionized Ammonia****: The discharge of wastes shall not cause concentrations of un-ionized ammonia (NH_3) to exceed 0.025 milligrams per liter (mg/L) (as N) in inland surface waters, enclosed bays and estuaries and coastal lagoons.*
- ***WQO for Contact Recreation****: In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any*

30-day period, shall not exceed a log mean of 200/100 milliliters (mL) nor shall be more than 10 percent of total samples during any 30-day period exceed 400/100 mL.

- ***WQO for Non-contact Recreation****: In waters designated for non-contact recreation (REC-2) and not designated for contact recreation (REC-1), the average fecal coliform concentrations for any 30-day period, shall not exceed 2,000/100 mL nor shall more than 10 percent of samples collected during any 30-day period exceed 4,000/100 mL.*

Tables 2-3 and 2-4 summarize the WQOs for inland surface waters and groundwater, respectively, for the San Dieguito Hydrologic Unit. According to the Basin Plan, concentrations are not to exceed WQOs more than 10 percent of the time during any 1-year period. Basin Plan surface water WQOs have been approved by the U.S. Environmental Protection Agency (USEPA) as representing federal water quality standards that are subject to regulation and enforcement under provisions of the Clean Water Act.

To support the use of the Basin as a future source of municipal water supply, the Basin Plan has incorporated State of California drinking water primary maximum contaminant levels (MCLs) for toxic inorganic and organic compounds within the groundwater and surface WQOs for the San Pasqual Hydrologic Unit. In addition to designating beneficial uses and WQOs to protect the uses, the Basin Plan establishes implementation policies necessary to protect the beneficial uses and achieve the WQOs. These implementation policies govern the Regional Board's regulation and control of point source discharges, nonpoint source discharges, remediation of pollution, implementation of Clean Water Act regulations regarding impaired waters, and implementation of groundwater management plans.

TABLE 2-3
WQOs for the San Dieguito Hydrologic Unit 905 for Inland Surface Waters
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

San Dieguito Hydrologic Unit 905	Solana Beach	Hodges	San Pasqual	Santa Maria Valley	Santa Ysabel
Hydrologic Unit Basin Number	5.1	5.2	**5.3**	5.4	5.5
Total dissolved solids (TDS)	500	500	**500**	500	500
Chlorine (Cl)	250	250	**250**	250	250
Sulfate (SO_4)	250	250	**250**	250	250
Sodium (Na) (percent)	60	60	**60**	60	60
Iron (Fe)	0.3	0.3	**0.3**	0.3	0.3
Manganese (Mn)	0.05	0.05	**0.05**	0.05	0.05
Methylene-Blue Active Substances (MBAS)	0.5	0.5	**0.5**	0.5	0.5
Boron (B)	0.75	0.75	**0.75**	0.75	0.75
Odor	None	None	**None**	None	None
Turbidity (nephelometric turbidity unit [NTU])	20	20	**20**	20	20

Note: Units are milligrams per liter (mg/L) unless otherwise noted.

TABLE 2-4
WQOs for the San Dieguito Hydrologic Unit 905 for Groundwater
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

San Dieguito Hydrologic Unit 905	Solana Beach	Hodges	San Pasqual	Santa Maria Valley	Santa Ysabel
Hydrologic Unit Basin Number	5.1	5.2	**5.3**	5.4	5.5
Total dissolved solids (TDS)	1,500	1,000	**1,000**	1,000	500
Chlorine (Cl)	500	400	**400**	400	250
Sulfate (SO_4)	500	500	**500**	500	250
Sodium (Na) (percent)	60	60	**60**	60	60
Nitrate (NO_3)	45	10	**10**	10	5

TABLE 2-4
WQOs for the San Dieguito Hydrologic Unit 905 for Groundwater
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

San Dieguito Hydrologic Unit 905	Solana Beach	Hodges	San Pasqual	Santa Maria Valley	Santa Ysabel
Iron (Fe)	0.85	0.3	**0.3**	0.3	0.3
Manganese (Mn)	0.15	0.05	**0.05**	0.05	0.05
Methylene-Blue Active Substances (MBAS)	0.5	0.5	**0.5**	0.5	0.5
Boron (B)	0.75	0.75	**0.75**	0.75	0.75
Odor	None	None	**None**	None	None
Turbidity (nephelometric turbidity unit [NTU])	5	5	**5**	5	5

Notes: Units are milligrams per liter (mg/L) unless otherwise noted.

2.7.2 Existing and Historical Water Quality

Surface water quality is first presented and discussed. Next, groundwater quality is summarized and reviewed, and then constituents of interest are presented.

2.7.2.1 Surface Water Quality

City of San Diego Surface Water Quality

The City monitors the seven major streams in and around the Basin for a variety of organic, inorganic, and metal constituents. Nitrate and total dissolved solid (TDS) concentrations from 2007 to the present can be found in Figures 2-8 and 2-9. Note that the primary MCLs, as defined by the California drinking water quality standards and the Regional Board Groundwater Quality Objectives, were issued for groundwater concentrations. MCLs are included in the surface water figures for reference of target values. Further explanation of the MCLs and Regional Board objectives can be found in Section 2.7.2.2.

Santa Ysabel Creek (YSA8) shows low concentrations of nitrate and TDS, with both below the respective primary and secondary MCLs. Guejito Creek (GJC4) also has low concentrations of nitrate and TDS below the primary and secondary MCLs, respectively. Santa Maria Creek (SMC4) has experienced low concentration of nitrate but elevated levels of TDS, exceeding the Regional Board's groundwater WQO of 1,000 mg/L.

Cloverdale, Kit Carson, and Sycamore creeks are experiencing TDS levels that exceed the Regional Board WQOs, likely due to increased human activity and urban stormwater runoff. These areas are surrounded by agricultural and residential land uses, which may be contributors to the high levels of TDS. However, nitrate levels at all three streams are generally consistently below the primary MCLs with the exception of one sample point.

The City also monitors Temescal Creek upstream from the Basin at the City's Station TEM1 sampling location. This sampling site helps determine background conditions before entering the Basin. Although land use of this sampling location is primarily forest land, the station has relatively high levels of TDS, which are higher than the constituent limit but still lower than the Regional Board WQO. Nitrate concentrations are very low at this location.

USGS Surface Water Quality

A limited number of water quality samples were collected from the USGS stations shown in Figure 2-5. Table 2-5 shows two samples collected in 1981 and 1982 at USGS Station No. 11026000 on Santa Ysabel Creek upstream of the Basin. The values in this table are consistent with the recent values gathered from the City's Station YSA8, which is also on Santa Ysabel River near the upstream end of the Basin.

TABLE 2-5
Santa Ysabel Creek Nitrogen and TDS Data from USGS Station No. 11026000
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Date of Sample	TN (mg/L)	NO_3-N (mg/L)	TDS[a] (mg/L)	TDS[b] (mg/L)
11/24/1981	1.8	0.23	442	443
3/24/1982	0.79	0.28	321	298

[a]Dissolved solids dried at 180 degrees Celsius, water, filtered
[b]Dissolved solids, water, filtered, sum of constituents

2.7.2.2 Groundwater Quality

City of San Diego Groundwater Quality

The GMP summarized a broad array of groundwater quality constituents for the Basin and found TDS and nitrate concentrations to be of particular concern (City of San Diego Water Department, 2007). This section describes historical groundwater quality monitoring from existing reports and current data from the City's 10 groundwater sampling wells.

Groundwater quality data in the San Pasqual area have been collected and reported periodically in various reports since 1950. The GMP provided maximum, average, and minimum values from 1950 through 2006. Table 2-6 compares groundwater quality data with applicable California drinking water quality standards (both primary and secondary MCLs). Primary MCLs are derived from health-based criteria that include technologic and economic considerations and are legally enforceable standards designed to protect the public health by limiting the levels of contaminants in public drinking water systems. Secondary MCLs are designed to regulate contaminants that may cause cosmetic effects such as skin or tooth discoloration or aesthetic effects such as taste or odor in drinking water. Also presented in Table 2-6 are ground water WQOs of the Regional Board for the San Pasqual Region within the San Dieguito Hydrologic Unit. Regional Board objectives are of interest because groundwater in the Basin cannot be degraded beyond these WQOs by any anthropogenic activity at the surface, including agriculture, urbanization, and groundwater recharge (MWH, 2010).

Based on the data in Table 2-6 and in Figures 2-10 and 2-11, TDS and nitrate continue to be the two primary constituents of interest in the Basin. TDS concentrations in the westernmost well (SP010) range from 604 mg/L to 1,050 mg/L, which indicates that groundwater is leaving the Basin with TDS concentrations exceeding the recommended secondary MCL of 500 mg/L. An analysis of existing historical data indicates that the TDS concentrations in the western portion of the Basin have generally increased since 1950; however, constituent concentration trends seem to have become more constant in the western portion of the Basin over the last decade, approximately.

Although the most recent nitrate concentrations in well SP010 are relatively low, average nitrate (as NO_3) concentrations in the western Basin are 40 mg/L with a maximum concentration of 174 mg/L; thus, the primary nitrate (as NO_3) MCL of 45 mg/L is exceeded in some areas (MWH, 2010). Historical data show that the general trend for nitrate concentrations has increased with the exception of wells SP089 and SP061, which have decreased from 1950 to 2010.

The City attempts to collect and analyze groundwater samples quarterly but often only one or two sampling events occur in a year. The samples are analyzed for a variety of inorganics, organics, and metals. Because nitrates and TDS have been evaluated as the constituents of interest, the most recent nitrate and TDS groundwater concentrations, from 2008 through 2012, were graphed (Figures 2-10 and 2-11). The overall trend shows that nitrate increases from east to west, and TDS is highest towards the middle of the Basin. However, the westernmost sampling location, SP010, has experienced much lower concentrations than the other western groundwater sites. This is consistent with historical data presented in Tables 2-6 and 2-7.

TABLE 2-6
Groundwater Quality Summary, 1950 through 2006
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Constituent	Primary MCL[h]	Secondary MCL[h]	Regional Board Groundwater WQO[c]	Units	Groundwater Results: Western Portion of Basin Maximum	Western Portion of Basin Minimum	Western Portion of Basin Average[g]	Eastern Portion of Basin Maximum	Eastern Portion of Basin Minimum	Eastern Portion of Basin Average[g]	Exceeds Primary or Secondary MCL[a]	Exceeds Regional Board Groundwater WQO[a]
General Mineral												
Calcium	--	--	--	mg/L	352	11	140	274	21	85	NA[b]	NA[b]
Chloride	--	250/500/600 [f]	400 [d]	mg/L	1,618	72	270	324	0.3	100	Yes	Yes
Fluoride	2	--	1.0 [d]	mg/L	2	< 0.03	0.5	62.1	< 0.03	0.6	Yes	Yes
Hardness (as $CaCo_3$)	--	--	--	mg/L	1,390	50	500	997	127	347	NA[b]	NA[b]
Magnesium	--	--	--	mg/L	170	< 3	60	121	4.6	35	NA[b]	NA[b]
Nitrate (as NO_3)	45	--	10 [d]	mg/L	174	<0.2	40	141.5	<0.2	20	Yes	Yes
Potassium	--	--	--	mg/L	28	0.604	3.5	12	<0.5	3	NA[b]	NA[b]
Sodium	--	--	--	mg/L	540	3.11	185	204	34	83	NA[b]	NA[b]
Sodium Percent	--	--	60 [e]	%	42%	19%	40%	27%	51%	33%	NA[b]	No
Sulfate	--	250/500/600 [f]	500 [d]	mg/L	1,063	3.9	310	519	10	100	Yes	Yes
Alkalinity (total)	--	--	--	mg/L	408	89.2	270	384	20	200	NA[b]	NA[b]
General Physical												
Total Dissolved Solids	--	500/1000/1500 [f]	1000 [d]	mg/L	3060	58	1300	4400	262	722	Yes	Yes
Inorganics												
Aluminum	1	0.2	--	mg/L	0.387	0.00205	0.0179	0.27	0.00136	0.0184	Yes	NA[b]
Antimony	0.006	--	--	mg/L	0.00587	0.00145	0.0039	<0.0005	<0.0005	<0.0005	No	NA[b]
Arsenic	0.01	--	--	mg/L	0.009	0.00102	0.0030	0.007	0.00075	0.0024	No	NA[b]
Barium	2	--	--	mg/L	0.135	0.00131	0.0576	0.294	0.00239	0.1280	No	NA[b]
Beryllium	0.004	--	--	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	No	NA[b]
Boron	--	--	0.75 [d]	mg/L	0.194	<0.0005	0.060	0.148	<0.0005	0.0400	NA[b]	No
Cadmium	0.005	--	--	mg/L	0.02	0.00115	0.004	0.003	0.00108	0.0030	Yes	NA[b]
Chromium	0.05	--	--	mg/L	0.0114	0.00101	0.004	0.0105	0.00101	0.0034	No	NA[b]
Copper	--	1	--	mg/L	0.05	0.00133	0.007	0.351	0.00101	0.0101	No	NA[b]

TABLE 2-6
Groundwater Quality Summary, 1950 through 2006
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Constituent	Primary MCL[h]	Secondary MCL[h]	Regional Board Groundwater WQO[c]	Units	Groundwater Results – Western Portion of Basin – Maximum	Western – Minimum	Western – Average[g]	Eastern Portion of Basin – Maximum	Eastern – Minimum	Eastern – Average[g]	Exceeds Primary or Secondary MCL[a]	Exceeds Regional Board Groundwater WQO[a]
Iron	--	0.3	0.3 [d]	mg/L	35.6	0.0266	2.060	4	0.01	0.3000	Yes	Yes
Lead	0.015	--	--	mg/L	0.05	0.000561	0.021	0.05	0.000844	0.0180	No	NA[b]
Manganese	--	0.05	0.05 [d]	mg/L	2.7	0.0002	0.300	5.67	0.0002	0.2000	Yes	Yes
Mercury	0.002	--	--	mg/L	0.00037	0.0002	0.0	0.0004	0.0002	0.0002	No	NA[b]
Nickel	0.1	--	--	mg/L	0.0687	0.00056	0.005	0.0858	0.0005	0.0040	No	NA[b]
Perchlorate	--	--	--	mg/L	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	NA[b]	NA[b]
Selenium	0.05	--	--	mg/L	0.012	0.001	0.0060	0.057	0.00137	0.0120	Yes	NA[b]
Silver	--	0.1	--	mg/L	0.01	0.00075	0.0092	0.01	0.01	0.0100	No	NA[b]
Thallium	0.002	--	--	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	No	NA[b]
Vanadium	--	--	--	mg/L	0.0253	0.00506	0.0126	0.0709	0.00301	0.0115	NA[b]	NA[b]
Zinc	--	5.0	--	mg/L	0.303	0.00201	0.0452	5.02	0.0023	0.0960	Yes	NA[b]
Organics												
Volatile Organic Compounds (Drinking Water)	-- [i]	-- [i]	-- [i]	mg/L	0.00284	<0.00001	-- [i]	0.00456	<0.00001	-- [i]	-- [i]	NA[b]

Notes:
Source: MWH, 2011a
[a]Indicates that at least one or more reported concentration exceeds the primary or secondary MCL or Regional Board groundwater WQO.
[b]To date, MCLs and groundwater WQOs have not been identified for this constituent.
[c]These values represent the Regional Board groundwater WQOs for the Basin.
[d]Detailed salt balance studies are recommended for this area to determine limiting mineral concentration levels for discharge. On the basis of existing data, the tabulated objectives would probably be maintained in most areas. Upon completion of the salt balance studies, significant WQO revisions may be necessary. In the interim, projects of groundwater recharge with water quality inferior to the tabulated numerical values may be permitted following individual review and approval by the Regional Board if such projects do not degrade existing ground water quality to the aquifers affected by the recharge.
[e]Na is measured as the % Na = (Na / (Na + Ca + Mg + K)) * 100%, where Na, Ca, Mg, and K are expressed in milliequivalent per liter (meq/L)
[f]Secondary MCLs limits presented in order of Recommended/Upper/Short Term.
[g]Average was calculated using detections recorded above the reporting limit. Therefore, nondetect or less than the detection limit values were not factored into the average calculation.
[h]The lowest respective U.S. Environmental Protection Agency or California Department of Health Services constituent MCL value is presented.
[i]Because multiple constituents are represented as volatile organic compounds, MCLs and average concentrations are not provided.

Key:
-- = Not Applicable
NA = not available

TABLE 2-7

Groundwater Quality Summary, 2007 through 2013

San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Constituent	Primary MCL[h]	Secondary MCL[h]	Regional Board Groundwater WQO[c]	Units	Groundwater Results – Western Portion of Basin – Maximum	Western Portion of Basin – Minimum	Western Portion of Basin – Average[g]	Eastern Portion of Basin – Maximum	Eastern Portion of Basin – Minimum	Eastern Portion of Basin – Average[g]	Exceeds Primary or Secondary MCL[a]	Exceeds Regional Board Groundwater WQO[a]
General Mineral												
Calcium	--	--	--	mg/L	256	66	142	206	83	111	NA[b]	NA[b]
Chloride	--	250/500/600[f]	400[d]	mg/L	558	125	267	318	131	162	Yes	Yes
Fluoride	2	--	1.0[d]	mg/L	0.97	0.06	0.35	0.35	0.21	0.24	No	No
Hardness (as $CaCo_3$)	--	--	--	mg/L	989	207	598	616	360	412	NA[b]	NA[b]
Magnesium	--	--	--	mg/L	127	2	57	72	11	35	NA[b]	NA[b]
Nitrate (as NO_3)	45	--	10[d]	mg/L	110	4	40	25	<0.2	7	Yes	Yes
Potassium	--	--	--	mg/L	9	<0.5	3	5	3	3	NA[b]	NA[b]
Sodium	--	--	--	mg/L	539	86	191	197	91	105	NA[b]	NA[b]
Sodium Percent	--	--	60[e]	%	59%	36%	49%	52%	38%	42%	NA[b]	No
Sulfate	--	250/500/600[f]	500[d]	mg/L	596	99	323	558	164	210	Yes	Yes
Alkalinity (total)	--	--	--	mg/L	375	106	244	276	172	191	NA[b]	NA[b]
General Physical												
Total Dissolved Solids	--	500/1000/1500[f]	1000[d]	mg/L	2160	10	1282	1410	720	827	Yes	Yes
Inorganics												
Aluminum	1	0.2	--	mg/L	2.8300	<0.0015	0.9519	0.0212	<0.0015	0.0205	Yes	NA[b]
Antimony	0.006	--	--	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	No	NA[b]
Arsenic	0.01	--	--	mg/L	0.0043	<0.0002	0.0032	0.0245	<0.0002	0.0243	Yes	NA[b]
Barium	2	--	--	mg/L	0.2760	<0.001	0.0761	0.1270	0.0001	0.0960	No	NA[b]
Beryllium	0.004	--	--	mg/L	<0.0002	<0.0002	<0.0002	0.0239	<0.0002	0.0223	Yes	NA[b]
Boron	--	--	0.75[d]	mg/L	0.2030	0.0510	0.1090	0.1190	<0.001	0.0655	NA[b]	No
Cadmium	0.005	--	--	mg/L	<0.0001	<0.0001	<0.0001	0.0242	<0.0001	0.0240	Yes	NA[b]
Chromium	0.05	--	--	mg/L	0.0043	<0.0001	0.0014	0.0208	<0.0001	0.0204	No	NA[b]
Copper	--	1	--	mg/L	0.452	0.003	0.025	0.028	<0.0005	0.012	No	NA[b]
Iron	--	0.3	0.3[d]	mg/L	0.1140	<0.005	0.0822	0.2420	<0.005	0.1257	No	No

TABLE 2-7
Groundwater Quality Summary, 2007 through 2013
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Constituent	Primary MCL[h]	Secondary MCL[h]	Regional Board Groundwater WQO[c]	Units	Groundwater Results						Exceeds Primary or Secondary MCL[a]	Exceeds Regional Board Groundwater WQO[a]
					Western Portion of Basin			Eastern Portion of Basin				
					Maximum	Minimum	Average[g]	Maximum	Minimum	Average[g]		
Lead	0.015	--	--	mg/L	0.0257	<0.0002	0.0074	0.0251	<0.0002	0.0139	Yes	NA[b]
Manganese	--	0.05	0.05 [d]	mg/L	4.05000	<0.0002	0.31918	0.15700	<0.0002	0.07074	Yes	Yes
Mercury	0.002	--	--	mg/L	0.0645	<0.00002	0.0328	0.0002	<0.00002	0.0002	Yes	NA[b]
Nickel	0.1	--	--	mg/L	0.0134	<0.0002	0.0043	0.0213	<0.0002	0.0041	No	NA[b]
Perchlorate	--	--	--	mg/L	0.0107	<0.0004	0.0107	0.0114	<0.0004	0.0114	NA[b]	NA[b]
Selenium	0.05	--	--	mg/L	0.0095	<0.0003	0.0049	0.0244	<0.0003	0.0069	No	NA[b]
Silver	--	0.1	--	mg/L	<0.0003	<0.0003	<0.0003	0.0099	<0.0003	0.0096	No	NA[b]
Thallium	0.002	--	--	mg/L	<0.0002	<0.0002	<0.0002	0.0254	<0.0002	0.0249	Yes	NA[b]
Vanadium	--	--	--	mg/L	0.02540	0.00492	0.01321	0.02730	<0.0002	0.00980	NA[b]	NA[b]
Zinc	--	5	--	mg/L	0.2280	<0.0015	0.0474	0.0240	<0.0015	0.0196	No	NA[b]
Organics												
Volatile Organic Compounds (Drinking Water)	-- [i]	-- [i]	-- [i]	mg/L	-- [i]	-- [i]	-- [i]	-- [i]	-- [i]	-- [i]	-- [i]	NA[b]

Notes:

[a]Indicates that at least one or more reported concentration exceeds the primary or secondary MCL or Regional Board groundwater WQO.
[b]To date, MCLs and groundwater WQOs have not been identified for this constituent.
[c]These values represent the Regional Board groundwater WQOs for the Basin.
[d]Detailed salt balance studies are recommended for this area to determine limiting mineral concentration levels for discharge. On the basis of existing data, the tabulated objectives would probably be maintained in most areas. Upon completion of the salt balance studies, significant WQO revisions may be necessary. In the interim, projects of groundwater recharge with water quality inferior to the tabulated numerical values may be permitted following individual review and approval by the Regional Board if such projects do not degrade existing ground water quality to the aquifers affected by the recharge.
[e]Na is measured as the % Na = (Na / (Na + Ca + Mg + K)) * 100%, where Na, Ca, Mg, and K are expressed in milliequivalent per liter (meq/L)
[f]Secondary MCLs limits presented in order of Recommended/Upper/Short Term.
[g]Average was calculated using detections recorded above the reporting limit. Therefore, nondetect or less than the detection limit values were not factored into the average calculation.
[h]The lowest respective U.S. Environmental Protection Agency or California Department of Health Services constituent MCL value is presented.
[i]Because multiple constituents are represented as volatile organic compounds, MCLs and average concentrations are not provided.

Key:
-- = Not Applicable
NA = not available

USGS Groundwater Quality

Groundwater quality is also monitored at one USGS monitoring well; however, limited data are available. Table 2-8 shows the TDS and nitrate concentrations measured at each different depth from December 2010. The closest well monitored by the City (private, not a City well) is SP061, which has experienced similar concentrations. The three USGS monitoring wells have well screens constructed in upper, middle, and deeper depth intervals. The upper well screens are generally located within alluvium, and the middle and lower well screens are general located within weathered or competent bedrock. Wells in Table 2-8 are listed from west to east, consistent with the general direction of groundwater flow.

TABLE 2-8
USGS Groundwater Well Nitrate and TDS Concentrations (December 2010)
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Site Name	SDSY 5S	SDSY 4S	SDSY 3S	SDSY 2S	SDCD 5S	SDCD 4S	SDCD 3S	SDLH 3S	SDLH 2S	SDLH 1S
Depth bgs	60 feet	90 feet	210 feet	340 feet	50 feet	130 feet	270 feet	50 feet	110 feet	270 feet
Nitrate										
Nitrate as Nitrogen as N (mg/L)	0.02	1.35	3.69	1.49	5.03	4.95	0.09	N/A	N/A	N/A
Nitrate + Nitrite as N (mg/L)	0.02	1.35	4.05	1.80	5.25	5.05	0.10	N/A	N/A	N/A
Total Dissolved Solids										
TDS[a] (mg/L)	212	725	776	710	1,720	569	522	2,360	660	476
TDS[b] (mg/L)	203	-	758	695	1,730	565	511	2,190	630	514

[a] To convert Nitrate-N to Nitrate, multiply by 4.43
[b] Dried at 180 degrees Celsius
[c] Sum of constituents

As shown in Table 2-8, the TDS and nitrate concentrations in well screen depth intervals corresponding to competent bedrock zones are below their respective groundwater WQO. The TDS and nitrate concentrations in groundwater at well SDSY, which is located along Santa Ysabel Creek in the east-central portion of the Basin (Figure 2-5), are greatest in the 3S screened (i.e., middle) interval, which is located near the bottom of the Basin alluvial aquifer. The TDS and nitrate concentrations in groundwater at well SDCD, which is located along Cloverdale Creek in the northwestern portion of the Basin (Figure 2-5), are greatest in the upper (5S) screened interval. This screened interval is located in alluvium, whereas the lower two screens with lower TDS and nitrate concentrations are located in bedrock. The TDS concentrations in groundwater at well SDLH, which is located along San Dieguito River in the southwestern portion of the Basin (Figure 2-5), are also greatest in the upper (3S) screened interval. This screened interval is located in the upper half of saturated alluvium. The TDS concentrations in the lower alluvium and bedrock at well SDLH are similar (630 mg/L versus 514 mg/L, respectively). Thus, water quality stratification in the water-bearing formations of the Basin is evident according to the data presented in Table 2-8.

2.7.3 Constituents of Interest

The San Pasqual Groundwater Monitoring Plan summarized a broad array of groundwater quality constituents for the Basin and found TDS and nitrate concentrations to be of particular concern (MWH, 2011a). Table 2-9 (derived from the State of the Basin report [MWH, 2011a]) provides data that suggest that TDS and nitrate continue to be constituents of interest.

TDS concentrations have historically exceeded the corresponding WQO throughout portions of the Basin. In addition, nitrate is of particular concern in the western portion where concentrations exceed the primary MCL. Recent San Pasqual groundwater sampling results for TDS and nitrate are summarized in Table 2-9.

TABLE 2-9
Basin Groundwater Quality Summary, 2008 through 2012
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

	Constituent Concentration Range*		
Constituent	**High (mg/L)**	**Mean (mg/L)**	**Low (mg/L)**
TDS	4,400	1,011	58
NO_3	89.6	30	0.69

Source: MWH, 2011a
*Groundwater samples were collected at approximately 10 sampling locations, two to four times per year.

Elevated concentrations of salts and nutrients in groundwater likely result from application of fertilizers and manure on crops, the evapoconcentration of salts through consumptive use of groundwater from irrigated crops and riparian vegetation, and the influences of urban runoff into surface drainages. Irrigating with saline groundwater, for example, increases the concentrations of salts due to a reduction in total water storage within the Basin, while reintroducing nearly the same mass load of salts into the groundwater system through leaching. This process also concentrates salts at the ground surface and can increase surface water salinity during runoff events. Additional evaluation of salts and nutrients is presented in Section 3.

CECs should be considered in supplemental monitoring in the future, as discussed in Section 4, but are not currently water quality constituents of interest. To provide a potable drinking water supply from groundwater, other constituents such as iron, lead, and manganese need to be treated in portions of the Basin to comply with the secondary MCLs.

2.8 Land Use Characterization

Most of the land overlying the Basin is owned by the City and is classified as agricultural. The primary land use is agriculture, consisting of avocado orchards, nurseries, sod farms, truck crops, citrus orchards, forage crops, dairy, and feedlots. Within the larger study area subcatchment, most of the land is in open space with native shrub land cover (Figure 2-12).

The land uses were delineated based on City lessee information, past land use classifications, aerial imagery, and field verification. Land uses were delineated on a per-field basis according to the primary land uses and cropping in the case of agricultural uses utilizing high-resolution (0.5- to 0.6-meter) satellite imagery from June 23, 2009 (Quickbird satellite), and July 1, 2012 (GeoEye-1 satellite). For the purposes of Basin water balance evaluations, primary land uses were assigned a secondary land use or surface cover. The entire area within the Basin boundary was delineated and classified. Primary land uses were defined based on the predominant land use and surface cover for each field/parcel. Secondary land uses were then defined based on the excess land not being utilized for the primary land use and generally consist of nonirrigated or low water-use cover. For example, for a vineyard field, the grape vines were considered the primary land use (representing irrigated and actively transpiring grape vines), and open ground or bare soil was the secondary land use (representing the area in roads and open spaces).

The primary/secondary land use proportion for each field was calculated using a Normalized Difference Vegetation Index (NDVI), created from two dates of high-resolution multispectral satellite imagery. Because the chlorophyll in actively growing plant leaves absorbs radiation in the red visible spectrum and strongly reflects radiation in the near-infrared (NIR) spectrum, the NDVI can be utilized to distinguish actively growing vegetation during mid-summer image dates (that is, irrigated crops, landscapes, and riparian vegetation) from other non-water-using land surfaces (that is, bare soil, hard surfaces, and dead vegetation). The NDVI is calculated using the NIR and red reflectance from Band 3 (Red) and Band 4 (NIR) of the satellite images as follows:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Figure 2-13 shows the satellite imagery, NDVI, and identification of primary land use areas with delineated fields. The purpose of the NDVI analysis was to refine the water balances for irrigated areas. NDVI was used to better define irrigated areas within the Basin that impact water balance components, including the soil moisture balance, ET, and quantity of groundwater extracted and recharged from groundwater pumping.

The distribution of land uses and cropping within the study area and within areas irrigated using groundwater sources pumped from inside the Basin are summarized in Table 2-10. Although the total area in this land use analysis was 26,955 acres, only 26,816 acres are represented in the groundwater model (see Appendix B). The difference between these two areas is represented by 139 acres of nursery production that is located outside the study area but receives water pumped from inside the Basin for irrigation use.

TABLE 2-10
Summary of Land Use and Irrigated Area
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Primary Land Use	Total Area in Subcatchment (acres)	Annual Irrigate Area in Subcatchment (acres)	Total Area Served by Basin Groundwater (acres)	Annual Irrigated Area Served by Basin Groundwater (acres)
Avocado	2,422	1,807	539	402
Citrus	645	486	496	374
Cut Flowers	222	123	222	123
Feedlot	372	104	372	104
Golf Course	171	165	0	0
Grapevines	185	107	185	107
Greenhouse	8	8	8	8
Landscape	2,385	843	543	181
Native Shrub (Open Space)	17,282	0	0	0
Nursery-Container	100	38	100	38
Nursery-Field	248	144	248	144
Open Water - Irrigation	15	0	0	0
Open Water - Groundwater	23	23	20	20
Riparian	1,533	0	0	0
Summer Forage	157	133	157	133
Truck Crops	224	123	206	112
Sod Farms	633	403	633	403
Winter Forage	329	0	0	0
TOTAL	26,955	4,507	3,729	2,149

As seen in Table 2-10, open space with native shrub land cover represents the largest land use within the subcatchment with agriculture being the second predominant land use. The total land in agricultural production (avocado, citrus, cut flowers, feedlot, grapevines, greenhouse, nursery, summer forage, truck crops, sod farms, and winter forage) within the subcatchment was estimated to be 5,545 acres, and the largest single crop area was attributed to avocados, which are grown on hillsides surrounding the Basin. These areas are followed by riparian areas covering 1,533 acres, landscaping (including residential development) at 2,395 acres, golf courses at 171 acres, and open-water ponds (both naturally groundwater fed and irrigation storage ponds) at 38 acres. It should be noted that the riparian areas identified in this analysis were only delineated in the Basin area. Additional riparian areas along drainages farther up in the subcatchment were identified through the groundwater modeling effort (see Appendix B) located in a portion of the area designated as Native Shrub (Open Space) in Table 2-10.

Many areas delineated for a particular irrigated crop use were only partially cropped and irrigated during the times of the 2009 and 2012 satellite images due to normal crop rotations and fallowing, and due to roads and other noncropped areas in fields. Utilizing the average of NDVI calculated areas from the 2009 and 2012 images, of the 3,729 acres of lands served by Basin groundwater pumping, an annual irrigated area of 2,108 acres was estimated.

LEGEND

- San Dieguito Drainage Basin
- San Pasqual Valley Groundwater Basin Boundary
- Study Area

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

0 4 8
Miles

FIGURE 2-1
San Dieguito Drainage Basin
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

CH2MHILL

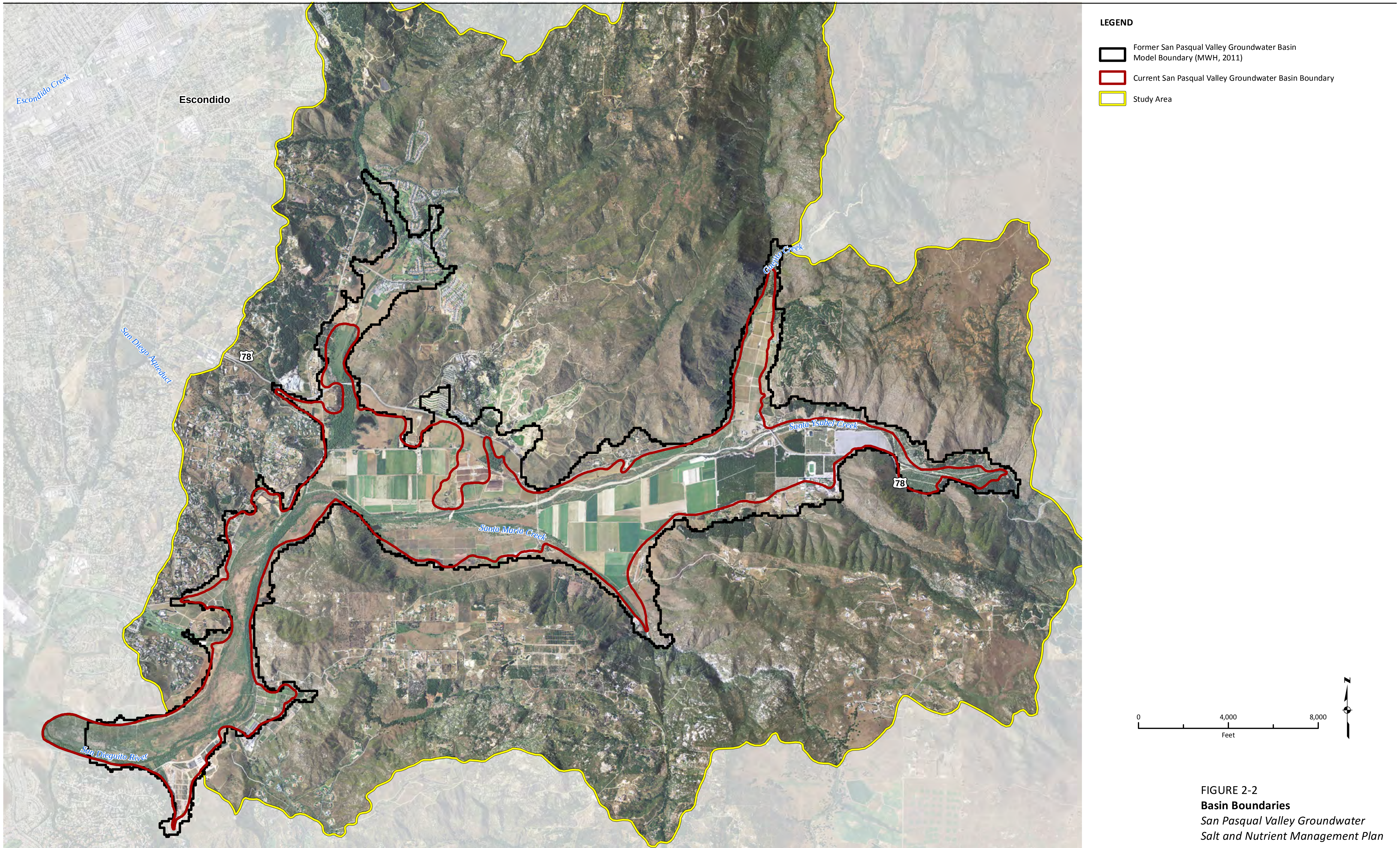

FIGURE 2-2
Basin Boundaries
San Pasqual Valley Groundwater Salt and Nutrient Management Plan

CH2MHILL.

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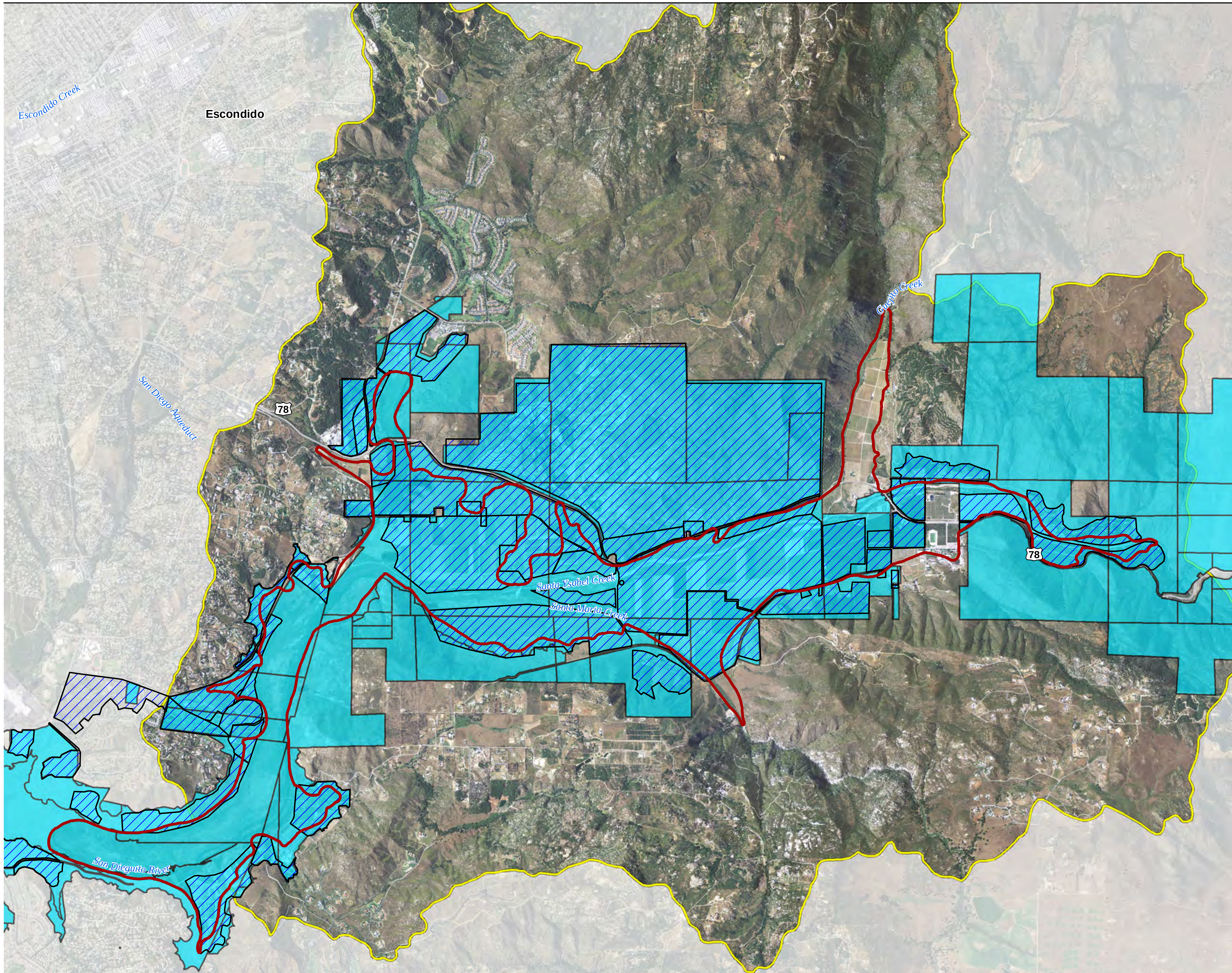

FIGURE 2-3
City-Owned Leases and Parcels
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

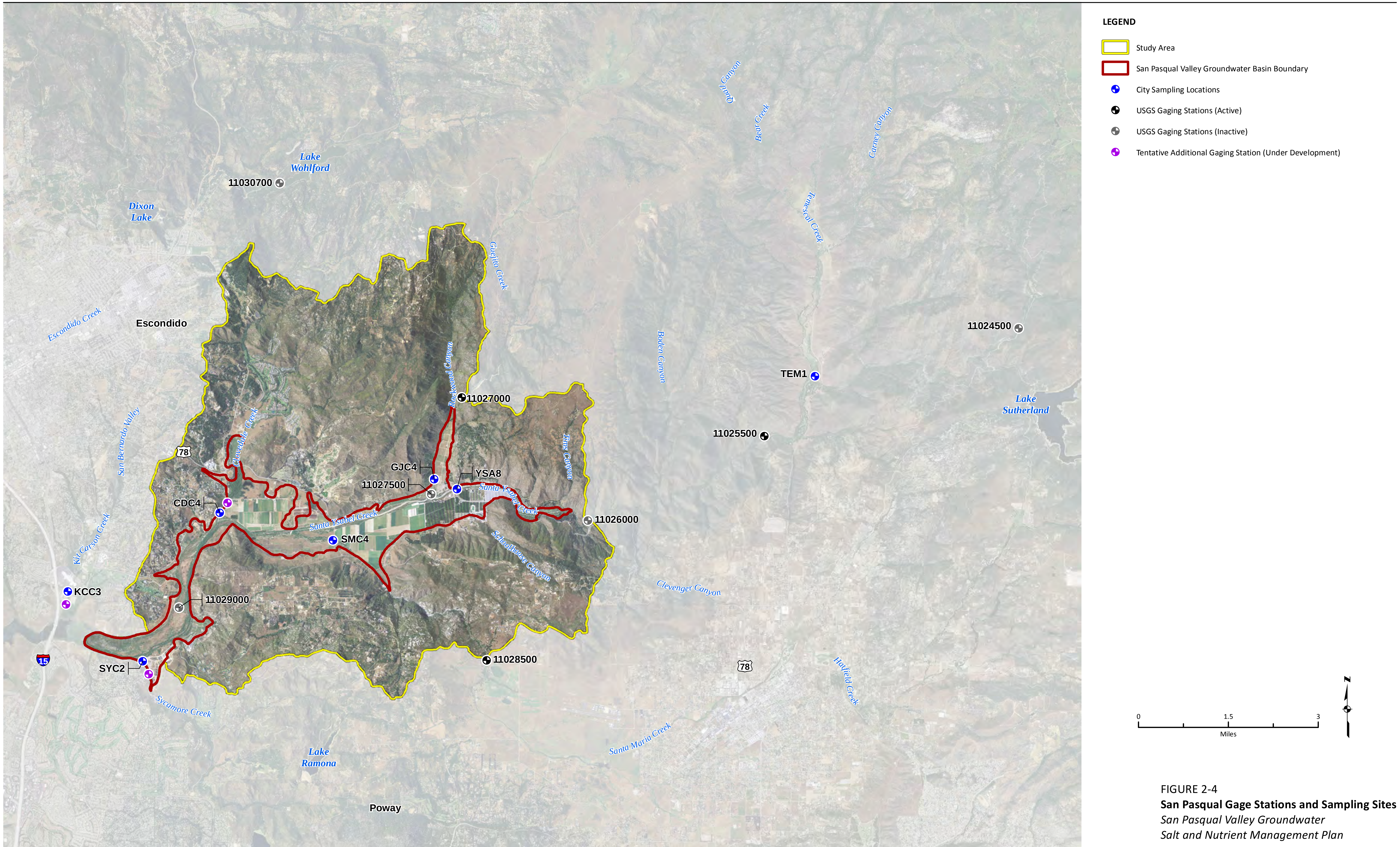

FIGURE 2-4
San Pasqual Gage Stations and Sampling Sites
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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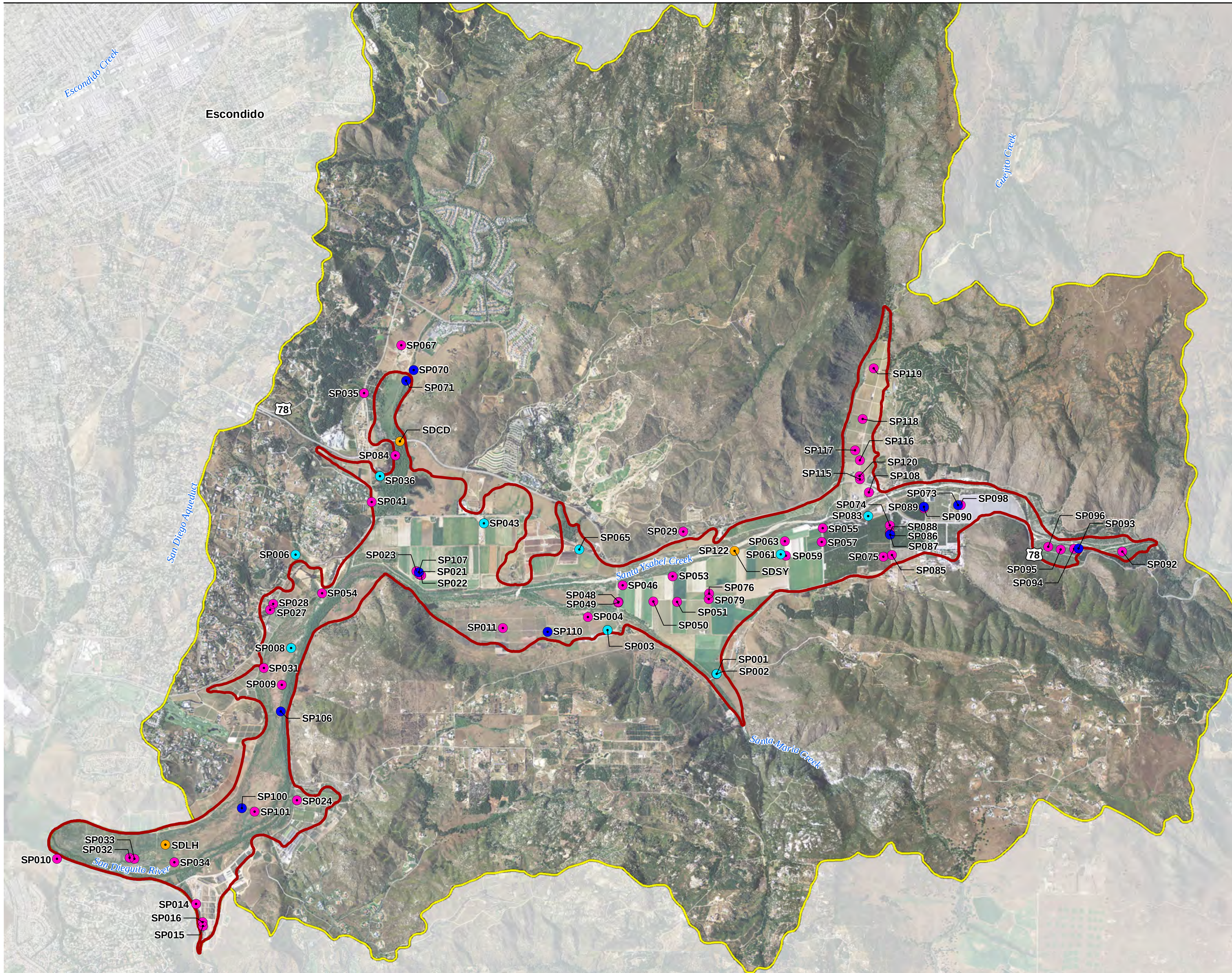

LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- Lessee Active Groundwater Production Well
- Lessee Groundwater Level Monitoring Well
- Lessee Groundwater Quality Monitoring Well
- USGS Groundwater Level Monitoring Well

NOTES:

Well SP083 is a monitoring well for both water level and water quality.

Some monitoring wells are also pumping wells .

0 4,000 8,000
Feet

N

FIGURE 2-5
Active Groundwater Wells
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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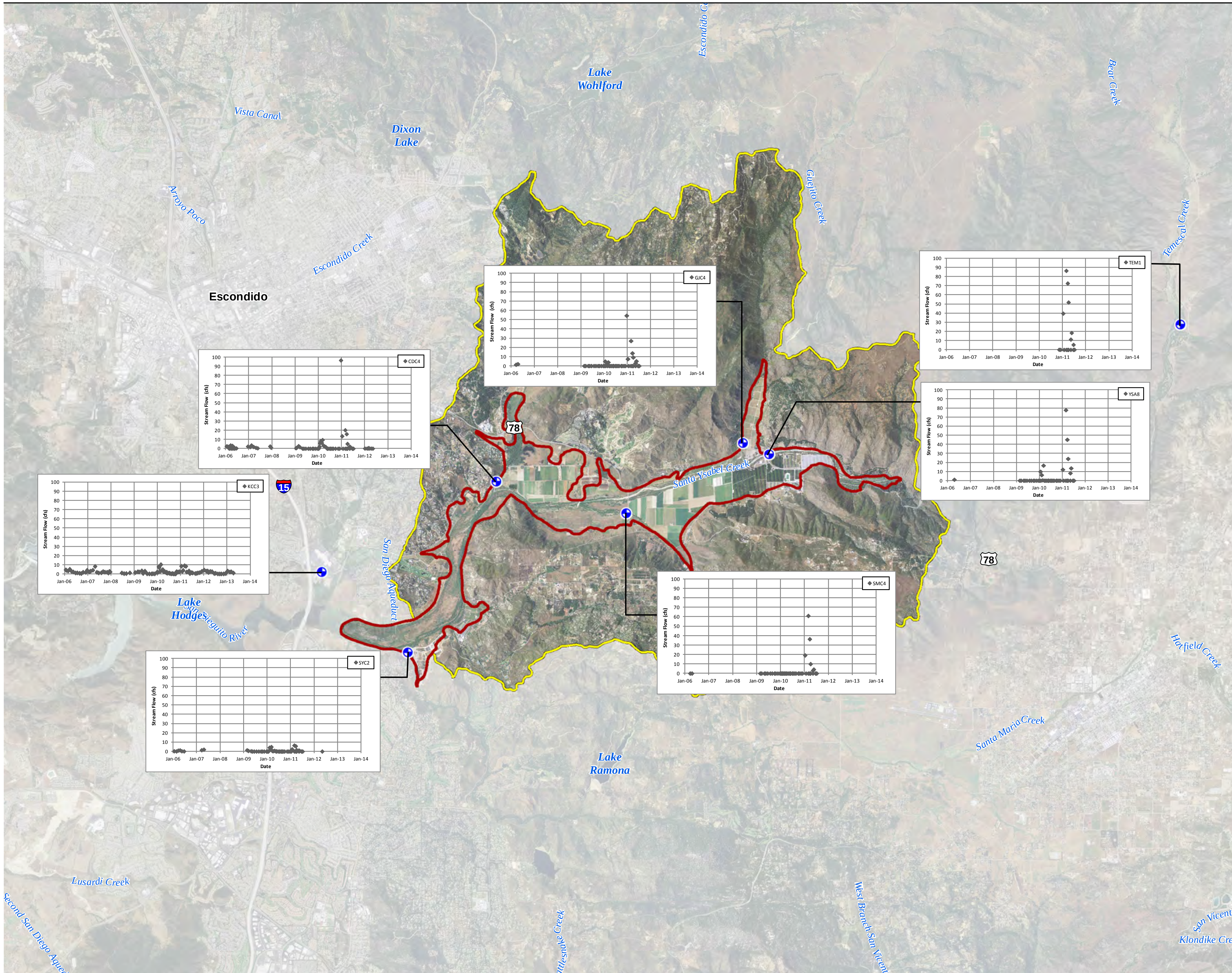

FIGURE 2-6
San Pasqual Surface Water Flow
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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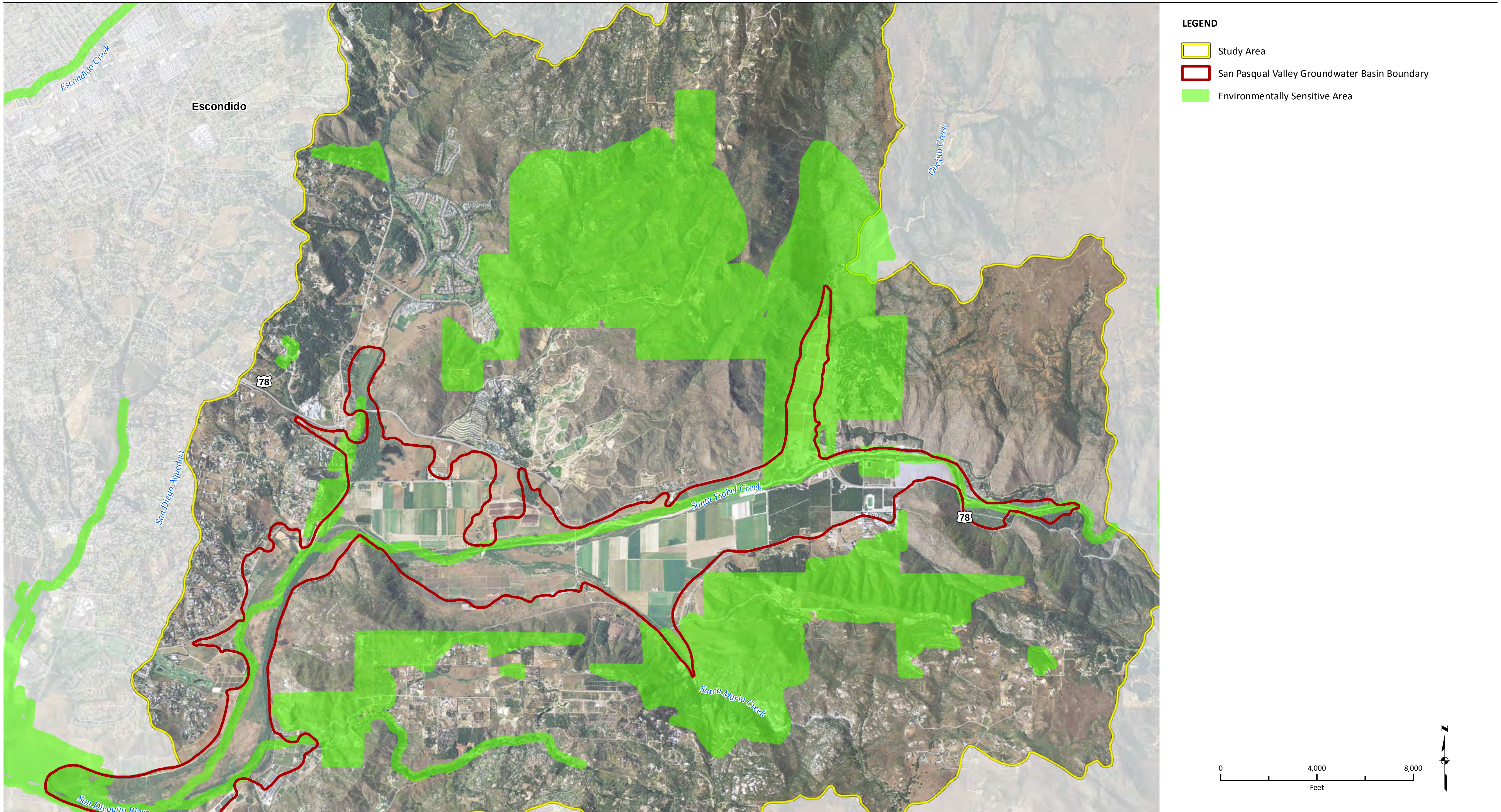

FIGURE 2-7
Environmentally Sensitive Areas
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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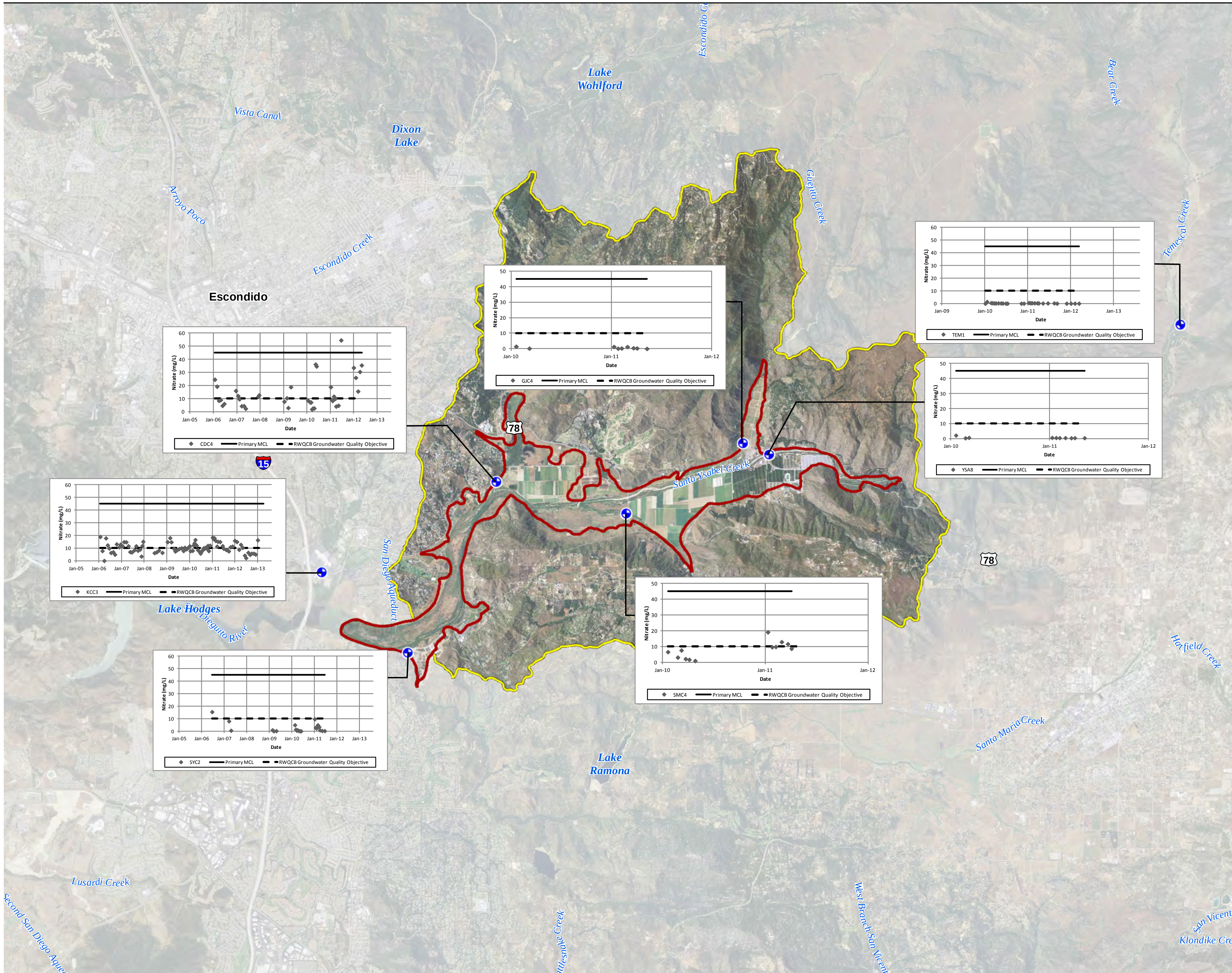

MAP LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

City Sampling Locations

GRAPH LEGEND

Nitrate Concentration in Surface Water (mg/L)

Nitrate Water Quality Objective (10 mg/L)

Nitrate USEPA Maximum Contaminant Level (45 mg/L)

NOTES:

Nitrate concentrations are expressed as NO_3.

mg/L = Milligrams per liter.

0 1.5 3
Miles

FIGURE 2-8
San Pasqual Surface Water Nitrate
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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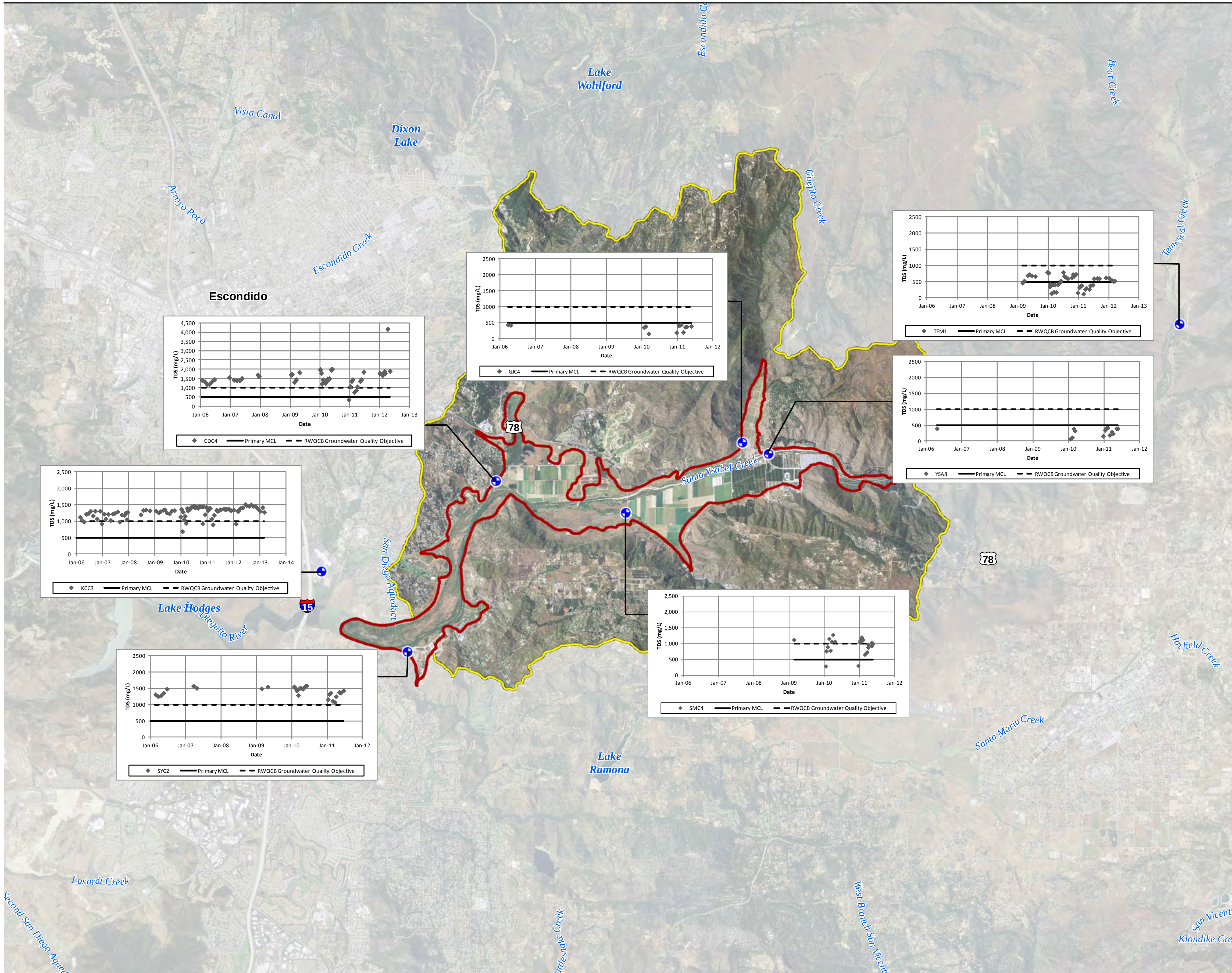

MAP LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

City Sampling Locations

GRAPH LEGEND

TDS Concentration in Surface Water (mg/L)

TDS Water Quality Objective (1,000 mg/L)

TDS USEPA Maximum Contaminant Level (500 mg/L)

NOTES:

mg/L = Milligrams per liter.

TDS = Total dissolved solids.

0 1.5 3
Miles

FIGURE 2-9
San Pasqual Surface Water Total Dissolved Solids
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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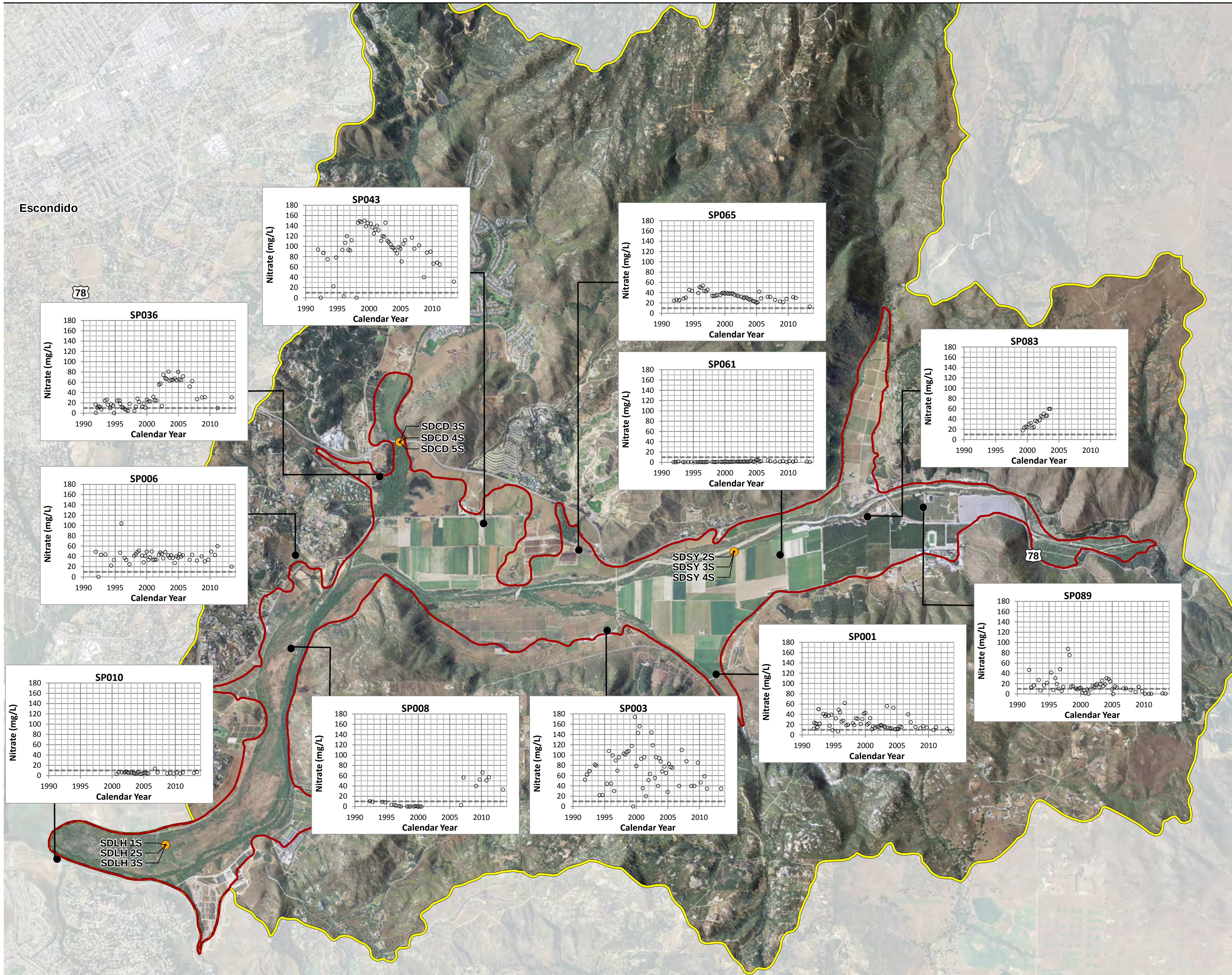

MAP LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

Monitoring Well

USGS Groundwater Level Monitoring Well

PLOT LEGEND

Measured Nitrate Concentration (mg/L)

Nitrate Groundwater Water Quality Objective (10 mg/L)

NOTES:

Nitrate concentrations are expressed as NO_3.

mg/L = Milligrams per liter.

0 4,000 8,000

Feet

N

FIGURE 2-10

Nitrate Concentration Trends

San Pasqual Valley Groundwater

Salt and Nutrient Management Plan

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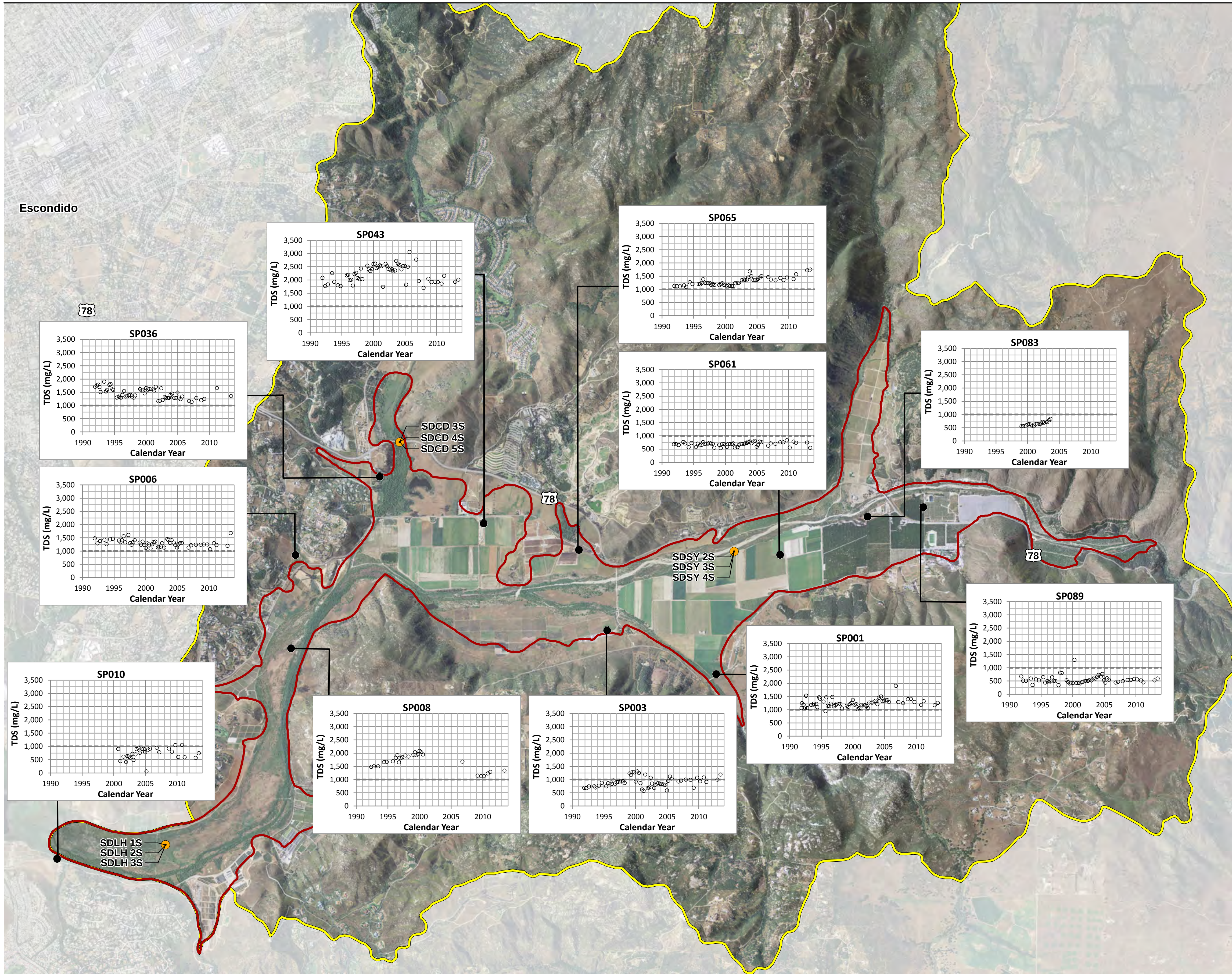


MAP LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- Monitoring Well
- USGS Groundwater Level Monitoring Well

PLOT LEGEND

- Measured TDS Concentration (mg/L)
- TDS Groundwater Water Quality Objective (1,000 mg/L)

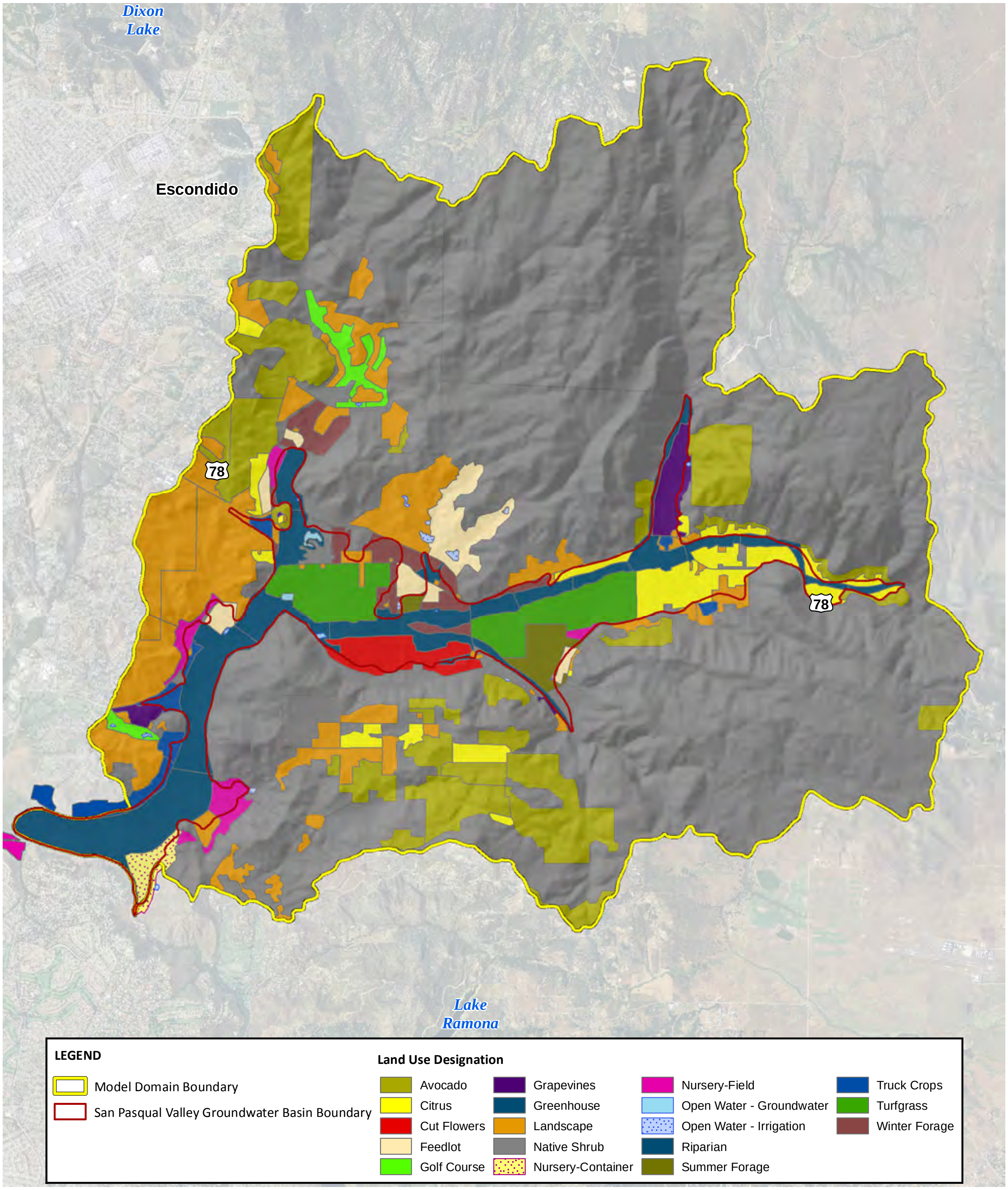
NOTES:

mg/L = Milligrams per liter.

TDS = Total Dissolved Solids.

0 4,000 8,000
Feet

FIGURE 2-11
Total Dissolved Solids Concentration Trends
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan



NOTE:

Land use designations based on 2009 and 2012 satellite imagery data.

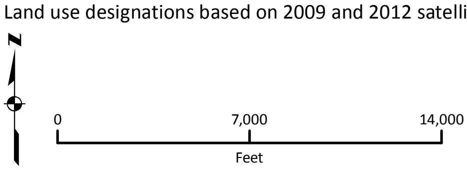


FIGURE 2-12
Land Use
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

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DigitalGlobe Quickbird multispectral imagery acquired on June 23, 2009. Red indicates actively growing vegetation.

Normalized Difference Vegetation Index (NDVI) image produced from Quickbird imagery with values from -1 to +1. Low values are in dark grey and high values are white. High values indicate actively growing vegetation with high leaf area indices and ample water supply.

Actively growing vegetation delineations from NDVI image. Green indicates areas of NDVI in excess of a threshold value set to identify the presence of significant green leaf area.

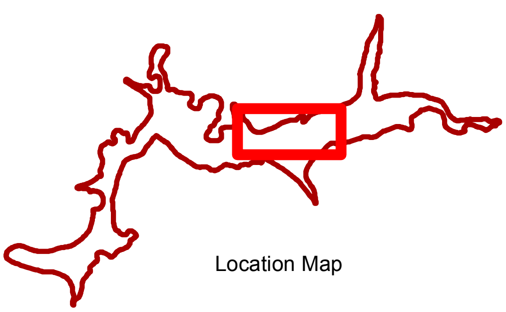
Land Uses
A - Turf Farm
B - Riparian
C - Summer Forage
D - Nursery
E - Citrus
F - Winter Forage
G - Avocado

LEGEND

Land Use Delineation

0 1,000 2,000 Feet

Approximate Scale 1:24,000



Location Map

Example area shown for illustrative purpose

FIGURE 2-13

Multispectral imagery, NDVI image, and vegetation identification

San Pasqual Valley Groundwater Salt and Nutrient Management Plan

SECTION 3

Salt and Nutrient Evaluation

The identification and quantification of salt and nutrient sources is a key initial step in the SNMP process and is necessary to facilitate the development of an action plan to improve groundwater quality. In this section, primary salt and nutrient sources are identified, and groundwater modeling results are presented to evaluate the Basin response to possible changes in water, salt, and nutrient management.

A multifaceted approach was taken in this SNMP to quantify salt and nutrient loads from various sources across the Basin and to simulate the processes governing transport of these constituents to groundwater. This process started with the identification of the primary salt and nutrient sources across the Basin and was followed by an estimation of the total mass loads contributed by each major source. Although nitrate is the primary nutrient of concern and focus of this SNMP, potential nitrate contributions were first addressed by evaluating total nitrogen loads from various sources. After these first steps, considerations for nitrogen losses, uptake, and transformations were made according the specific nitrogen sources and practices. The same process was used for evaluating salt transport. This information was incorporated into the groundwater models, where simulated groundwater quality could be compared against measured groundwater quality data and transport parameters could be adjusted to obtain reasonable agreement between measured and simulated groundwater quality. The last step of the process was to use the groundwater models to evaluate future groundwater quality that could be anticipated under a baseline scenario and that could result from implementing certain water, salt, and nutrient management strategies.

3.1 Salt and Nutrient Sources and Contributions

Salts and nutrients enter the groundwater system from different sources and through various pathways. Through the process of evaluating land uses and activities throughout the Basin, the following potential salt and nutrient sources and processes were identified:

- Fertilizers used for agricultural crop production and landscapes
- Manure from animal facilities
- Recharge from distributed septic systems
- Imported water from outside the Basin used for irrigation
- Wastewater discharges from treatment facilities
- Surface water inflows, including urban stormwater drainage
- Naturally occurring sources
- Evapoconcentration of salts from irrigated agriculture and phreatophytes

Although the evapoconcentration of salts is not a source of salts, it does contribute to increases in groundwater salinity, which has an effect similar to the other sources listed.

Mass loading rates for basinwide water quality evaluations are typically difficult to estimate due to the lack of detailed recordkeeping and reporting across the diverse land uses and management practices that could affect water quality. This Basin is no different in that there are no available records of irrigation or fertilizer applications from crop lands and limited records of waste generation from permitted facilities. Furthermore, knowledge of the total production and use of salt- and nutrient-containing materials such as fertilizers across the land surface alone is not enough to accurately predict the direct loadings or impacts to groundwater. Processes such as surface water and groundwater recharge rates and dilution, leaching, crop uptake and removal, and biologically mediated nitrogen transformations (i.e., mineralization, nitrification, and denitrification) come into play and are dependent upon site soil, groundwater, climate, and specific management practices (e.g., tillage, cropping, irrigation, fertilizer, septic system management).

For this SNMP, directly measured water quality and quantity data used to calculate salt and nutrient loading were derived from required regulatory reports on three separate permitted facilities and from water quality, surface water flow, and groundwater monitoring data, in addition to stakeholder input and records. For the permitted facilities, the required regulatory reports have limited data, and water quality measurements were sporadic; therefore, loading estimates derived from these data should be considered approximations as opposed to validated measurements. The salt and nutrient contributions from other activities and processes throughout the Basin were estimated using the land use characterization and typical ranges of salt and nutrient loads from these land uses. Stakeholder input was incorporated into the SNMP, particularly for identifying land uses, fertilizer management, manure management, and land management practices.

3.1.1 Historical Land Use Considerations

The land uses that were evaluated for this SNMP are based on the conditions represented by 2009 and 2012 aerial imagery and recent operational records from stakeholders in the Basin. Land uses are dynamic and constantly changing, and some historical land uses not addressed by this plan could have influenced current water quality conditions in the Basin differently than current uses. Recent land use changes that have occurred since 2012 are also generally not reflected in this plan. The approach taken in this SNMP was to evaluate a recent baseline land use condition that could be supported with available data and to develop a plan for managing the Basin moving forward.

3.1.2 Point Sources

Point sources, as referred to in this report, encompass the facilities that operate under specific WDRs issued by the Regional Board or under general permits issued by the California Integrated Waste Management Board.

3.1.2.1 Facilities Operating with Waste Discharge Requirements

Inside the Basin

Currently, three permitted facilities operate within the Basin in accordance with WDRs that require annual reports to the San Diego Regional Board—the Konyn Dairy (General Order No. R9-2008-0130), the San Pasqual Academy (General Order No. R9-2009-0072), and the San Diego Wild Animal Park, now operating as San Diego Zoo Safari Park (General Order No. 99-04). The Verger Dairy was also permitted for operation by General Order No. R9-2008-0130 but ceased operations by January 31, 2011. This section briefly describes the information on nutrient loading as summarized from the respective monthly and annual reports.

Konyn Dairy

The Frank J. Konyn Dairy (Konyn Dairy) is an existing dairy located at 15777 Old Milky Way Road in the central portion of the Basin (Figure 3-1) and has been in operation at this location since 1962. This dairy is regulated as an animal feeding operation (AFO) under General Order No. R9-2008-0130 with a maximum allowed number of milking cows established in the WDR at 695. The dairy adopted a Comprehensive Nutrient Management Plan (CNMP) on January 1, 2010, which was developed by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) in cooperation with the dairy. The purpose of a CNMP is to identify deficiencies in nutrient management and to set a schedule for progressive improvements. The progressive improvement schedule established in the Konyn Dairy CNMP spans a 7-year period from 2010 through 2016 and various elements of this plan have already been implemented, including construction of a liquid waste storage pond and development of irrigation systems to enhance forage crop production and nutrient utilization. Changes in land use implemented since 2012 (e.g., conversion of dry-land winter forage adjacent to the Dairy to irrigated summer forage) are not reflected in this plan.

Manure solids from the dairy are separated from manure liquids, with all solids being transferred to and processed at the adjacent licensed composting facility, San Pasqual Valley Soils. Per the WDR annual reports (2008, 2009, and 2011) to the Regional Board, 6,170 cubic yards of solid manure were produced each year, and the same volume was sold or given away to the public each year with no excess manure being stockpiled onsite. The reports state that 40 ac-ft of liquid manure were produced each year and were spread over 40 acres through irrigation to pasture Bermuda and rye grass forage crops. Information on nutrient and salt content of the manure solids and liquids was not available from the WDR annual reports.

The primary potential sources of TDS and nitrogen loading to groundwater from this facility include rainfall-driven infiltration and stormwater runoff from animal containment areas and the compost facility area, irrigation of liquid manure to land application fields, and spreading of composted manure for crop fertilization. Using the number of animals reported in WDR annual reports, along with typical animal excretion rates of TDS and total nitrogen (TN), estimated annual TDS and TN production rates are presented in Table 3-1.

TABLE 3-1
Konyn Dairy Estimated TDS and TN Production from Manure
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Type of Cow	Number of Cows[a]	TDS (lb/cow/day)[b]	TDS (lb/day)	TDS (lb/year)[b]	TN (lb/cow/day)[b]	TN (lb/day)	TN (lb/year)[c]
Milking	695	2.01	1,397	509,887	0.99	688	251,138
Heifer	660	0.84	554	202,356	0.26	172	62,634
Dry	130	1.30	169	61,685	0.50	65	23,725
Calf	315	0.29	91	33,259	0.14	44	16,097
Total Production	**1,800**			**807,000**			**354,000**

Notes:
lb/cow/day = pounds per cow per day
lb/day = pounds per day
lb/year = pounds per year
[a]Number of cows as reported in 2008, 2009, and 2011 WDR annual reports to the Regional Board.
[b] Source: ASAE, 2005. TDS calculated as Total Solids minus Volatile Solids minus Total Nitrogen.
[c] Annual totals reported to the nearest 1,000 lb.

These estimates suggest that approximately 807,000 pounds (lb) of TDS and 354,000 lb of TN are produced from manure at the Konyn Dairy on an annual basis under current conditions. However, nitrogen losses and manure transport to areas outside the Basin also influence the total amount of TDS and TN that is effectively managed inside the Basin. Information provided by Konyn Dairy in stakeholder meetings indicated that approximately 60 percent of the manure solids are transported outside the Valley on an annual basis. The remaining approximately 40 percent of manure solids are utilized for fertilization of forage crops grown at the former Verger Dairy site. An estimated distribution of the original source TDS and TN from dairy manure is presented in Table 3-2.

TABLE 3-2
Konyn Dairy Estimated TDS and TN Distribution/Use from Manure
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Description	TDS (lb/yr)	TN (lb/yr)
Total animal excrement	807,000	354,000
N - volatilization loss [a]		134,520
Animal excrement after volatilization	807,000	219,480
Manure load transferred to compost facility [b]	605,250	164,610
Manure/liquids utilized at Konyn Dairy [c]	201,750	54,870
Manure/compost exported from Basin [d]	363,150	98,766
Manure/compost utilized at Verger Dairy fields [e]	242,100	65,844
Total Manure Utilized within Basin [f]	**444,000**	**121,000**

Notes:
[a] 38% ammonia volatilization loss of N assumed as reported in Viers et al. (2012).
[b] Assumes 75% of all excrement is collected and transported offsite.
[c] Assumed remaining 25% of excrement after volatilization utilized for forage crop production at the Konyn Dairy.
[d] 60% of manure/compost is exported from the Basin.
[e] 40% of manure/compost is utilized at Verger Dairy fields for forage crop production.
[f] Sum of manure/compost utilized at Verger Dairy fields and manure/liquids utilized at Konyn Dairy. Annual TN and TDS loads rounded to the nearest 1,000 lb.

Based on the estimated distribution/use of manure from the dairy, approximately one-half of the TDS and one-third of the TN production from manure are utilized within the Basin. This results in approximately 444,000 lb of TDS and 121,000 lb of TN from manure at the Konyn Dairy being utilized within the Basin annually. These amounts represent approximately 12 percent of the Basin nitrogen load and 1 percent of the Basin salt load.

Verger Dairy

The Bert Verger Dairy (Figure 3-1) was in operation from 1977 through 2011 and was located on a City-leased parcel overlying the Basin near Santa Maria Creek. This dairy was allowed up to 530 milking cows under General Order No. R9-2008-0130 for existing dairy AFOs in Escondido, San Diego County. Although the dairy is no longer in operation as of January 31, 2011, the identification of this former operation is important to understanding past practices that may have impacted groundwater quality in the Basin. When the facility was in operation, runoff from both the corrals and the manure area was collected in two storage ponds. Solids were settled in one pond; overflow went to a second pond. Liquid from the second pond was applied to the land using a sprinkler irrigation system to meet agronomic crop demands. The crops grown at the facility were typically rye grass during the winter months and Bermuda grass during the summer months (MWH, 2010). In recent years, after Verger Dairy ceased operation, composted manure from the Konyn Dairy has been utilized to grow irrigated forage crops (alfalfa inter-seeded with grass) over approximately 138 acres of the former Verger Dairy fields. It is estimated that the total annual nitrogen loading to these fields is approximately 480 lb of nitrogen per acre, using manure nutrient load estimates from Table 3-2, compared to approximately 340 lb of nitrogen per acre of crop harvest removal, based on crop harvest records from the Dairy. Additional record-keeping on manure analysis and manure loading rates to these fields would help to improve these estimates.

San Pasqual Academy

The San Pasqual Academy is located at 17701 San Pasqual Valley Road in the eastern portion of the Basin and is a residential education campus designed for 184 foster teens, with approximately 325 total staff and students (Figure 3-1). This facility is located outside the City-owned and -leased areas of the Basin, residing in the jurisdiction of San Diego County. The 238-acre campus features its 0.05-million-gallon-per-day (mgd) wastewater treatment plant, which receives sewage from the San Pasqual Academy and adjacent residential buildings. Treated wastewater effluent is pumped from the aeration pond to a 1-acre grass strip percolation/spray irrigation bed bounded with eucalyptus trees. Screenings and sludge are dried onsite and then hauled to the Ramona Landfill or the Otay Landfill.

Evaporation of wastewater from the discharger's aeration pond and the use of water softeners in the older residential units are reportedly contributing to elevated concentrations of TDS in the effluent. At times, these concentrations have exceeded the 30-day average discharge specifications of 800 mg/L for TDS. Average flows, along with TDS and TN concentrations and mass loadings, can be found in Table 3-3.

TABLE 3-3
San Pasqual Academy Flow and Nitrogen and TDS Loading[a]
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Month	Daily Flow[b] (gallons)	Monthly Flow (gallons)	TDS[b] (mg/L)	Daily TDS Load (lb)	Monthly TDS Load (lb)	TN[c] (mg/L)	Daily TN Load (lb)	Monthly TN Load (lb)
January	5,506	170,686	757	35	1,078	29	1.3	41
February	4,752	133,056	761	30	845	29	1.2	32
March	5,732	177,692	767	37	1,137	29	1.4	43
April	3,718	111,540	800	25	745	29	0.9	27
May	4,226	131,006	781	28	854	29	1.0	32
June	4,356	130,680	817	30	891	29	1.1	32
July	65,333	2,025,323	856	467	14,468	29	15.8	490
August	5,750	178,250	761	37	1,132	29	1.4	43
September	5,817	174,510	878	43	1,279	29	1.4	42
October	6,380	197,780	863	46	1,424	29	1.5	48
November	4,610	138,300	831	32	959	29	1.1	33
December	5,150	159,650	813	35	1,083	29	1.2	39
Annual Totals[d]		**3,728,000**			**25,900**			**900**

Notes:
[a]Data were processed from monitoring reports from 2007, 2008, first half of 2009, 2010, and first half 2012.
[b]Flows and TDS concentrations were gathered from quarterly self-monitoring reports.
[c]A single 12-month average TN concentration was available from the 2010 annual report.
[d]Annual totals reported to the nearest 1,000 gallons and 100 lb.

According to the San Pasqual Academy WDRs, TN is not required to be monitored. Only one data point was found in the semiannual reports, with a TN concentration of 29 mg/L for a 12-month average in 2010. This value was used to estimate the TN mass load throughout the year (as shown in Table 3-3), resulting in an estimated annual TN load from the San Pasqual Academy of 900 pounds. With all of the effluent discharged over the 1-acre grass strip percolation/spray irrigation bed, annual loading rates within the discharge area are estimated at 25,900 lb of TDS and 900 lb of TN. These loads represent less than 1 percent of the salt and nitrogen loads in the Basin.

San Diego Zoo Safari Park

The San Diego Zoo Safari Park, owned by the Zoological Society of San Diego, is located along the northern edge of the Basin on City-leased property at 15500 San Pasqual Valley Road (Figure 3-1). The Safari Park has been in operation at this location since 1969 and maintains a long-term lease with the City of San Diego for approximately 2,045 acres.

The Safari Park operates its own wastewater treatment plant that is designed for a maximum peak daily flow rate of 0.15 mgd. This facility treats domestic wastewater generated from the facilities at the park. After being held in an onsite storage pond, the disinfected secondary-treated reclaimed water is utilized for irrigation of the northern and western portions of the animal lands in the African Plains exhibit, in locations separated from public access. The estimated flows and mass loads of TDS and TN in the reclaimed water are presented in Table 3-4. Using the data provided in required monitoring reports, the estimated annual mass loads are 1,700 lb of TN and 93,700 lb of TDS. These loads represent less than 1 percent of the salt and nitrogen loads in the Basin.

TABLE 3-4
San Diego Zoo Safari Park Recycled Water Irrigation Flow and Loadings of Nitrogen and TDS
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Month	Ave Daily Flow (gallons) [a]	Monthly Flow (gallons)	TDS (mg/L) [b]	Daily TDS Load (lb)	Monthly TDS Load (lb)	Nitrate-N (mg/L) [b]	Daily Nitrate-N Load (lb)	Monthly Nitrate-N Load (lb)
January	35,377	1,096,693	581	172	5,318	10.4	3.1	95
February	34,921	977,782	581	169	4,741	10.4	3.0	85
March	40,353	1,250,955	581	196	6,065	10.4	3.5	109
April	133,202	3,996,065	581	646	19,376	10.4	11.6	347
May	46,416	1,438,890	581	225	6,977	10.4	4.0	125
June	52,919	1,587,575	581	257	7,698	10.4	4.6	138
July	61,611	1,909,933	581	299	9,261	10.4	5.3	166
August	58,697	1,819,592	581	285	8,823	10.4	5.1	158
September	43,015	1,290,460	581	209	6,257	10.4	3.7	112
October	40,113	1,243,515	581	194	6,029	10.4	3.5	108
November	44,558	1,336,746	581	216	6,481	10.4	3.9	116
December	44,104	1,367,212	581	214	6,629	10.4	3.8	119
Annual Totals[c]		**19,315,000**			**93,700**			**1,700**

Notes:

[a] Flows gathered from monthly self-monitoring reports in accordance with WDRs.

[b] Wastewater effluent quality was analyzed on a single sample from December 27, 2010, and was reported in the 2010 annual report.

[c] Annual totals reported to the nearest 1,000 gallons and 100 lb.

The Safari Park obtains water from two primary sources—1) the city of Escondido and 2) groundwater from the Basin alluvial aquifer via the Valley Well." These primary water sources are recycled and reused throughout the park operations through irrigation reuse of treated water from the wastewater treatment plant and irrigation of water collected in the ponds throughout the park. The amount of water imported from the city of Escondido was 522 ac-ft in 2003, 613 ac-ft in 2004, and was reported by the Safari Park in 2013 to currently be 411 ac-ft on an annual basis. Based on the Soil Moisture Budget (SMB) irrigation water demand calculations (see Appendix B and Attachment B1), it was estimated that the total annual irrigation water use is 621 AFY on average across the Safari Park and that groundwater pumping is approximately 210 AFY.

The Safari Park reports the total volumes of manure, green waste, and dried sludge (biosolids) that are managed each year in the WDR required annual reports to the Regional Board. The green waste is disposed of by Edco Waste & Recycle on a weekly basis, and the sludge is hauled offsite per the annual reports. All animal manure consisting of manure and shavings is composted by a local farmer on property located across San Pasqual Valley Road from the Safari Park. The manure is spread and disced into these fields where winter forage crops are grown for use in feeding animals at the Safari Park. The Safari Park annual reports state that the amount of manure collected and transferred offsite averaged 11,075 U.S. tons per year in 2010 and 2011 (1 U.S. ton per year is equivalent to 2,000 lb per year [lb/yr]). Information provided by the Safari Park through the stakeholder process established that the amount of manure collected and transferred offsite in recent years for use in this SNMP should be 8,356 U.S. tons per year. Therefore, this amount was used for the calculations and modeling performed to support this SNMP.

Using the reported amount of manure collected and transferred to adjacent fields each year, the total annual nutrient and salt loads from animal excrement across the Safari Park was estimated. In the absence of reported manure analytical data, manure moisture, TN, and TDS content were first estimated using typical manure compositions from equine facilities and beef cattle on an earthen lot (ASAE, 2005). Because the collected manure represents only a portion of the total excrement, adjustments were needed to estimate the total production of salt and nutrients. Animal enclosure conditions across the Safari Park vary, and the collection efficiency of animal excrement is also expected to vary. Assuming that 75 percent of the total animal excrement is collected and transported offsite each year, estimated total loads of salt and nutrients are presented in Table 3-5. Note that the remaining 25 percent of animal excrement that is not collected includes urine, which is impractical to collect and transport offsite.

TABLE 3-5
San Diego Zoo Safari Park Estimated Nitrogen and TDS Loadings from Animal Excrement
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Description	Value
Annual amount of manure generated (lb) [a]	16,712,000
Estimated moisture content (% by mass) [b]	43%
Estimated TN content (% by mass) [b]	0.76%
Estimated TDS content (% by mass) [b]	2.75%
Estimated TN load in collected manure utilized on winter forage fields (lb/year) [c, d]	72,000
Estimated TDS load in collected manure utilized on winter forage fields (lb/year) [c, d]	261,000
Estimated TN load in uncollected excrement utilized on-site (lb/year) [c, d]	24,000
Estimated TDS load in uncollected excrement utilized on-site (lb/year) [c, d]	87,000
Estimated TN load from all animal excrement (lb/year) [c, d]	**96,000**
Estimated TDS load from all animal excrement (lb/year) [c, d]	**348,000**

Notes:

[a] Source: Information provided by the Safari Park in February 2014.

[b] Source: ASAE, 2005 – Based on manure from equine facilities and beef cattle on an earthen lot. TDS calculated as sum of Ca, Na, Mg, S, Cl. Nitrogen, phosphorous, and potassium excluded from TDS load.

[c] Assumes 75% of all excrement is collected and transported offsite.

[d] Annual TN and TDS loads rounded to the nearest 1,000 lb.

Based on these calculations, the estimated annual contributions from animal excrement from the Safari Park that are managed inside the Basin are 96,000 lb of TN per year and 348,000 lb of TDS per year. These amounts represent approximately 9 percent of the Basin nitrogen load and 1 percent of the Basin salt load.

Using maps provided by the Safari Park, the total area of winter forage fields that receive manure application is 116 acres. As a result, the estimated annual manure use on these fields is approximately 72 wet tons per acre; using the estimated manure composition, this application supplies approximately 620 lb of nitrogen per acre to these fields each year. It is estimated that nonirrigated winter forage with a crop yield of 2 tons per acre removes approximately 64 lb of nitrogen per acre in harvested forage material each year. Additional record-keeping on manure analysis, manure loading rates, and annual crop yields from these fields would help to improve these estimates and to establish whether changes to manure nutrient management are warranted.

Outside the Basin

Two permitted facilities are operating near the Basin and within contributing watersheds of the Basin, as described below (Figure 3-2). These facilities discharge recycled water to a combination of an ocean outfall, golf course and other urban irrigation reuse areas, and agricultural spray fields. Some of the nutrient and salt mass from these discharges may enter the Basin indirectly through stormwater flows from tributary creeks. The nutrient and salt loads from tributary creeks are addressed separately and apply only to that portion of discharge that contributes to Basin loading; thus there is no need to separately address the total nutrient and salt loads from the two permitted facilities. A general description of each facility and their operations is provided below.

Santa Maria Wastewater Treatment Plant

The Santa Maria Wastewater Treatment Plant, located at 260 North Sawday Street in Ramona is operated by the City of Ramona. The treatment plant discharges tertiary-treated wastewater to a local golf course (Mt. Woodson Golf Course) and secondary-treated effluent to agricultural spray fields. Total treatment capacity is 1.0 mgd, but dry-weather flows average closer to 0.7 mgd. Approximately 0.4 mgd is conveyed to the golf course, and 0.3 mgd is sent to the agricultural spray fields. The Santa Maria Wastewater Treatment Plant is within the Santa Maria Creek subwatershed, and either deep percolation from land applied secondary-treated effluent or surface runoff could impact water quality in Santa Maria Creek. It is assumed that associated salt and nutrient loading to the Basin from the Santa Maria Wastewater Treatment Plant is reflected in Santa Maria Creek water quality measurements.

Hale Avenue Resource Recovery Facility

The Hale Avenue Resource Recovery Facility located at 1521 South Hale Avenue in Escondido is operated by the city of Escondido. Effluent from the facility discharges to an ocean outfall pipe (offshore) and is conveyed to satisfy local reuse demands (for golf courses, parks, schools). Treatment capacity is 18 mgd, with daily flows currently at 15.6 mgd; up to 9 mgd are conveyed for local reuse. Most of the reuse areas are located outside the areas that drain into the Basin; they are generally west of Interstate 15 or north of Lake Hodges. Salt and nutrient loading from the Hale Avenue Resource Recovery Facility to the Basin is expected to be minimal.

3.1.2.2 Facilities Operating with General Waste Management Permits

The San Pasqual Valley Soils facility is regulated under Permit No. 37-AB-0015, issued on November 19, 2007, as a composting (green waste) operation. This facility is owned by Frank Konyn of the Konyn Dairy and is operated as a green material composting process designed to manage dairy manure through composting with higher carbon materials, utilizing an outdoor open-windrow process. The facility is inspected quarterly and is permitted to process 150 U.S. tons per day or 77,375 U.S. tons per year on a total of 12 acres.

The total load of salt and nutrients that is managed by this facility has been accounted for in the manure production calculations from the Konyn Dairy.

3.1.3 Nonpoint Sources

Nonpoint sources include all the distributed sources of salt and nutrients across the Basin that are not specifically identified under the point source category.

3.1.3.1 Nonpoint Source Regulations

Historically, only a small portion of the potential nonpoint source contributions in the Basin have been regulated under conditional waivers with varying levels of regulatory interaction. To a large extent, BMPs for water quality protection have been implemented on a voluntary basis, and no monitoring is required. Nonpoint sources that are regulated under conditional waivers are summarized in Table 3-6.

TABLE 3-6
Regional Board Conditional Waivers Applicable to Certain Operations in the San Pasqual Valley
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Conditional Waiver	Type of Discharge	Conditional Waiver Feature/Requirement
Conditional Waiver No. 1	Onsite Disposal Systems	Applies to septic tank/subsurface disposal systems for residential and commercial/industrial use. Several BMPs are specified, which if followed, cover the onsite disposal system under this conditional waiver of WDRs. There are no recordkeeping or reporting requirements, so enforcement of this waiver is operated primarily on a complaint-based system or is associated with inspections required during disposal system upgrades or replacement.
Conditional Waiver No. 3	Animal Operations	Applies to discharges from small (fewer than 300 animals) and medium (300 to 999 animals) animal feeding operations, stormwater runoff, discharges of manure to soil, and discharges from grazing lands. Several BMPs are specified, which if followed, cover the animal operation under this conditional waiver of WDRs. Applicable animal feeding operations and grazing lands are eligible for the waiver without enrollment as long as wastes and activities are properly managed. Enforcement actions can be taken against facilities that fail to comply with the waiver conditions; however, no recordkeeping or reporting requirements exist, so enforcement of this waiver is operated primarily on a complaint-based system.
Conditional Waiver No. 4	Agricultural and Nursery Operations	Applies to discharges of plant crop residues to land, stormwater runoff, amendments or mulches to soil, and discharge of agricultural irrigation return water, and nursery irrigation return water. A water quality monitoring program is required and several BMPs are specified, which if followed, cover the agricultural and nursery operations under this conditional waiver of WDRs. The applicability of this waiver extends only to commercial operations. To qualify as a commercial operation, the agricultural or nursery operation must have generated gross sales of at least $1,000 per average year. An average year is defined as the average gross sales for the previous 3 calendar years. This waiver required owners/operators of agricultural and nursery operations to file a notice of intent to comply by January 2, 2011. This waiver required submittal of a monitoring program by December 31, 2012.

Note: Other conditional waivers (CW) not specifically listed above include CW2 – "Low Threat" Discharges to Land; CW5 – Discharges from Silvicultural Operations; CW6 – Discharges of Dredged or Fill Materials Nearby or Within Surface Waters; CW7 – Discharges of Recycled Water to Land; CW8 – Discharges of Solid Wastes to Land; CW9 – Discharges of Slurries to Land; CW10 – Discharges of Emergency/Disaster Related Wastes; and CW11 – Aerially Discharged Wastes Over Land.

Conditional Waivers No. 1 and No. 3 are implemented on a complaint-based system only and are not expected to yield supplemental data in support of this SNMP. Based on information provided by the San Diego County Farm Bureau, the agricultural and nursery operations participating in the monitoring group for Conditional Waiver No. 4 selected two different watersheds in San Diego County for monitoring. In the short term, no monitoring of agricultural or nursery runoff from within the Basin is anticipated from this program.

3.1.3.2 Septic Systems

The majority of residents in the unincorporated areas of the Basin rely on septic systems for in-ground disposal of domestic wastewater. An estimate of the number of septic systems in and around the Basin was based on an aerial image analysis of major residences and buildings that appear to be outside the sewer service limits of the city of Escondido, the San Diego Zoo Safari Park, and the San Pasqual Academy. Residences within 1,000 feet of the Basin boundary were included in the evaluation. Approximately 78 buildings in and around the Basin utilize an in-ground septic system. Of these 78 buildings, approximately 46 total septic systems are operated within the Basin, assuming that some buildings and residences located on the same property are served by shared systems (shown in Figure 3-2).

For the septic system loading estimates, water use was assumed to be 161 gallons per capita per day with 2.8 persons per household and with 50 percent of that water being for indoor water use (Todd Engineers, 2012). Mass loads were estimated assuming an average effluent concentration of 63 mg/L TN (Lowe et al., 2009) and an average TDS increase over the source water of 200 mg/L due to domestic water use (Kaplan, 1987). Table 3-7 presents a summary of the estimated nitrogen and salt loadings from septic systems in and around the Basin. Based on these calculations, septic systems are estimated to contribute 2,000 lb /yr of TN and 6,300 lb/yr of TDS to groundwater recharge. These loads represent less than 1 percent of the salt and nitrogen loads in the Basin.

TABLE 3-7
Estimated Septic System Loadings in the Basin
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Description	Value
Approximate number of rural septic systems	46
Estimated daily water use per system (gallons per day)	451
Total annual residential water use (gallons)	7,568,932
Estimated gray water and wastewater discharge to septic systems (gallons)	3,784,466
Estimated residential outdoor use (gallons)	3,784,466
Estimated TN concentration of septic liquid discharge (mg/L)	63
Estimated TN load by septic system leaching to groundwater (lb/year)[a]	**2,000**
Average TDS increase in septic liquid discharge (mg/L)	200
Estimated annual TDS load to groundwater (lb/year)[a]	**6,300**

Note:
[a]Annual TN and TDS loads are rounded to the nearest 100 lb.

3.1.3.3 Fertilizer Use from Agricultural Crop Production and Landscapes

The largest land use overlying the Basin is agriculture, which can contribute nonpoint source loading to surface and groundwater by runoff and leaching of salts and nutrients from applied fertilizer sources. Landscapes, including residential, golf courses, and recreational facilities like the Safari Park, also receive fertilization to support plant growth. Nitrogen is a necessary nutrient for plant growth, and commercial nitrogen fertilizers are typically formulated as a nitrate or ammonium containing salt. Animal manure and other organic composts may also be used as a fertilizer to supply nutrients and as a soil conditioner, which contributes additional salt loading. Actual fertilizer loading rates vary widely depending upon crop type, expected yields, soil conditions, and many other irrigation and nutrient management factors.

Both stakeholder input and several sources of nitrogen fertilizer recommendations, along with nitrogen use surveys for different crop and land uses, were evaluated to develop estimates of annual nitrogen applications, as presented in Table 3-8. All of these recommendations and surveys were based upon information collected from operations in the Basin or, where not available from in-Basin sources, from other operations in California. To estimate the TDS contribution from nitrogen fertilization, the TDS content of three common commercial nitrogen fertilizers (ammonium nitrate, calcium nitrate, and urea fertilizer) was utilized.

As seen in Table 3-8, the estimated annual mass loading rates from fertilizer applications are 734,000 lb/yr for TN and 2,129,000 lb/yr for TDS. These amounts represent approximately 70 percent of the Basin nitrogen load and 5 percent of the Basin salt load.

The largest source of nitrogen contribution from fertilizer use was from avocado production due to the large area in production on hillsides surrounding the Basin but within the study area subcatchment. The second largest contribution was from landscapes in residential developments across the subcatchment. These estimates exclude the nutrient applications from animal manure, which are accounted for in separate estimates presented for the respective animal facilities.

3.1.3.4 Evapoconcentration of Salts from Irrigated Agriculture and Phreatophytes

Evaporation from the land surface and water uptake and transpiration through vegetation removes water from the Basin while leaving the dissolved salts in the soil water behind for leaching to the aquifer. This process is termed “evapoconcentration.” Evapoconcentration of dissolved salts from the groundwater system is most pronounced in areas that are irrigated using water pumped from the groundwater system and where phreatophytic vegetation extracts water from shallow groundwater or the capillary fringe, primarily in riparian areas along stream drainages. Although the process of evapoconcentration is not a source of new salts in the Basin, it has the same effect as other sources in contributing to the increase in groundwater salinity.

Calculations performed as part of the groundwater modeling effort (see Appendix B) indicate the evapoconcentration effect from both the irrigation of Basin groundwater sources and from phreatophyte water uptake throughout the subcatchment. For the irrigation contributions, the concentration of TDS in deep percolation was compared to the irrigation source water TDS concentration, and the difference in those two concentrations times the deep percolation flux was accumulated and attributed to evapoconcentration. In essence, an increase in TDS concentration in return flows to groundwater was attributed to evapoconcentration. For the phreatophyte water uptake through the subcatchment, groundwater models were run with and without salt uptake associated with shallow groundwater ET in the riparian areas. The simulation that included uptake of TDS by riparian phreatophytes provided an estimate of the evapoconcentration effect on groundwater salinity.

On an average annual basis, the evapoconcentration effect is estimated to contribute 8,168,000 lb of TDS from riparian areas and 12,717,000 lb from irrigation of Basin groundwater. Together, these two processes account for approximately 48 percent of the Basin salt load.

TABLE 3-8
Agricultural Crop Production Estimated Fertilizer Nitrogen and Salt Loadings
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Primary Land Use	Total Area in Subcatchment (acres)	Irrigated Area in Subcatchment (acres)[a]	Estimated Nitrogen Application Rate (lb/ac/yr)[b]	Estimated TDS Load (lb/yr)[c]	Estimated TN Load (lb/yr)	Nitrogen Application Rate Data Source
Avocado	2,422	1,807	120	628,969	216,886	Fertilizer records from Whitman Ranch
Citrus	645	486	120	168,990	58,273	Fertilizer records from Whitman Ranch
Cut Flowers	222	123	400	143,205	49,381	Tjosvold, 1999
Golf Course	171	165	174	83,270	28,714	Henry et al., 2002
Grapevines	185	107	38	11,744	4,050	Rosenstock et al., 2013. Average of raisin, table, and wine grapes
Greenhouse	8	8	909	20,266	6,988	Fertilizer records from The Pinery
Landscape	2,385	843	174	425,824	146,836	Henry et al., 2002
Nursery-Container	100	38	909	100,707	34,726	Fertilizer records from The Pinery
Nursery-Field	248	144	54	22,618	7,799	Fertilizer records from Whitman Ranch and Big Trees Nursery
Truck Crops	224	123	217	141,141	48,669	Rosenstock et al., 2013. Average of 13 different fresh vegetable crops
Sod Farms	633	403	200	366,926	126,526	Fertilizer records from Whitman Ranch
Winter Forage[d]	66	0	80	15,312	5,280	NRCS, 2008. Nonirrigated ryegrass hay
Totals[e]	**7,310**	**4,247**		**2,129,000**	**734,000**	

Notes:

[a] Irrigated areas were used as the basis for fertilizer application estimates except for Truck Crops and Sod Farms. The irrigated area represents the amount of area irrigated at any given time during the growing season. Due to crop rotation across fields in Truck Crops and Sod Farms and general utilization of the full cropped areas over the course of an annual cycle, the total area was used for fertilizer calculations on these crops.

[b]Estimated nitrogen application rates were derived from the data sources listed in this table and are based on locally derived records where available.

[c]TDS contributions from fertilizer applications were estimated using an average analysis of ammonium nitrate, calcium nitrate, and urea fertilizer at 2.9 lb of TDS per 1 lb of nitrogen.

[d]Winter and summer forage fields receiving manure applications are accounted for separately and are not included in this table.

[e]Annual TN and TDS loads rounded to the nearest 1,000 lb.

Provided that an adequate quantity and quality of natural recharge is available, pumping and beneficially using groundwater within a basin can represent a valuable water quality management strategy. However, the water supply solutions that may be most beneficial (pumping versus importing) could change, depending upon location within the basin, surface/groundwater connections, and the quality of external water sources. For instance, in the eastern portions of the Basin where groundwater is deep and does not restrict the recharge of high-quality surface flows, importing water of better quality than the native groundwater for irrigation might be a beneficial alternative to native groundwater pumping in that specific area. In the western portions of the Basin where groundwater depths are shallow, groundwater pumping may be more beneficial, especially for uses that ultimately remove salts from the Basin and do not recycle salts through return flows. Overall, the uptake and removal of salts through crop harvest is relatively minor, but practices that promote enhanced high-quality recharge and surface and subsurface outflow of native salts are important. Another potential management strategy is limiting the amount of consumptive use and subsequent annual evapoconcentration of salts in the Basin. This strategy is discussed further in Section 3.3 and in Appendix B.

3.1.3.5 Surface Water Inflows, Including Urban Stormwater Drainage

Four primary watersheds contribute water through streambed infiltration and subsurface inflows into the Basin—Santa Ysabel Creek, Guejito Creek, Santa Maria Creek, and Cloverdale Creek. These watersheds range from largely undeveloped areas to highly urbanized areas, and the quality of surface water reflects these differences in land use.

The periphery of the Valley has urban development (particularly the west side of the Basin) that contributes urban stormwater drainage to the Valley and San Dieguito River. Impervious surfaces created by developments and roads cause rainwater to flow quickly over the landscape, rather than infiltrate naturally into the soil. Urban stormwater runoff often carries constituents such as petroleum products (originating from parking areas); nitrogen, phosphorus, and other nutrients (from fertilizers applied to lawns and urban landscaping); and sediment (potentially exacerbated by increased peak flows of surface runoff caused by compacted soils and impervious areas). In Order R9-2007-0001, the Regional Board lists bacterial indicators, sulfate, color, nitrogen, phosphorus, and TDS in the San Dieguito River as 303(d) pollutants of concern or water quality effect (from urban stormwater runoff).

Urban stormwater runoff of a municipal separate storm sewer system (MS4) is governed by National Pollutant Discharge Elimination System (NPDES) Permit No. CAS0108758. To mitigate the pollution concerns associated with urban runoff and to comply with regulations of the Regional Board, cities surrounding the Valley utilize a Standard Urban Stormwater Mitigation Plan (SUSMP). The SUSMP identifies a number of stormwater best management practices (BMPs) to protect and enhance surface water quality.

Drainage from the contributing watersheds of Santa Maria Creek and Cloverdale Creek may release some salts to stormwater from irrigation of recycled water upstream of the Basin in the Santa Maria Creek watershed and from irrigation return flows from avocado orchards and urban areas in the Cloverdale Creek watershed.

The City collects surface water samples at six sampling locations in the Basin. Figure 2-4 shows San Pasqual gage stations and surface water sampling sites. Results of analysis of surface water samples for nitrate and TDS during 2006 through 2011 are summarized in Figures 2-8 and 2-9, respectively. Flow-weighted average nitrate and TDS concentrations are summarized in Table 3-9.

TABLE 3-9
Surface Water Quality Flow-Weighted Average Concentrations
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Sampling Location	Average Annual Discharge (AFY)[a]	Flow-Weighted Nitrate Concentration[b] (mg/L)	Flow-Weighted TDS Concentration[b] (mg/L)
YSA 8, Santa Ysabel Creek on the east side of the Basin	5,262	0.5	218
GJC4, Guejito Creek, just upstream of confluence with Santa Ysabel Creek	1,509	0.93	256
SMC4, Santa Maria Creek, just upstream of confluence with Santa Ysabel Creek	2,615	10.2	562
CDC4, Cloverdale Creek, just upstream of confluence with San Dieguito River	1,162	7.2	1,290
Total	10,548		

Notes:
[a]Average flows reported from USGS gages for the 2008 through 2012 period for all stations except Cloverdale Creek. Cloverdale Creek flows estimated from Cloverdale Canyon return flows (CH2M HILL, 2001).
[b]Processed from surface water samples collected by the City from 2006 through 2011, which were analyzed in the City's water quality laboratory.

Observations of significance for surface water quality and potential contributions to groundwater quality include the following:

- Basin surface water data suggest that drainages with urban development appear to have elevated concentrations of nitrate and TDS compared to drainages with minimal urban development.
- Surface water quality appears better on the east (upstream) side of the Basin compared to the west (downstream) side of the Basin.
- Flow-weighted average nitrate and TDS concentrations are below the Basin WQOs (1,000 mg/L for TDS and 10 mg/L for NO_3) except for nitrate on Santa Maria Creek and TDS on Cloverdale Creek.
- Although below the groundwater WQO, the Cloverdale Creek nitrate concentration is elevated (7.2 mg/L) relative to the other surface water inflows (Santa Ysabel Creek and Guejito Creek), which have average nitrate concentrations below 1 mg/L.
- Cloverdale Creek has a significant variation in measured nitrate concentrations (2.4 mg/L to 55 mg/L).
- Surface water quality data of Kit Carson Creek suggest impacts from urban development, but this has no effective impact on the quality of Basin groundwater because Kit Carson Creek discharges into Lake Hodges.

The total annual loadings of nitrate and TDS from streambed infiltration across the study area subcatchment were developed through the groundwater modeling effort presented in Appendix B. The cumulative streambed infiltration across the entire subcatchment is estimated to contribute 20,000 lb/yr of TN and 12,561,000 lb/yr of TDS to the groundwater system. These amounts represent approximately 2 percent of the Basin nitrogen load and 29 percent of the Basin salt load.

3.1.3.6 Small Animal Facilities

A number of animal operations generate manure inside the Basin and are operated without permit requirements due to their size. Through a survey of City leaseholders within the Basin, five nonpermitted small animal facilities were identified. These parcels range from properties with a few goats, pigs, and poultry to one parcel with 160 head of cattle. Manure management practices also vary across these parcels.

A summary of the information compiled on small animal facilities is presented in Table 3-10, along with projections of the total TDS and TN loads managed within the Basin. These calculations used the same assumptions applied to the Safari Park and Konyn Dairy for ammonia volatilization rates and percentage of collection efficiency for total animal excrement that can be collected and transported offsite.

TABLE 3-10
Estimated Small Animal Facility Loadings within the Basin
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Lease Number	Animal Quantity and Type	Manure Management	Total Animal Excrement TDS (lb/yr)	Total Animal Excrement TN (lb/yr)	Manure Utilized in Basin TDS (lb/yr)	Manure Utilized in Basin TN (lb/yr)
28	90 horses	Hauled out of the valley	52,600	6,600	13,200	1,000
33	29 goats, 50 chickens, 5 pigs, 1 turkey, 5 peacocks	Spread in cropped fields	1,600	600	1,600	400
45	10 horses, 5 cows, 4 min. donkeys, 1 alpaca, 2 ostrich, 6 goats, 11 chickens, 12 ducks, 1 guinea hen	Hauled out of the valley	8,300	1,800	2,100	300
46	70 sheep, 8 chickens, 12 ducks	Sheep manure hauled offsite	4,100	1,500	1,000	200
52	160 cattle	Managed onsite	27,600	21,000	27,600	13,000
Totals			**94,200**	**31,500**	**45,500**	**14,900**

Based on the information in Table 3-10, the estimated annual contributions from animal excrement managed inside the Basin due to small animal facilities are 14,900 lb/yr of TN and 45,500 lb/yr of TDS. These amounts represent approximately 2 percent of the Basin nitrogen load and less than 1 percent of the Basin salt load.

3.1.3.7 Imported Water From Outside the Basin Used for Irrigation

Although the primary water source for irrigated lands overlying the Basin is groundwater, significant portions of the study area subcatchment are supplied with imported water source used for irrigation. These include water supplies delivered by the cities of Escondido, Ramona, and Poway, and by Rincon Del Diablo Water District. These water sources are generally low in TDS (345 to 482 mg/L) and nitrate (0 to 0.17 mg/L), but the mass contribution of imported salts and nutrients cannot be ignored due to the volume of water use. Based on the water source and water use calculations for the study area, the estimated imported loads are 6,962,000 lb/yr of TDS and 1,000 lb/yr of nitrate. These amounts represent less than 1 percent of the Basin nitrogen load and approximately 16 percent of the Basin salt load.

3.1.3.8 Naturally Occurring Salts and Other Constituents

A portion of the nutrients and salts occur naturally in the groundwater system and represent contributions that cannot be removed by changed land and water management within the Basin. Naturally occurring nitrogen can come from a variety of sources, including atmospheric deposition through rainfall and dry deposition, atmospheric nitrogen from nitrogen-fixing plants, decomposition and nitrogen release from organic materials imported into the Basin through wildlife or surface water flows, and import of dissolved nitrogen through surface and subsurface inflows. Naturally occurring salts may be contributed from dissolution of minerals in the groundwater system, import of dissolved salts through surface and subsurface inflows, and evapoconcentration of dissolved salts through shallow groundwater ET in riparian areas.

The National Atmospheric Deposition Program (NADP)/National Trends Network (NTN) operates a network of monitoring stations around the U.S. that are used to measure the atmospheric deposition of various chemicals, including inorganic nitrogen. Based on 1982 to 2010 data from the closest operational station to the Valley (Tanbark Flat station in Los Angeles County), the annual average deposition of inorganic nitrogen is estimated at 1.9 lb per acre per year (NADP/NTN, 2013). Over the subcatchment area of 26,816 acres, this represents an annual TN contribution of 50,950 lb/yr, which constitutes approximately 5 percent of the Basin nitrogen load.

Although it is difficult to pinpoint the nutrient and salt loads contributed from all naturally occurring processes, water quality data can be useful to establish effective background concentrations that incorporate these effects. This approach was used in this SNMP. Nitrate concentrations measured in streamflow from YSA8 (Santa Ysabel Creek on the east side of the Basin) and GJC4 (Guejito Creek, just upstream from confluence with Santa Ysabel Creek) water quality monitoring sites (Table 3-9) are representative of sites with relatively undeveloped contributing watersheds and exhibit flow-weighted nitrate concentrations of 0.5 to 0.9 mg/L.

3.1.4 Summary of Point and Nonpoint Sources and Processes

Following the estimation of salt and nutrient contributions across the spectrum of important point and nonpoint sources, sources and processes can be compared using a common metric (lb/yr of TN and TDS) to assist in developing an understanding of the relative importance of each source and process. Table 3-11 presents a summary of the annual TN and TDS loading data presented from previous sections. Summary pie charts are presented in Figures 3-3 and 3-4 to graphically display the relative magnitude of each source or process.

TABLE 3-11
Estimated Nitrogen and Salt Loadings from Various Sources and Processes across the Basin
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Salt and Nutrient Sources and Processes	Estimated Total Nitrogen Load (lb/yr)	Estimated TDS Load (lb/yr)
Septic System Discharge	2,000	6,300
San Pasqual Academy Effluent	900	25,900
Small Animal Facilities	14,900	45,500
Atmospheric Deposition	51,000	51,000
San Diego Zoo Safari Park - Reclaimed Water	1,700	93,700
San Diego Zoo Safari Park – Manure	96,000	348,000
Landscape Fertilizer Use	147,000	426,000
Konyn Dairy	121,000	444,000
Commercial Crop Fertilizer Use	587,000	1,703,000
Imported Water	1,000	6,962,000
Evapoconcentration in Riparian Areas	0	8,168,000
Surface Water Inflows	20,000	12,561,000
Evapoconcentration from Irrigation	0	12,717,000
	1,042,500	**43,551,400**

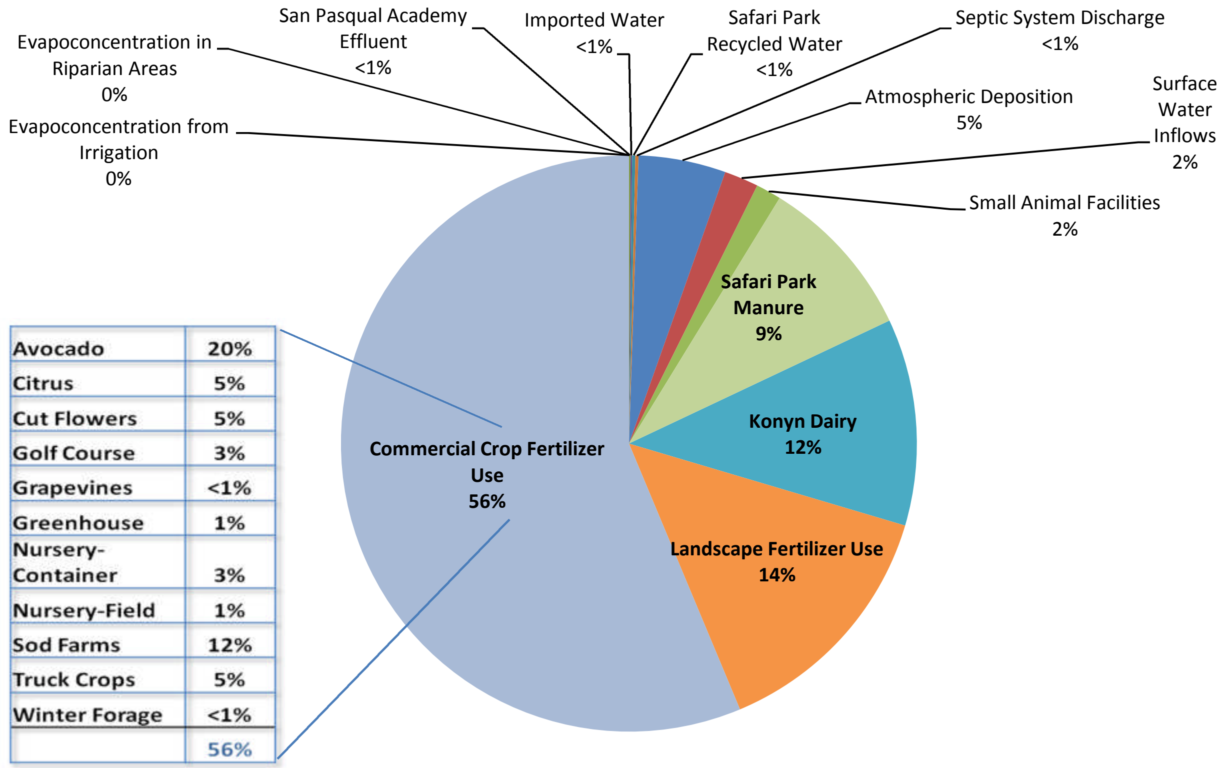


Figure 3-3 Estimated Contribution of Total Nitrogen from Various Sources and Processes

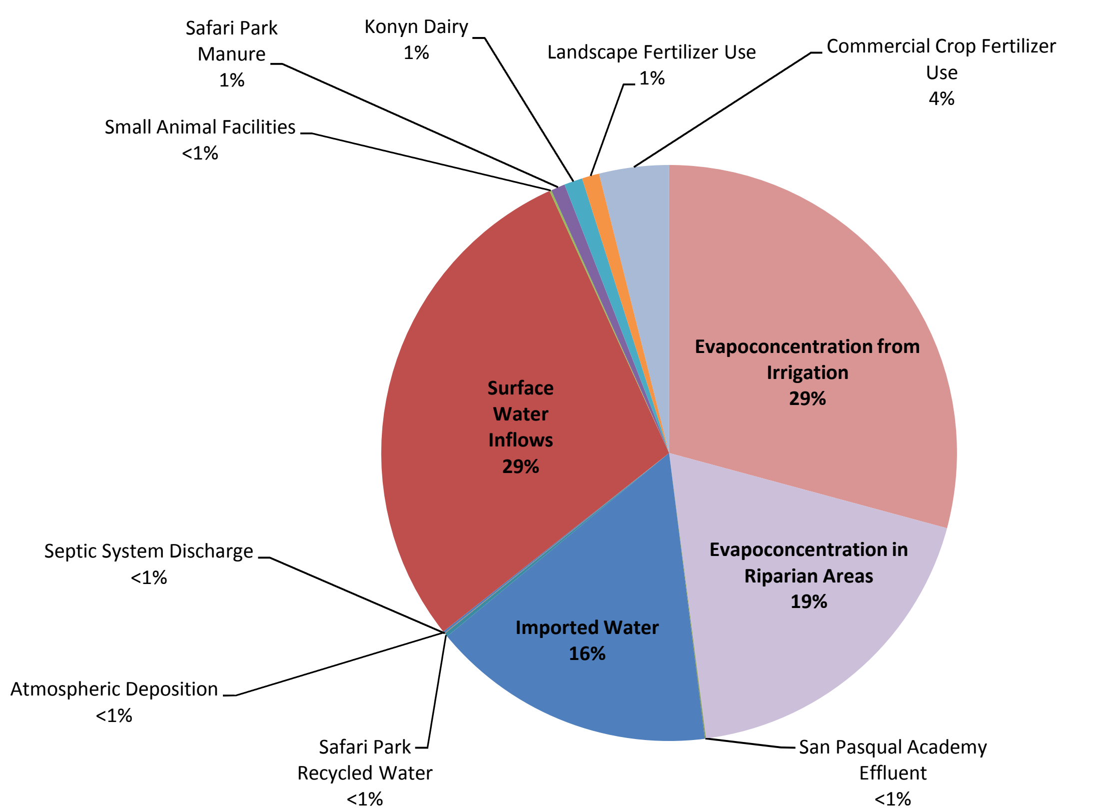


Figure 3-4 Estimated Contribution of Total Dissolved Solids from Various Sources and Processes

Using the estimates presented in Table 3-11 and Figures 3-3 and 3-4, a number of observations can be drawn. In terms of salt contributions across the Basin, evapoconcentration of groundwater is the largest contributing factor of salt accumulation in the Basin at an estimated 48 percent of the total. This result suggests that managing the volume of groundwater consumed through pumping for irrigation and passive use by phreatophytes could be an important component of groundwater salinity control.

Surface water inflows are estimated to contribute 29 percent of the total salt load. The majority of this load is contributed by Cloverdale Creek and Santa Maria Creek, which account for approximately one-third of the Basin inflows from the major stream drainages. The salt loads contributed by Santa Ysabel Creek and Guejito Creek, although not insignificant in mass, are not considered detrimental to groundwater salinity because they are associated with large volumes of water and enter the Basin at average TDS concentrations of 218 mg/L and 256 mg/L, respectively, thus providing dilution of the other salt loads.

The single largest contributing source of nitrogen is commercial crop fertilizer use at 56 percent of the Basin total followed by landscape fertilizer use at 14 percent. Nitrogen managed through in-Basin manure applications at the Konyn Dairy and Safari Park represents a combined 21 percent of the Basin total, with other nonregulated small animal facilities comprising 2 percent of the Basin total. With over 90 percent of the total nitrogen contributions to the Basin coming from fertilizer and manure use, and given the historical elevated nitrate levels in groundwater, these data suggest that ensuring effective nutrient management across agricultural and urban landscapes might be an important component of Basin water quality management.

The nitrogen source assessment in this section represents the total amount of nitrogen managed in the Basin from manure sources after accounting for Basin manure exports and nitrogen losses, from imported fertilizer use, and from other inflows measured at the surface. The actual contribution of nitrate-nitrogen to the groundwater system after accounting for crop uptake and removal is accounted for separately within the groundwater model presented in Appendix B. This source assessment is most useful, however, in assessing the overall nitrogen loads being managed in the Basin.

3.2 Groundwater Assessment

As previously discussed, the Basin is classified as a Tier A basin. The SNMP guidelines for Tier A basins recommend the use of numerical groundwater flow and transport models as appropriate tools. Thus, the City and CH2M HILL have developed a numerical groundwater flow model (GFM) and constituent transport models of an area encompassing and including the Valley to support the development of this SNMP. This section includes an overview of the application of these numerical groundwater models, and Appendix B includes a detailed description of the development, calibration, and application of these numerical groundwater models.

The GFM and constituent transport models described herein help provide insight into the relevant subsurface parameters and processes that control the persistence and movement of two constituents of interest identified for this modeling effort—TDS and nitrate.

3.2.1 Groundwater Modeling Objectives

The modeling objectives, which were developed collaboratively by the City and CH2M HILL, include the following:

- Support the SNMP development process.
- Evaluate the Basin water budget under recent conditions.
- Gain insight into the travel times of water, as well as TDS and nitrate through the Basin.
- Integrate hydraulic, TDS, and nitrate loading information into a numerical framework to help explain the sources of TDS and nitrate measured under current groundwater conditions.

- Identify how current surface loading rates for TDS and nitrogen might impact future groundwater quality, compared to groundwater WQOs for TDS and nitrate, as established in the Basin Plan.
- Provide insights into how alternative future salt and nutrient management strategies might impact groundwater quality.

3.2.2 Overview of Groundwater Flow and Constituent Transport Models

Figure B1-2 in Appendix B shows the location of the Basin and surrounding study area. The boundaries of the study area and numerical groundwater models (shown in yellow in Figure B1-2) were selected to coincide with natural hydrologic features, such as subcatchment and Basin boundaries, to help establish a hydrologic framework for these models reflective of sources of salts and nutrients within and surrounding the Basin. The study area subcatchment encompasses approximately 42 mi^2, whereas the Basin within the subcatchment encompasses approximately 5.5 mi^2. CH2M HILL developed five vertically stacked layers to provide a three-dimensional representation of the aquifer system beneath the Basin and subcatchment. These layers represent the Basin alluvium, which can reach a thickness of approximately 200 feet bgs, as well as bedrock down to a depth of 450 feet bgs.

The numerical groundwater models described herein were developed and calibrated with consideration of the availability and reliability of input data to fulfill the modeling objectives. These models were constructed and calibrated to simulate steady-state (i.e., average) groundwater flow, along with the transport of TDS and nitrate through the steady-state groundwater flow field. These models were developed using relevant hydrologic, land use, groundwater use, and agricultural data where and when it was available for the last approximately 10-year period. Additional details for the GFM and constituent transport models are provided in Appendix B.

3.2.3 Overview of Modeling Scenarios

Although it is impossible to predict with certainty the future hydrology, availability and quality of imported and local water, land use, water use, and constituent conditions, the GFM and constituent transport models were used to forecast potential outcomes from hypothetical actions. The City has not proposed land management changes aimed at reducing constituent concentrations in the Basin; however, four scenarios with the GFM and constituent transport models were evaluated. These scenarios were developed to help forecast the impact of changed water and nutrient management within the Basin and, in some cases, were selected to evaluate the sensitivity of the Basin to extreme changes in land management rather than to represent any recommended action. Table 3-12 presents a summary of these four scenarios.

TABLE 3-12
Summary of Predictive Modeling Scenarios
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Scenario Name	Modeled Constituent	Description
Scenario 1– Baseline	TDS and Nitrate	Baseline scenario that assumes current land and water uses in the study area would continue for another 50 years. Having baseline predictive scenarios for both TDS and nitrate provides predictive simulations against which other scenarios are compared.
Scenario 2– Reduced Irrigated Area	TDS	Scenario aimed at reducing TDS concentrations in the Basin alluvial aquifer by reducing irrigated areas served by Basin groundwater pumping, thereby reducing consumptive use and TDS loading from irrigated parcels represented in the model. An aggressive assumption was selected to assume fallowing 50 percent of the irrigated areas served by Basin groundwater pumping. The reduction in the applied water demand results in a decrease in agricultural pumping in the Basin alluvial aquifer by approximately 2,900 AFY.

TABLE 3-12
Summary of Predictive Modeling Scenarios
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Scenario Name	Modeled Constituent	Description
Scenario 3–Improved Nutrient Management	Nitrate	Scenario aimed at reducing nitrate concentrations in the Basin alluvial aquifer by implementing changes in nitrogen management throughout the subcatchment, thereby reducing nitrogen loading from agricultural and urban landscapes represented in the model. The first Scenario 3a was designed to evaluate the physical limit of potential groundwater nitrate improvements resulting from complete land conversion assuming surface nitrate loads to groundwater were reduced by 95 percent. The second Scenario 3b was constructed to evaluate more practical reductions in nitrate loading to groundwater from changed fertilizer and manure management where associated nitrate loads to groundwater were reduced by 25 percent from current levels. Groundwater pumping and water use conditions are consistent with Scenario 1.
Scenario 4–Conjunctive Use	TDS	Scenario aimed at reducing TDS concentrations in the Basin alluvial aquifer by implementing a conjunctive use project. Conceptually, desalinization pumping from 10 extraction wells would result in approximately 2,470 AFY of groundwater with elevated TDS being treated to remove some of the salts. This scenario assumes that treated groundwater would have 345 mg/L of TDS and would be used to irrigate selected parcels near the central and western portions of the Basin in lieu of using 1,974 AFY of untreated local groundwater to irrigate these parcels. The desired outcome of implementing this scenario would be to remove substantial TDS mass from the aquifer and reduce TDS loading from the selected irrigated parcels. It is assumed that the brine by-product from the treatment process would be disposed of outside the study area.

Notes:
All predictive modeling scenarios are simulated for a period of 50 years from 2015 through 2064.
Additional details associated with these scenarios are provided in Appendix B.

All predictive modeling scenarios simulate conditions from 2015 through 2064. A 50-year predictive simulation period was deemed adequate to achieve the modeling objectives. Considering the modeling objectives described in Section 3.2.1, output from each predictive simulation was evaluated using several methods. However, the primary qualitative and quantitative metrics used for scenario evaluation were as follows:

- A color flood map was prepared for each scenario. The maps depict the locations in the study area where constituent concentrations exceed groundwater WQOs at the end of the 50-year (i.e., 2015 through 2064) predictive simulation and compared with that presented for Scenario 1. This comparison is useful for gaining insights into potential areal improvements to the Basin assimilative capacity by implementing each scenario.
- The total constituent mass in the Basin alluvial aquifer was computed at the end of the 50-year predictive simulation for each scenario and compared with that presented for Scenario 1. This comparison is useful for gaining insights into the potential effectiveness of reducing overall constituent mass in the Basin alluvial aquifer by implementing each scenario.
- The constituent mass flux exiting the Basin alluvial aquifer as subsurface outflow was computed at the end of the 50-year predictive simulation for each scenario and compared with that presented for Scenario 1. This comparison is useful for gaining insights into the potential effectiveness of reducing constituent mass loading from the Basin alluvial aquifer to Lake Hodges by implementing each scenario.

3.2.4 Modeling Results and Discussion

Figures B4-3 and B4-4 in Appendix B depict locations of the Basin alluvial aquifer where TDS and nitrate concentrations, respectively, are forecast to exceed the TDS and nitrate groundwater WQOs at the end of the 50-year predictive simulation period of Scenario 1. In Appendix B, Figures B4-5, B4-6, and B4-7 depict locations of the Basin alluvial aquifer where constituent concentrations are forecast to exceed their respective groundwater WQO at the end of the 50-year predictive simulation periods of Scenarios 2, 3a, and 4, respectively. Blue areas in Figures B4-3 through B4-7 in Appendix B coincide with modeled TDS and nitrate concentrations of less than 1,000 mg/L and 10 mg/L, respectively, and indicate locations and depths where some assimilative capacity for these constituents would remain at year 2065 (i.e., at the end of the 50-year predictive simulation period). Orange areas coincide with modeled TDS and nitrate concentrations greater than 1,000 mg/L and 10 mg/L, respectively, and indicate locations and depths where no assimilative capacity for these constituents would remain at year 2065. Portions of the study area that are not color-filled with blue or orange and show only the aerial photograph base map coincide with model cells representing unsaturated (i.e., vadose zone) locations.

Two-dimensional (i.e., “footprint”) areas were computed for model cells representing the saturated portions of the Basin alluvial aquifer (blue areas depicted in Figure B3-10 in Appendix B) to help assess the modeled areal extent of Basin alluvial aquifer groundwater that exceeds the constituent groundwater WQOs. The upper plots in Figures B4-8 and B4-9 in Appendix B summarize these footprint areas exceeding the TDS and nitrate groundwater WQOs, respectively. These footprint areas are shown for all scenarios in 2015 (i.e., the beginning of the predictive simulation period) and for each individual scenario at the end of the predictive simulation period in 2065. The middle plots in Figures B4-8 and B4-9 in Appendix B summarize the modeled TDS and nitrate mass, respectively, in the model cells representing the saturated portions of the Basin alluvial aquifer at 2015 and 2065. The lower plots in Figures B4-8 and B4-9 in Appendix B summarize the modeled TDS and nitrate mass flux, respectively, from the Basin alluvial aquifer as subsurface outflow to Lake Hodges in 2015 and 2065. Values listed in parentheses at the tops of the 2065 bars in Figures B4-8 and B4-9 in Appendix B indicate the percent increase or decrease from the 2015 value.

Forecasts associated with Scenarios 2, 3a, 3b, and 4 indicate smaller footprint areas exceeding constituent groundwater WQOs and less constituent mass in the Basin alluvial aquifer than the 2065 forecast associated with Scenario 1 (see upper and middle plots in Figures B4-8 and B4-9 in Appendix B). Implementation of Scenario 3b would help keep the footprint areas exceeding nitrate groundwater WQOs and the nitrate mass in the Basin alluvial aquifer similar to current conditions. Forecasts associated with Scenario 3a for nitrate and Scenario 4 for TDS are the only forecasts that indicate reductions in areas exceeding constituent groundwater WQOs and reductions in constituent mass in the Basin alluvial aquifer, compared with 2015 conditions. In other words, the modeling results suggest that continuing current land management practices under Scenario 1 conditions, or reducing the applied water demand in the study area by approximately 2,900 AFY (i.e., 50 percent of current demands) under Scenario 2 conditions would both result in decreased assimilative capacity for TDS and nitrate over the next 50 years.

Modeling results further suggest that under all scenarios described herein, subsurface mass fluxes of TDS and nitrate to Lake Hodges are expected to increase over time, compared with current conditions (see lower plots in Figures B4-8 and B4-9 in Appendix B). This is due in part to the relatively large mass of nitrate already in the groundwater system near the outflow to Lake Hodges, the limited pumping of groundwater but high use of phreatophyte water in this area, and the continued migration of nitrate mass in the groundwater system downgradient. Furthermore, increased constituent mass fluxes to Lake Hodges could result from increased groundwater elevations near the middle of the Basin relative to those in the lower San Pasqual Narrows under some scenarios, thereby increasing the overall Basin hydraulic gradient and volumetric groundwater flow into Lake Hodges. If there were an increase in the volumetric groundwater outflow from the Basin alluvial aquifer to Lake Hodges, then constituent loads could increase despite small decreases in constituent concentrations in the San Pasqual Narrows, according to the model.

The hydraulic restriction to groundwater outflow from the Basin caused by Lake Hodges limits the amount of groundwater outflow at the lower Basin boundary. The horizontal hydraulic gradient in the San Pasqual Narrows (i.e., 2×10^{-3} foot per foot, see Figure B3-8 in Appendix B), coupled with the horizontal hydraulic conductivity values in that portion of the Basin (i.e., 37.5 feet per day; see Figure B3-2 in Appendix B), indicate that the average groundwater "particle" not intercepted by pumping wells would take more than 100 years to move through the San Pasqual Narrows to the Basin boundary near Lake Hodges (approximately 20,000 feet), assuming an effective porosity of 0.16. This limited groundwater flushing through the San Pasqual Narrows is likely due in part to a backwater effect from Lake Hodges that flattens the hydraulic gradients near the downgradient end of the Basin. This backwater effect might also contribute to shallow groundwater levels and increased evapoconcentration of salts in lower portions of the San Pasqual Narrows. Thus, reductions in subsurface mass fluxes of TDS and nitrate to Lake Hodges in the lower San Pasqual Narrows in response to changes in land and water management in upgradient areas of the Basin could take several decades or may never be manifest.

Modeling results also suggest that even an unrealistic reduction of 95 percent of the nitrate concentrations associated with nitrogen loading from fertilizer and manure management under Scenario 3a conditions would not decrease the footprint area where nitrate concentrations exceed the nitrate groundwater WQO by more than half ($2.1\ mi^2 \div 4.2\ mi^2$) of what would result under Scenario 1 conditions (see upper plot in Figure B4-9 in Appendix B). Under current land use and current nutrient management practices, the assimilative capacity for nitrate will decrease over time, according to the model. However, implementation of Scenario 3b, which assumes a 25 percent reduction in nitrate loading from fertilizer and manure management is projected to curb further increases in nitrate mass in the Basin alluvial aquifer over time.

For comparative purposes, in addition to evaluating modeled nitrate concentrations against the Basin groundwater WQO of 10 mg/L (as NO_3), comparisons were made against USEPA's MCL of 45 mg/L (as NO_3). Figure B4-10 in Appendix B compares the footprint areas where modeled nitrate concentrations exceed both 10 mg/L and 45 mg/L. As expected, a greater portion of the Basin would have remaining assimilative capacity for nitrate if the nitrate groundwater WQO of the Basin were equal to the USEPA MCL, according to the model. Implementation of Scenario 3b would help keep the footprint areas exceeding nitrate groundwater WQOs and MCLs similar to current conditions, according to the model (see Figure B4-10 in Appendix B).

Scenario 4 was the only scenario evaluated that resulted in improved groundwater TDS conditions in the future relative to current conditions (see Figure B4-8 in Appendix B). The model suggests that improvements could be made in different subareas of the Basin under Scenario 4 conditions, but the overall forecast suggests only limited improvements would occur within 50 years of implementing the conjunctive use project simulated. Conjunctive management scenarios that are more aggressive than those evaluated for the SNMP could be evaluated with future model updates, if needed.

A previous conjunctive use study for the Basin (Camp Dresser & McKee [CDM], 2010) examined aquifer storage and recovery scenarios that might, in concept, improve the overall reliability and flexibility of the City's water supply. The conjunctive use projects evaluated in that study were focused specifically on water supply objectives. Based on preliminary analysis using the GFM developed under this study, however, there may be potential to combine water supply objectives and WQOs in redesigning conjunctive use strategies and realize additional benefits from these projects in the future.

3.3 Salt and Nutrient Evaluation Key Findings

Estimates of salt and nutrient contributions across the spectrum of the major point and nonpoint sources within the Basin were developed using available data. This was followed by the development and application of a groundwater flow and transport model of the Basin to evaluate the impact of implementing potential groundwater quality management strategies. Below, several important findings from these efforts are discussed that could help guide future salt and nutrient management efforts within the Basin.

3.3.1 Nutrient Sources

The single largest contributing source of nitrogen is commercial crop fertilizer use at 56 percent of the Basin total, followed by landscape fertilizer use at 14 percent. Nitrogen, managed through in-Basin manure applications at the Konyn Dairy and Safari Park, represents a combined 21 percent of the Basin total, with other nonregulated small animal facilities comprising 2 percent of the Basin total. With over 90 percent of the total nitrogen contributions to the Basin coming from fertilizer and manure use, and given the historical elevated nitrate levels in groundwater, these data suggest that ensuring effective nutrient management across agricultural and urban landscapes should be an important component of Basin water quality management.

3.3.2 Salt Sources

Although the process of evapoconcentration is not a source of new salts in the Basin, it is the largest contributing factor of salt accumulation in the Basin at an estimated 48 percent of the total. This result suggests that managing the volume of groundwater consumed through pumping for irrigation and through passive use by phreatophytes could be an important component of groundwater salinity control.

Surface water inflows and imported water used for irrigation contribute 29 percent and 16 percent, respectively to the total Basin salt load. The majority of the surface water salt load is contributed by Cloverdale Creek and Santa Maria Creek, which account for approximately one-third of the Basin inflows from the major stream drainages. The majority of the surface water and imported water inflows are associated with TDS concentrations below 500 mg/L and contribute water volume to the Basin, which helps to mitigate TDS concentrations in groundwater. Because of the volume of these contributing sources, however, future changes to the quality of surface water inflows or imported water sources should be evaluated carefully for potential impact to the Basin.

3.3.3 Assimilative Capacity

TDS and nitrate concentrations exceed their groundwater WQOs in portions of the Basin, while assimilative capacity for TDS and nitrate remains in other portions of the Basin. If salt and nutrient loading rates to groundwater remain similar to those under current conditions, it is likely that TDS and nitrate concentrations in groundwater will increase and that the overall assimilative capacity for these constituents will decrease over time. Thus, implementing salt and nutrient management strategies to mitigate elevated TDS and nitrate concentrations and to increase the assimilative capacity over time is recommended.

It is believed that the Regional Board may move forward with efforts to make Basin Plan nitrate objectives consistent with drinking water objectives (45 mg/L) for many basins within Region 9. If this occurs, there is no reason to preclude the Basin from this change such that the Basin nitrate WQO would be revised to 45 mg/L for consistency with other basins in Region 9. If this change were implemented, a significantly greater portion of the Basin area and groundwater storage volume would be in conformance with the Basin nitrate WQO. However, efforts to reduce nitrogen loads from current levels would still be necessary to prevent further degradation in groundwater quality.

3.3.4 Groundwater Processes

More salts and nutrients are currently entering the aquifer than are being removed, which has resulted in an overall increase in groundwater TDS and nitrate concentration over time. Based on current land uses and land management practices, the approximate net increase in constituent mass that is stored in water-bearing formations is approximately 8,000 U.S. tons annually for TDS and 520 U.S. tons annual for nitrate, according to the groundwater model presented in this report.

Groundwater modeling suggests that it takes more than a decade in some areas of the Basin for surface constituents to reach the water table, and lateral groundwater movement of constituents through the aquifer occurs over multiple decades. Site-specific flow dynamics in the Basin cause some subareas to transmit groundwater and constituents more readily than in other subareas. Consequently, it may take several years to decades after implementing salt and nutrient management strategies before there would be noticeable changes in TDS and nitrate concentrations in groundwater in some portions of the Basin.

Due to the large number of production wells in the Basin, groundwater may be intercepted and reused multiple times as it moves through the alluvial aquifer. While this recycling process offers the opportunity to remove nutrient mass from the groundwater system through irrigation combined with effective nutrient management, the recycling process also concentrates salts when water is consumptively removed from the Basin resulting in increased groundwater salinity.

Groundwater quality varies spatially, both horizontally and vertically. Groundwater quality also varies temporally, depending on the quantity of water being stored in the aquifer and by constituent transport through the aquifer. A qualitative analysis of TDS and nitrate concentration trends indicates that groundwater quality may have improved at certain locations, particularly for nitrate, during the last 5 years. However, TDS and nitrate concentration trends at other locations indicate that groundwater quality may be declining, which is also supported by the groundwater model predictions. A statistical trend analysis has not been conducted to confirm any actual trends that can be separated from natural variations; however, trend analysis of groundwater constituent concentrations should be included as part of future efforts to track water quality changes and to assess the effectiveness of salt and nutrient management strategies.

3.3.5 Impact of Potential Management Strategies

Groundwater modeling results indicate that continuing current land management practices or implementing any one of the Basin management scenarios evaluated in this report will not individually decrease TDS or nitrate concentrations to below the groundwater WQOs in the Basin within the next 50 years. However, a combination of practical efforts to address salt and nutrient sources could work to prevent further groundwater quality degradation and to improve groundwater quality relative to current conditions. Effective resource management requires a combination of multiple management strategies, potentially including additional monitoring and reporting, refining and expanding existing studies, and implementing physical projects.

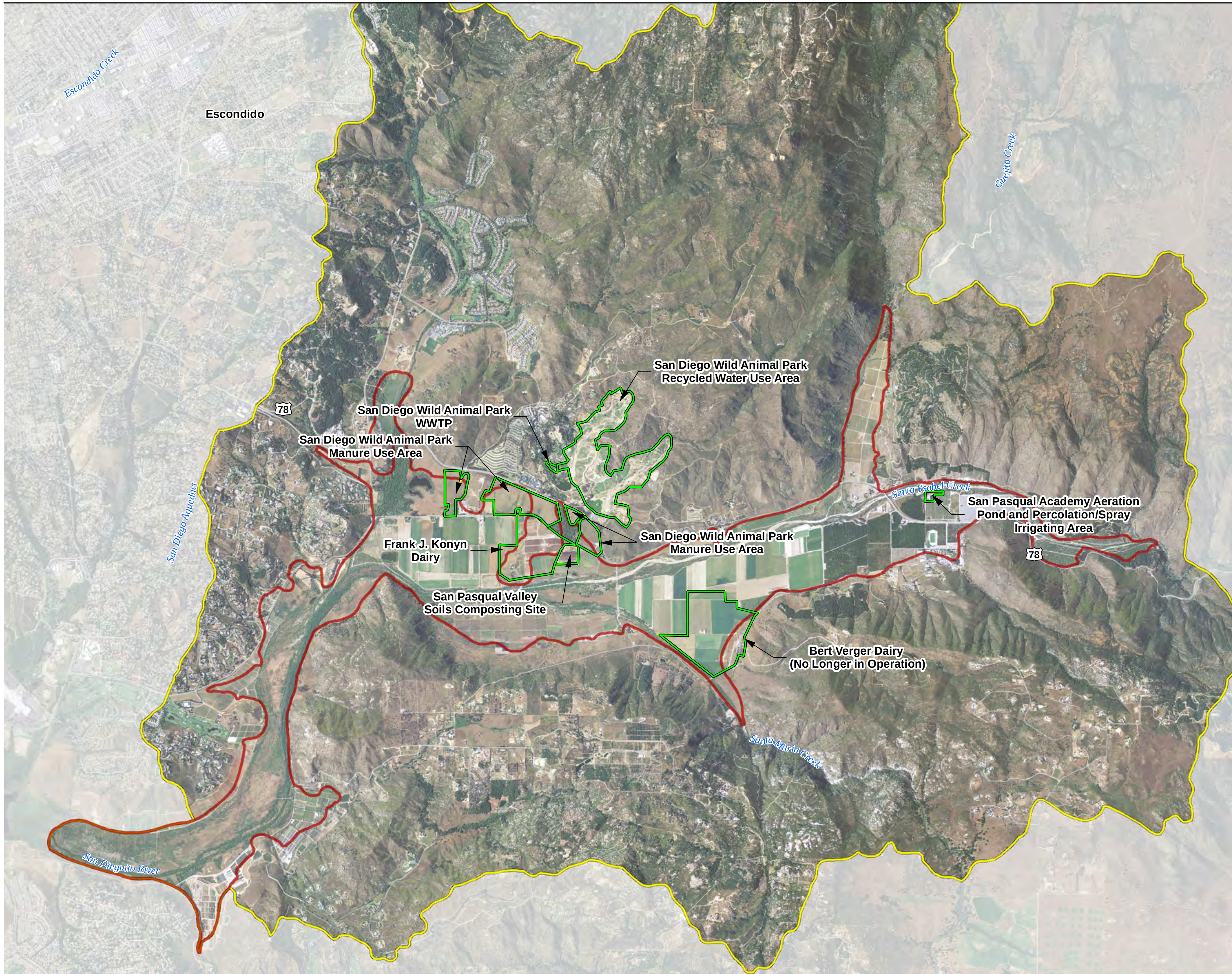
The most promising nutrient management strategy involves reducing nitrate loading to groundwater through improved nutrient management of fertilizer and manure applications. Reducing the net nitrate loading to the groundwater system by 25 percent from current levels is projected to curb the trend of increasing groundwater nitrate concentrations across the Basin and result in an overall reduction in groundwater nitrate concentrations over time. Due to the time lag for transport to groundwater, past practices may continue affecting groundwater for 5 to 25 years following management changes.

According to the groundwater model presented in this report, the annual nitrate mass flux from the Basin alluvial aquifer to Lake Hodges could increase by up to 20 percent over the next 50 years. This increase might occur regardless of reasonable reductions in nitrogen loading to the groundwater system over the next 50 years. The model suggests that most of the nitrate mass that is already present in the groundwater system near the downstream end of the Basin and in the San Pasqual Narrows will eventually flow into Lake Hodges, unless intercepted/consumed by vegetation or mitigated by a physical project.

Reductions in TDS levels may be more difficult to achieve than reductions in nitrate levels in this Basin. This is partially due to the limited flushing of groundwater and salts through the downstream end of the Basin through the Narrows relative to the amount of salts that enter the Basin or are further concentrated within the Basin on an annual basis. The most effective salt management strategy that was evaluated in this report was removal of salts from the Basin by a conjunctive use project involving pumping and desalinization of groundwater extracted from high-TDS locations in the Basin and replacement of current irrigation water sources from groundwater pumping with the desalinated water. Implementing this project with 2,470 AFY of groundwater pumping and desalination is projected to decrease the total TDS mass in the alluvial aquifer by approximately 7 percent over the next 50 years. Projects such as this, potentially combined with conjunctive use projects for seasonal groundwater storage and extraction, could be further optimized for both water supply and water quality benefits. In summary, management strategies that enhance the export of salts from the Basin are expected to be the most beneficial for addressing TDS issues but will take time to evaluate and plan.

3.3.6 Use of Salt and Nutrient Evaluation Conclusions

Uncertainty in salt and nutrient loading rates and transport processes, compounded by slow groundwater quality responses to land management changes, complicates forecasting the impacts of current and potential future management practices. Although predictive uncertainty is part of any numerical model forecast, this uncertainty should not prevent stakeholders from gaining insight into the Basin hydrologic processes and expected outcomes from potential projects or management actions. Thus, use of the salt and nutrient source assessment and groundwater model results presented here to help guide the overall recommendations for future salt and nutrient management efforts within the Basin is reasonable and appropriate.



LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

WDR Facility

NOTE:

WDR = Waste Discharge Requirement.

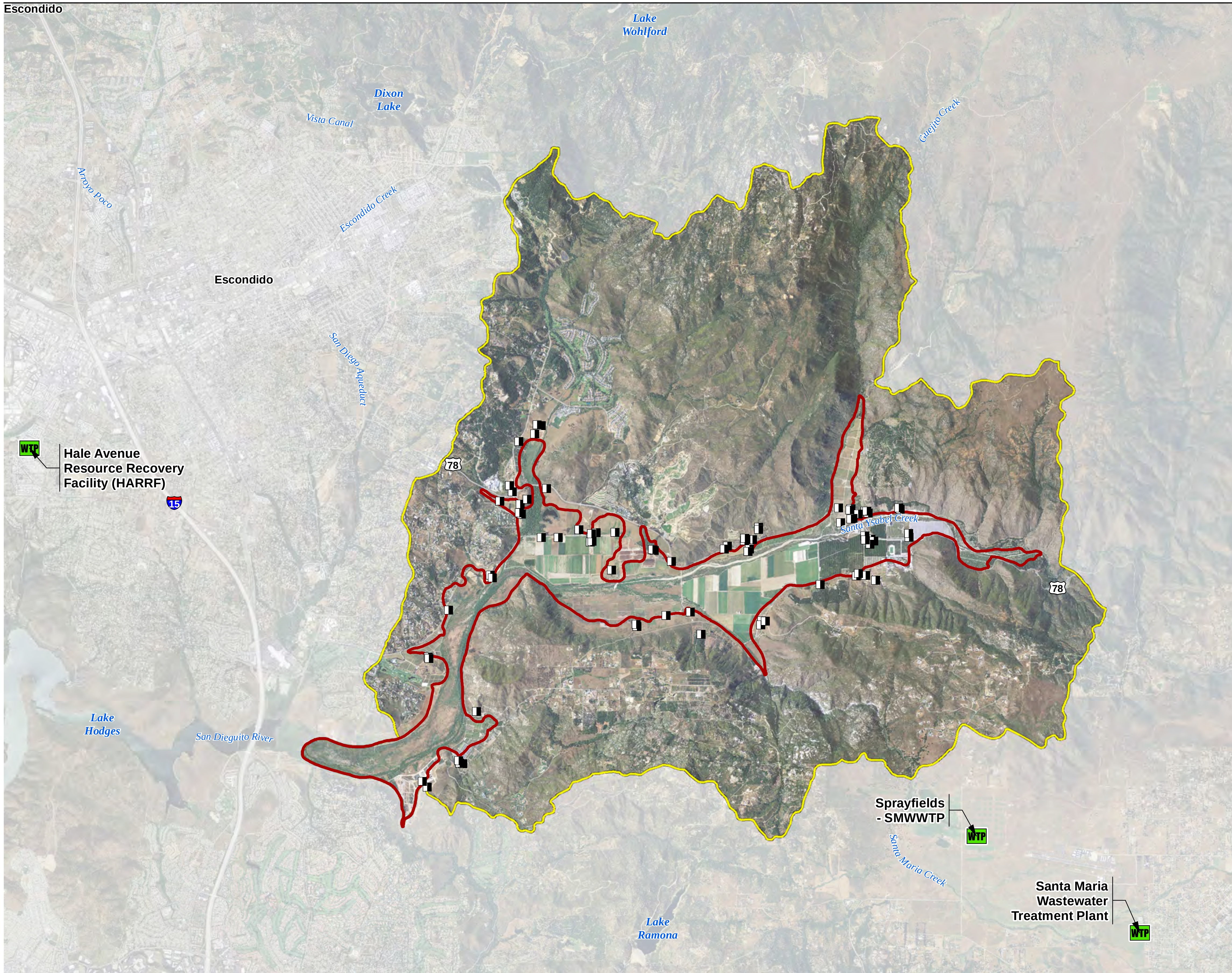
0 4,000 8,000
Feet

FIGURE 3-1

San Pasqual Locations of Facilities with Waste Discharge and Composting Permitted Requirements

San Pasqual Valley Groundwater Salt and Nutrient Management Plan

CH2MHILL



LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- Building on Septic System (Estimated)
- Wastewater Treatment Plant Location

0 6,000 12,000
Feet

FIGURE 3-2
San Pasqual Estimated Septic Systems
San Pasqual Valley Groundwater
Salt and Nutrient Management Plan

CH2MHILL

SECTION 4

Supplemental Monitoring

The Basin has been extensively studied and sufficient data were available to support the development of this SNMP. In areas where monitoring data were not available, enough information was available to make reasonable estimates of salt and nutrient loads and Basin processes to support the development of potential management strategies. However, additional monitoring will be required to support SNMP implementation.

Groundwater monitoring and additional data collection efforts are ongoing and refinements of monitoring programs are planned, all of which will help to support ongoing resource management in the Basin. This section identifies recommended supplemental monitoring efforts that will enhance the existing data sets and help to improve the understanding of water quality and quantity across the Basin in the future. Supplemental monitoring efforts described in this section are grouped into groundwater monitoring and surface water monitoring activities. Monitoring efforts planned by the City and others are discussed, and final monitoring recommendations are presented with an identification of the lead entity and a target schedule.

The evaluation and prioritization of Basin management strategies can move forward while these additional data collection activities are planned and implemented. The ongoing and planned data collection efforts will be used to support the implementation of SNMP recommended management strategies and to enable the evaluation of SNMP effectiveness in the future.

4.1 Groundwater Monitoring

4.1.1 Groundwater Level and Quality Monitoring

The City plans to continue its current groundwater level and quality monitoring program. The City currently measures groundwater levels from a network of up to 12 monitoring wells on a target frequency of once per month. Additionally, the City collects groundwater samples for analysis of constituent concentrations by an analytical laboratory. Samples are typically collected approximately two to four times per year from a network of up to 11 wells.

4.1.2 Groundwater Well Metering

Approximately 59 of the 64 active groundwater production wells in the Valley do not have flowmeters. Historically, Valley groundwater pumping rates and volumes have been estimated using land use information and assumptions on typical irrigation water management practices. However, additional precision is needed to enable more effective water resource management in the Basin moving forward, as identified in the GMP and as supported by the conclusions of this SNMP.

Collecting and reporting flow metering data are expected to aid in the following:

- Provide better estimates of actual groundwater use throughout the Basin
- Provide data to support improved predictive capabilities of the Basin groundwater model
- Support the implementation of management strategies identified in this SNMP

Coupling the amount of pumping at each well with the place of use will provide data that allow water users and the City to evaluate how much water is being used on irrigated areas around the Basin and to compare actual measured water use against projected or required water use for those areas. In coordination with irrigation water management plans, flow metering data can sometimes aid the identification of equipment and/or management issues. Addressing those issues results in better irrigation management and improved water use efficiency, which ultimately aid in improvements to nutrient management and overall agricultural production.

Lessees are allowed to drill and operate groundwater production wells. In most instances, the lessees pay the power cost associated with groundwater pumping but generally do not otherwise pay for water costs associated with groundwater pumping. In addition to providing data that would enable better understanding of Basin hydrology, groundwater well metering would provide the opportunity for the City to implement volumetric water pricing in the future.

The City is planning to implement groundwater well flow metering in a phased installation approach where wells are prioritized based on both their location and flow rate. The highest priority group selected for initial flowmeter installation will be identified to capture the largest production wells representing the greatest annual pumped volumes in the Basin.

4.2 Surface Water Monitoring

The Basin GMP identified management action of continuing to collect, evaluate and archive stream flow data from the creeks and streams entering and exiting the Basin. Although the City monitors surface water on an ongoing basis, a more comprehensive program for monitoring surface water is recommended and specific considerations are described below.

4.2.1 Surface Water Flow

Improving the accuracy and consistency of surface water flow measurements in the Basin would facilitate future studies of the Basin water balance under varied hydrologic conditions. Specific considerations when developing a surface water monitoring program for the Basin include:

- Equip Cloverdale Creek with a “simple” gaging station configuration. Cloverdale Creek is the largest creek not monitored and would provide the greatest value for the investment (MWH, 2011b).
- Reactivate or reestablish the USGS gage at Station 11029500 on the San Dieguito River near Interstate 15. This location has the potential to provide total surface flow from the Basin into Lake Hodges. That flow was previously recorded from 1912 to 1915 (MWH, 2011b).
- Equip Santa Ysabel Creek with a gaging station at the entrance of the Basin to improve evaluating surface water inflows to the Basin.
- Evaluate the feasibility of continuously monitoring surface water using instrumentation and dataloggers
- Evaluate the feasibility and benefit of monitoring stormwater discharges from the San Diego Zoo Safari Park.

4.2.2 Surface Water Quality

The City currently attempts to collect surface water quality samples up to monthly at six sites. However, surface water quality data are discontinuous for several reasons. Flow is intermittent, and no flow during a sampling session means no sample can be collected. Additionally, the City currently has one person on staff to collect surface water samples, and if this individual is unavailable, the sampling does not take place. Lastly, after collection, a sample might not be analyzed if other work takes priority. A process of further defining and implementing a revised surface water quality monitoring program, including the consideration of water quality instrumentation, for the Basin is currently being considered by the City.

4.3 Supplemental Monitoring Plan

Continued refinement and enhancement of the Basin monitoring program is recommended to support effective and sustainable salt, nutrient, and water management in the Basin. The monitoring program will be particularly beneficial to aid in improving the understanding of Basin hydrogeology and trends, for assessing SNMP management strategy effectiveness, and for further developing future management strategies. Table 4-1 presents a summary of the recommended monitoring plan.

TABLE 4-1
San Pasqual Valley Supplemental Monitoring Recommendations
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Monitoring Item	Brief Description	Lead Entity	Target Schedule
Groundwater level and quality monitoring	Continue groundwater monitoring and data collection/archiving	City	Groundwater monitoring is ongoing.
Groundwater well metering	Phased implementation of installing flowmeters on production wells on agricultural leases	City	Initiate first phase by 2017.
Surface water flow and quality monitoring	Ongoing surface water monitoring plus a revised monitoring plan, which might include additional gaging stations	City	Surface water monitoring is ongoing. Update surface water monitoring plan by 2017.

Updating the City's database with groundwater elevation and quality, well construction and lithology, and borehole geophysical data and surface water stream gage data was listed as a management action in both the GMP (City of San Diego Water Department, 2007) and 2010 State of the Basin Report (MWH, 2011a) (see Appendix D for the December 2010 status of Groundwater Management Actions). This action is reported here as recommended action because effective upkeep and management of the database with current information will be important for future projects and Plan effectiveness evaluations (see Section 6).

SECTION 5

Management Goals and Strategies

The San Pasqual GMP (City of San Diego Water Department, 2007) previously identified several management strategies to address certain water quality issues, some of which are described in this SNMP. The analyses presented in this SNMP expanded upon the information presented in the GMP and other previous studies to develop a more comprehensive understanding of the relative contributions of significant salt and nutrient sources throughout the Basin and subcatchment. This improved understanding has enabled further refinement of the management strategies that are most likely to benefit groundwater quality in the Basin.

This section utilizes the key findings presented in Section 3 to develop management strategies that can be explored to help meet the Basin Management Objectives (BMOs) and utilization goals. The section begins by defining BMOs and utilization goals that are used to guide salt and nutrient management strategies. An evaluation of the need for any Basin Plan modifications is then presented. Potential management strategies to meet the goals are then discussed, followed by selection and prioritization of management strategies in an implementation plan.

5.1 Basin Management Objectives and Utilization Goals

The Basin is managed for multiple resource uses and the City has established a policy to guide the coordinated management of the Basin. Consequently, any Basin utilization goals must be consistent with San Pasqual guiding policy documents (see Section 1). As stated in the Council Policy 600-45 ("Protection of Water, Agricultural, Biological, and Cultural Resources within the San Pasqual Valley"):

> *Implementation of this Policy should ensure that the primary goal of protecting water resources and subsequent goals of natural habitat preservation, retention of agriculture, and passive recreation are achieved in a manner which is complimentary to each other, thus avoiding any condition in which one goal would compete with another.*

To accomplish these goals, the policy document identified several implementation steps, including the following:

- Amend the Land Development Code to preserve agricultural, recreation, and open space uses in the valley.
- Develop Watershed and Groundwater Management Plans.
- Establish an active land lease management committee with regular reporting of activities.
- Construct an Interpretive center focused on public education.
- Establish a San Pasqual Land Use Task Force.
- Establish cooperative relationships with surrounding municipalities and other entities to work together in protecting the resources of the Basin.
- Have the City notify designated community planning groups of any proposals that affect lands within the San Pasqual Valley planning area.
- Have the City investigate methods of ensuring long-term protection of the Valley's water, agricultural, biological, and cultural resources.

These policies were considered in the development of this SNMP to ensure that proposed management strategies for addressing groundwater quality are consistent with overall Basin utilization goals established by the City. A summary of Basin utilization goals is presented in Table 5-1.

TABLE 5-1
Summary of Basin Utilization Goals
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

No.	Goal	Currently Active[a]	Currently Active, Future Changes[b]	Yet to be Implemented[c]
1	Develop sustainable groundwater yield for municipal supply			X
2	Maintain open space, including multi-habitat planning areas, multiple species conservation program		X	
3	Preserve agricultural operations	X		
4	Maximize recycled water use[d]			X
5	Stabilize groundwater levels		X	
6	Improve groundwater quality		X	
7	Enhance public education/showcase Basin management		X	
8	Restore or enhance function of habitat		X	
9	Protect Lake Hodges watershed and manage stormwater		X	
10	Improve understanding and efficiency of groundwater use		X	
11	Enhance stakeholder involvement		X	
12	Enhance natural recharge			X
13	Protect against flood and erosion		X	
14	Sustain a reliable water supply for agriculture		X	
15	Provide outreach and education (cultural and community, flood protection, habitat)		X	

Notes:
[a] Currently Active = Goals that are currently being achieved with no foreseeable changes
[b] Currently Active, Future Changes = Goals that are currently being achieved but that are likely to evolve or implement additional components within the next 5 years
[c] Yet to be Implemented = Projects in support of these goals that are likely to occur but have not yet been implemented
[d] Maximizing recycled water use will only be implemented where it can improve water quality in the Basin and Lake Hodges.

BMOs that focused specifically on water resource management were established previously according to the Groundwater Management Plan (City of San Diego Water Department, 2007) and are consistent with the utilization goals presented in Table 5-1. These BMOs provide the primary motivation for the additional management strategies that have been defined and recommended for implementation under this SNMP. The five key BMOs are as follows:

- Protect and enhance groundwater quality
- Sustain a safe, reliable local groundwater supply
- Reduce dependence on imported water
- Improve understanding of groundwater elevation, Basin yield, and hydrogeology
- Partner with agricultural and residential communities to continue to improve implementation BMPs

5.2 Basin Plan Modification Needs

No revisions to the groundwater WQOs are proposed at this time. TDS and nitrate concentrations exceed their groundwater WQOs in portions of the Basin, while assimilative capacity for TDS and nitrate remains in other portions of the Basin. Groundwater WQOs described in the Basin Plan are protective of beneficial uses and consistent with the Basin management objectives and Basin utilization goals of the City.

It is understood that the Regional Board might proceed with efforts to make Basin Plan nitrate groundwater WQOs consistent with drinking water objectives (nitrate 45 mg/L) for basins in Region 9. If this occurs, there is no reason to preclude the Basin from this change such that the Basin nitrate WQO would be revised to 45 mg/L for consistency with other basins in Region 9.

5.3 Management Strategies

This section presents management strategies that are aimed at improving the groundwater quality in the Basin and that are aligned with the Basin utilization goals and management objectives. They include strategies for implementation by the City, lessees, and other entities and have been grouped into three primary themes.

- Nutrient Management
- Salinity Management
- Groundwater Resource

The following subsections present potential management strategies that have the potential to protect and improve Basin groundwater quality. The highest priority management strategies with the greatest potential of successful implementation are recommended for inclusion in the implementation plan, and other strategies are identified that may require further consideration such as additional stakeholder review and input or further study, evaluation, or refinement of an implementation approach.

5.3.1 Nutrient Management

As presented in Section 3, more than 90 percent of the total nitrogen contributions to the Basin are from fertilizer and manure use. Based on the groundwater model results, reducing the amount of nitrate returned to the groundwater system from fertilizer and manure use by 25 percent from current levels could effectively curb the current trend of increasing nitrate levels in groundwater across the Basin over time, although groundwater quality response times may take 5 to 25 years depending on a variety of physical factors.

The vast majority of the nutrient contributions to the Basin are either not regulated or are regulated under conditional waivers. Consequently, the nutrient management strategies presented in this section focus on cooperative efforts that can be implemented by the Basin stakeholders outside of or in parallel with other regulatory activities. Other minor nutrient contributions are also discussed to address sources that can be controlled effectively by Basin stakeholders.

The four primary nutrient management strategies discussed in this section include:

- Nutrient Management on City Leased Lands
- Nutrient Management Outreach for Private Lands
- Stormwater Management
- Septic System Management

5.3.1.1 Nutrient Management on City Leased Lands

Nutrient management entails the transportation, storage, and application of nutrients (commercial fertilizers and manures) as part of agricultural operations to support crop production. It also entails the management of those nutrients in the field through balancing nutrient deliveries to the agronomic rates for the particular cropping system and effectively managing irrigation to support crop growth while minimizing water and nutrient losses to groundwater. At each stage of nutrient handling, there are risks of excess release to surface water or groundwater resources that can be controlled through application of best management practices.

Although many Basin stakeholders have already taken a proactive approach to nutrient monitoring and management in the Basin, it is likely that a more consistent and comprehensive basinwide nutrient management planning and reporting program could result in improved resource management and a reduction in overall nitrate loading to groundwater in time. Since the majority of the agricultural operations that directly overlay the groundwater Basin are located on City-owned leased properties, the City plans to work with leaseholders to implement nutrient and irrigation water management planning and reporting on these properties. Although these management plans need to be developed by the individual operators on a site-specific basis, the City will develop a consistent set of standards based on industry accepted standards that are adaptable to all leaseholders.

The planned City-lease property nutrient management planning and reporting requirements will follow the U.S. Department of Agriculture's NRCS guidelines. This approach will help to ensure consistency with common accepted industry standards, allow the efforts by leaseholders to be eligible for federal technical assistance and cost-share incentive programs, and utilize materials already customized to support this type of program. In addition to the requirements outlined in the applicable NRCS programs, the City will require annual monitoring reports from each leaseholder documenting the nutrient management practices utilized during the prior year. This is anticipated to be a letter report with a brief narrative of practices utilized in the prior year accompanied by completed standardized reporting forms that will be developed collaboratively with the Basin stakeholders.

There are three primary NRCS conservation activities that will be utilized to support City lease property nutrient management program. These activities are presented in Table 5-2 along with the anticipated criteria for lease applicability. Additional detail on the specific requirements for each of these practices is presented in Appendix C.

TABLE 5-2
Summary of City Lease Property Nutrient Management Requirements
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

NRCS Conservation Practice	Description	Applicability to City Leases
Nutrient Management Plan (NMP)-Practice/Activity Code (102)	Supports the management of nutrients applied to support plant production	Leases of more than 10 acres that apply fertilizer or manure to support crop production and that are not otherwise required to prepare a CNMP
Comprehensive Nutrient Management Plan (CNMP) - Practice/Activity Code (104)	Supports the management of nutrients associated with animal feeding operations	Leases with livestock on the premises in excess of 10 animal units (see notes)
Irrigation Water Management Plan (IWMP) - Practice/Activity Code (118)	Supports the efficient management of irrigation water	Leases of more than 10 acres that utilize groundwater for irrigation

Notes:

For the purposes of this program, an animal unit is defined as a 440-kilogram heifer, or the equivalent in terms of manure nitrogen production using ASAE (2005).

Implementation of this program will be handled in a phased approach to first develop the specific program requirements and provide outreach to leaseholders, and secondly to write these conditions into each lease at the time of renewal. The conditions will specify time limits for the renewing or new leaseholders to develop and implement their plans and for commencing annual reporting.

The City plans to review data reported by the lessees in annual reports to help ensure that management practices comply with the site-specific NMP, CNMP, and/or IWMP.

5.3.1.2 Nutrient Management Efforts Already in Progress in the Basin

The Konyn Dairy, is already in the process of implementing a CNMP that was prepared in coordination with NRCS. Continued progress on the phased implementation of this plan, including construction of new waste-holding facilities and irrigation systems, as well as implementation of BMPs for irrigation and nutrient management, is expected to benefit groundwater quality and should meet most of the requirements of the proposed new program. Additional record keeping and reporting, consistent with future requirements for all applicable leaseholders, is expected to aid in better future characterization of the Basin nutrient balance.

The Safari Park has developed elements of an integrated water quality and watershed preservation program. This program includes measures aimed at improving surface and groundwater quality through the following actions:

- Restore native riparian habitat within the animal exhibits.
- Install barriers to exclude animal stock from natural waterways.
- Reroute, treat, and reuse water needed for irrigation, wash-down, and exhibit elements such as lagoons, streams, and waterfalls.
- Enhance wetlands for additional stormwater treatment.

Additionally, Safari Park reported that it implements a number of BMPs for animal health purposes and because it is a tourist resource, including the following:

- In order to manage odor and insects, manure removal is conducted daily, thus reducing the opportunity time for leaching into the groundwater basin. No manure is used for fertilization on Safari Park grounds.
- Safari Park trains staff in handling animal manure and urine, along with training of groundskeepers in landscaping and irrigation BMPs.
- Because of strict animal health needs, landscaping chemicals, fertilizers, and soil amendments are not used on Safari Park grounds with the exception of the Cheetah Run.
- Grounds staff inspect Safari Park landscaping irrigation lines daily and conduct immediate fixes when needed so that runoff or ponding does not occur.
- As part of the tight control of irrigation to eliminate any overspray or runoff from oversaturation of landscaping, soil probes are used on a regular basis to confirm that the appropriate amount of irrigation is being applied.
- Soil sampling is conducted approximately every 3 years in areas displaying need.

Although practices are tightly controlled inside Safari Park, further development, implementation, and reporting of BMPs specifically related to its offsite manure and nutrient management, consistent with the agronomic needs of the crops being grown, would help to address the overall salt and nutrient contributions from Safari Park to the Basin.

5.3.1.3 Nutrient Management Outreach for Private Lands

The majority of landscape fertilizer use within urban areas and a sizeable fraction of the agricultural nutrient use occur on private lands within the subcatchment. The most significant agricultural operations on private lands within the subcatchment are the avocado orchards on hillside lands surrounding the groundwater Basin and the irrigated lands located along the Guejito Creek drainage.

To address the contributions, an educational and technical assistance outreach program is recommended to support landowners willing to participate in nutrient management programs. This program would be developed in cooperation with the water districts serving the respective areas and with the local NRCS service center. Nutrient management strategies similar to the ones described above for the City-leased property nutrient management program would be encouraged for these landowners. Furthermore, federal technical assistance and cost-share incentive programs through the NRCS would be leveraged to the extent that landowners are eligible and local funding is available.

5.3.1.4 Stormwater Management

Nutrients contained in stormwater sources can infiltrate the creek channels in the Basin and contribute to groundwater nutrient loads, as well as contribute to surface water quality issues in Lake Hodges. Controlling the discharge of sediments and nutrients in stormwater from both urban stormwater drainage and agricultural runoff is recommended.

The current City leases require lessees to prepare and comply with a Stormwater Pollution Protection Plan (SWPPP). Preliminary review of the documents referenced in the Henry Ranch lease suggests that the stormwater guidance provided may be more targeted at urban controls than agricultural controls. This guidance should be reviewed further to evaluate whether the controls are appropriate to address the potential release of sediments and nutrients through stormwater runoff from agricultural lands.

5.3.1.5 Natural Treatment Systems

Natural treatment systems are constructed or modified ecosystems that use natural biological, physical, and chemical processes to improve water and soil quality. Example applications are constructed treatment wetlands or upland phytoremediation systems designed to passively treat water discharges that are high in nutrients. Natural treatment systems are being studied for application to areas of the Basin that have particularly high-constituent groundwater concentrations and areas with potentially high nutrient loads in stormwater runoff. The City plans to continue to support these efforts and to study where the application of these strategies could provide cost-effective benefits to Basin water quality.

5.3.1.6 Septic System Evaluations

Most facilities and residences in the Valley are on septic systems. Septic systems that are loaded past their design capacity and systems that are not regularly pumped to remove solids can result in poor treatment and excess loading of nutrients to groundwater. Septic systems are part of the assets and possible liabilities of the leased lands; as such, their locations, conditions, and uses should be understood and managed. Systems already in a poor or failing condition should be properly abandoned, and new systems should be installed for any needed future uses. If residences or buildings with bathroom facilities are provided as part of the leased land assets, operational septic systems should be confirmed before finalizing lease terms. Existing systems in good working condition should be rated for capacity, and their use should be restricted to the design capacity.

Regular maintenance and pumping of septic tanks, as well as record keeping, should be required of all lessees. When short-term uses exceed the capacity of existing septic systems (for example, during harvest season), lessees should be required to provide and maintain portable toilets. When long-term uses exceed the capacity of existing septic systems (for example, an onsite workforce that is too large for the system to support), a new larger-capacity septic system should be designed and installed in accordance with all local and state requirements. During septic system evaluations, it is recommended that a water softener inventory be conducted. Water softeners can be a significant source of salt loading to groundwater. The extent of water softener use in the Basin is currently unknown.

Although septic systems are a relatively minor contribution to Basin salt and nutrient loads, their contributions should be managed to ensure that BMPs are being followed and that the contributions are minimized. Evaluation of City lease operations procedures relative to septic system management is recommended.

5.3.2 Salinity Management

In the simplest form, Basin TDS concentration potentially can be reduced by decreasing the quantity of salts entering the Basin, by increasing the quantity of salts leaving the Basin, by decreasing the amount of groundwater consumptive use, or by increasing the volume of water stored in the aquifer using high-quality water sources. As presented in Section 3, the single largest salt contribution to the Basin, at an estimated 48 percent of the Basin total, results from the process of evapoconcentration of salts due to the consumptive use of groundwater from irrigation pumping and through phreatophyte water use in riparian areas. Based on the groundwater model results, reducing the consumptive use of groundwater by up to half of current levels could reduce the rate of TDS increase over time, but TDS levels are still projected to increase under this scenario. The groundwater model results show that more active conjunctive use projects could help to stop the overall trend of increasing TDS levels. In this section, two potential management strategies are presented.

5.3.2.1 Riparian Area Management

Approximately 19 percent of the effective Basin “salt load” results from the process of evapoconcentration from consumptive use of groundwater by phreatophytes in riparian areas. Although riparian vegetation can be an important habitat resource and can help to sequester nutrients, some of the riparian areas in the Basin are dominated by invasive non-native species such as giant reed (*Arundo donax*) and tamarisk (*Tamarix* spp.) that grow at particularly high densities with higher groundwater use rates and lower habitat value than native riparian vegetation.

Several studies and programs for the control and eradication of invasive species have been conducted in the Basin, as outlined in the GMP (City of San Diego Water Department, 2007). These included programs led by the Mission Resource Conservation District, the San Dieguito Watershed Council, the San Dieguito River Valley Conservancy, the San Dieguito River Park Joint Powers Authority, and the City and County of San Diego. These programs require certain regulatory permits and planning before carrying out the invasive species removal and native plant restoration projects. As part of the SNMP implementation, the City plans to continue supporting these efforts and to provide updates on the progress in the biennial State of the Basin reports.

Future riparian management efforts should also evaluate improved cattle isolation along creeks to maintain suitable buffers, reducing direct nutrient loading to surface water and promoting stream bank stabilization. Riparian area restoration projects could have impacts to surface water quality and groundwater concentrations of both nitrate and TDS. Riparian area restoration could be aimed at improving cattle isolation from creeks and increasing native vegetation for habitat enhancement, which could have the benefits of reduced nutrient loading to the creek and stream bank stabilization. However, Basin TDS analysis indicates that riparian consumptive use is a significant contributing factor of salt evapoconcentration and the associated impact to increasing groundwater TDS. Consequently, potential riparian area restoration projects should be evaluated closely to consider the basinwide benefits and disadvantages, including impacts to both TDS and nitrate management.

5.3.2.2 Conjunctive Use

As discussed in Section 3 and Appendix B, more salts are currently entering the TDS mass in the aquifer than are being removed, and this condition is forecast to increase even with the implementation of BMPs unless a comprehensive approach is taken to manage TDS as recommended. (See additional discussion in Section 3.3 and detailed numerical modeling results in Appendix B.) It is likely that a conjunctive use project with imported water and demineralization components would be required to reduce the total salt mass in the Basin aquifer below current conditions. That is, provided only reasonable and practical reductions in groundwater pumping and evapotranspiration (without demineralization), salt mass in the aquifer might increase without imported water and desalinization. The groundwater modeling that was developed to support this report suggests that salts are likely to continue to accumulate in the aquifer. Consequently, it is recommended that the City and other stakeholders consider conducting a detailed demineralization study, to supplement previous studies.

Conjunctive use projects involve beneficially using a combination of both surface water and groundwater to support Basin utilization objectives and can include specific components such as imported water, aquifer storage and recovery (ASR), municipal water supply, and/or demineralization. Several conjunctive use studies have been conducted previously (CDM, 2010). The 2010 State of the Basin Report listed as a management action the need to continue to investigate conjunctive use opportunities and to implement technically, economically, and environmentally feasible projects (MWH, 2011a). The same report presents the need to continue investigating groundwater desalinization opportunities on the west side of the Basin.

As discussed in Appendix B, more salts are currently entering the aquifer than are being removed. Considering a reasonable reduction in salt loading to the aquifer through continued implementation of BMPs, there is a potential that salts will continue to accumulate in the aquifer and that assimilative capacity might be reduced under current land uses. Therefore, conjunctive use projects may need to continue to be considered as a management alternative approach to mitigating salt accumulation in the aquifer.

5.3.3 Groundwater Resource Protection

Groundwater resource protection was one of the key components of the GMP and was focused on measures designed to reduce the risk of groundwater contamination through direct surface connections. As presented in the GMP, this component included actions such as implementing policies for well construction, well abandonment, and deconstruction, and for protecting recharge areas. The City continues to make measured progress in this area as described in the 2010 State of the Basin Report (see Appendix D for the December 2010 status of groundwater management actions from the GMP).

A series of potential additional groundwater resource protection strategies are presented below to augment the actions identified in the GMP (City of San Diego Water Department, 2007).

5.3.3.1 Wellhead Condition Assessments

Groundwater wells that are improperly designed or maintained can pose a significant risk for facilitating surface contamination into the aquifer. This includes wells that do not have backflow preventers, wells that have inadequate well seals, and wells that are in locations subject to flooding. A comprehensive wellhead condition assessment would assist the development and implementation of a wellhead management plan and would help prioritize those wells that should be considered for abandonment. During wellhead condition assessments, wells should be surveyed and video-logged to verify their construction and condition and to provide additional information on screened intervals.

5.3.3.2 Backflow Prevention

Groundwater wells that do not have backflow preventers or have backflow preventers that are not properly functioning are a particular risk for facilitating surface contamination into the aquifer. As part of the groundwater resource protection program, wells and backflow preventers should be inspected. Requiring well owners and lessees to maintain backflow preventers in good working condition should also be a condition included in the City leases.

The injection of fertilizers and other chemicals into irrigation systems presents an added risk to possible backflow and groundwater contamination. USEPA regulates the application of pesticides through chemigation. USEPA's Pesticide Registration Notice 87-1 ("Label Improvement Program for Pesticides Applied through Irrigation Systems [Chemigation]") requires that pesticide products registered under the Federal Insecticide, Fungicide and Rodenticide Act of 1972 (FIFRA) and applied through irrigation systems should include labeling requirements that specify required backflow prevention controls (e.g., check valves, vacuum-relief valves, drains, interlocks between irrigation pump and chemical pumps, and control valves). Although these are good practices and requirements for any chemical injection into irrigation systems, only registered pesticides carry these requirements. Requiring lessees to comply with these obligations for any injection of chemicals (i.e., fertilizers, water conditioners, pesticides) into irrigation systems would provide added protection.

The City should consider conducting periodic inspection of fertigation systems to ensure compliance with lease requirements. If lessees plans to utilize chemigation or fertigation, these systems should be described in the lessee's NMP or CNMP.

5.4 Implementation Plan

Evaluation of salts and nutrients (as summarized in Section 3.3 and Appendix B) suggest that no single approach or project will unilaterally improve groundwater quality. Selected management strategies are long-term and will likely require a comprehensive approach that includes implementing several projects aimed at improving both water supply reliability and groundwater quality. It should be recognized that additional management strategies may be needed in the future, as discussed in Section 6.

Selected management strategies are presented in Table 5-3 and have been prioritized with the highest priority actions presented first.

TABLE 5-3
Implementation Plan Summary
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Selected Management Strategy	Brief Description	Lead Entity	Target Completion Schedule
Nutrient Management Plans	Site-specific nutrient management plans and annual reporting for certain qualifying City-leased lands. Develop program and incorporate requirements into leases at the time of renewal.	City	Define a nutrient management planning approach by mid-2016. Annual reporting by qualifying lessees each year thereafter.
Nutrient Management Outreach	Promote the adoption of nutrient management best management practices on stakeholder and private lands throughout the subcatchment.	City	Complete the first phase of outreach by mid-2016.
Stormwater Management	Evaluate leases for stormwater management on agricultural lands and promote efforts to use natural treatment systems for nutrient treatment.	City	Evaluate leases by mid-2016. Present a status of natural treatment system projects in the Basin in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.
Septic System Evaluations	Develop procedures to evaluate septic system condition when renewing City leases and coordinate with lessees to perform regular septic system maintenance.	City	Coordinate with the City Real Estate Assets Department and develop lease terms related to septic system evaluations and maintenance by July 2016.
Riparian Area Management	Continue supporting and cooperating with other entities to promote on-the-ground projects for control of invasive non-native species in the Basin.	City	Update on progress in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.
Conjunctive Use	Expand upon previous studies and projects to further evaluate conjunctive use project(s) aimed at reducing salt accumulation in the aquifer	City	Present findings in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.

TABLE 5-3
Implementation Plan Summary
San Pasqual Valley Groundwater Basin Salt and Nutrient Management Plan

Selected Management Strategy	Brief Description	Lead Entity	Target Completion Schedule
Groundwater Resource Protection	Proceed with recommendations for well construction, abandonment, and deconstruction, and for protecting recharge areas as described in the *San Pasqual Groundwater Management Plan* (City of San Diego Water Department, 2007). Include the actions of wellhead condition assessments and backflow prevention program.	City	Present findings in the first SNMP effectiveness review, approximately 2 years after adopting this SNMP.

5.5 CEQA Considerations

The California Environmental Quality Act (CEQA) applies to any discretionary activity proposed to be carried out or approved by a California public agency. CEQA and antidegradation assessments are not required at present because no modification of Basin Plan WQOs or implementation provisions are proposed or required, and because none of the selected management strategies requires CEQA compliance at this time.

The City of San Diego would be the lead agency under CEQA for implementation of SNMP management strategies if and when a project is identified that is subject to CEQA. As the CEQA lead agency, the City would first review the project for exemptions. If no exemptions are applicable, the City would then determine the appropriate action to comply with CEQA beginning with an Initial Study of the proposed project.

SECTION 6

Plan Effectiveness

The City intends to evaluate management strategy effectiveness every 2 years in conjunction with the San Pasqual State of the Basin updates. Management strategy effectiveness reviews will include determining whether amending or adding management strategies should be evaluated further, as discussed below.

The City intends to conduct SNMP audits every 10 years. SNMP audits will be conducted by the City in coordination with other Basin stakeholders every 10 years to determine whether comprehensive updates to the SNMP are needed.

6.1 Management Strategy Effectiveness

This section presents an approach for assessing the effectiveness of selected salt and nutrient management strategies. As discussed in Section 5 and Appendix B, it might take decades to observe or measure significant groundwater quality improvement resulting from implementing management strategies identified in this SNMP because of the slow groundwater response time. Combined with natural variability of groundwater quality in response to hydrology, trends of improvement or degradation in water quality can be difficult to discern. Preliminary approaches for future evaluations are therefore presented below.

A requirement during evaluations of plan effectiveness is to review the current state of affairs, including the following actions:

- Identifying active salt and nutrient management strategies
- Determining whether policy changes have occurred
- Confirming that the WQOs are adequate and aligned with Basin utilization objectives

Selected management strategies have been grouped into the following management categories:

- Basin monitoring program
- Nutrient management program
- Salinity management program
- Groundwater resource protection program

An approach to evaluate the effectiveness of each category of salt and nutrient management strategies is presented below.

6.1.1 Basin Monitoring Program

A Basin monitoring program will allow the City to compare groundwater quality measurements with BMOs. The Basin monitoring program would likely include surface water monitoring and groundwater monitoring. Development of a detailed Basin Monitoring Program will define specific requirements of field measurements to be conducted. The City plans to biennially evaluate the effectiveness of the Basin monitoring program using criteria such as those listed below:

- Review of water quality trends
- Locations or constituents of concern
- Data gap evaluation
- Statistical trend analysis

Items such as those listed above will be used to determine whether additional monitoring is required, or whether certain monitoring activities should be suspended. The evaluation might also provide insight into the need for and potential benefits of focused efforts such as case studies, forecasting such as numeric modeling, or special monitoring.

6.1.2 Nutrient Management Program

The effectiveness of the nutrient management program will be evaluating by considering factors such as:

- Evaluation of lessee compliance with nutrient management plan and annual letter report submittal requirements
- Evaluation of lessee feedback on the City-lease property nutrient management program
- Evaluation of participation levels from nutrient management outreach activities for private lands
- Geographic areas of concern regarding nitrate concentrations and trends
- Data gap evaluation

The determination of the overall effectiveness of the nutrient management program will consider statistical nitrate concentration trends and changes to basinwide assimilative capacity.

6.1.3 Salinity Management Program

The effectiveness of the nutrient management program will be evaluating by considering factors such as:

- Progress on implementing non-native invasive species removal programs
- Progress on planning and implementation of conjunctive use projects
- Geographic areas of concern regarding nitrate concentrations and trends
- Data gap evaluation

The determination of the overall effectiveness of the salinity management program will consider statistical TDS concentration trends and changes to basinwide assimilative capacity.

6.1.4 Groundwater Resource Protection Program

The effectiveness of the groundwater resource protection program will be evaluating by considering factors such as:

- Progress on implementing policies for well construction
- Progress on implementing policies for well abandonment and deconstruction
- Progress on implementing wellhead condition assessments
- Progress on implementing backflow prevention measures
- Data gap evaluation

The determination of the overall effectiveness of the groundwater resource protection program will consider the measured progress toward achieving the end goals of each of the specified management actions.

6.2 SNMP Audit

SNMP audits will be conducted every 10 years to determine whether updates to the SNMP are needed. The City will lead the audits and will engage Basin stakeholders. The SNMP Audit process will consider the monitoring results and management strategy effectiveness evaluations presented in the San Pasqual State of the Basin updates. The audits will also consider recent or planned changes to land use or water management in the Basin that may have a significant influence on the recommended management strategies to improve water quality in the Basin. If the City and stakeholders mutually agree that an SNMP update would improve the understanding and management of the Basin given new information, the City will initiate an SNMP update in coordination with the Regional Board.

SECTION 7
References

American Society of Agricultural Engineers (ASAE). 2005. *Manure Production and Characteristics*. Publication ASAE D384.2 MAR2005. St. Joseph, MI. March.

California Department of Water Resources (DWR). 1993. *San Diego Region Groundwater Studies, Phase VI, Hodges Hydrologic Area, Highland Hydrologic Subarea, and Update of Las Lomas Muertas Hydrologic Subarea*.

California Department of Water Resources (DWR). 2003. "Hydrologic Region South Coast, San Pasqual Valley Groundwater Basin." *Bulletin 118, California's Groundwater*. Available at: http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/9-10.pdf. Accessed April 23, 2013.

California Regional Water Quality Control Board (Regional Board). 1994. *Water Quality Control Plan for the San Diego Basin*. September 1994, with amendments effective April 2007.

California Regional Water Quality Control Board, San Diego Region (Regional Board). 2010. *Resolution No. 2010-0125, A Resolution Endorsing the Proposed Guidelines for Salinity and Nutrient Management Planning in the San Diego Region*.

California State Water Resources Control Board. 2009. Resolution No. 2009-011, "Adoption of a Policy for Water Quality Control for Recycled Water."

CDM. 2008. *Well Construction Report*. October.

CDM. 2010. *San Pasqual Groundwater Conjunctive Use Study Final Report*. May.

CH2M HILL. 2001. *Groundwater Asset Development and Protection Program, Characterization of Assets, San Pasqual Groundwater Basin*. April.

CH2M HILL. 2012. Project *Path Forward: San Pasqual Basin Groundwater Protection (Task Order 2) Draft Memorandum*.

City of San Diego. 1995. *City of San Diego San Pasqual Vision Plan.*

City of San Diego Planning Department. 2006. *San Pasqual Valley Community Plan*. February. Available at: http://www.sandiego.gov/planning/community/profiles/pdf/sanpasqual/spvpfv.pdf. Accessed April 2013.

City of San Diego Water Department. 2007. *San Pasqual Basin Groundwater Management Plan*. Prepared by the City of San Diego Water Department, MWH Americas, and Katz and Associates. November.

City of San Diego. 2008. *City of San Diego General Plan,* "Conservation Element." March 10. Available at: http://www.sandiego.gov/planning/genplan/index.shtml. Accessed April 2013.

County of San Diego. 1998 (with updates through 2010). *Multiple Species Conservation Program*. Available at: http://www.sdcounty.ca.gov/pds/mscp/index.html. Accessed April 2013.

County of San Diego. 2011a. *County of San Diego Standard Urban Stormwater Mitigation Plan, Requirements for Development Applications*. January 8. Revised August 1, 2012. Available at: http://www.sdcounty.ca.gov/dpw/watersheds/susmp/susmppdf/susmp_manual_2012.pdf. Accessed May 2013.

County of San Diego. 2011b. *San Diego County General Plan,* "Conservation Element." August 3. Available at: http://www.sdcounty.ca.gov/pds/generalplan.html. Accessed April 2013.

Greeley and Hansen, in association with HYA Consulting Engineers. 1993. *Rancho Bernardo Reclaimed Water Facilities Plan and San Pasqual Valley Groundwater Management Concepts*.

Henry, M.J., V.A. Gibeault, and V.F. Lazaneo. 2002. *Practical Lawn Fertilization*. Publication 8065. Prepared for University of California, Division of Agriculture and Natural Resources.

Izbicki, J.A. 1983. *Evaluation of the San Dieguito, San Elijo, and San Pasqual Hydrologic Subareas for Reclaimed Water Use, San Diego County, California*. Water-Resources Investigations Report 83-4044. Prepared for United States Geological Survey. August. Available at: http://ca.water.usgs.gov/sandiego/resources/refs.html. Accessed April 2013.

Kaplan, O. Benjamin. 1987. *Septic Systems Handbook*. Lewis Publishers.

Lowe, Kathryn S., Maria B. Tucholke, Jill M.B. Tomaras, Kathleen Conn, Christiane Hoppe, Jörg E. Drewes, John E. McCray, Junko Munakata-Marr. 2009. *Influent Constituent Characteristics of Modern Waste Stream from Single Sources.*

Metcalf & Eddy. 1997. *San Pasqual Valley Water Resources Management Plan*. September.

MWH. 2009. *San Pasqual Groundwater Basin Conjunctive Use Study – Task 3.1 Groundwater Model Documentation*. Technical Memorandum. April.

MWH. 2010. *Salinity Study Memorandum*. June.

MWH. 2011a. *2010 Groundwater Management State of the Basin Report*. June.

MWH. 2011b. *San Pasqual Surface Water Monitoring*. September.

National Atmospheric Deposition Program/National Trends Network (NADP/NTN). 2013. Tanbark Flat station located in Los Angeles County (Monitoring Location CA42). Information from monitoring databank active from 1982 to present. Available at http://nadp.sws.uiuc.edu/sites/siteinfo.asp?net=NTN&id=CA42. Accessed April 2013.

Natural Resources Conservation Service (NRCS). 2008. *Comprehensive Nutrient Management Plan, Frank Konyn Dairy.*

RBF Consulting. 2011. *San Pasqual Brackish Groundwater Desalination Demonstration Project*. November.

Rosenstock, T.S., D. Liptzin, J. Six, and P. Tomich. 2013. "Nitrogen Fertilizer Use in California: Assessing the Data, Trends, and a Way Forward." *California Agriculture*. Volume 67 (Issue 1):E68-E79. April-June.

Tjosvold, S.A. 1999. *Effect of Nitrogen on Quality and Production of Field-Grown Field Flowers.* Kee Kitayama Research Foundation Final Report. December. Santa Cruz County UC Cooperative Extension.

Todd Engineers. 2012. *Salt and Nutrient Balance and Fate and Transport Analysis*. San Benito County.

Viers, J.H., D. Liptzin, T.S. Rosenstock, V.B. Jensen, A.D. Hollander, A. McNally, A.M. King, G. Kourakos, E.M. Lopez, N. De La Mora, A. Fryjoff-Hung, K.N. Dzurella, H.E. Canada, S. Laybourne, C. McKenney, J. Darby, J.F. Quinn, and T. Harter. 2012. "Nitrogen Sources and Loading to Groundwater." Technical Report 2 in: *Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater*. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis.

Waste Discharge Requirements for County of San Diego, San Pasqual Academy. 2009. Order No. R9-2009-0072. December.

Waste Discharge Requirements for Existing Dairy Animal Feeding Operations in the San Diego Region. 2008. General Order No. R9-2008-0130. December.

Waste Discharge Requirements for the Zoological Society of San Diego, San Diego Safari Park, San Diego County. 1999. Addendum No. 1 to Order No. 99-04. March.

Welch, Michael. 2010. *Proposed Guidelines for the Salinity/Nutrient Management Planning in the San Diego Region*. Prepared for the Southern California Salinity Coalition and the San Diego County Water Authority. September.

Appendix A
Responses to Comments and Stakeholder Meeting Summary

Responses to Stakeholder Comments – San Pasqual Salt and Nutrient Management Plan March 2014 Draft Final

Stakeholder Comments on the Draft Final Salt and Nutrient Management Plan

Reponses to Comments, April 25, 2014

Comment No.	Page/ Section	Comment	Reviewer	Response
1	3.3.3	Can the plan be made to allow for both scenarios for Nitrates given that the regional board may change the allowable nitrate amount from I believe 10 mg/l to 45 mg/l?	Matt Witman/ Witman Ranch Inc. April 10, 2014	We acknowledge revising the WQO for nitrate from 10 mg/L to 45 mg/L would be more consistent with federal standards and would increase the assimilative capacity. Even if the WQO for nitrate was revised, however, certain areas of the basin would exceed WQOs. The findings, recommended activities, and implementation strategies presented in the SNMP are valid for both nitrate WQO scenarios. In that regard, both nitrate WQO scenarios are accounted for in the SNMP.
2	3.3.4	In regards to recycling the groundwater to remove nutrient mass. I feel that this is definitely occurring, but its affects are overall negative. We currently use the nitrate in the water as part of our applied nitrogen in the groves, but the higher nitrate wells invariably carry overall high salt as well. The consumptive concentration of the salts out weighs any benefit of the overall nitrogen use. It does however save us a little of our fertilizer cost.	Matt Witman/ Witman Ranch Inc. April 10, 2014	We agree with this comment. Plant uptake of nitrogen in pumped groundwater is substantial, while most of the salts in pumped groundwater remain within the Basin through the evapoconcentration process. Consequently, evapoconcentration is the most significant factor contributing to increased salinity concentrations in the Basin. We will add a clarifying sentence to the end of the referenced paragraph.
3	3.3.5	I feel that the value of removing the salt from the basin can't be overstated and should be more emphasized as a priority since it is the only thing in the plan that will improve the salt and nitrogen situation in the basin, even if it done on a small scale.	Matt Witman/ Witman Ranch Inc. April 10, 2014	Loading evaluations and groundwater modeling analysis presented in the SNMP generally support this comment. While certain best management practices and implementation strategies will help minimize or delay an increase in salt mass in the Basin, conjunctive use that includes removing salt from the Basin will likely be a component of long-term salinity management. This is consistent with findings and conclusions presented in the SNMP, but further emphasis of the value of removing salt from the Basin will be considered as suggested.
4	4.1.2	Section 4.1.2 states that the city owns the groundwater wells, and the lessees operate the groundwater wells. Our leases are clear that we are allowed to drill wells and pump the water. At the time the leases are terminated the city has the right to retain or have the lease destroy the well. The city does not own them until that time. This needs to be changed.	Matt Witman/ Witman Ranch Inc. April 10, 2014	We appreciate the clarification. The discussion of well ownership will be revised.
5	5.3.1	Section 5.3.1 states that reducing the amount of fertilizer and manure 25% from current levels would effectively curb the current trend of increasing nitrate levels in the groundwater. This is an incorrect statement since earlier in the report you state that it takes 5 to 25 years for current activities to affect the groundwater. It may well slow down the trend, but for the next 5-25 years past practices will continue to affect the groundwater	Matt Witman/ Witman Ranch Inc. April 10, 2014	The referenced sentence will be revised. The groundwater modeling scenarios considered a 50-year period. We agree that the time for the groundwater system to respond to changes (improvements or otherwise) may take 5 to 25 years, depending on a variety of physical factors.
6	B4	Section B4 needs a scenario where much of the agriculture that is irrigated with county water authority water is eliminated. This will happen based on the increasing price of the water. There are economic studies that show this. Perhaps the local farm bureau could be a resource on this.	Matt Witman/ Witman Ranch Inc. April 10, 2014	Thank you for the insightful comment. Additional scenarios and economic studies are not required to proceed with finalizing the SNMP. However, the City will take this comment into consideration for future Basin studies.
7	-	I feel that both the city and RWQCB need to be flexible in their approach to this study. The economic impacts have not been studied. That would be a good item to add as well. The economics of ag are constantly changing. As an example, Highland Valley to the southwest of San Pasqual used to be mainly avocados, Now the avocados have mostly disappeared, but vineyards are popping up. The elimination of cropland and the change in crops will have an affect on the future of water in the san Pasqual valley.	Matt Witman/ Witman Ranch Inc. April 10, 2014	The comment correctly states that economic impacts and future land use projections have not been a focus of the salt and nutrient evaluation. While these items might be considered during future studies, we believe the findings, recommended activities, and selected implementation strategies presented in the SNMP are still valid.

Comment No.	Page/ Section	Comment	Reviewer	Response
8	-	Thank you for the opportunity to comment on the Draft Final Salt and Nutrient Management Plan (SNMP) Report. RMC Water & Environment is a California-based environmental engineering company focused exclusively on water. For the last five years, we have assisted numerous agencies across the state in developing their SNMPs to be responsive to requirements of the 2009 Recycled Water Policy. We appreciate the changes that were made on the Draft SNMP Report to refine the loading evaluation pertaining to the San Diego Zoo Safari Park operations. In reviewing the Draft Final SNMP, we have some clarification questions; a few small refinements to the loading analysis are needed, and request that more emphasis and endorsement be placed on the current management practices employed at the Safari Park. The comments below reflect these sentiments.	Safari Park/RMC April 14, 2014	Thank you for your comments. Refinements to the loading analysis are not required at this time as described in responses to your additional specific comments provided below. As you suggested, additional information provided in your letter will be used to place more emphasis on current management practices employed at the Safari Park.
9	-	Since the 25% of animal waste loading on Safari Park grounds is attributable to animal urine, please describe how ammonia transformations are accounted for in the model and confirm that attenuation is considered.	Safari Park/RMC April 14, 2014	Ammonia transformations and attenuation were accounted for by two means in the SNMP loading analysis. First, the analysis accounts for nutrient uptake by plants where animal waste (both urine and manure) is applied. Secondly, a factor is applied to consider transformations of ammonia to nitrate and subsequent loss to denitrification in the groundwater system.
10	-	The Draft Final SNMP now considers the "basin" to be the entire watershed area which encompasses a much larger area than the groundwater basin. While a portion of loading in watershed areas may reach the groundwater basin through both runoff and subsequent infiltration, a large part of loading will not reach the groundwater basin as it will infiltrate and be held within bedrock. For example, urine seeping into hills within animal enclosures will not all move into the groundwater aquifer system, therefore the 25% animal waste loading value that was assumed does not fully load to the system. Because the large majority of Safari Park lands are on parcels outside of the groundwater basin, it is important to apply an additional factor to the 25% value to account for the fact that only a portion of the loading attributable to the Safari Park operations will reach the groundwater basin.	Safari Park/RMC April 14, 2014	The groundwater flow and solute transport models account for the items listed, including areas with bedrock, variable rates of horizontal and vertical water movement and associated solute transport. Additional loading factors/adjustments are not needed to account for these factors.
11	-	The San Diego Zoo Safari Park utilizes Integrated Pest Management (IPM) in lieu of standard chemical fertilizers and soil amendments on Safari Park grounds (with the exception of the Cheetah Run). The Cheetah run is only 20 feet wide by 300 feet in length (0.14 acres), and the turf grass is maintained similar to a golf green using organic fertilizers. No soil amendments are used within the Safari Park, and no animal manure is spread for fertilization. Please revise the loading analysis to account for fertilizers only in the 0.14 acres of the Cheetah Run.	Safari Park/RMC April 14, 2014	The current loading analysis is generally consistent with your letter. The SNMP analysis assumed that no synthetic fertilizers are applied on Safari Park grounds. The addition of synthetic fertilizers to the loading analysis for the Cheetah Run (0.14 acres) would have a negligible impact to Basin nutrient loading, and this small refinement would not change the conclusions or recommendations of the SNMP.

Comment No.	Page/ Section	Comment	Reviewer	Response
12	-	The San Diego Zoo Safari Park has been operated at the site for over 40 years, with little fluctuation in number of animals during that period. Prior to being operated as the Safari Park, the land was used for large cattle grazing operations. These cattle operations did not have the same animal waste removal practices as the Safari Park, and one would expect lower loading concentrations with current Safari Park operations. The data shown on Figure 2-8 indicates relatively stable nitrate trends within the groundwater basin with the exception of well CDC4 which shows an increasing trend. Considering the number of historical dairies in the valley, stable trends would indicate that the soils are able to attenuate nutrients more effectively than modeled. Therefore, the loading model is overly conservative and targeting the Safari Park lands for implementing a Nutrient Management Plan is not appropriate until a longer monitoring record is established to confirm modeled predictions. Given that the Safari Park employs stringent best management practices (BMPs), cataloging their existing BMPs within the Final SNMP should consist of the Safari Park's nutrient management reporting without further official report submittals. We suggest that the implementation measures be revised to specifically exclude the Safari Park from having to submit a Nutrient Management Plan as other City Leasees will be required to do in July 2016.	Safari Park/RMC April 14, 2014	The City is committed to ongoing collaboration with stakeholders to proactively manage salts and nutrients in the San Pasqual Valley and appreciates that many lessees have been in operation for multiple decades. Likewise, the City is committed to protecting resources in the San Pasqual Valley. The groundwater models were calibrated for current land use and land management conditions, and we do not believe that they are overly conservative. Although a statistical trend analysis has not been performed, the SNMP discusses groundwater quality trends, which includes potentially favorable groundwater quality trends at certain locations. (Note that your reference to Figure 2-8 is related to surface water, and we have inferred that the intended reference was to Figure 2-10.) Ongoing groundwater quality monitoring, as discussed and recommended in the SNMP, is an important component of groundwater management in the Basin and will be continued. Based on current information and available data that were presented in the Draft Final SNMP, it is likely that, for current land uses and management practices, basinwide nutrient loading would be increasing the nutrient mass in the aquifer over time. Nutrient management planning and reporting will be an important salt and nutrient management strategy moving forward. Because of stakeholder commitment to Basin resource management and groundwater protection, it is unrealistic to specifically exclude a lessee from salt and nutrient management strategies in the SNMP.
13	-	Please elaborate on the San Diego Zoo Safari Park's existing BMPs within the Draft Final SNMP in Section 5.3.1.2. (a.) For animal health and because it is a tourist resource, the San Diego Zoo Safari Park implements a number of BMPs above and beyond typical facilities where animals are present. These BMPs include the following: (i.) In order to manage odor and insects, manure removal is conducted daily, thus not allowing for time for leaching into the groundwater basin. Manure is removed and transported to an offsite agricultural farm (located south of Highway 78 and north of the Milky Way) where it is disked into the soil to assist in plant growth. No manure is used for fertilization on Safari Park grounds. (ii.) At the farm where the Safari Park manure is transported, the land is dry farmed and not irrigated. (iii.) Training of staff in handling animal manure and urine, along with training of groundskeepers in landscaping and irrigation BMPs. (iv.) Because of strict animal health needs, landscaping chemicals, fertilizers, and soil amendments are not used on Safari Park grounds with the exception of the Cheetah Run. IPM measures are used in lieu of common landscaping chemicals and fertilizers. (v.) Grounds staff inspect Safari Park landscaping irrigation lines daily and conduct immediate fixes when needed so that runoff or ponding does not occur. (vi.) As part of the tight control of irrigation to eliminate any overspray or runoff from oversaturation of landscaping, soil probes are used on a regular basis to confirm that the appropriate amount of irrigation is being applied. (vii.) Soil sampling is conducted approximately every three years in areas displaying need.	Safari Park/RMC April 14, 2014	Thank you for the additional information on the Safari Parks BMPs. Elaboration on the Safari Park's existing BMPs will be incorporated into the SNMP in Section 5.3.1.2 as suggested. Manure management described in this comment is consistent with the loading analysis presented in the Draft Final SNMP.

Comment No.	Page/ Section	Comment	Reviewer	Response
14	-	Given the tight controls on animal waste practices and landscaping measures, it does not seem appropriate nor feasible for the Safari Park to implement any further nutrient management measures. The SNMP should reflect and endorse the full spectrum of existing BMPs employed by the Safari Park and farm where manure is utilized, and acknowledge that there is little room for curbing loading further on these lands. To do this, Section 5.3.1.2 should be revised to include the listed management measures, and the statement on page 5-5, "Further development and implementation of these solutions in tandem with improved overall nutrient management would help to address the salt and nutrient contributions from the Safari Park. Implementing the City-leased lands nutrient management program on the fields currently receiving manure applications from the Safari Park is also expected to benefit the Basin." should be changed to "Continued implementation of these existing BMPs helps to address the salt and nutrient contributions from the Safari Park and associated farm, and no additional management measures are recommended for the Safari Park at this time."	Safari Park/RMC April 14, 2014	Section 5.3.1.2 will be revised by considering the information provided. Based on information available and data provided by the Safari Park, nutrient loading to the dry farmed areas outside the park may be exceeding the agronomic nutrient requirement. Site-specific nutrient management planning and reporting will provide the opportunity to assess nutrient management practices using more refined site-specific information and will be an important salt and nutrient management strategy moving forward. Therefore, we do not believe the recommended revisions to page 5-5 should be incorporated.
15	1-4 Last Paragraph	The "tentative meeting for 4/3/14" needs to be updated, as this day has come and gone.	JE/Rincon del Diablo April 18, 2014	The stakeholder public meeting was held April 3, 2014. This paragraph will be updated to reflect the recent stakeholder outreach activities.
16	2-1	The study area indicates the various agency with interests in Lake Hodges which Rincon is not a part; however a portion of Rincon's service area is located within and above the San Pasqual basin and this should be mentioned here.	JE/Rincon del Diablo April 18, 2014	The suggested revision will be incorporated.
17	2.6.2	The City of Escondido does not use groundwater for potable purposes in the basin, so residential water use is strictly CWA water. Although not 100% certain, we believe they do not use groundwater for irrigation of the golf course either.	JE/Rincon del Diablo April 18, 2014	Your comment is consistent with analyses in the SNMP except that the Vineyard Golf Course has a groundwater well and uses groundwater for irrigation. Per Brad Van Horn, manager, the Vineyard Golf Course has a groundwater well which pumps groundwater into their storage pond. Water from the storage pond is used to irrigate the golf course. Recycled water from the City of Escondido is also used to fill the storage pond. The statement in the referenced paragraph regarding City of Escondido water sources will be clarified.
18	2.6.3 - last paragraph on page	This paragraph mentions that the Sutherland Dam was built in 1954, but no water has ever been released from the dam. What is the dam's purpose and where/how is this water used? It is understood Ramona MWD is a partner for this dam. Do they use this water for anything other than recreational purposes? If this dam did not exist, or if releases from the dam were more frequent, what might be the implications for water quality in the San Pasqual basin?	JE/Rincon del Diablo April 18, 2014	2.6.3 states that "...no water has been released from the dam to the creek." There is an existing pipeline from Sutherland Reservoir to transfer water from Sutherland to San Vicente Reservoir. An agreement between the City & Ramona Municipal Water District (RMWD) allows water deliveries to RMWD's Bargar Treatment Plant. The water from Sutherland Reservoir is used primarily for water supply. The City does not know what the implications for water quality would be if Sutherland Dam did not exist. Black Canyon, Bloomdale, and Witch Creeks are major tributaries to Santa Ysabel Creek upstream from Sutherland Reservoir.
19	2.6.5, 2nd paragraph	This section mentions in-stream recharge. It is not clear whether this recharge is from surface water, underlying groundwater that reaches the surface, or if there another source of water released into the stream?	JE/Rincon del Diablo April 18, 2014	We agree that this sentence was out of context for this paragraph (taken from a previous conjunctive use study) and will be removed.
20	2.7.2.2	Why is there is a big difference in inorganics reported to exceed primary/secondary MCLs between Tables 2-6 and 2-7. Is this because testing for the inorganics did not occur in the earlier period, or are there any hypotheses why these inorganics showed up?	JE/Rincon del Diablo April 18, 2014	The referenced column indicates that at least one or more reported concentration values exceeded the primary or secondary MCL or Regional Board groundwater WQO. It has not been determined that inorganic concentrations have been increasing.
21	5.1	Rincon looks forward to continued dialogue and collaborating with the City with a focus on conjunctive use within the San Pasqual area.	JE/Rincon del Diablo April 18, 2014	Agreed - the City looks forward to continued dialogue and collaboration with stakeholders including Rincon WD for effective resource management in the San Pasqual area.
END				

Stakeholder Meeting Summary
February 3, 2014

San Pasqual Salt and Nutrient Management Plan Stakeholder Conference Call

ATTENDEES:	**San Pasqual Valley Stakeholders**:	
	Mat McKellips/Pinery	George Adrian/City of San Diego
	Charlie Janzig/Big Tree Nursery	Antero Penaflor/City of San Diego
	Bob McLure/Safari Park	Lea Adriano/City of San Diego
	Frank Konyn/Konyn Dairy	Brett Isbell/CH2M HILL
	Matt Witman/Witman Farms	Jason Smesrud/CH2M HILL
	Fisayo Osibodu/RWQCB	Tom Henderson/CH2M HILL
	Larry Abutin/City of San Diego	
COPY TO:	George Adrian/City of San Diego	
	Larry Abutin/City of San Diego	
PREPARED BY:	CH2M HILL	
DATE:	Conference Call on February 3, 2014	

The City of San Diego and CH2M HILL hosted a conference call to review comments received from San Pasqual Valley stakeholders. These meeting notes contain the following items:

- Meeting announcement that was sent to San Pasqual Valley stakeholders
- Meeting notes recorded during the conference call on February 3, 2014
- Responses to stakeholder comments that were distributed prior to the conference call (Stakeholder comments were on the October 2013 *Draft San Pasqual Salt and Nutrient Management Plan*)
- Responses to additional information received from stakeholders after the conference call on February 3, 2014, but before February 11, 2014

These activities are part of the stakeholder outreach program that supports the preparation of a San Pasqual Salt and Nutrient Management Plan (SNMP).

Meeting Announcement

Dear San Pasqual Valley stakeholders:

Thank you for providing comments on the *Work-In-Progress Draft San Pasqual Salt and Nutrient Management Plan* (October 2013). Responses to comments made on the draft plan will be reviewed in preparation for a final plan submittal to Regional Water Quality Control Board by May 2014. A conference call has been scheduled to discuss comments made by San Pasqual Valley stakeholders.

Conference Call

Date:	February 3, 2014
Time:	1:00 - 2:00 p.m.
Conference Call Dial-In:	866-203-7023
Access Code:	428.458.6838

Agenda

1. Introduction(s)
2. Present Responses to Comments

3. Next Steps
   - SNMP Final Draft in early March 2014
   - Presentation to stakeholders March/April 2014
   - Final submittal to Regional Water Quality Control Board May 2014
4. Other

On behalf of the City of San Diego and CH2M Hill, thank you for your participation in developing the Salinity and Nutrient Management Plan. We look forward to the discussion.

Meeting Notes

Notes recorded during the conference call meeting on February 3, 2014:

- Consider separating container nurseries from other field-grown ornamentals. The Suncoast Botanicals site was primarily cut flower production, and several at the other sites identified as nurseries are operated as field-grown rather than container nurseries. The field-grown ornamentals will have much lower fertilizer rates than the container nurseries.
- The Pinery keeps records of fertilizer use and can provide that information.
- Stakeholders were invited to provide additional input on revised nitrogen loading assumptions by February 7, 2014. It was requested that stakeholders provide additional input on total nitrogen supplied on an annual basis (pounds per acre per year) and the fertilizer product used to deliver the nitrogen. CH2M HILL will incorporate the updated information into the groundwater model and the SNMP.
- Matt Witman questioned whether the riparian areas were going to be operated under a nutrient management plan. Jason Smesrud explained that the riparian areas might actually help with the nutrient issues, serving as somewhat of a nitrogen filter, but is expected to contribute to increases in total dissolved solids (TDS). The riparian area contribution to evapoconcentration of groundwater will be presented separately from the irrigation use contribution to evapoconcentration of salts in the SNMP. Based on those results, we will evaluate whether the riparian areas warrant some sort of specific management recommendation.
- The nitrogen and TDS from animal excrement (manure and urine) has been assumed to be collected at 75 percent collection efficiency for both Konyn Dairy and Safari Park. Bob McLure and Frank Konyn did not have specific estimates of collection efficiency available, but stated that their collection efficiency is very high due to their frequent collection to manage odors and flies. It was clarified that the collection efficiency considers urine, which can infiltrate directly into the soil and is impractical to collect in open enclosures.
- Winter forage west of the Konyn Dairy has been converted to summer forage within approximately the last 2 years since the time of the summer 2012 satellite image.
- Winter forage at the confluence of Santa Ysabel and Santa Maria Creek should be riparian.
- CH2M HILL clarified that summer forage accounts for irrigated sites, and winter forage accounts for non-irrigated sites.
- CH2M HILL clarified that summer forage includes winter and summer forage production.

Stakeholder-Provided Information on Nitrogen Fertilizer Management (February 2014)

San Pasqual Valley Salt and Nutrient Management Plan

Responses to Stakeholder-Provided Information on Nitrogen Fertilizer Management

Stakeholder	Information Provided	Date	Interpretation of Information Provided	Revisions to Salt and Nutrient Sources Incorporated into SNMP and Model
Mat McKellips, Pinery Tree Farms	Purchased 18,100 gal of Can-17 last year. Can-17 consist of 4.6 % ammonical nitogen, 11.1 % nitrate, and 1.3 % urea. The product weighs 12.7 lbs/gal = 2.1 lbs of N per gal of can-17. Over 120 acres this would equate to about 316 lbs of N /acre over last year. We did put on some top dress, slow release on some can tight pine crops in the fall, but not a huge amount.	2/3/2014 email	In the SNMP, fertilizer loading to container nursery crops is applied only to the fraction of area covered by green plants, not the total parcel area. Irrigation demands are calculated over the same area, which was determined using satellite images from the 2009 and 2012 growing seasons. For the 120 acres at the Pinery, 43 acres (39% of the total area) was estimated to be covered by green plants. Annual total N applied is estimated as: 18,100 gal product x 12.7 lb product/gal product x 0.17 lb N/lb product = 39,078 lb N. The annual unit area application rate to get the correct total applied N is: 39,078 lb N/43 acres = 909 lb N/ac.	Change the unit area fertilizer N application rate for container grown nursery stock from 1,000 lb N/ac/yr to 909 lb/ac/yr. Separate assumptions will be applied to field grown nursery stock.
Bob McClure, San Diego Zoo Safari Park	The correct figure that is taken to our composting site on the south side of Hwy 78 is 8,356 tons. Please use this figure in the SNMP calculations.	2/6/2014 email	The amount of manure reported in annual WDR reports to the regional board were 10,050 tons in 2010 and 12,100 tons in 2011 for an average of 11,075 tons. The more recently provided value of 8,356 tons will be used in the SNMP calculations.	Change the amount of manure transferred off-site from the Safari Park from 11,075 ton/yr to 8,356 ton/yr.
Charlie Jancic, Big Trees Nursery	The only fertilizer we have used in the past 10 years has been about 150 lbs per acre of 38-0-0 urea formaldehyde applied as top dressing on specimen trees. Our plant coverage was about 5 acres. The low rate is due to mature specimen trees in field soil at very wide spacing that we really don't want to grow much.	2/4/2014 email	The annual unit area application rate is estimated as: 150 lb product/acre x 0.38 lb N/lb product = 57 lb N/ac. The field-grown nursery stock warrants a separate land use classification from container nursery stock. Big Trees Nursery parcels will be changed to the new "Nursery-Field" land use category.	Separate the "Nursery" land use category into "Nursery-Container" and "Nursery-Field" categories. For "Nursery-Field" category, use 54 lb N/ac/yr for fertilizer rate assumptions. This is an average of information provided by Big Trees Nursery and Witman Ranch.
Matt Witman, Witman Ranch	We grow 12 acres of field grown palms. This is an operation that we a phasing out of. Currently we put in a total of 50 lbs of Nitrate nitrogen per acre per year in the form of CAN-17. There is no additional fertilizer added.	2/5/2014 email	The field grown nursery stock warrants a separate land use classification from container nursery stock. The Whitman Ranch field grown palms parcel will be changed to the new "Nursery-Field" land use category.	Separate the "Nursery" land use category into "Nursery-Container" and "Nursery-Field" categories. For "Nursery-Field" category, use 54 lb N/ac/yr for fertilizer rate assumptions. This is an average of information provided by Big Trees Nursery and Witman Ranch.
Matt Witman, Witman Ranch	We currently grow 382 acres of Citrus in the valley. The amount of fertilizers vary somewhat based on variety. In general we put on 120 lbs. of nitrate nitrogen per acre per year. This is in the form of CAN-17 for 50% of the total, the remaining 50% is in the form of UN 32 or various sources of organic nitrogen for our organically produced oranges.	2/5/2014 email	Previous SNMP assumptions were based on a study summarizing citrus N fertilization rates across California estimated at 95 lb N/ac/yr. The fertilization rates provided at 120 lb N/ac/yr will be used.	Change the N fertilizer rates for citrus from 95 lb/ac/yr to 120 lb/ac/yr.
Matt Witman, Witman Ranch	We currently grow 135 acres of avocados in the valley. We apply about 120 lbs of Nitrate nitrogen per acre on the avocados. This is in the form of CAN-17 and UN32, 50% for each.	2/5/2014 email	Previous SNMP assumptions were based on a study summarizing avocado N fertilization rates across California estimated at 112 lb N/ac/yr. The fertilization rates provided at 120 lb N/ac/yr will be used.	Change the N fertilizer rates for avocados from 112 lb/ac/yr to 120 lb/ac/yr.
Matt Witman, Witman Ranch	We also oversee 300 acres of commercial sod production. This is harder to pin down since the harvested acres vary each season, but in general, for a calendar year, we will apply about 200 lbs of nitrate nitrogen. This is in both organic and inorganic forms. CAN-17 is the dominant inorganic form.	2/5/2014 email	Previous SNMP assumptions were based on typical residential lawn N fertilization rates in California estimated at 174 lb N/ac/yr. The fertilization rates provided at 200 lb N/ac/yr will be used. These are applied only over the area actively growing sod, which averaged 58% of the total sod production field acreage on the Whitman lease for 2009 and 2012 growing seasons.	Change the N fertilizer rates for sod production from 174 lb/ac/yr to 200 lb/ac/yr.

Matt Witman, Witman Ranch	I believe that the container nurseries that are used are smaller containers that are not rooted into the soil. Based on that, only a small fraction of san Pasqual nurseries are of that type. Once you allow the larger containers to root into the soil, they respond just like any other plant, and the nitrogen needs go down because that can utilize better what is applied. The largest nursery operations of the Pinery, Evergreen nursery, 3C growers, Southcoast botanical, and us are all of the type that much lower fertilizer amounts are used. Additionally we talked about Southcoast being a cut flower-foliage operation and not a nursery.	2/5/2014 email	Information provided by Whitman Ranch and Big Trees Nursery for field-grown tree nursery stock N fertilization rates will be used for revised N loading assumptions on a new land use category "Nursery-Field." This will be applied to all formerly classified "Nursery" sites except for the Pinery and Suncoast Botanicals. The Pinery parcel will be classified as "Nursery-Container" and Suncoast Botanicals parcel will be classified as "Cut Flower." Nitrogen fertilizer amounts for the container nursery operation were provided by the Pinery. Cut flower nitrogen fertilizer rates will be estimated from California cooperative extension research on other cut flower operations.	Split the former "Nursery" land use category into three separate categories with leases designated as follows: "Nursery-Container": Pinery "Nursery-Field": Whitman field grown palms, Evergreen Nursery, 3C Growers, Big Trees Nursery, tree nursery stock grown on Cloverdale Stables lease "Cut Flower": Suncoast Botanicals Apply N fertilization rate information provided by basin stakeholders for container-grown nursery stock (909 lb N/ac/yr), field-grown tree nursery stock (54 lb N/ac/yr), and estimates from California cooperative extension research for cut flowers (400 lb N/ac/yr).
Frank Konyn, Konyn Dairy	The land parcel identified as "Winter Forage" near the confluence and between Santa Ysabel and Santa Maria Creeks is not cropped and should be classified as "Riparian."	2/3/2014 conference call	This area was classified based on the satellite images from 2009 and 2012, which showed the area devoid of riparian vegetation and appearing similar to other cultivated "Winter Forage" fields. Given the information that this field is not cultivated or cropped to winter forage, and given the absence of riparian vegetation, the land use category will be changed to "Native Shrub."	Change the land use category from "Winter Forage" to "Native Shrub" for the parcel located near the confluence and between Santa Ysabel and Santa Maria Creeks.
Frank Konyn, Konyn Dairy	The land parcel identified as "Winter Forage" immediately to the west of the Konyn Dairy had an irrigation system installed and is now growing irrigated summer forage and winter forage crops.	2/3/2014 conference call	Since the basis for the land use classification is the 2009 and 2012 conditions and the area was not irrigated during at the time of the June 2009 or July 2012 satellite images, the area will be kept under the "Winter Forage" land use for purposes of the SNMP calculations. It will be noted in the SNMP text that this field has been converted to irrigated summer forage since the time of the 2012 satellite image.	Note in the SNMP text that a portion of the dairy lease has been converted to irrigated summer forage since 2012, which should improve forage crop productivity and nitrogen utilization.
Frank Konyn, Konyn Dairy	In the calendar year of 2013, we harvested 3068 bales of feed from KD Farms located on Bandy Canyon Road. This is for approximately 140 acres of irrigated land that is planted with summer and winter crops including alfalfa, rye grass, fescue grasses, orchard grasses, bermuda grasses, and sorghum sudan. These bales averaged approximately 1900 pounds and were approximately a 55% dry matter basis. In addition, we harvest another approximately 176 similarly sized bales from the 40 acres of irrigated land on Frank Konyn Dairy. This land is planted with fescue grasses, rye grasses, clover, and bermuda grasses. In addition, this same 40 acres of land was available for 9 months of the year as pasture for a group of 80 animals whom were consuming approximately 15.4 pounds of 100 percent dry matter feed each on a daily basis.	2/9/2014 email	This information will be helpful to adjust the summer forage crop yield and N removal estimates previously taken from the Konyn Dairy CNMP estimates. From the information provided, annual dry matter yield is estimated as: 3068 bales x 1900 lb total weight/bale x 0.55 dry weight/total weight = 3,206,060 lb dry matter = 1603 tons dry matter. Based on the satellite imagery from 2009 and 2012, the total area cropped to irrigated summer forage at this location is 138 acres. Combining the yield and acreage results in 11.6 ton/ac of dry matter yield. Performing the same calculation for the 40 acres at the Konyn Dairy, the resulting yield is estimated at 2.3 ton/ac of dry matter yield harvested as baled hay. Using the animal grazing information: 80 animals x 15.4 lb dry matter/animal/day x 9 months x 30 days/month = 332,640 lb dry matter = 166 tons dry matter. Over 40 acres, the grazing yield adds 4.2 ton/ac. Combined grazing and hay harvest yield is 6.5 ton/ac of dry matter. The average dry matter yield across these two fields is 9.1 ton/ac/yr.	Change the average summer forage yield assumption from 5 ton/ac/yr as assumed in the Konyn Dairy CNMP to 9.1 ton/ac/yr based on updated information. This increases the crop N removal for summer forage from 169 lb N/ac/yr to 343 lb N/ac/yr and reduces the estimated excess N to groundwater.
END				

Responses to Stakeholder Comments – San Pasqual Salt and Nutrient Management Plan October 2013 Work-In-Progress Draft

San Pasqual Salt and Nutrient Management Plan October 2013 Work-In-Progress Draft
Reponses to Stakeholder Comments

San Pasqual Salt and Nutrient Management Plan - October 2013 Work-in-Progress Draft				Comments:	December 1, 2013
Stakeholder Comments				Responses:	January 20, 2014
No.	Page	Reference	Comment	Reviewer	Response
1	3-15	figure 3-3	the nursery fert use is 22% ? Who are we talking about besides the Pinery, I would like to see it broken up to we can see where its coming from. As you know , how the plant is fertilized and how it is watered ; drip,overhead, micor irrigation can have a huge impact on how much nitrogen is dropping into the ground.	Mat McKellips, The Pinery 11/27/2013	Aside from the Pinery, there are 6 other leases that have areas identified as a nursery land use. Figure 2-12 in the Work-In-Progress Draft SNMP shows the land use map. An updated map will be included in the revised SNMP. Fertilizer use was derived from published annual fertilizer use for container nurseries. We agree that there are many management measures that affect this contribution. These are factors that can be addressed in site specific nutrient management plans as part of the SNMP implementation.
2			I reviewed your list of questions that you left behind. Once again, I think we are still focusing on what is going on in the Valley today, instead of also taking a step back and looking at the broader history of what has happened in the Valley. You seemed surprised when I said that at one time there were 7 dairies in the Valley. Starting at the east end of the Valley, they included the Seventh Day Adventist Academy, Judson Dairy, Bishop Dairy, Verger Dairy, Konyn Dairy, and then in Cloverdale Canyon there was the Cloverdale Dairy, and the Brower Dairy. All of these dairies were in existence as recently as 1980. There were even beef cattle grazing on the hillsides where the present day Westfield Shopping Center is. And knowing what I know about water quality regulations today, we can be assured that all of these would not have been on the honor roll! Historically if you go back to the turn of the century, there were several more dairies in the Valley, hence how Old Milky Way got its name. As dairies and cattle feed land have left the Valley, they have been replaced by boxed nurseries, and sod farms, which have brought in more of the concentrated synthetic fertilizers and herbicides. Also the Eagle Crest Development in the early 90's dramatically altered the runoff, and natural ecosystem that existed in Cloverdale Canyon.	Frank Konyn, Konyn Dairy	The SNMP contains evaluations and assessments to provide insight on current and future projected water quality in the San Pasqual Basin under different management scenarios. Historical uses will also be described in more detail in the draft SNMP to the extent that this information is readily available.
3			To answer your last question, we have been in business since 1962 in this Valley. The Real Estate Assets Dept. should be able to give you a better idea of the starting and stopping dates of various other leases.	Frank Konyn, Konyn Dairy	Thank you for the information.
5			I am sure that the infiltration rates of the salts and nitrogen into the groundwater occur at different rates depending on your soil type. Animals housed on granite bedrock will have different leaching responsibilities than animals housed on sandy soil. Similarly, farmers applying fertilizers on sandy soils will have different infiltration rates, than farmers applying fertilizer on rocky hill sides. To summarize, the study looked at what the current ongoing practices in the Valley are, and I believe that the scope should be widened to include what activities occur on what soil types.	Frank Konyn, Konyn Dairy	A groundwater model has been developed to assess salts and nutrients in the San Pasqual Basin. The groundwater model accounts for spatial variability of soil texture in projecting recharge rates to groundwater. The model also has spatially variable thickness of alluvial aquifer/water bearing strata (i.e. in some areas the aquifer is over 100 feet thick and in other areas it is limited to less than 10 feet thick). This model was developed after the Work-In-Progress Draft SNMP and will be documented in the draft SNMP.

No.	Page	Reference	Comment	Reviewer	Response
6			Additionally, I do not know, but would be very interested to understand how the groundwater quality varies at different depths. In your maps in the draft, you show SP43 which is a small shallow well, and you compare it to SP65 which is a medium sized well that is deeper and pumps more, and then there are wells such as the Park's which is a large well. I am sure that the USGS survey wells could explain to us how the groundwater quality varies at different depths.	Frank Konyn, Konyn Dairy	This is a good question. To provide insight on this subject, the groundwater model has five layers that model groundwater flow/flux and water quality. However, additional information on well construction and screening is still needed for many wells and future water samples collected at various depths at the same location (i.e. multi-completion monitoring well) during the same sampling event would help answer this question. This will be a data gap that is identified in the plan.
7			Thank you for taking the time to meet with me after the meeting the other evening. I think it is safe to say that this draft is far from complete, and do to a lack of complete gathering of information (both current and historical) it has presented the Frank Konyn Dairy in a unfair light to the initial readers of the draft.	Frank Konyn, Konyn Dairy	The Work-In-Progress Draft SNMP was based on preliminary information and was not intended to be a complete draft. Additional information has been provided for Konyn Dairy and other land uses in the basin; updated information will be presented in the draft SNMP.
8			Upon further review and self-education, I believe some of our differences come from the interchangeability of Nitrate-Nitrogen (NO3-N) and Nitrate (NO3). As you know, in 1974, Congress passed the Safe Drinking Water Act. As a result, the U.S. Environmental Protection Agency (EPA) set a recommended maximum level of nitrate concentration in drinking water that they regard as safe for human consumption. That level is 10 milligrams per liter of Nitrate-Nitrogen (NO3-N) **OR** its equivalent of 45 milligrams per liter of Nitrate (NO3).	Frank Konyn, Konyn Dairy	We agree that water quality values must be reported and discussed accurately including Nitrate-Nitrogen compared to Nitrate compared to Total Nitrogen. The San Pasqual Basin water quality objective for Nitrate (NO3) is 10 milligrams per liter.
9			In Table 2-4 of the draft, you state that the goal of the groundwater is to be 10 mg/l of Nitrate (NO3). That is less than a quarter of what is allowable for drinking water by federal law. I assumed (my mistake) that your goal of 10 mg/l was for Nitrate-Nitrogen (NO3-N), not Nitrate (NO3). The attached document is a table summary of all of the data that I have submitted to the Regional Water Quality Control Board as part of my yearly reporting. The reason that our numbers did not appear to match, is that I am required to report Nitrate-Nitrogen (NO3-N) and your Figure 2-10 shows the figures expressed as Nitrate (NO3). With that understanding, I am happy to report that after conversion, our numbers do show similarity.	Frank Konyn, Konyn Dairy	Thank you for providing clarification.
10			This similarity between our numbers includes the unexplainable spike in late 2012 that both the City and I saw in our results. My numbers are more current than your numbers for SP65, and I am happy to report that in 2013 we are back down to much more acceptable numbers. However, in further examining the spike in 2012 in SP65, I saw there was also a spike in SP43. Looking at the flow diagram depicted in Figure 3-7, I see that both of these wells receive their water from the north, which is interesting, compared to much of the rest of the Valley that receives its water from the east. It would be interesting to see if there was an identifiable event in early to mid 2012, north of these wells, which could have caused this effect.	Frank Konyn, Konyn Dairy	Thank you for providing additional information.

No.	Page	Reference	Comment	Reviewer	Response
11			Moving on to Figure 2-11, you will note that the City's results for the TDS in SP65 is consistently higher than my results. Perhaps we could find an answer for this also, (different testing methods) or we should take the same sample and send it to two different labs.	Frank Konyn, Konyn Dairy	We do not have an explanation for this discrepancy. This recommendation will be considered when evaluating a groundwater monitoring plan.
12			Lastly, I did find my error on my math on Figure 3-6. The inflows do match the outflows. My apologies	Frank Konyn, Konyn Dairy	Noted - thanks.
13			1. I believe that the contribution of the Nursery, Dairy, and perhaps the Safari Park are overstated in the plan. I am wondering if the numbers that are used to calculate the salt loading are based on the state of the art operation, and not on historical practices.	Matt Witman, Witman Ranch	Updated data and information have been provided for Konyn Dairy and the Safari Park and have been incorporated into revised salt and nutrient loading assessments. Salt and nutrient loading values are based on current land uses.
14			2. It takes many years for salts to reach the groundwater. Has that timelag somehow been calculated into the contributions of the dairy and nursery percentages?	Matt Witman, Witman Ranch	Yes, an assessment of the time lag between surface loading and percolation to underlying groundwater will be provided in the draft SNMP.
15			3. Are the mitigation measures for the above operations taken into account. I refer to the dairy exporting much of their manure, and I believe that the Pinery recycles much of their tailwater.	Matt Witman, Witman Ranch	Assessments for the SNMP use available data for current land use and current operations. Note that updated information regarding Konyn Dairy manure management (e.g. exports vs. in-basin use and locations) has been provided and has been incorporated into the revised assessment that will support the draft SNMP.
16			4. It is my personal belief that the basin is now being overdrafted. While not part of this study, the salinity increases as the water table decreases. How is this being calculated into the overall plan?	Matt Witman, Witman Ranch	A groundwater model has been developed to assess salts and nutrients in the San Pasqual Basin and support development of the SNMP. The groundwater model accounts for constituent concentrations that change depending on the quantity of groundwater in the aquifer. Scenarios will be run that change assumptions in groundwater use across the basin.
17			5. Were the riparian areas figured into the salt loading. The vegetation in the riverbed is certainly contributing something to the degradation of the basin.	Matt Witman, Witman Ranch	The groundwater model accounts for all land area within the basin including riparian vegetation (i.e. there is a specific land use with unique properties for 'riparian vegetation'). The riparian vegetation consumes water leaving salts behind and contributes to evapoconcentration of existing salts within the basin.
18			We believe that the nitrogen and TDS contribution for the Safari Park in this preliminary estimate is being overestimated for the following reasons: - Use of dairy cow fecal nitrogen production to estimate the fecal nitrogen production from our greatly varying species that range in size from elephants to pudu (averaging 13" tall and 11 lbs.) is not appropriate. - Use of annual report numbers related to manure tonnage, number of animals, etc., is not appropriate.	Robert McClure. Safari Park	Calculations of total nitrogen and TDS contribution from animal manure at the Safari Park was based on annual manure tonnage reported by the Safari Park in annual WDR reports. No assumptions were made on the type or number of animal contributing to that manure mass. In absence of reported information on manure nutrient analysis, assumptions were made with regards to manure moisture content and manure nitrogen and TDS content. Assumptions were also made as to percentage of total animal excrement (manure and urine) that is collected and removed from the site.

No.	Page	Reference	Comment	Reviewer	Response
19			Our animal manure practices include the collection and removal of manure to a nearby agricultural plot where a large percentage of the nitrates are drawn by crops, bedding straw/shavings that are collected with the manure, and leaching. This uptake does not seem to be accounted for. Additionally, if fertilization practices on agricultural lands are already accounted for in your model, then associating the manure loading with the Safari Park may be double counting the loading.	Robert McClure, Safari Park	With the information provided by the Safari Park on the lands that receive manure, the analysis has been revised. The revised analysis also ensures that lands receiving manure are not double counted for fertilizer loading.
20			We also noticed that fertilizer and soil amendment practices specific to the Park have not been incorporated. Information from the Safari Park Horticulturist and Nutritionist should be collected and incorporated to refine the estimate for loading on Park lands.	Robert McClure, Safari Park	This would be good information for the Safari Park to compile in support of a site-specific nutrient management plan as part of the SNMP implementation.
21			Under the Regional Water quality Control Board's Waiver No. 4 there is no call for monitoring and testing the waters of the San Pasqual Valley. While a mandate does exist for agricultural producers to enroll in a monitoring group and conduct testing, the San Pasqual Valley is not an identified testing site. The Regional Board is now proposing that Waiver No. 4 be replaced with a General Waste Discharge Requirement for agricultural operators. The draft plan, which if adopted would go into effect in 2015, does not call for testing of the waters of the San Pasqual Valley in the short term. In the draft plan all monitoring groups would be testing the San Luis Rey Watershed for five years followed by five years of testing the Upper Santa Margarita Watershed. The San Dieguito Hydrologic Unit is not slated for monitoring until 2025-2030.	Eric Larson, San Diego County Farm Bureau	Thank you for the information and clarification. Revised content will be incorporated into the draft SNMP.
END					

Appendix B
Groundwater Model Documentation for the Salt and Nutrient Management Plan

Appendix B

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

City of San Diego

March 19, 2014

Contents

Attachment

Tables

Figures

Acronyms and Abbreviations

α	dispersivity
λ	first-order denitrification rate
θ_{im}	immobile porosity
θ_m	mobile porosity
θ_t	total porosity
ρ_b	bulk density
ρ_s	grain density
3D	three dimensional
AFY	acre-feet per year
ATO	adaptive time-stepping and output control
AWHC	available water holding capacity
Basin Plan	*San Pasqual Basin Groundwater Management Plan*
Basin	San Pasqual Valley Groundwater Basin
bgs	below ground surface
City	City of San Diego
CDM	Camp Dresser & McKee, Inc.
CSM	conceptual site model
DDMT	dual-domain mass transfer
DEM	digital elevation model
DWR	Department of Water Resources
ET	evapotranspiration
ft/day	feet per day
ft^3/day	cubic feet per day
GFM	groundwater flow model
GIS	geographic information system
gpm	gallons per minute
HGL	HydroGeoLogic
HSG	hydrologic soil group
in/yr	inches per year
Kc	crop coefficient
K_h	horizontal hydraulic conductivity
K_v	vertical hydraulic conductivity
MCL	maximum contaminant level

ME	mean error
MFSF	MODFLOW-SURFACT
mg/L	milligrams per liter
mi^2	square mile
NA	not applicable
NAVD88	North American Vertical Datum of 1988
NDVI	net difference vegetation index
NO_3	nitrate
PEST	Model-Independent Parameter Estimation & Uncertainty Analysis software package
R^2	coefficient of determination
RMSE	root mean squared error
RMSE/Range	root mean squared error divided by the range of target head values
SMB	Soil Moisture Budget
SNMP	Salt and Nutrient Management Plan
SSURGO	Soil Survey Geography
TDS	total dissolved solids
U.S. tons/yr	United States tons per year (equivalent to 2,000 U.S. pounds)
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
Valley	San Pasqual Valley
WQO	water quality objective

SECTION B1

Introduction

The City of San Diego (City) and CH2M HILL, its consultant, have developed a numerical groundwater flow model (GFM) and constituent transport models of an area encompassing and including the San Pasqual Valley (Valley) in San Diego County, California. This report documents the development, calibration, and application of these numerical groundwater models to support the preparation of the Salt and Nutrient Management Plan (SNMP). The electronic modeling files associated with these numerical groundwater models serve as companion files to this report, include additional details not covered in this report, and are available for review upon request.

The center of the Valley is located at latitude 33°5.0'N and longitude 116°59.5'W, approximately 25 miles north of downtown San Diego and approximately 5 miles southwest of Escondido. Figures B1-1 and B1-2 (figures are located at the end of their respective sections) show the location of the Valley at two different scales to help orient the reader both regionally and locally. The study area boundary (shown in red in Figures B1-1 and B1-2) was selected to coincide with natural hydrologic features, such as subcatchment and San Pasqual Valley Groundwater Basin (Basin) boundaries, to help establish a hydrologic framework for the GFM and constituent transport models.

Numerical GFMs compute groundwater levels and flows throughout a modeling domain. Numerical constituent transport models compute constituent concentrations and fluxes throughout a modeling domain, but such models require a mathematical solution for groundwater levels and flows before computing constituent concentrations and fluxes. Thus, all numerical constituent transport models used for computing constituent concentrations and fluxes in groundwater systems either must be used in conjunction with a numerical GFM or must have the necessary governing groundwater flow equations integrated within the numerical constituent transport code.

The numerical models described herein are fully integrated numerical groundwater flow and constituent transport models and are the first of their kind developed for the study area. These models help provide insight into the relevant subsurface parameters and processes that control the persistence and movement of two constituents of interest identified for this modeling effort—total dissolved solids (TDS) and nitrate. Although TDS is not a single constituent, it can be modeled as such under a set of assumptions, as is discussed later in this report.

B1.1 Modeling Objectives

The modeling objectives, which were developed collaboratively by the City and CH2M HILL, include the following:

- Support the SNMP development process.
- Evaluate the Basin water budget under recent conditions.
- Gain insight into the travel times of water and TDS and nitrate through the Basin.
- Integrate hydraulic, TDS, and nitrate loading information into a numerical framework to help explain the sources of TDS and nitrate measured under current groundwater conditions.
- Identify how current surface loading rates for TDS and nitrogen might impact future groundwater quality, compared to groundwater WQOs for TDS and nitrate, as established in the Basin Plan.
- Provide insights into how alternative future salt and nutrient management strategies might impact groundwater quality.

B1.2 Model Function

The numerical models described herein were developed and calibrated with consideration of the availability and reliability of input data to fulfill the modeling objectives. These models were constructed and calibrated to simulate steady-state groundwater flow, along with the transport of TDS and nitrate through the steady-state groundwater flow field. The transport simulations also include the dual-domain transport formulation. This transport formulation conceptualizes the subsurface with interconnected pore spaces (where advection is the dominant transport process) and immobile constituent mass storage zones (where diffusion is the dominant transport process).

The period of record for hydraulic model calibration data includes calendar years 2008 through 2013, whereas that for the constituent model calibration data includes calendar years 1992 through 2013. These periods contained the most continuous and consistent hydraulic and constituent data. The period of record for hydraulic model inputs (e.g., areal groundwater recharge rates) includes calendar years 2003 through 2012. Constituent concentrations associated with the areal groundwater recharge rates are based on nutrient management practices specific to land use and on data received from stakeholders representing conditions over the past 5 years. Overall, these models were developed using relevant hydrologic, land use, groundwater use, and agricultural data where and when it was available for the last approximately 10-year period.

B1.3 Conceptual Site Model Overview

For this project, the conceptual site model (CSM) is defined as a theoretical construct of the study area groundwater system developed through assimilation and interpretation of relevant site information. Following is a brief overview of the CSM as understood at the time this report was developed. This CSM served as the primary basis for developing the numerical groundwater models described herein.

B1.3.1 Hydrologic Setting

The study area lies within the Peninsular Range Province in a central portion of San Diego County, California. The study area is a 42-square-mile (mi^2) (26,816-acre) subcatchment that includes the 5.5-mi^2 (3,500-acre) Basin (Figure B1-2). The climate is characteristic of a Mediterranean-type climate with dry hot summers and mild winters. The average precipitation at San Pasqual Battlefield State Park is approximately 14 inches per year with most of the precipitation falling December through March.[1]

The study area includes the Valley and several canyons—most notably Rockwood Canyon, Bandy Canyon, and Cloverdale Canyon. Santa Ysabel Creek in the Valley, Guejito Creek in Rockwood Canyon, Santa Maria Creek in Bandy Canyon, and Cloverdale Creek drain most of the study area. San Dieguito River is formed at the confluence of Santa Ysabel Creek and Santa Maria Creek, and flows into Hodges Reservoir (commonly, and hereafter, referred to as Lake Hodges) downgradient from the southwest boundary of the study area (Figure B1-2). Of these streams, only Cloverdale Creek and San Dieguito River in the downgradient portion of the Basin have perennial streamflow. The deep percolation of applied water on hillside avocado groves in Cloverdale Canyon has turned Cloverdale Creek from an intermittent stream into a perennial stream (Izbicki, 1983).

B1.3.2 Water-bearing Formation

The primary water-bearing formation of interest in the study area is alluvium beneath the Valley and its contributing streams. This permeable alluvium consists of poorly consolidated deposits of gravel, sand, silt, and clay and can be more than 200 feet thick in some areas. The unconfined aquifer that exists within this alluvium has an estimated specific yield of 0.16 (Izbicki, 1983). This unconfined aquifer is surrounded by weathered and unweathered, low-permeability crystalline rocks.

B1.3.3 Groundwater Flow

Groundwater in the study area generally converges on the Basin and flows westward toward Lake Hodges. The eastern end of the Basin is a groundwater recharge area where the aquifer receives water primarily from streambed infiltration of Guejito, Santa Maria, and Santa Ysabel Creeks.

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[1] http://www.weather.com/weather/wxclimatology/monthly/graph/12161:19 (Accessed February 12, 2014)

As groundwater moves along its flow path, some of it is intercepted by groundwater wells or is partially consumed by evaporation and transpiration (the combined process of shallow groundwater evapotranspiration [ET]) within riparian or groundwater discharge areas. Groundwater that is extracted through pumping is used for irrigation and domestic potable water and is partially consumed through ET. The portion of this pumped flow that is not consumed through ET reenters the aquifer as groundwater recharge from the deep percolation of applied irrigation water or recharge from wastewater ponds or septic tanks. The process of groundwater being intercepted by groundwater wells, stream channels, and phreatophytes and then reapplied to the land surface for irrigation continues along its generally westward flow path, with some groundwater eventually exiting the Basin as subsurface outflow. Thus, groundwater flowing from the Basin has been “recycled” several times to sustain the predominantly agricultural land uses within the study area before emerging from the Basin as subsurface outflow.

Figure B1-3 illustrates groundwater level trends at locations for which time-series data are available for model calibration. Figure B1-3 indicates that, as a recharge area, groundwater levels fluctuate more on the eastern portion of the Basin than in the central portion of the Basin, where the groundwater levels are moderated by less streambed infiltration and outflows such as pumping and discharges to streams. Downstream from the San Pasqual Narrows, groundwater levels are more stable as the Basin transitions to a discharge area, where groundwater discharges primarily to streams and phreatophyte ET, in addition to some pumping and outflow to Lake Hodges.

The primary components of groundwater inflow and outflow to and from the study area are listed in Table B1-1.

TABLE B1-1
Primary Groundwater Balance Components
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Primary Groundwater Inflow Components	Primary Groundwater Outflow Components
Groundwater recharge from precipitation and applied water	Shallow groundwater ET
Groundwater recharge from streams	Groundwater pumping
Subsurface inflow from adjacent areas	Groundwater discharge to streams
	Subsurface outflow to adjacent areas

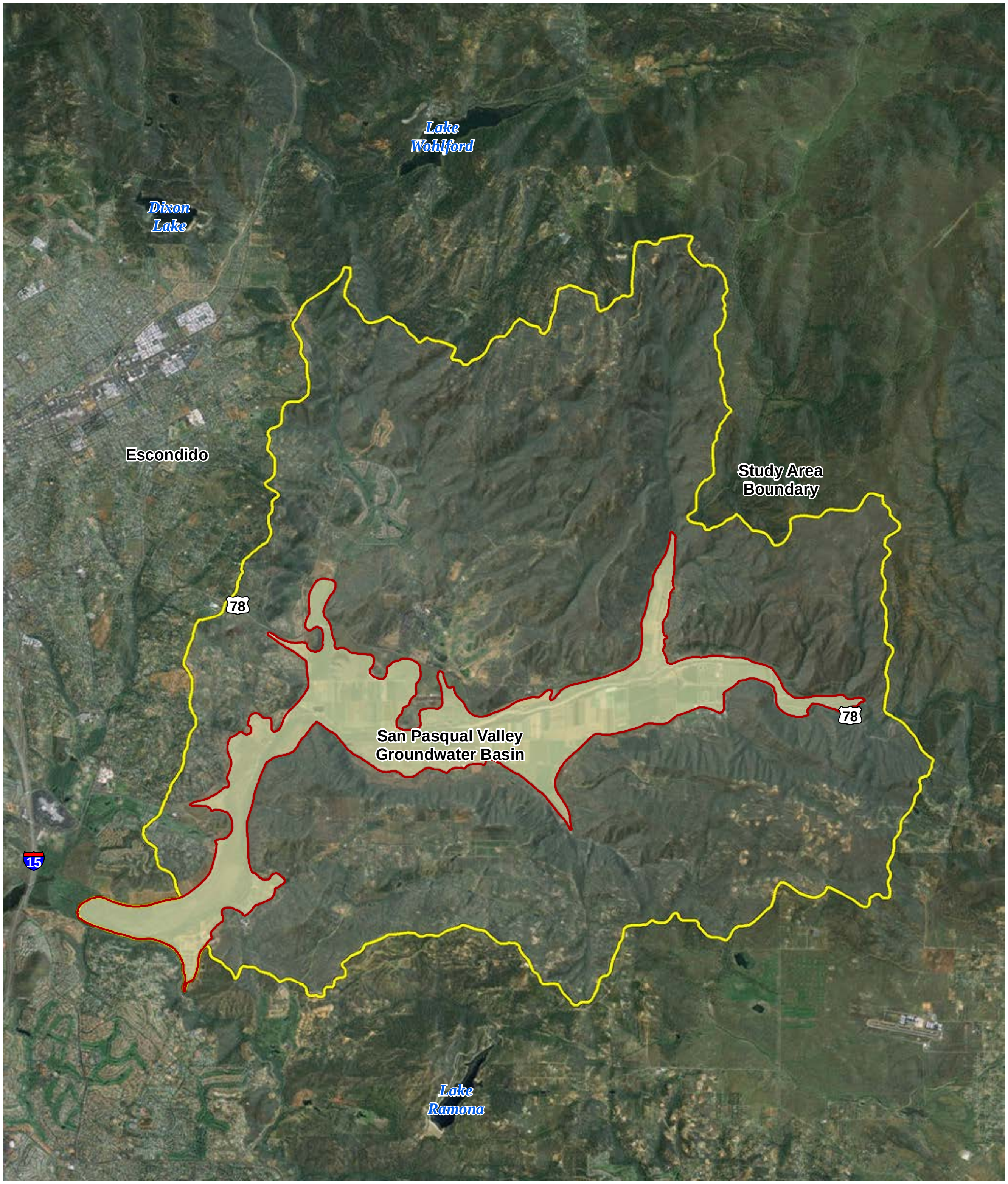
B1.3.4 Groundwater Quality

Groundwater quality in the alluvium has deteriorated over the years because of agricultural water use (Izbicki, 1983). The TDS concentration in many areas, particularly in the lower part of the Basin, exceeds the Basin groundwater WQO of 1,000 milligrams per liter (mg/L). High concentrations of nitrates are another water-quality concern, particularly within the western portion of the Basin where nitrate concentrations exceed the Basin groundwater WQO of 10 mg/L (as nitrate [NO_3]). Without changes to land and water use practices, the deterioration of groundwater quality is expected to continue in some subareas of the Basin.

Figures B1-4 and B1-5 illustrate that TDS and nitrate concentration trends at locations for which time-series data are available with sufficiently long records allow trends to be assessed for model calibration. Figure B1-4 indicates that the three easternmost wells, located in the groundwater recharge area, are below the Basin groundwater WQO for TDS (1,000 mg/L). Well SP001, also within the general groundwater recharge area, receives its water mainly from streambed infiltration from Santa Maria Creek, which is generally above Basin TDS groundwater WQOs. This creek carries water derived from the city of Ramona, including effluent from its wastewater treatment facility. All the other downgradient wells in the Basin are generally at or above the Basin TDS groundwater WQOs; most TDS time-series data show substantial variability, with trends that appear quasi-stable, although some appear to be either increasing (well SP065) or decreasing (well SP036).

Figure B1-5 indicates that nitrate concentrations in the eastern portion of the Basin vary, and are both above and below the Basin nitrate groundwater WQO. Well SP003, which is located near the edge of the Basin and is surrounded by commercial greenhouse and field-cut flower operations, shows the highest degree of variability in nitrate among the Basin wells. Wells SP010 and SP061 show almost no variability in concentrations over time and are the only 2 of the 11 monitoring wells that have nitrate concentrations consistently below the nitrate groundwater WQO. It is uncertain why these wells exhibit such different concentration profiles than the other wells in the Basin. The time-series plots indicate that nitrate around the Basin historically has been elevated above the nitrate groundwater WQO.

FIGURE B1-1
Regional Location Map
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



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

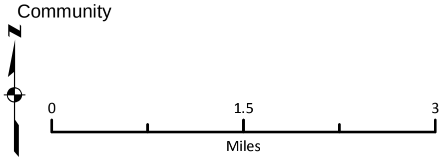
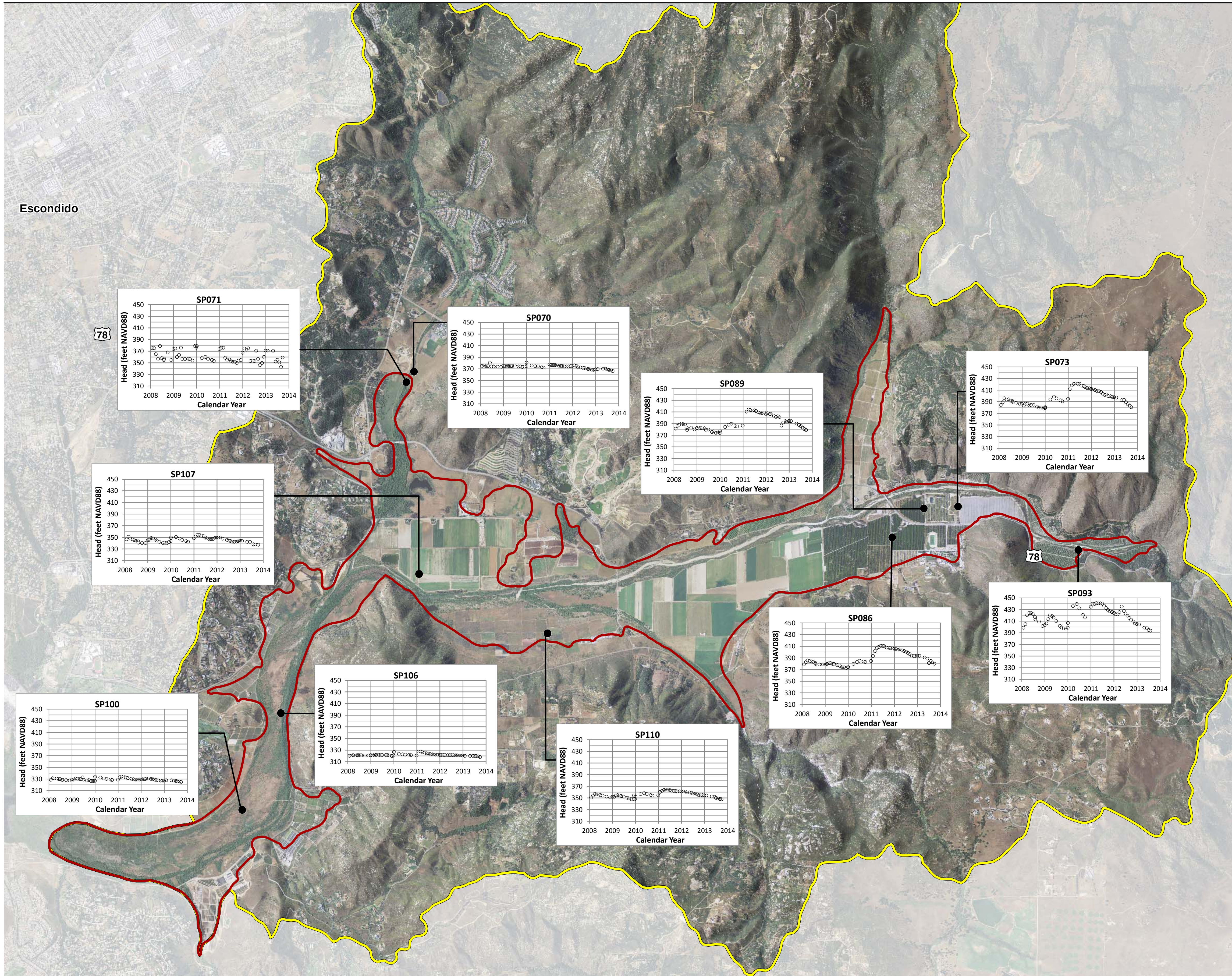


FIGURE B1-2
Study Area Map
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



MAP LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

● Monitoring Well

PLOT LEGEND

○ Measured Groundwater Elevation (feet NAVD88)

NOTE:

NAVD88 = North American Vertical Datum of 1988.

0 4,000 8,000

Feet

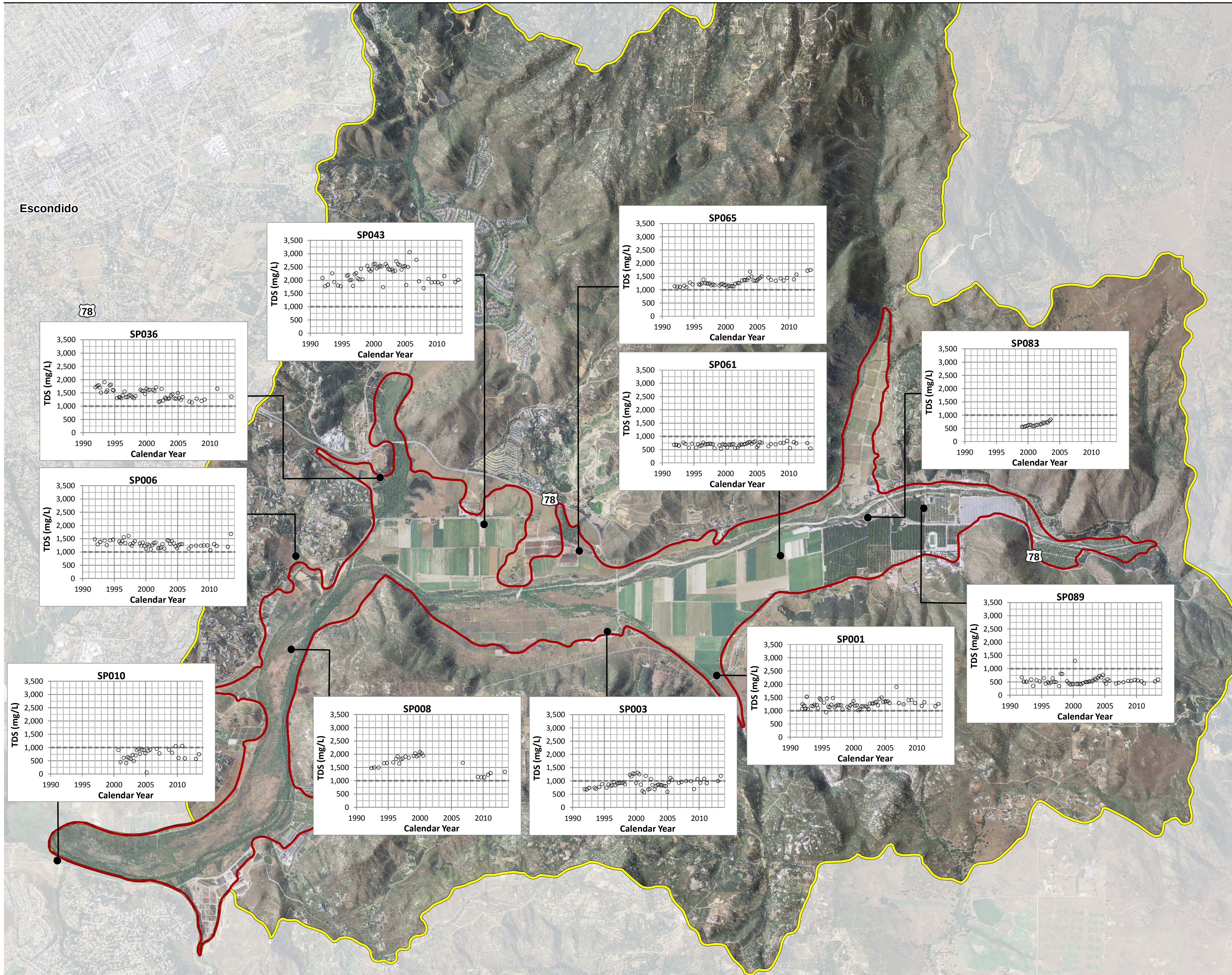
N

FIGURE B1-3

Groundwater Level Trends

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

CH2MHILL.



MAP LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

Monitoring Well

PLOT LEGEND

Measured TDS Concentration (mg/L)

TDS Groundwater Water Quality Objective (1,000 mg/L)

NOTES:

mg/L = Milligrams per liter.

TDS = Total Dissolved Solids.

FIGURE B1-4

Total Dissolved Solids Concentration Trends

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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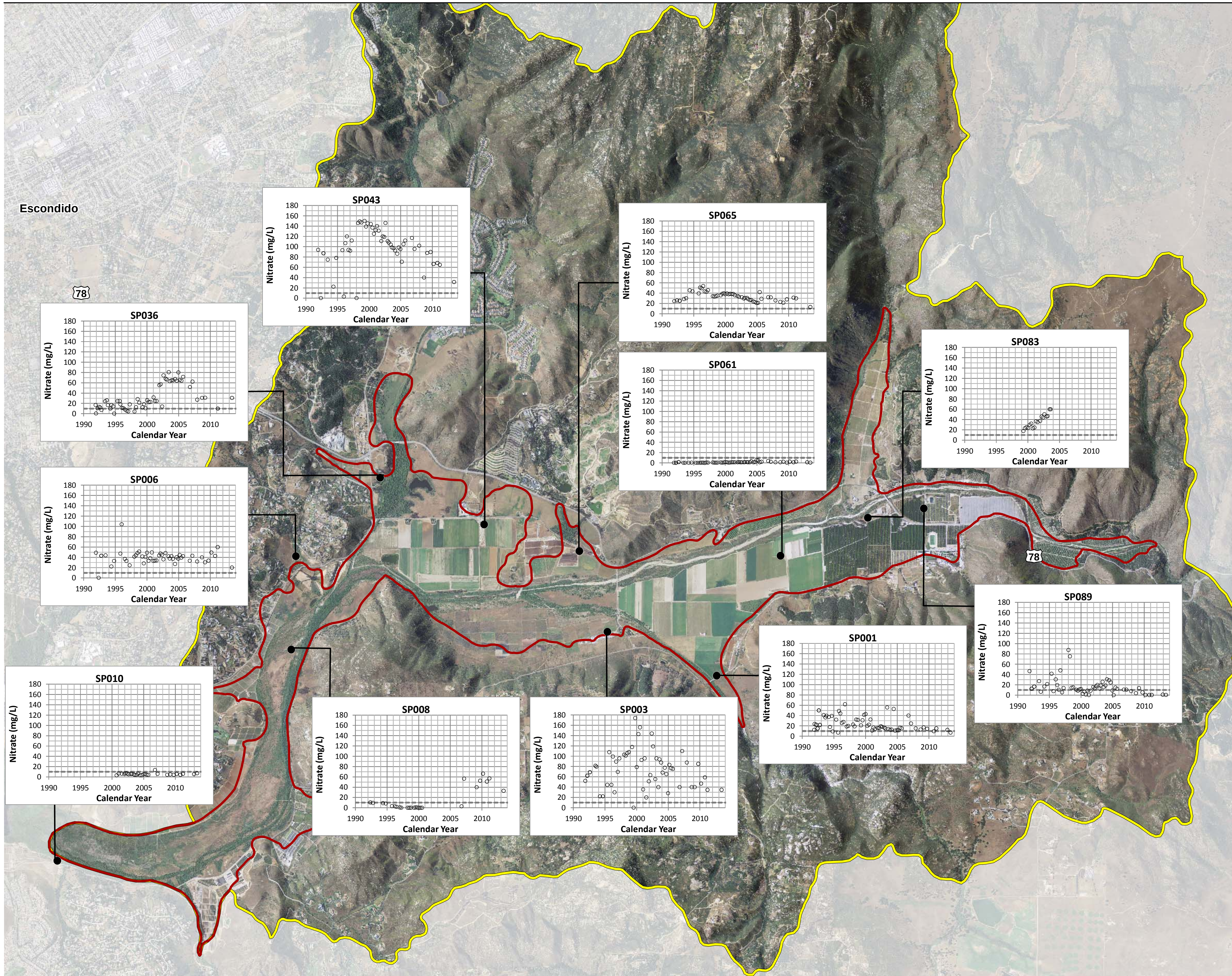

MAP LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

Monitoring Well

PLOT LEGEND

Measured Nitrate Concentration (mg/L)

Nitrate Groundwater Water Quality Objective (10 mg/L)

NOTES:

Nitrate concentrations are expressed as NO_3.

mg/L = Milligrams per liter.

0 4,000 8,000
Feet

FIGURE B1-5
Nitrate Concentration Trends
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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SECTION B2

Numerical Model Construction

The mathematical model design is the result of translating the CSM into a form that is suitable for numerical modeling. The following steps were included in the development of the mathematical model design:

1. Selecting numerical groundwater flow and constituent transport model codes
2. Establishing a model domain and developing a model grid
3. Spatially distributing land surface elevation values
4. Spatially distributing land cover parameter values
5. Spatially distributing subsurface hydraulic parameter values
6. Spatially distributing subsurface transport parameter values and establishing initial constituent conditions
7. Establishing boundary conditions for groundwater flow and constituent transport
8. Selecting a time-discretization approach appropriate for evaluating the field problem and fulfilling the modeling objectives (Section B1.1)

The following subsections describe the methodology for executing these eight design steps.

B2.1 Code Selection

The MODFLOW-SURFACT (MFSF)[2] Version 4 code (HydroGeoLogic, Inc. [HGL], 2011) was selected for this effort, in conjunction with Groundwater Vistas[3] Version 6 as the primary pre- and post-processing software package. MFSF is a physically based, spatially distributed numerical modeling code that includes several packages for simulating three-dimensional (3D) groundwater flow and constituent transport. MFSF is an enhanced version of three numerical modeling codes—MODFLOW (McDonald and Harbaugh, 1988; Harbaugh et al., 2000; Hill et al., 2000; Harbaugh, 2005), MT3DMS (Zheng, 1990; Zheng and Wang, 1999; Zheng, 2010), and RT3D (Clement, 1997). The MFSF code was selected for the following reasons:

- MODFLOW, MT3DMS, and RT3D have been used extensively in groundwater evaluations worldwide for many years and are well documented. MFSF is an enhanced version of each of these codes in one package, which enables the simultaneous simulation of groundwater flow and multi-species, reactive constituent transport.
- MFSF has been benchmarked and verified; therefore, the numerical solutions generated by the code have been compared with one or more analytical solutions, subjected to scientific review, and used on previous modeling projects. Verification of the code confirms that MFSF can accurately solve the governing equations that constitute the mathematical model.
- CH2M HILL has experience applying MFSF to assess complicated constituent transport problems.

Thus, MFSF is the code on which the numerical GFM and constituent transport models are built. The following subsections describe the numerical assumptions, scientific bases, and limitations inherent in MFSF. The MFSF user's manual (HGL, 2011) contains additional information on the code.

While MFSF provides the computational engine that integrates the water and constituent dynamics in the subsurface, the Soil Moisture Budget (SMB) model was used to integrate land use, soil, and climate information to provide boundary conditions to the MFSF model. The SMB model is a distributed water balance tool that computes the monthly water budget for each identified polygon within a spatial dataset, which in this case was represented by a land use geographic information system (GIS) coverage. The theoretical framework of the SMB

[2] http://www.hgl.com/wp-content/uploads/Modflow-Surfact.pdf (Accessed February 12, 2014)

[3] http://www.groundwatermodels.com/Groundwater_Vistas.php (Accessed February 12, 2014)

model is described in detail in Attachment B1. This tool was used to define groundwater pumping rates, irrigation rates, and deep percolation recharge rates across the model domain based on the land use analysis.

B2.1.1 Numerical Assumptions

B2.1.1.1 Subsurface Hydraulics

The GFM is conceptualized mathematically into a single-density subsurface flow regime. The subsurface flow regime includes the hydraulic properties that control groundwater movement and rates. Model layers are treated as vertically integrated, unconfined to leaky-confined layers to facilitate accurate simulation of 3D groundwater flow conditions, with the exception of Model Layer 5, which is modeled as confined. The GFM developed for use on this project accommodates the standard suite of groundwater flow boundary conditions. These boundary conditions are mathematical rules that govern the addition and removal of water in different portions of the GFM domain.

B2.1.1.2 Subsurface Constituent Transport

The constituent transport models implement the dual-domain transport formulation, as opposed to a more simplified single-domain transport formulation. With single-domain transport models, the porous medium is conceptualized as one transport domain with a defined distribution of effective porosity. The effective porosity represents the interconnected pore space in the subsurface where the dominant transport process is advection, as opposed to diffusion. Dead-end pore spaces and other zones, where only very slow advection and diffusion are the dominant transport processes, are not adequately conceptualized with the single-domain transport formulation. In addition, with single-domain transport models, it is assumed that all of the pore space represented by the assigned effective porosity value is available for fluid flow and constituent transport, whereas the remaining pore space within the total porosity (θ_t) of the porous medium is ignored. This can be problematic when simulating multi-decade-old constituents, because they have had sufficient subsurface emplacement times to diffuse into less-mobile portions of the subsurface.

The dual-domain transport formulation conceptualizes the porous medium with both a mobile porosity (θ_m) and an immobile porosity (θ_{im}). This particular formulation allows the transport model to simulate both forward- and back-diffusion to and from immobile constituent mass storage zones, in addition to the standard transport processes. Having the constituent transport models consider both the mobile and immobile portions of the subsurface allows consideration of subsurface processes that are likely to be important for salt and nutrient management in the Basin. Thus, CH2M HILL implemented the dual-domain transport formulation with the constituent transport models to improve their predictive capabilities over what could be achieved with single-domain transport models.

Mathematical solutions from the constituent transport models are based on the assumption that changes in the constituent concentration field do not significantly affect the groundwater flow field. These transport models simulate dissolved concentrations of TDS and nitrate in groundwater considering advection, dispersion, dual-domain mass transfer, and denitrification. These transport models accommodate the standard suite of specified-concentration and mass-flux boundary conditions. These boundary conditions are mathematical rules that govern the addition and removal of constituent mass in different portions of the modeling domain.

B2.1.2 Scientific Bases

The theory and numerical techniques that are incorporated in the numerical models described herein have been scientifically tested. The governing equations for variably saturated subsurface flow are well established and have been solved by several modeling codes over the past few decades on a wide range of field problems. The MFSF code includes governing equations for subsurface constituent transport that include more traditional formulations, as well as research-level formulations, to facilitate modeling constituent transport on a wide range of field problems. Thus, the scientific bases of the theory and the numerical techniques for solving these equations have been well established. The MFSF user's manual (HGL, 2011) details the governing equations and the numerical techniques for solving the system of equations.

B2.1.3 Limitations

Mathematical models can only approximate processes of physical systems. Models are inherently inexact not only because the mathematical description of the physical and chemical system is imperfect, but also because the understanding of interrelated physical and chemical processes is incomplete. However, CH2M HILL incorporated enough detail of the physical system into the numerical models to fulfill the modeling objectives described in Section B1.1.

B2.2 Model Domain

Space is continuous in the real world, but a numerical model must use discrete space to represent the hydrologic system. The simplest way to discretize space is to subdivide the study area into many subregions (i.e., grid blocks) of the same size. This grid-building strategy was implemented for this modeling effort and is described in the following subsections.

B2.2.1 Areal Characteristics of Model Grid

CH2M HILL developed a numerical model grid that mathematically represents the 42-mi^2 study area, which is a subcatchment encompassing the 5.5-mi^2 Basin and vicinity. Figure B2-1 illustrates the numerical grid of the GFM and constituent transport models. This grid has been areally discretized into uniform grid-block (i.e., cell) spacings on 100-foot centers. The locations of the lateral model domain boundaries shown in Figure B2-1 were selected to coincide with natural hydrologic features, such as subcatchment boundaries and to help establish a hydrologic framework within and surrounding the Basin.

B2.2.2 Vertical Characteristics of Model Grid

CH2M HILL developed five vertically stacked layers to provide a 3D representation of the subsurface system. Elevation datasets for the ground surface and the top of indurated bedrock were used to define the vertical characteristics of the model grid. The top elevation of Model Layer 1 was set equal to the ground surface elevation, which was derived from 10-meter digital elevation model (DEM) data. The top and bottom model layers for the subsequent layers were defined using constant layer thicknesses. This approach used thinner layer thicknesses in Model Layer 1 and gradually increased the thickness of deeper model layers. This technique allows for greater vertical cell resolution near the land surface where increased precision is desired with respect to surficial hydraulic and solute transport processes such as ET and interaction with head-depended boundaries, while minimizing the numerical burden of an excessive number of layers. The 3D geometry of the alluvial aquifer was specified by assigning alluvial aquifer hydraulic conductivities representative of alluvium to the appropriate cells and layers using the estimated alluvium thickness at each grid cell location within the Basin boundary. If the alluvium depth was estimated to extend more than half the thickness of a cell in a particular layer, then that cell was assigned a hydraulic conductivity value representative of alluvium. Table B2-1 lists the model layer designations, layer thicknesses, and layer depths, and Figure B2-2 illustrates the model grid in profile views.

TABLE B2-1
Summary of Model Layer Designations
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Model Layer	Description	Model Layer Thickness (feet)	Depth of Layer Bottom (feet bgs)
1	Alluvium/Weathered bedrock	7.5	7.5
2	Alluvium/Indurated bedrock	15	22.5
3	Alluvium/indurated bedrock	45	67.5

TABLE B2-1
Summary of Model Layer Designations
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Model Layer	Description	Model Layer Thickness (feet)	Depth of Layer Bottom (feet bgs)
4	Alluvium/indurated bedrock	127.5	195
5	Indurated bedrock	255	450

bgs = below ground surface
Note:
Model Layers 1 through 4 were set as unconfined to allow transmissivity to vary according to the layer's saturated thickness and horizontal hydraulic conductivity. Model Layer 5 was set as confined, so transmissivity only varied according to the cell thickness and horizontal hydraulic conductivity in this layer.

B2.3 Topography

A 100-meter DEM raster dataset forms the basis for land surface elevations covering the modeling domain. These land surface elevations were assigned to the top of Model Layer 1. Elevation data were processed using ArcGIS[4] Version 10. Figure B2-3 illustrates the land surface elevations incorporated into the top of the model grid.

B2.4 Land Cover Parameters

Land cover parameters provide an important component to the modeling framework because they affect the SMB model hydraulic calculations, such as irrigation pumping rates and deep percolation recharge rates that provide MFSF boundary conditions. The land cover parameters also influence the constituent concentrations of TDS and nitrate in deep percolation recharge based on irrigation and fertilization practices for each identified land use.

B2.4.1 Soils

Soil survey information was compiled from the United States Department of Agriculture (USDA) Natural Resources Conservation Service Soil Survey Geography (SSURGO) geodatabase for the study area. The primary parameters utilized from this data source are as follows:

- Average available water holding capacity (AWHC) over the 5-foot soil profile: This information is utilized in the SMB model monthly water budget calculations and influences deep percolation recharge rates and irrigation water demands.
- Hydrologic soil group (HSG): This information is utilized in the SMB model monthly water budget calculations and influences runoff rates, which in turn influences deep percolation recharge rates and irrigation water demands.

The distribution of different HSGs across the model domain is presented in Figure B2-4. For the HSGs, the dominant group within each land use polygon was selected for the SMB model computations. For the AWHC inputs, this variable was areally weighted across the soil map units within each land use polygon.

B2.4.2 Land Use

The land use designations used to define the SMB model inputs are based on a combination of different data sources, including City lease information, California Department of Water Resources (DWR) and county land use surveys, and 2009 and 2012 satellite imagery; however, the primary source of data used for the final assignment of land cover types was the 2009 and 2012 satellite imagery. Areas were first classified into different land use categories that were developed to align with specific land uses within the Basin, because they relate to differences in hydrology and irrigation and nutrient management practices. Following the initial land use

[4] http://www.esri.com/software/arcgis/arcgis10 (Accessed February 12, 2014)

characterization, the percent of irrigated area within irrigated land uses was analyzed from net difference vegetation index (NDVI) calculations on the multispectral satellite images, as described in more detail in the SNMP. A map of the land use characterization developed from this effort is presented in Figure B2-5.

In the SMB model, a number of factors affecting ET rates, irrigation demands, and site hydrology were defined by land use type. Table B2-2 presents the runoff curve numbers that were used to define rainfall runoff rates by land use and HSG. Table B2-3 presents the input variables defining ET rates and irrigation demands. These data were compiled from a number of different sources (Orang et al., 2004; Allen et al., 1998), along with professional judgment and experience based on local practices and conditions. Land uses with an irrigation flag set to "Y" are assigned irrigation demands in the SMB model. For land uses with an NDVI flag set to "Y", satellite imagery was used to define the fraction of the defined parcel that is actually irrigated. For these land uses, a secondary land use of bare soil or native grass was defined to allow the separation of water balance calculations for irrigated and nonirrigated fractions of each parcel that were combined through areally weighting at the end of each SMB model time step.

TABLE B2-2
Runoff Curve Numbers for Each Land Use and Hydrologic Soil Group
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Land Use	HSG-A	HSG-B	HSG-C	HSG-D
Avocado	36	60	73	79
Bare Soil	77	86	91	94
Citrus	36	60	73	79
Cut Flowers	72	82	87	89
Feedlot	49	69	79	84
Golf Course	49	69	79	84
Grapevines	62	71	78	81
Greenhouse	72	82	87	89
Landscape	49	69	79	84
Native Grass	39	61	74	80
Native Shrub	39	61	74	80
Nursery-Container	72	82	87	89
Nursery-Field	72	82	87	89
Open Water - Irrigation	0	0	0	0
Summer Forage	45	61	74	80
Truck Crops	66	74	80	82
Turf Grass	39	61	74	80
Winter Forage	63	74	82	85

TABLE B2-3

Model Input for Land Use Based Water Balances

Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Land Use	Rooting Depth (in)	MAD [a] (percent)	Crop Coefficient (Kc) Values for Evapotranspiration Calculations												Irrigation Efficiency	Irrigation Flag	NDVI Flag
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Avocado	30	50	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.75	Y	Y
Bare Soil [b]	24	50	0.40	0.70	0.25	0.21	0.08	0.02	0.01	0.02	0.06	0.13	0.25	0.70	NA	N	N
Citrus	36	50	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.75	Y	Y
Cut Flowers	24	50	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.65	Y	Y
Feedlot	24	50	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.65	Y	Y
Golf Course	18	50	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.65	Y	Y
Grapevines	36	40	0.23	0.23	0.23	0.54	0.73	0.80	0.80	0.80	0.74	0.49	0.35	0.23	0.75	Y	Y
Greenhouse	24	50	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.65	Y	N
Landscape	24	50	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.65	Y	Y
Native Grass [b]	24	75	0.44	0.92	0.60	0.38	0.25	0.07	0.03	0.03	0.04	0.19	0.48	0.51	NA	N	N
Native Shrub	36	75	0.42	0.84	0.61	0.54	0.36	0.10	0.03	0.02	0.02	0.15	0.49	0.47	NA	N	N
Nursery-Container	24	50	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.65	Y	Y
Nursery-Field	24	50	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.65	Y	Y
Open Water – Irrigation [c]	NA	NA	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.00	Y	N
Summer Forage	30	55	0.40	0.40	0.40	0.51	0.76	1.01	1.15	1.15	1.15	1.03	0.78	0.53	0.65	Y	Y
Truck Crops	20	40	0.23	0.23	0.80	0.80	0.82	0.87	0.90	0.90	0.06	0.13	0.23	0.23	0.65	Y	Y

TABLE B2-3
Model Input for Land Use Based Water Balances
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

			Crop Coefficient (Kc) Values for Evapotranspiration Calculations														
Land Use	**Rooting Depth (in)**	**MAD [a] (percent)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Irrigation Efficiency**	**Irrigation Flag**	**NDVI Flag**
Turf Grass	18	50	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.65	Y	Y
Winter Forage	30	60	0.81	1.10	1.10	0.96	0.43	0.02	0.01	0.02	0.06	0.13	0.33	0.40	NA	N	N

NA = Not applicable; Y = Yes; N = No
Notes:
[a] MAD = Maximum allowable depletion of available soil water storage before ET begins to decline and at which point irrigation is demanded for irrigated land uses.
[b] Bare soil and native grass are secondary land uses associated with the nonirrigated portions of the parcels.
[c] Values were used for open water evaporation. Recharge rates to groundwater assumed 3.10 feet per year deep percolation based on an assumed $1.0x10^{-6}$ cm/sec soil liner. Irrigation demand for these ponds was the sum of the net evaporation (minus precipitation) plus the recharge.

B2.5 Subsurface Hydraulic Parameters

The subsurface hydraulic parameters required by the steady-state flow model are the horizontal hydraulic conductivity (K_h) and vertical hydraulic conductivity (K_v).

B2.5.1 Horizontal Hydraulic Conductivity

Data from previous models of the area and professional judgment formed the basis for the initial K_h and K_v values incorporated into the numerical models. The initial K_h values used in the models ranged from 50 to 250 feet per day (ft/day) in the more permeable model layers, based on previous modeling (Camp Dresser & McKee, Inc. [CDM], 2010) and from 0.023 to 0.10 ft/day in the less permeable model layers, based on typical K_h values for fractured indurated rock (Freeze and Cherry, 1979). Section B3 describes the modification of these values during the calibration process.

B2.5.2 Vertical Hydraulic Conductivity

The K_v values were initially assigned according to an assumed K_h:K_v (i.e., vertical anisotropy) ratio of 10:1 for each model layer. The K_v was parameterized on a cell-by-cell basis by dividing K_h by a value of 10. Section B3 describes the modification of these values during the calibration process.

B2.6 Subsurface Transport Parameters

The subsurface transport parameters required by the constituent transport models are the θ_m, θ_{im}, bulk density (ρ_b), dual-domain mass transfer (DDMT) coefficient, first-order denitrification rate (λ), and dispersivity (α). First-order denitrification was applicable only to nitrate transport in subareas where it was necessary to simulate denitrification to improve the consistency between the modeled and target nitrate concentrations. These subareas include the areas underlying the San Diego Zoo Safari Park and the middle portion of the Basin upgradient from the San Pasqual Narrows.

B2.6.1 Physical Transport Parameters

Physical (alluvium and bedrock) transport parameters of interest include θ_t, θ_m, θ_{im}, and ρ_b. A value of 0.40 for θ_t was input to the constituent transport models on the basis of a measured ρ_b value of 1.6 grams per cubic centimeter and an assumed grain density (ρ_s) of 2.65 grams per cubic centimeter, according to Equation B2-1:

$$\theta_t = 1 - \frac{\rho_b}{\rho_s} \qquad \text{(B2-1)}$$

Because no tracer studies have been conducted in the study area, there are no available estimates for the θ_m term. Thus, the θ_m was assumed to equal 0.16, or 40 percent of the θ_t term, based on a 0.16 specific yield estimate from Izbicki (1983). The θ_{im} term was computed to equal θ_t minus θ_m, or 0.24.

B2.6.2 Constituent Transport Parameters

Chemical transport parameters of interest include the DDMT coefficient for TDS and nitrate. It was assumed that neither TDS nor nitrate would adsorb to the porous medium; therefore, there is no need to input a value for the distribution coefficient, which is needed with adsorbing solutes.

When an advecting constituent undergoes first-order mass transfer between the mobile and immobile domains, the reciprocal of the DDMT coefficient provides an approximation of the mean residence time of the constituent in the immobile storage zone. Assuming the anthropogenic constituents were emplaced beginning about 100 years (36,525 days) ago, an estimate for the DDMT coefficient of 2.7×10^{-5} per day (i.e., 1 ÷ 36,525) was used in the transport simulations.

A starting α value of 10 feet for the constituents was assigned based on professional judgment; however, this starting value was modified during the calibration process, as described in Section B3. A starting λ value of 4.11×10^{-4} per day (equivalent to a degradation half-life of approximately 1,700 days or 4.6 years) for the constituents was assigned based on the middle of the range of moderate first-order half-lives provided in Tesoriero and Puckett (2011); however, this starting value was modified during the calibration process, as described in Section B3.

B2.6.3 Initial Constituent Conditions

As described in Section B3, model calibration began with background TDS and nitrate concentrations of 225 mg/L and 0.5 mg/L, respectively, in both the mobile and immobile porosity domains. This setup allowed the simulations to evolve the dissolved constituent concentrations in the modeled aquifer system through time from a nonzero starting point.

B2.7 Boundary Conditions

Figure B2-6 and Table B2-4 summarize the boundary conditions used with the GFM and constituent transport models. Boundary conditions for flow and constituent transport models are mathematical statements (i.e., rules) that specify groundwater elevation (i.e., head), concentration, and mass flux, or that otherwise govern mass fluxes at selected locations within the model domain. The following three types of boundary conditions were used to develop the GFM and constituent transport models:

- Specified-flux: Mass fluxes of water and constituents are specified.
- Head-dependent flux: Given elevation or conductance values, mass fluxes of water and constituents are internally computed at the boundary using an appropriate governing equation.
- No-flow: Groundwater and constituents can flow parallel to the boundary but not across it.

TABLE B2-4
Summary of Boundary Conditions
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Process	Specified-flux Boundary	Head-dependent Flux Boundary
Subsurface Hydraulics		
Groundwater recharge from precipitation and applied water	X [a]	
Groundwater recharge from streams	X [b]	X [c]
Groundwater pumping	X [a]	
Shallow groundwater ET		X
Groundwater discharge to streams		X
Subsurface outflow to adjacent areas		X
TDS Transport		
TDS loading from land use	X [a]	
TDS loading from streams	X [b]	X [c]
TDS loss to streams		X
TDS loss to subsurface outflow		X
Nitrate Transport		
Nitrogen loading from land use	X [a]	
Nitrogen loading from streams	X [b]	X [c]
Nitrate loss to streams		X

TABLE B2-4
Summary of Boundary Conditions
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Process	Specified-flux Boundary	Head-dependent Flux Boundary
Nitrate loss via shallow groundwater ET		X
Nitrate loss via denitrification[d]	See Table Note D	See Table Note D
Nitrate loss to subsurface outflow		X

[a] Computed using the SMB tool described in Attachment B1.
[b] Specified-flux using the well package of MFSF in streams conceptualized as being decoupled from the aquifer.
[c] Head-dependent flux using the river package of MFSF in streams conceptualized as typically being coupled with the aquifer.
[d] The denitrification process is neither a specified-flux nor a head-dependent flux boundary condition. This process was simulated by assigning a first-order denitrification rate in cells representing the subsurface beneath selected dairies.
Notes:
Figure B2-6 presents a graphical depiction of boundary conditions.
No-flow boundary conditions are assigned in cells representing areas outside the study area and below Model Layer 5.

The following subsections describe the basis for selection of these boundary conditions.

B2.7.1 Specified-flux Boundaries

B2.7.1.1 Groundwater Recharge and Constituent Loading from Precipitation and Applied Water

Steady-state recharge rates in units of cubic feet per day (ft^3/day) are applied to the top of Model Layer 1 and represent areal groundwater recharge (i.e., deep percolation) from precipitation and applied water. These areal recharge rates vary according to land use and were computed using the SMB tool described in Attachment B1 with inputs described in Section B2.4. Areal groundwater recharge is assigned in the model using the recharge package of MFSF.

TDS and nitrate concentrations in units of mg/L are also specified along with the areal groundwater recharge rates in MFSF. Internally, the constituent transport models compute constituent loading by taking the product of the specified areal groundwater recharge rate and specified constituent concentration at each specified-flux boundary condition cell.

TDS concentrations in deep percolation recharge were calculated using the water source TDS for irrigated areas, the evapoconcentration of the source TDS due to evapotranspiration or consumptive use of a portion of applied water, and the amount of TDS applied through manure and fertilizer sources. All irrigated land areas within the model domain were assigned to a specific water source as shown in Figure B2-7. The water quality associated with these water sources is presented in Table B2-5. For the San Pasqual Basin Groundwater Users category, individual wells were assigned to each irrigated parcel. This pairing of wells to parcels was based on information provided by the City for known wells associated with leased parcels and was estimated based on well proximity and ownership information in cases where well assignments were not previously documented. Following the pairing of wells to parcels, the Basin was divided into eight generalized water source zones, where water quality was averaged from historical data to develop average TDS and nitrate concentrations.

The specified constituent concentrations from areal nitrogen loading are based on calculations that combine the water budget output from the SMB model with water source quality and land-use-specific nutrient management information. For the land use parcels where site-specific nutrient management practice information was available, this information was used to define model inputs for nitrate concentration calculations. In other areas, generalized fertilization practices were applied based on literature values. The development of these model input assumptions is described in more detail in the SNMP. Following the specification of nitrogen loading rates from fertilizer and manure applications, nitrogen uptake was estimated by land use/crop category as presented in Table B2-6. The unused portion of applied nitrogen was assumed to be available for leaching as nitrate and was utilized to calculate the nitrate concentrations in the deep percolation recharge.

TABLE B2-5
Modeled Water Quality Associated with each Water Source
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Site	Water Source TDS (mg/L)	Water Source Nitrate (mg/L)
Vineyard Golf Course in Escondido	776	8.6
Escondido, Poway, Ramona Water District (WD) Customers	482	0.17
Rincon Del Diablo WD Customers	345	0
San Diego Wild Animal Park	672	3.7
Konyn Dairy Groundwater	1174	27
San Pasqual Basin Groundwater Users	531 to 1,856	6.1 to 71.3

TABLE B2-6
Estimated Fertilizer Nitrogen and Salt Loadings and Nitrogen Uptake
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Primary Land Use	Estimated Fertilizer TDS Loading Rate (lb/ac/yr)[a]	Estimated Fertilizer Nitrogen Application Rate (lb/ac/yr)[b]	Estimated Nitrogen Harvest Removal (lb/ac/yr)	Excess Nitrogen to Groundwater (lb/ac/yr)	PNB[c]	Harvest removal notes
Avocado	348	120	25	95	21%	Viers et al. (2012), Appendix Table 7
Citrus	348	120	46	74	39%	Viers et al. (2012), Appendix Table 7
Cut Flowers	1,160	400	150	250	38%	Tjosvold (1999)
Golf Course	505	174	70	105	40%	Harvest removal calculated using an assumed 40% N removal rate.
Grapevines	110	38	17	21	45%	Viers et al. (2012), Appendix Table 7
Greenhouse	2,636	909	400	509	44%	Set to upper end of nitrogen uptake percentage reported in Evans et al. (2007)
Landscape	505	174	70	105	40%	Calculated using an assumed 40% N removal rate.
Nursery-Container	2,636	909	400	509	44%	Upper end of nitrogen uptake percentage reported in Evans et al. (2007)
Nursery-Field	157	54	43	11	80%	Calculated using an assumed 80% N removal rate.
Summer Forage[d]	1,243	429	343	86	80%	Frank Konyn data (2/9/2014 email) and an assumed 80% N removal rate for grain-hay from Viers et al. (2012).
Truck Crops	629	217	98	119	45%	Harvest removal calculated from average of multiple truck crops in Viers et al. (2012).
Sod Farms	580	200	80	120	40%	Harvest removal calculated using an assumed 40% N removal rate.
Winter Forage[d]	232	80	64	16	80%	Konyn Dairy CNMP (NRCS, 2008) and an assumed 80% N removal rate for grain-hay from Viers et al. (2012).

Notes:
[a]TDS contributions from fertilizer applications were estimated using an average analysis of ammonium nitrate, calcium nitrate, and urea fertilizer at 2.9 lb of TDS per 1 lb of nitrogen.
[b] Fertilizer nitrogen application rate assumptions are documented in Section 3.0 of the SNMP.
[c] PNB = partial nutrient balance which is the harvest/uptake N removal divided by the fertilizer N applied.
[d]Typical winter and summer forage fertilizer N requirements are presented here but actual N loading from calculated manure applications were used in the groundwater loading calculations. Those loading rates are presented separately in Section 3.0 of the SNMP.

Following the SMB modeling, water source identification, and land-use-specific nutrient budgeting process, calculations were performed to estimate the TDS and nitrate concentrations in deep percolation and the loading rates to groundwater for both TDS and total nitrogen. The areal distribution of these loading factors for the baseline (current conditions) scenario is presented in Figures B2-8 and B2-9.

B2.7.1.2 Groundwater Recharge and Constituent Loading from Decoupled Streams

Steady-state recharge rates in units of ft^3/day are specified in cells representing decoupled stream reaches using the well package of MFSF. For this modeling effort, “decoupled streams” are assigned to cells that are conceptualized as having the water table below the bottom of the streambed. The groundwater recharge rate from cells representing decoupled streams is not dependent on the elevation of the water table, but rather is computed based on the water depth in the stream and the infiltration capacity of the streambed sediments. Thus, as long as the water table remains decoupled from the stream bottom, groundwater recharge rates from the decoupled stream are independent of groundwater levels. Although many of the stream channels in the study area are dry for several months each year, groundwater recharge from the decoupled stream channels in the GFM occurs throughout the decoupled stream reaches shown in Figure B2-6 because the GFM is a steady-state model. The groundwater inflow from decoupled streams was assigned to the model as continuous lines of specified inflow cells representing the tributary streams within the Basin (depicted in blue in Figure B2-6). These modeled streams were discretized into reaches to allow flexibility in the inflow rate and location of assigned groundwater recharge from decoupled streams.

The precise groundwater recharge volume associated with different decoupled stream reaches is not known and would require detailed streamflow monitoring to ascertain. It has been suggested that a large portion of the tributary inflow into the subcatchment enters the Basin through streambed infiltration and exits the Basin as subsurface outflow from the San Pasqual Narrows (Izbicki, 1983). There is uncertainty associated with the precise fraction of this stream discharge that recharges the Basin alluvial aquifer. The intermittent nature of the decoupled streams adds a level of complexity when attempting to compute statistical summaries of stream discharge for the steady-state GFM. Frequency-discharge relationships were evaluated for the decoupled streams to assess the range of stream discharge values to consider when assigning groundwater recharge rates for decoupled stream reaches in the GFM. This frequency-discharge evaluation used mean daily discharge data from 2003 through 2012, as provided in Table B2-7. The time-weighted mean discharge was computed by dividing the cumulative volume of discharge from 2003 through 2012 by this duration. This calculation results in a time-weighted average that includes periods of zero discharge at the gages. The frequency-discharge evaluation helped guide the calibration process by assuring that the calibrated values of groundwater recharge from decoupled streams are plausible.

TABLE B2-7
Summary of Frequency-Discharge Evaluation
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Stream (USGS Gage No.)	50% Exceedance Discharge (gpm)	70% Exceedance Discharge (gpm)	90% Exceedance Discharge (gpm)	Time-weighted Mean Stream Discharge (gpm) a
Santa Ysabel Creek (11025500)	10 b	540 b	5,835 b	3,260 b
Guejito Creek (11027000)	5 b	325 b	1,435 b	935 b
Santa Maria Creek (11028500)	20 b	95 b	1,660 b	1,620 b
Cloverdale Creek (NA)	NA	NA	NA	720 c
Total	NA	NA	NA	6,535c

TABLE B2-7

Summary of Frequency-Discharge Evaluation

Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Stream (USGS Gage No.)	50% Exceedance Discharge (gpm)	70% Exceedance Discharge (gpm)	90% Exceedance Discharge (gpm)	Time-weighted Mean Stream Discharge (gpm) a

gpm = gallons per minute
NA = not applicable (no stream gage)
USGS = United States Geological Survey
[a] Value represents a time-weighted average because it accounts for periods with no stream discharge.
[b] Stream discharge data from USGS gages from 2003 through 2012.
[c] Estimated Cloverdale Canyon return flows (CH2M HILL, 2001).

The initial rates of groundwater recharge from Santa Ysabel, Guejito, and Santa Maria Creeks were based on the time-weighted mean discharge from records between 2003 through 2012, and were evenly distributed along their respective stream reaches. Stream discharge from Cloverdale Creek is not metered, so estimates from CH2M HILL (2001) were used to assign groundwater recharge from Cloverdale Creek.

TDS and nitrate concentrations in units of mg/L are also specified, along with the groundwater recharge rates from decoupled streams. The decoupled stream concentrations in each of the headwater reaches was assigned the flow-weighted average concentration listed in Table B2-8. The decoupled stream concentrations in reaches downstream from stream confluences were assigned values representing the flow-weighted concentrations from the two upgradient stream reaches (using the mean stream discharge). For example, in Figure B2-6, Reach D4 of Guejito Creek was assigned a TDS concentration of 256 mg/L, and Reaches D6 and D7 of Santa Ysabel Creek were each assigned a TDS concentration of 218 mg/L, consistent with the TDS concentrations listed for these streams in Table B2-8. However, Reaches D3 and D2 of Santa Ysabel Creek were each assigned a TDS concentration of 226 mg/L, based on the following calculations (see Table B2-8 for basis of values used in the calculations and Figure B2-6 for the locations of the stream reaches):

$$Q_{Reach\ D4} = 935;\ C_{Reach\ D4} = 256$$

$$Q_{Reach\ D6} = 3{,}260;\ C_{Reach\ D6} = 218$$

$$Q_{Reach\ D3} = Q_{Reach\ D4} + Q_{Reach\ D6} = 4{,}195$$

$$C_{Reach\ D3} = \frac{Q_{Reach\ D4} \cdot C_{Reach\ D4} + Q_{Reach\ D6} \cdot C_{Reach\ D6}}{Q_{Reach\ D3}} = 226$$

where

$Q_{Reach\ D4}$ = time-weighted mean stream discharge in Reach D4 of Guejito Creek (gallons per minute [gpm])

$C_{Reach\ D4}$ = flow-weighted TDS concentration in Reach D4 of Guejito Creek (mg/L)

$Q_{Reach\ D6}$ = time-weighted mean stream discharge in Reach D6 of Santa Ysabel Creek (gpm)

$C_{Reach\ D6}$ = flow-weighted TDS concentration in Reach D6 of Santa Ysabel Creek (mg/L)

$Q_{Reach\ D3}$ = sum of time-weighted mean stream discharge in Reaches D4 and D6 (gpm)

$C_{Reach\ D3}$ = flow-weighted TDS concentration in Reach D3 of Santa Ysabel Creek (mg/L)

TABLE B2-8

Decoupled Stream Inflow Concentrations in Headwater Reaches of the Study Area

Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Decoupled Stream (USGS Gage No.)	Time-weighted Mean Stream Discharge (gpm) [a]	Flow-weighted TDS (mg/L) [d]	Flow-weighted Nitrate (mg/L) [d]
Santa Ysabel Creek (11025500)	3,260 [b]	218	0.5

TABLE B2-8
Decoupled Stream Inflow Concentrations in Headwater Reaches of the Study Area
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Decoupled Stream (USGS Gage No.)	Time-weighted Mean Stream Discharge (gpm) [a]	Flow-weighted TDS (mg/L) [d]	Flow-weighted Nitrate (mg/L) [d]
Guejito Creek (11027000)	935 [b]	256	0.93
Santa Maria Creek (11028500)	1,620 [b]	562	10.2
Cloverdale Creek (NA)	720 [c]	1,290	7.2

NA = not applicable (no stream gage)
USGS = U.S. Geological Survey
Notes:
[a] Value represents a time-weighted average because it accounts for periods with no stream discharge.
[b] Average discharge from USGS gages from 2003 through 2012.
[c] Estimated Cloverdale Canyon return flows (CH2M HILL, 2001).
[d] Calculated from flow and water quality monitoring sampling conducted by the City during 2006 through 2011.

Internally, the constituent transport models compute constituent loading by taking the product of the specified groundwater recharge rate at cells representing decoupled streams and the associated specified constituent concentration. The specified constituent concentrations associated with decoupled streams are based on flow-weighted averages calculated from flow and water quality monitoring sampling that was conducted by the City over the 2006 through 2011 period.

B2.7.1.3 Groundwater Pumping

Groundwater pumping rates were computed based on calculations of applied water demand associated with the land use illustrated in Figure B2-5. The applied water demand rates were computed (using the SMB tool described in Attachment B1) using the factors presented in Section B2.4. These demands were then applied to specific wells within the Basin using the process described in Section B2.7.1.1.

Groundwater pumping is assigned in the model using the well package of MFSF. Constituent mass in the groundwater being removed by the pumping well leaves the groundwater modeling domain. The constituent mass that leaves the groundwater modeling domain via groundwater pumping was qualitatively considered with the calculation of constituent loading terms associated with groundwater recharge from applied water. However, the current version of the groundwater model does not dynamically link the modeled groundwater quality at modeled pumping wells and the specified constituent concentrations in the groundwater recharge of applied water term. It is possible to provide more dynamically linked boundary conditions, but that would require more advanced modeling packages than used for this effort.

B2.7.2 Head-dependent Flux Boundaries

B2.7.2.1 Evapotranspiration of Shallow Groundwater and Associated Constituent Losses

The ET process has been accounted for in two different ways with this modeling effort. The surficial ET associated with precipitation and applied water on the vegetative cover at the land surface is accounted for in the SMB tool described in Attachment B1. However, there is an additional component of ET that occurs where phreatophytes consume water directly from the underlying aquifer in riparian areas along stream channels. This occurs where the water table exists within the rooting depth of healthy phreatophytes.

Shallow groundwater ET is assigned in the model using the ET package of MFSF. This package requires the assignment of the maximum groundwater ET rate and rooting depth at each groundwater ET boundary condition cell. Maximum groundwater ET rates of 0.013 ft/day (57 inches per year) were assigned to ET cells within the

Basin based on riparian potential ET for conditions in a broad floodplain (crop coefficient factors of 0.80 to 1.20). Maximum groundwater ET rates of 0.025 ft/day (110 inches per year) were assigned to ET cells in the narrow stream canyons outside the Basin based on riparian potential ET for conditions in narrow stands of trees surrounded by dry conditions (crop coefficient factor of 2.0). These ET rates represent maximum potential groundwater ET rates and are moderated by the rooting depth.

Rooting depths of 5, 10, and 15 feet below ground surface (bgs) were assigned to surface cells representing grassy, valley riparian, and narrow riparian areas, respectively. Maximum groundwater ET rates are simulated where the groundwater level in Model Layer 1 is at the land surface elevation. The rate of groundwater ET decreases as groundwater elevation within the assigned rooting depth decreases. Thus, the rooting depth represents the depth to which water can be extracted from the ground by phreatophytes, and consequently, shallow groundwater ET occurs only when saturated conditions are predicted by the model within the upper 5 feet to 15 feet of the modeled subsurface.

The ET package also serves as a sink for constituents exiting the model domain through shallow groundwater ET. The ET package of MFSF includes a root uptake factor that defines the fraction of each constituent that can leave the groundwater system with the ET flux. For example, if the root uptake factor equals 0.0, the ET package would remove shallow groundwater but leave constituent mass behind in the shallow groundwater system. If the root uptake factor equals 1.0, then 100 percent of the constituent mass in the ET flux would leave the groundwater system. Root uptake factors of 0.0 and 1.0 are used for the TDS and nitrate transport simulations, respectively. The consumption of nitrate in groundwater by phreatophytes is a process by which nitrate mass is removed from the modeled aquifer. However, salts in groundwater are not consumed by phreatophytes. Thus, as groundwater is consumed via ET in the GFM and TDS transport model, the salts are left behind and concentrated—a process known as evapoconcentration. The evapoconcentration of salts has a significant effect on TDS concentrations in some portions of the study area.

B2.7.2.2 Groundwater and Constituent Exchange with Coupled Streams

Steady-state surface water level (i.e., stage) and streambed K_v values are specified in cells representing coupled stream reaches using the river package of MFSF. The stream stage was specified to be 1 foot above the bottom of Model Layer 1. The streambed K_v was initially set at 50 ft/day, which is a reasonable starting assumption for stream sediments in the study area.

For this modeling effort, “coupled streams” include cells that are conceptualized as having the water table above the bottom of the streambed. Figure B2-6 illustrates the streams in the western portion of the Basin that were simulated as head-dependent flux boundaries. These streams were identified as coupled streams because of shallow groundwater levels in the western portion of the Basin. The modeled groundwater/surface-water interaction at cells representing coupled streams is governed by Darcy’s Law, using the elevation of the modeled water table, the assigned stream stage, and the assigned streambed K_v. If the modeled water table at a river package cell is above the bottom of the streambed elevation, but below the assigned stage, then the modeled aquifer receives recharge from the stream. If the modeled water table at a river package cell is above the assigned stage, then the modeled aquifer discharges groundwater to the stream. Thus, the direction and rate of the exchange of water between the modeled aquifer and stream are head-dependent, as opposed to being constant like the groundwater recharge rate from a decoupled stream cell.

TDS and nitrate concentrations in units of mg/L are also specified, along with the stream stage and streambed K_v in cells representing coupled streams. Internally, the constituent transport models compute constituent loading by taking the product of the computed groundwater recharge rate at cells representing coupled streams and the associated specified constituent concentration. The specified constituent concentrations associated with coupled streams are based on flow-weighted averages that are calculated using the City surface water quality monitoring data from 2006 through 2011. If the modeled water table is higher than the specified stream stage, then constituent mass will leave the modeled aquifer with the groundwater discharge flux to the stream. This discharged constituent mass is not dynamically tracked after it is removed from the modeled aquifer. As indicated previously, it is possible to provide more dynamically linked boundary conditions, but that would require more advanced modeling packages than used for this effort.

B2.7.2.3 Subsurface Outflow

Subsurface outflow from the modeling domain is simulated using the general head package of MFSF. This type of head-dependent flux boundary condition is similar to the river and ET packages of MFSF in that the flux of groundwater is computed using Darcy's Law and depends on an external feature (e.g., the modeled water table for the river and ET packages). The general-head cells for this modeling effort are assigned along the southwest model boundary where it intersects the cells representing the San Dieguito River (see purple cells at the exit point of the Basin in Figure B2-6). The external feature that is conceptually linked to the general-head cells is the steady-state stage of Lake Hodges. Thus, a steady-state Lake Hodges stage, an assumed K_h between the general-head cells and Lake Hodges, and the distance from the general-head cells to the eastern water line of Lake Hodges is assigned to each general-head cell.

A steady-state Lake Hodges stage value of 300 feet above the North American Vertical Datum of 1988 (NAVD88), along with an assumed K_h of 50 ft/day and distance from the model boundary to Lake Hodges equal to 1,800 feet, was assigned to these general-head cells. These values were assigned to each of the cells colored purple in Figure B2-6 in all model layers to allow horizontal subsurface outflow from the modeling domain. Any constituent mass present in these boundary cells leaves the modeled aquifer, along with the subsurface outflow.

B2.7.3 No-flow Boundaries

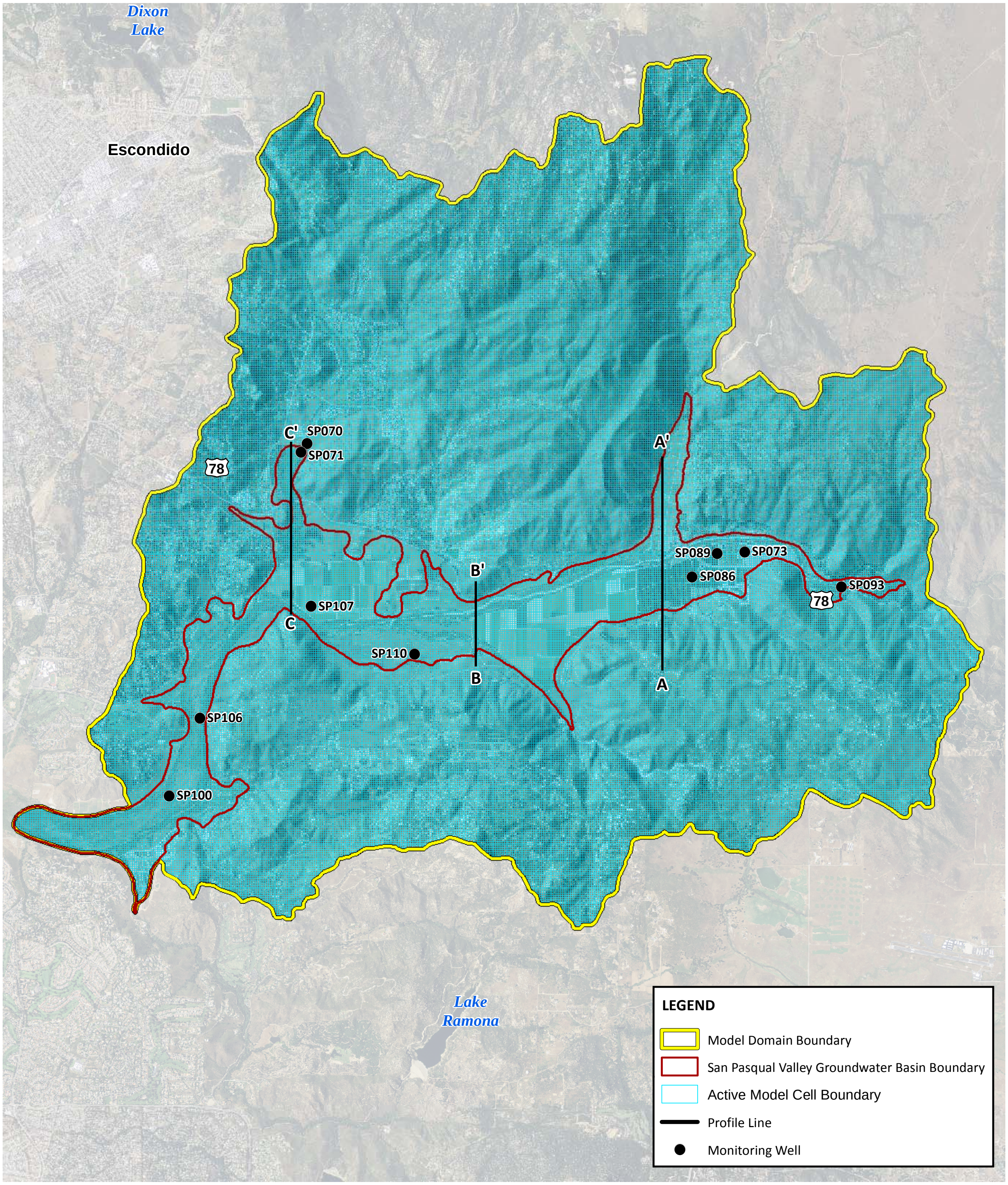
The lateral model boundary cells depicted in Figure B2-6 that are not assigned as head-dependent flux boundaries and the bottom of the deepest model layer (i.e., Model Layer 5) are assigned the no-flow boundary condition. Inherent with the assignment of no-flow boundaries is the assumption that these boundaries coincide with locations of groundwater divides. The no-flow assumption for the lower model layers might not be valid at all locations along the lateral model boundaries. However, these lateral model boundaries were purposely located far enough from cells representing the Basin to avoid adverse boundary effects that could result from conceptual errors along the margin of the model domain.

B2.8 Time Discretization

Time is continuous in the physical system, but a numerical model must describe the field problem at discrete time intervals. The GFM was set up to simulate average steady-state flow conditions that are generally representative of the last 10 years. As such, the hydraulics associated with the modeled groundwater flow system are constant through time.

A 50-year simulation period was established for constituent transport modeling. The purpose for this simulation period was not to attempt to simulate actual conditions from 1965 through 2014, but rather to allow several decades for constituents to become assimilated into the modeled aquifer, given that the Basin has been subject to intensive agriculture for several decades.

To complete constituent transport simulations as efficiently as possible, the adaptive time-stepping and output control (ATO) package of MFSF was employed. The ATO package allows input of minimum and maximum time-step durations, and MFSF automatically selects a time-step duration between these values to efficiently achieve a mass-conserved mathematical solution while minimizing model run times.



NOTE:

Figure B2-2 illustrates the model layer profiles along A-A', B-B', and C-C'.

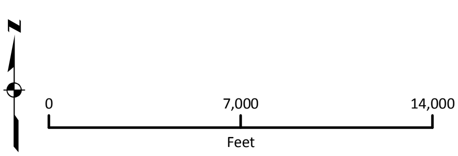


FIGURE B2-1
Model Domain: Plan View
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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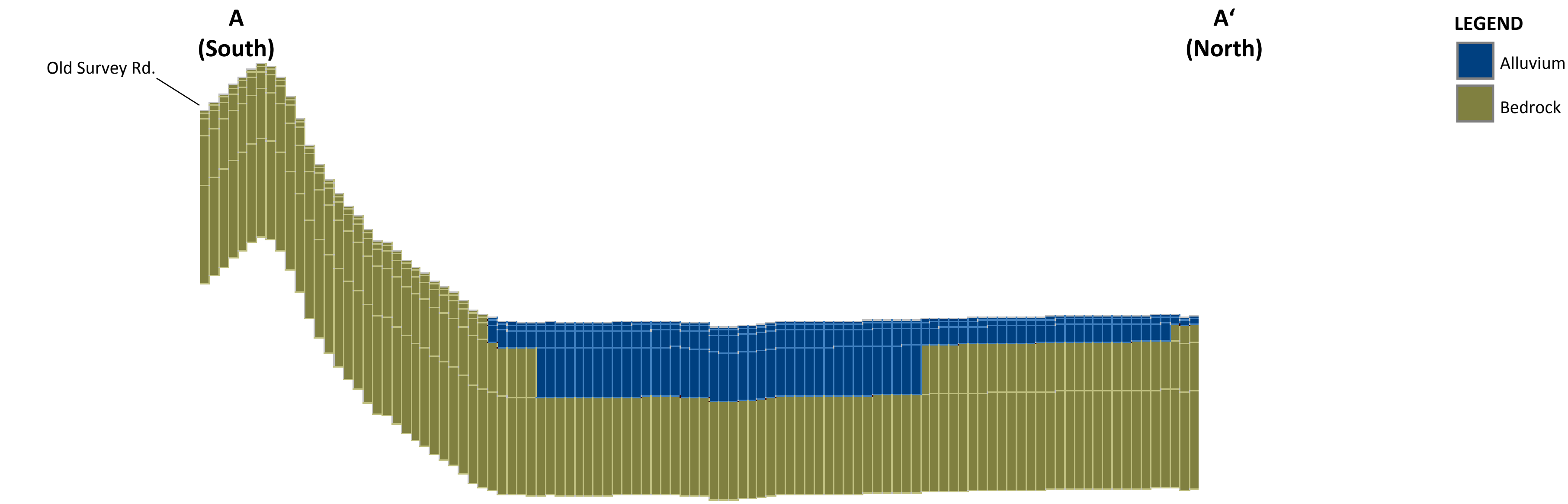

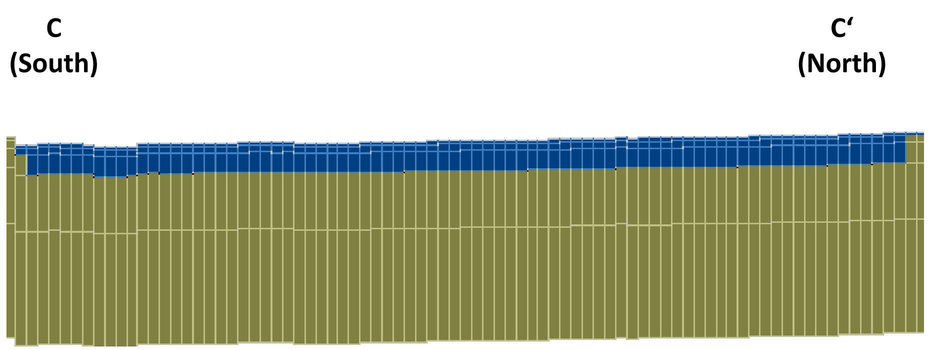

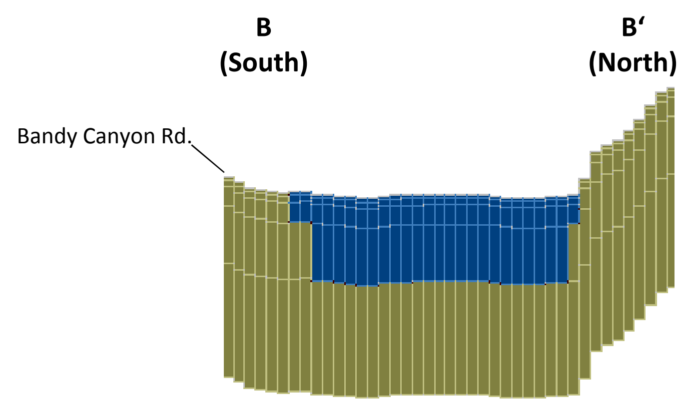

NOTES:

Images are not to scale and are vertically exaggerated by a factor of 4.

Figure B2-1 depicts the locations of the A-A', B-B', and C-C' profile lines.

Numerical groundwater model includes five vertically stacked, mathematical layers with uniform thicknesses of 7.5, 15, 45, 127.5, and 255 feet from top to bottom, respectively.

FIGURE B2-2
Model Domain: Profile Views
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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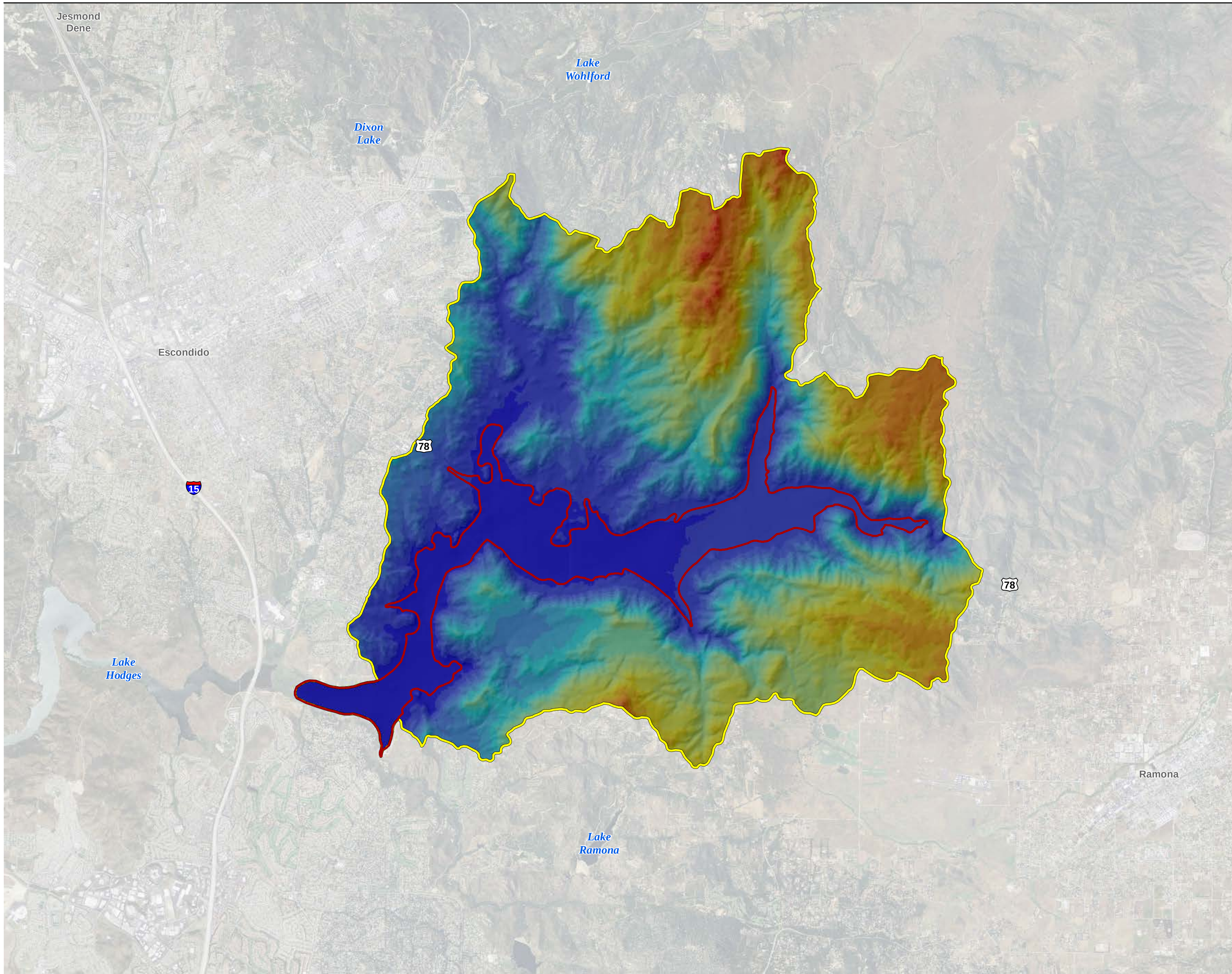

LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary

Modeled Land Surface Elevation (feet NAVD88)

- 2,200 to 2,260
- 2,100 to 2,200
- 2,000 to 2,100
- 1,900 to 2,000
- 1,800 to 1,900
- 1,700 to 1,800
- 1,600 to 1,700
- 1,500 to 1,600
- 1,400 to 1,500
- 1,300 to 1,400
- 1,200 to 1,300
- 1,100 to 1,200
- 1,000 to 1,100
- 900 to 1,000
- 800 to 900
- 700 to 800
- 600 to 700
- 500 to 600
- 400 to 500
- 315 to 400

NOTES:

Elevations based on 10-meter Digital Elevation Model data.

NAVD88 = North American Vertical Datum of 1988.

0 7,000 14,000
Feet

N

FIGURE B2-3
Modeled Land Surface Elevations
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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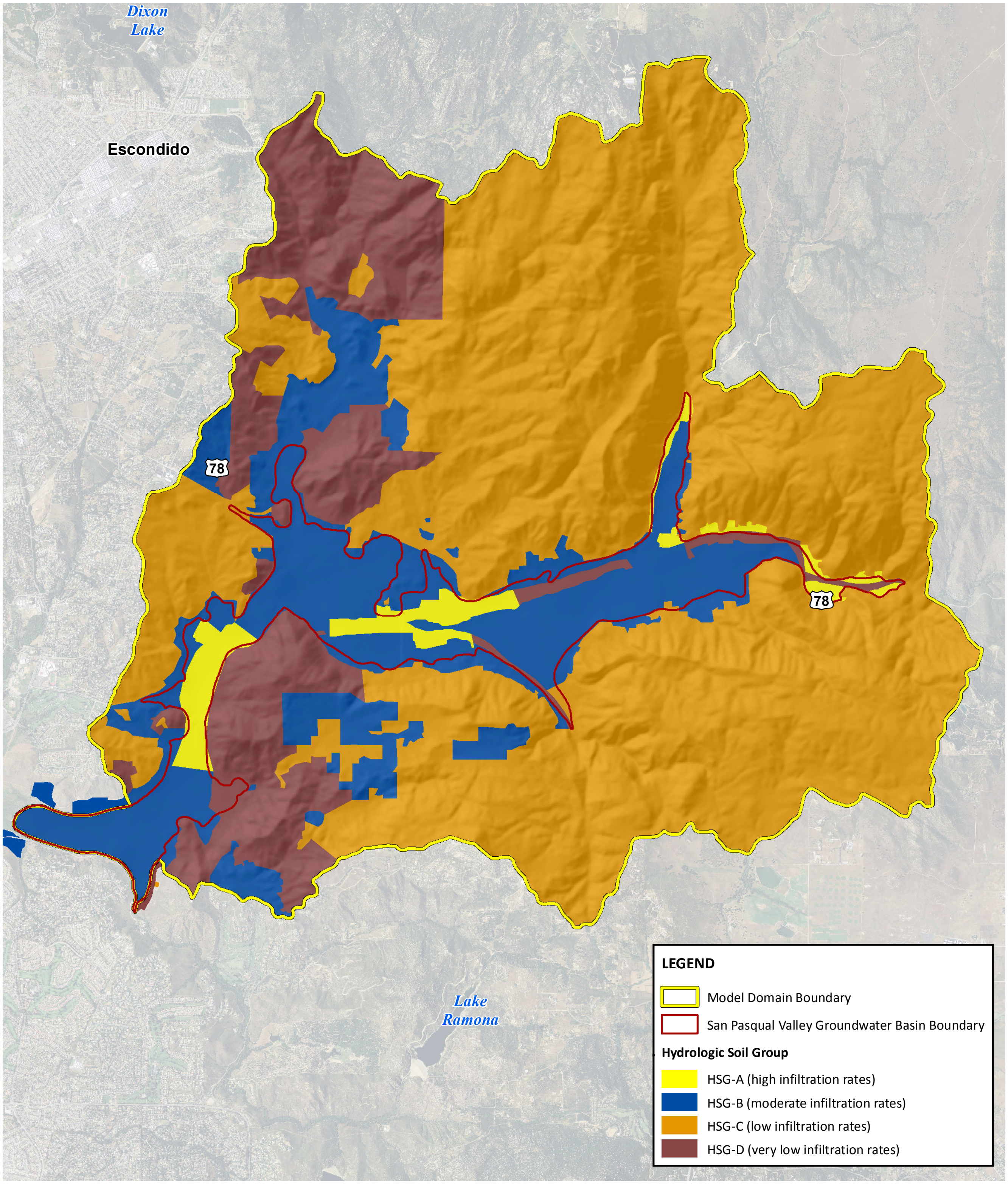

NOTE:

HSG designations based on 20?? data.

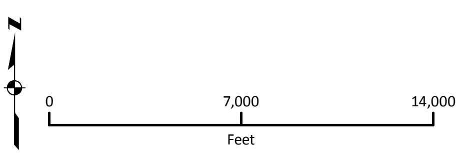

FIGURE B2-4

Modeled Hydrologic Soil Groups

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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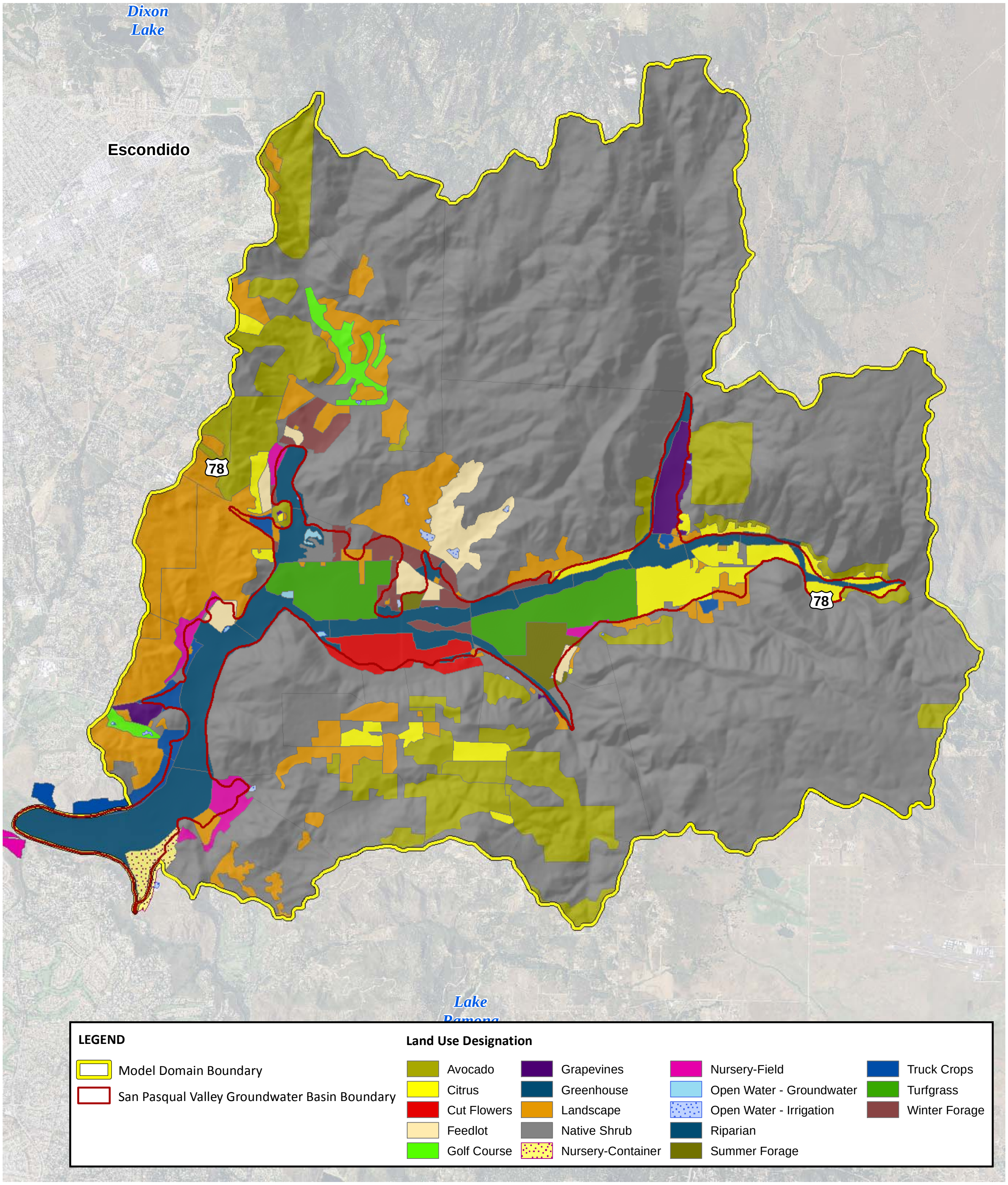

NOTE:

Land use designations based on 2009 and 2012 satellite imagery data.

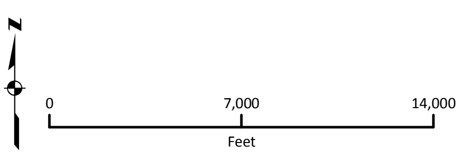

FIGURE B2-5
Modeled Land Use Designations
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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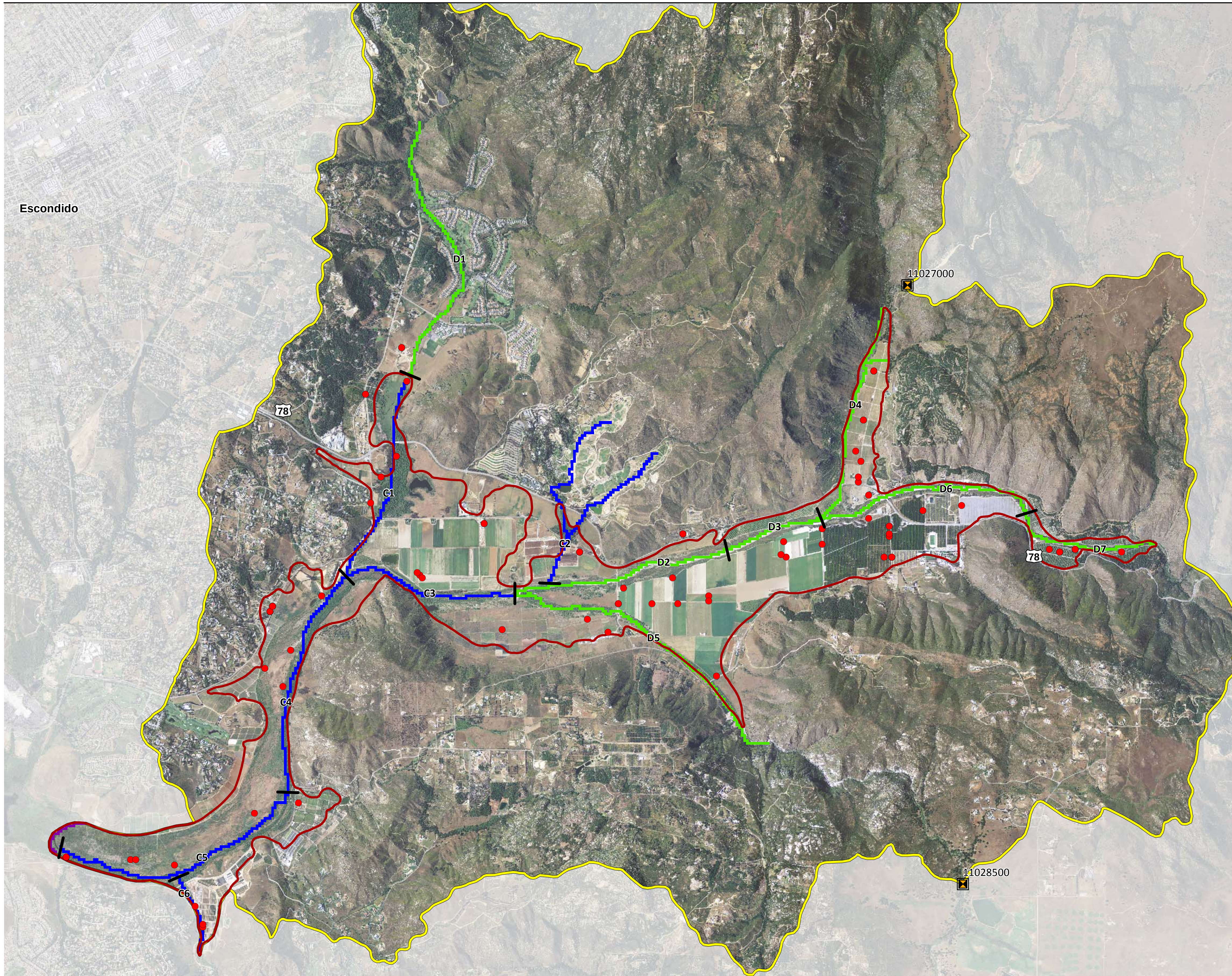

LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

USGS Stream Gage

Boundary Condition

Subsurface Outflow Cell (head-dependent-flux boundary)

Coupled Stream Cell (head-dependent flux boundary)

Decoupled Stream Cell (fixed-flux boundary)

Pumping Well Cell (fixed-flux boundary)

Stream Reach Boundary

NOTES:

No-flow boundary cells are located along the margins of each model layer and at the bottom of Model Layer 5.

The areal groundwater recharge (fixed-flux boundary) and shallow groundwater ET (head-dependent flux boundary) cells are located at all surface cells not already assigned to other boundary conditions.

The areal groundwater recharge term represents the deep percolation of precipitation and applied water. Stream reach labels beginning with "D" and "C" refer to stream reaches being conceptualized as decoupled and coupled, respectively.

USGS stream gage 11025500 is located approximately 4.5 river miles upstream from the eastern Basin boundary on Santa Ysabel Creek (east of the map view).

0 4,000 8,000
Feet

FIGURE B2-6
Modeled Boundary Conditions
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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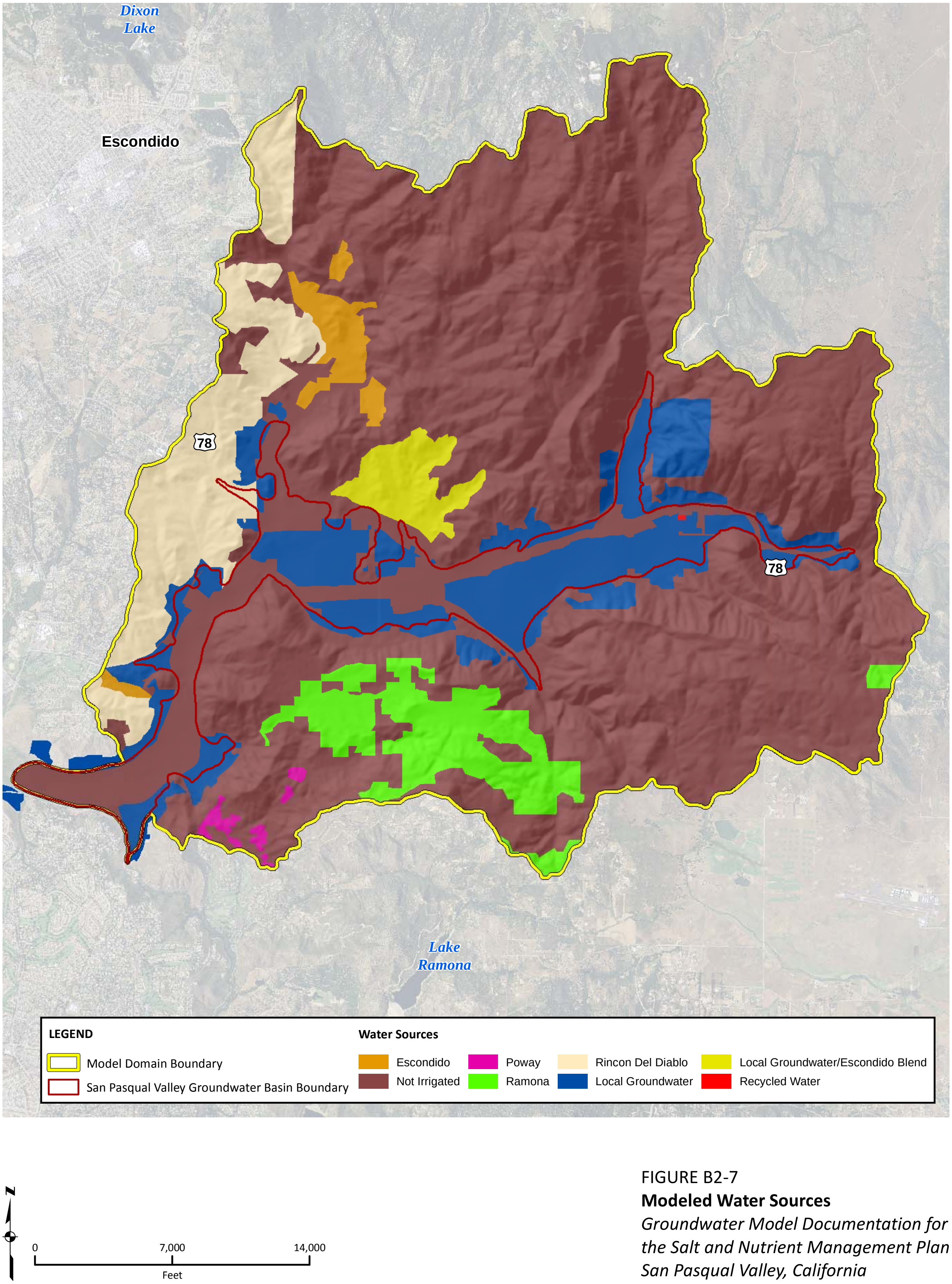

FIGURE B2-7
Modeled Water Sources
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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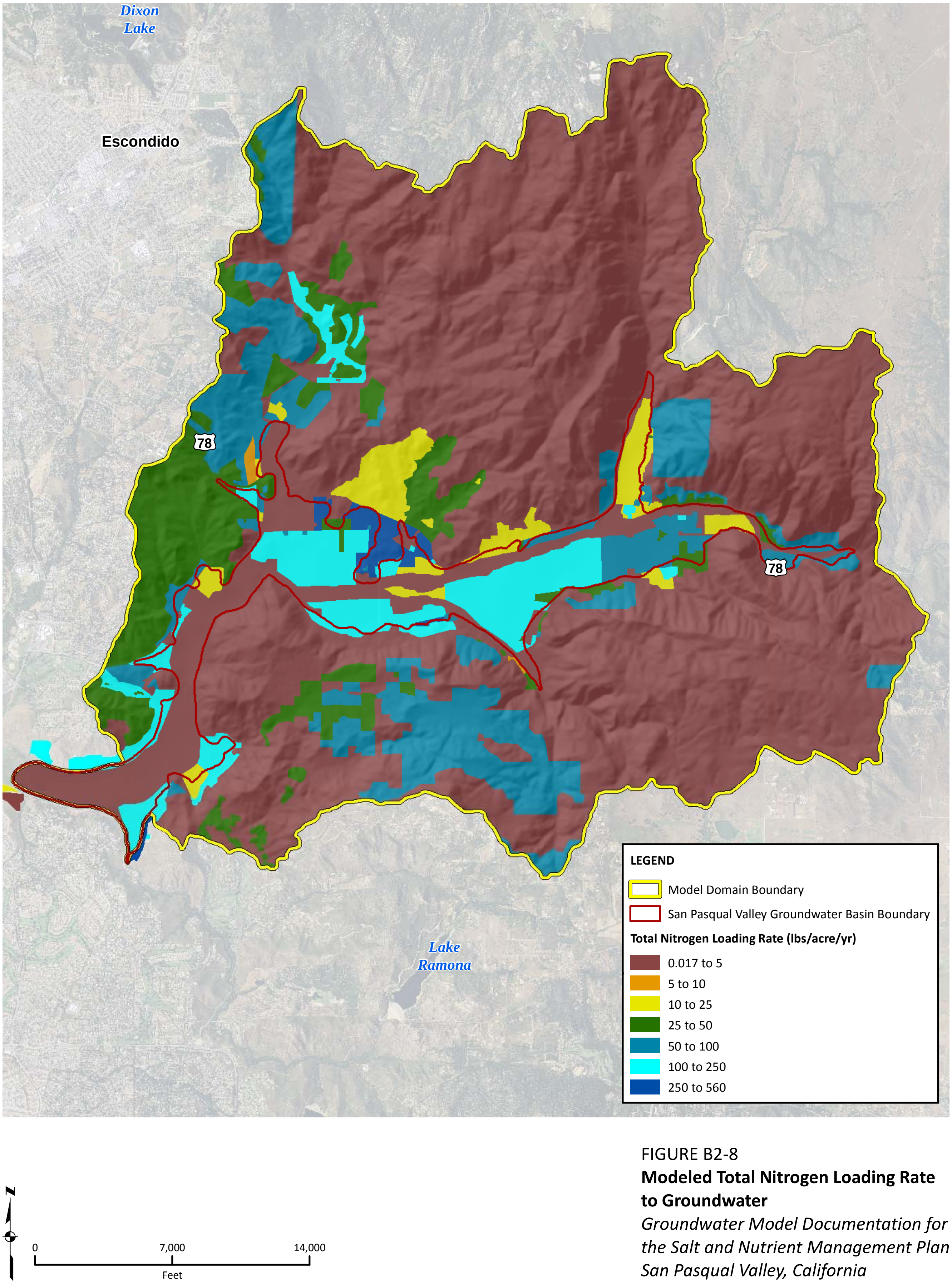

FIGURE B2-8
Modeled Total Nitrogen Loading Rate to Groundwater
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

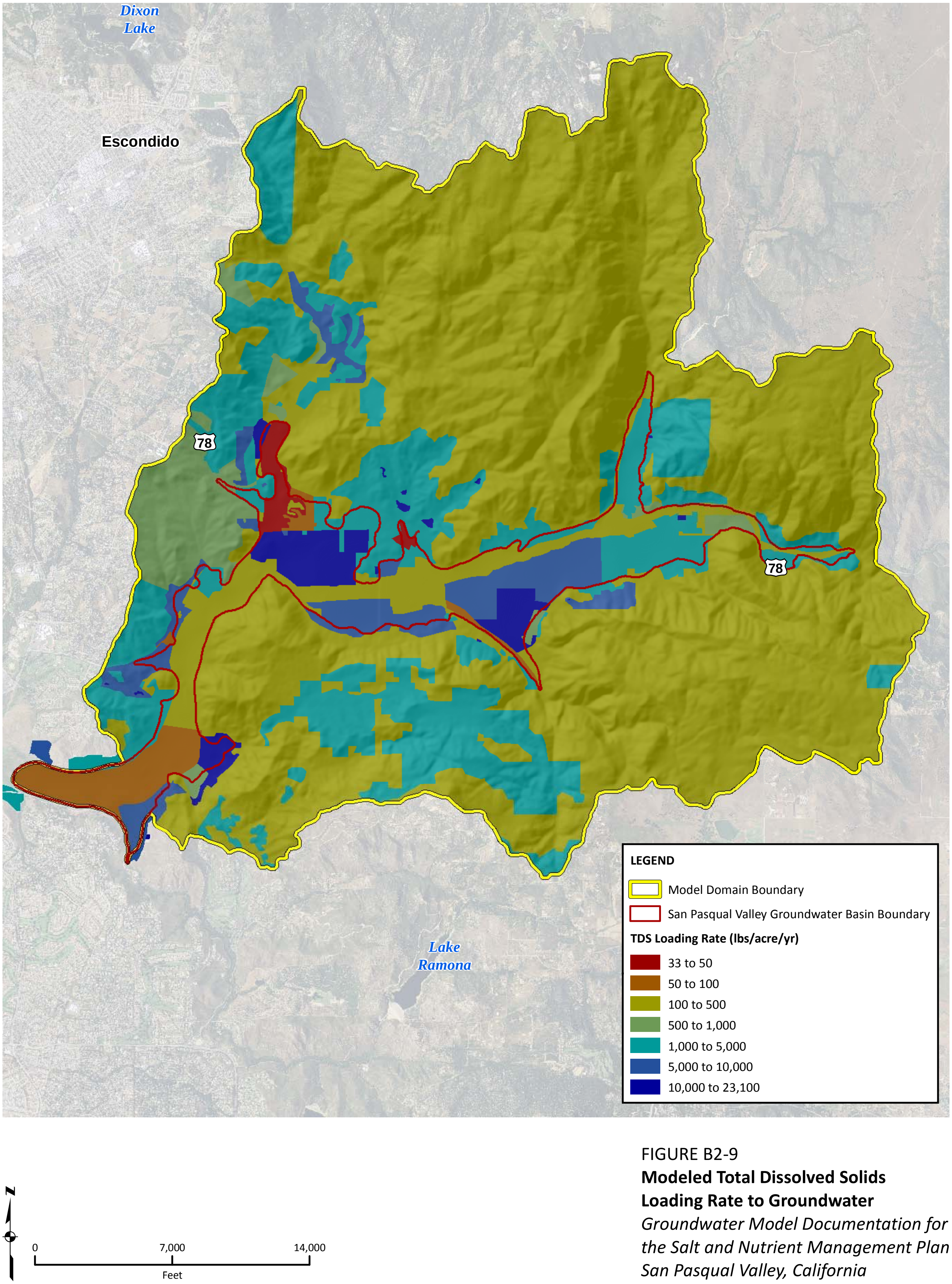

FIGURE B2-9
Modeled Total Dissolved Solids Loading Rate to Groundwater
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

CH2MHILL.

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SECTION B3

Model Calibration

Model calibration is a process of tuning a numerical model to simulate observed subsurface flow and constituent conditions in the field (as described with measured data) within a reasonable degree of accuracy. The numerical models described herein were calibrated in accordance with the *Standard Guide for Calibrating a Ground-Water Flow Model Application* (American Society for Testing and Materials, 1996). This section discusses the calibration targets, process, and results.

B3.1 Calibration Targets

Calibration targets are defined as the selected field-measured values that quantify site conditions of interest with consideration of data quality and reliability. Hydraulic, chemical, qualitative, and quantitative calibration targets were selected to evaluate the progress of calibration during numerical model development. Field-derived groundwater elevation (i.e., head), along with TDS and nitrate concentration data provided the bases for the calibration targets.

B3.1.1 Hydraulic Calibration Targets

Measured heads, averaged over the period of 2008 through 2012 for each of the 10 groundwater-level monitoring wells depicted in Figure B3-1, served as quantitative calibration targets. The overall modeled groundwater flow patterns served as a qualitative calibration target with consideration of the CSM for groundwater flow in the study area. Calibration summary statistics were computed to provide a quantitative measure of the model's ability to replicate calibration-target head values. Head calibration was evaluated using the following summary statistics:

- Residual error, computed as the modeled head value minus the target head value
- Mean error (ME), computed as the sum of all residual errors divided by the number of observations
- Coefficient of determination (R^2), computed as the square of the correlation coefficient
- Root mean squared error (RMSE), computed as the square root of the mean of all residual squared errors
- RMSE divided by the range of target head values (RMSE/Range)

During the quantitative calibration, CH2M HILL developed the following goals:

- Minimize spatial bias of residual errors in key areas of the domain.
- Minimize residual error, ME, RMSE, and RMSE/Range values.
- Maintain R^2 values as close to unity as practicable.

Figure B3-1 depicts the locations of the hydraulic calibration targets selected for this effort, which includes the 10 groundwater-level monitoring locations.

B3.1.2 Constituent Calibration Targets

Constituent calibration targets include observations of temporal and/or spatial patterns of field-derived concentrations of TDS and nitrate. The constituent calibration targets described below are qualitative (calibration summary statistics were not computed for these targets); however, despite being classified as qualitative, they are important calibration components.

The constituent calibration targets include time-series TDS and nitrate concentration data resulting from analysis of groundwater samples collected at 11 monitoring wells. Figure B3-1 depicts the locations of the 11 constituent concentration target locations.

B3.2 Calibration Process

CH2M HILL implemented a calibration approach that included a combination of both manual and autocalibration techniques to achieve sufficient, effective calibration. This approach consisted of three general phases. The first phase included initial model setup, defining locations with field-derived parameter values, and establishing approximate parameter fields; this resulted in a reasonably close match to both quantitative and qualitative targets. The second phase implemented autocalibration techniques, employing the Model-Independent Parameter Estimation & Uncertainty Analysis (PEST)[5] optimization software (Doherty, 2004, 2010) to obtain the best fit to the calibration targets. The third phase involved interpreting the autocalibration results with respect to the quantitative and qualitative calibration targets and further revising parameter values either to maintain consistency with or to refine the CSM.

B3.3 Calibration Results and Discussion

The calibrated hydraulic and constituent transport parameters are discussed in the following subsections. The calibrated parameters that are presented are the same in the GFM and each constituent transport model, unless otherwise noted.

B3.3.1 Subsurface Hydraulics

B3.3.1.1 Hydraulic Parameter Values

Figures B3-2 and B3-3 present the calibrated distributions of K_h and K_v for each model layer (shown in text boxes on upper left side of each model layer frame), respectively. Calibrated K_h values range from 37.5 to 85 ft/day in the alluvial aquifer and 1.5×10^{-2} to 250 ft/day in the rock and riparian aquifers surrounding the alluvial aquifer. Calibrated K_v values range from 3.75 to 8.5 in the alluvial aquifer and 1.5×10^{-2} to 25 ft/day. These values are consistent with estimates reported in Izbicki (1983) and CH2M HILL (2001) and are within the range of literature values for the materials present in the study area.

Figure B3-4 shows the calibrated areal distribution of groundwater recharge from precipitation and applied water. These recharge fluxes were computed with the aid of the SMB tool described in Attachment B1, and range from 0.6 to 13 inches per year (in/yr) under all areas except irrigated ponds, which range to nearly 61 in/yr. The highest rates correspond to locations of surface bodies of water and irrigated areas, whereas the areas of lowest recharge rates correspond to the areas outside the Basin that are covered with native vegetation or areas with shallow groundwater levels near the exit point of the Basin, downstream from the San Pasqual Narrows.

Figure B3-5 presents the modeled distribution of shallow groundwater ET. The model internally computes the groundwater ET fluxes based on the specified maximum ET rate, rooting depth, and modeled water table elevation. The calibrated shallow groundwater ET rate ranges from 0 to 110 in/yr. Areas with little to no modeled groundwater ET correspond to areas with either no vegetation or assigned rooting depths that occur very near or above the modeled water table.

Streambed K_v values of 50 to 100 ft/day were calibrated for different reaches of river package cells representing coupled streams in the western portion of the study area. This range of streambed K_v values is reasonable considering the permeable sediments in the study area stream channels.

B3.3.1.2 Groundwater Elevations

Table B3-1 and Figures B3-6 and B3-7 provide summary statistics and plots characterizing the match between modeled and calibration-target heads. Data presented in Figure B3-6 indicate good agreement between modeled and calibration-target heads. Because the points fall above, below, and close to the 1:1 correlation line, no global bias in modeled heads is evident from Figure B3-6. The summary statistics presented in Figure B3-6 are also consistent with the calibration goals described in Section B3.1.1.

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[5] http://www.pesthomepage.org/ (Accessed February 12, 2014)

TABLE B3-1
Comparison of Modeled and Calibration-target Heads
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Calibration-target Well Name	Model Layer	Calibration-target Head (feet NAVD88) [a]	Modeled Head (feet NAVD88)	Residual Error (feet) [b]
SP070	2	373.7	368.4	-5.3
SP071	3	361.7	366.9	5.2
SP073	3	397.1	398.3	1.2
SP086	3	389.5	389.2	-0.3
SP089	3	391.3	394.1	2.8
SP093	3	417.8	419.2	1.4
SP100	3	329.4	319.7	-9.7
SP106	3	321.7	324.1	2.4
SP107	3	345.7	339.4	-6.3
SP110	3	355.6	360.7	5.1

[a] Calibration-target head values were computed by averaging field-measured heads for the 2008 through 2012 period.
[b] Residual error was computed as modeled head value minus calibration-target head value.
Note
Figure B3-1 depicts the calibration-target well locations.

Figure B3-7 presents a map of head residual errors. This map aids in identifying whether spatial bias is present in the head residual errors; such bias would be revealed by clusters of wells in which larger residual errors occur. As Figure B3-7 shows, even though wells in the eastern portion of the Basin exhibit a smaller magnitude of head residual errors than the wells in the central and western portions of the Basin, there is not an area of the model where head residuals are generally high or low. Thus, the modeling results do not indicate spatial bias in the distribution of residual errors in modeled heads. Some head-target wells with large residuals such as SP071 and SP107 are near pumping wells, and water levels in these wells vary by 20 to 30 feet over their period of record (see hydrographs in Figure B1-3). The two westernmost head-target wells, SP100 and SP106, are peculiar in that the water levels in the downgradient well (SP100) are higher than those of SP106 by approximately 10 feet; the model matches SP106 better than it does SP100. There are no well logs available to ascertain whether this difference could be due to vertical head gradients at these locations. Their hydrographs (Figure B1-3) are relatively stable, indicating pumping or long-term trends are not causing this difference. A resurvey of the measuring point elevations and inventories of the well screen elevations associated with these and other wells would be useful in understanding the cause for the difference in water levels in the lower portion of the Basin.

Figure B3-8 shows the modeled water table contours for those in the Basin (5-foot contour intervals) and those in the adjacent rock aquifer (50-foot contour intervals). Figure B3-8 indicates that the modeled water table is topographically controlled in the rock aquifer and that the modeled water table is influenced both by topography and by groundwater extraction. This overall pattern of groundwater flow fits this geographic setting, which includes shallow groundwater levels interacting with surface drainages, particular in tributary canyons and in the central portion of the Basin where modeled groundwater levels are shallow.

Figure B3-9 shows the modeled depth to groundwater, which ranges from less than 5 feet to more than 100 feet. Generally, the low-lying areas such as canyons and flat areas with thin or no alluvium exhibit the shallowest depths to groundwater. Conversely the depth to groundwater is greater than 100 feet in the upland areas. The water table maps shown in Figures B3-8 and B3-9 are consistent with the overall hydrogeologic setting.

B3.3.1.3 Steady State Groundwater Balance

Table B3-2 lists the components of the modeled groundwater balance. The groundwater balance is reported for the entire subcatchment study area and the Basin alluvial aquifer to illustrate the magnitudes of components at different spatial scales. Figure B3-10 shows layer-by-layer areas used for evaluating the groundwater balance inside the Basin alluvial aquifer (see blue areas inside the Basin boundary). Data in Table B3-2 indicate that

9,490 acre-feet per year (AFY) (5,879 gpm) of groundwater flows through the saturated Basin alluvium. This magnitude of underflow is reasonable considering the relatively high K_h and K_v values being modeled in cells representing the Basin alluvium and the overall groundwater use. The total estimated pumping of groundwater from inside the Basin is 5,932 AFY.

TABLE B3-2
Modeled Groundwater Balance
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

	Inflow Rate (AFY)			Outflow Rate (AFY)	
Inflow Component	**Subcatchment [a]**	**Basin [b]**	**Outflow Component**	**Subcatchment [a]**	**Basin [b]**
Groundwater recharge from precipitation and applied water	7,853	1,196	Shallow groundwater ET	5,786	989
Groundwater recharge from streams	6,965	6,263	Groundwater pumping	6,046	5,932
Subsurface inflow from adjacent areas	0	2,031	Groundwater discharge to streams	2,773	2,199
			Subsurface outflow to adjacent areas	213	370
Total groundwater inflows	14,818	9,490	Total groundwater outflows	14,818	9,490

[a] Includes active cells representing the entire subcatchment study area (42 mi^2; 26,816 acres).
[b] Includes cells representing the alluvial aquifer within the Basin inside of the subcatchment (5.5 mi^2; 5,465 acres).
Notes:
Figure B1-2 shows the extents of the subcatchment study area and Basin.
Presented values are rounded to the nearest whole number.

B3.3.2 Subsurface Constituent Transport

Table B3-3 lists the calibrated constituent transport parameter values. The values reported in Table B3-3 are generally consistent with typical constituent transport parameter values for constituent transport simulations of similar spatial and temporal scale. One exception is that α values used in the constituent transport models are lower than those typically reported for large alluvial areas because implementing the dual-domain transport (mass-transfer) formulation allows additional constituent spreading to occur in the model, beyond that caused by advection. Thus, having larger α values is not necessary, or even appropriate, when implementing the dual-domain transport formulation (Flach et al., 2004).

TABLE B3-3
Calibrated Transport Parameter Value
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Transport Parameter	Calibrated Value
Dispersivity, α (feet)	100/10/1 [a]
Mobile porosity, θ_m (percent)	16
Immobile porosity, θ_{im} (percent)	24
Total porosity, θ_t (percent)	40
DDMT coefficient (per day)	2.7×10^{-4} (3,653 days) [b]
First-order denitrification rate, λ (per day)	8.2×10^{-4} (843 days) [c]

Notes:
[a] Longitudinal/transverse/vertical.
[b] Value in parentheses is the equivalent mass transfer timescale computed as 1÷ DDMT Coefficient.
[c] Value in parentheses is the equivalent denitrification half-life.

Figures B3-11 and B3-12 show the time-series modeled versus target constituent concentrations (i.e., chemographs) at each calibration-target location. The time span of the chemographs covers only the period of available analytical data, even though the calibration simulation began in 1965. Figures B3-11 and B3-12 provide a general sense of whether the combination of hydraulic and transport parameter values, their spatial distributions, and boundary conditions can come close to generating a distribution of constituent concentrations similar to that observed over the recent past. Although there are differences in modeled versus target constituent concentrations, the overall constituent conditions are considered reasonably well calibrated for achieving the modeling objectives discussed in Section B1.1 and informing land management decisions.

Table B3-4 summarizes the constituent mass balance for conditions at the end of the calibration simulation (i.e., the end of 2014). The constituent mass balance provides insight into how constituent mass is introduced into the modeled aquifer and how this mass is either consumed or removed from the modeled aquifer. Table B3-4 indicates that most of the TDS mass loss is due to groundwater pumping, and most of the nitrate mass loss is due to denitrification. This seems plausible considering the relatively rapid denitrification rates assigned in the model to achieve the model calibration. The net increase in constituent mass stored in the water-bearing formations at the end of the calibration simulation is computed by subtracting the total mass loss from the total mass gain. Table B3-4 indicates that annually, approximately 8,000 net tons of TDS and 524 net tons of nitrate are added to the subcatchment each year under current conditions.

TABLE B3-4
Modeled Groundwater TDS and Nitrate Balance Under Current Conditions for the Model Domain
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Mass Balance Component	TDS (US tons/yr)	Nitrate (US tons/yr)
Mass gain from areal groundwater recharge from precipitation and applied water	13,818	1,454
Mass gain from groundwater recharge from streams	6,280	44
Total mass gain	20,098	1,498
Mass loss to shallow groundwater ET	0	198
Mass loss to groundwater pumping	7,572	257
Mass loss to groundwater discharge to streams	4,460	52
Mass loss to subsurface outflow to Lake Hodges	120	1
Mass loss to denitrification	0	466
Total mass loss	12,152	974
Net increase in mass stored in the water-bearing formations	7,946	524

Figure B3-13 shows the estimated average travel time for modeled constituents starting at the ground surface to reach the water table under steady-state existing conditions. These were computed according to Equation B3-1:

$$Average\ Travel\ Time\ [years] = \frac{Depth\ to\ Water\ [feet] \times 0.10\ Moisture\ Content}{Groundwater\ Recharge\ Rate\ [feet\ per\ year]} \qquad \text{(B3-1)}$$

Travel times are smallest in the western to central parts of the Basin and along drainages within the subcatchment, which corresponds to areas with a shallow water table. Within the Basin boundary, the longest travel times occur in the easternmost portion of the Basin and are on the order of two decades, reflecting a deeper water table. Basinwide, the longest travel times are more than 100 years in the highest elevations, particularly in the eastern portion of the Basin where the depths to water are the greatest.

B3.4 Model Calibration Summary

The GFM and constituent transport models described herein were developed and calibrated with consideration of the availability and reliability of input data to fulfill the modeling objectives. These models were constructed and calibrated to simulate steady-state groundwater flow, along with the transport of TDS and nitrate through the steady-state groundwater flow field. The transport simulations also include the dual-domain transport formulation, which conceptualizes the subsurface as having both mobile and immobile pore spaces.

The period of record for hydraulic model calibration data includes calendar years 2008 through 2013, whereas that for the constituent model calibration data includes calendar years 1992 through 2013. These periods contained the most continuous and consistent hydraulic and constituent data. The period of record for hydraulic model inputs (e.g., areal groundwater recharge rates) includes calendar years 2003 through 2012. Constituent concentrations associated with the areal groundwater recharge rates are based on land-use-specific nutrient management practices and data received from stakeholders representing conditions over the past 5 years. Overall, the models described herein are generally intended to represent Basin conditions over the last 10 years, and we used data where and when it was available within that 10-year timeframe.

Calibration results are consistent with the CSM summarized in Section B1.3, indicating stable to increasing constituent concentrations in different portions of the Basin alluvial aquifer. The assigned constituent mass fluxes into the modeled aquifer are based on limited available data, discussions with City personnel, and professional judgment. The geographic pattern of modeled and target constituent concentrations are generally consistent, where available data allow such comparisons. The process of calibrating the GFM and constituent transport models to average groundwater levels, groundwater flow directions, and constituent concentrations has resulted in models that are suitable for their intended application. The primary attributes that make the GFM and constituent transport models appropriate for their intended uses are as follows:

- The GFM is capable of simulating average heads to within an acceptable degree of accuracy considering the reliability of the available groundwater-level data and lack of information about well construction.
- The GFM is capable of simulating groundwater flow directions that are reasonable and plausible considering the topography, hydrogeology, and groundwater use in the study area.
- The constituent transport models are capable of simulating geographic patterns of constituent concentrations that are reasonably consistent with patterns that have been recently observed.

No model perfectly represents the physical and chemical reality of a particular site. However, the ability of the GFM and constituent transport models to simulate the physical and chemical hydrogeology described in this report demonstrates that these models are capable of informing decisions related to land management.

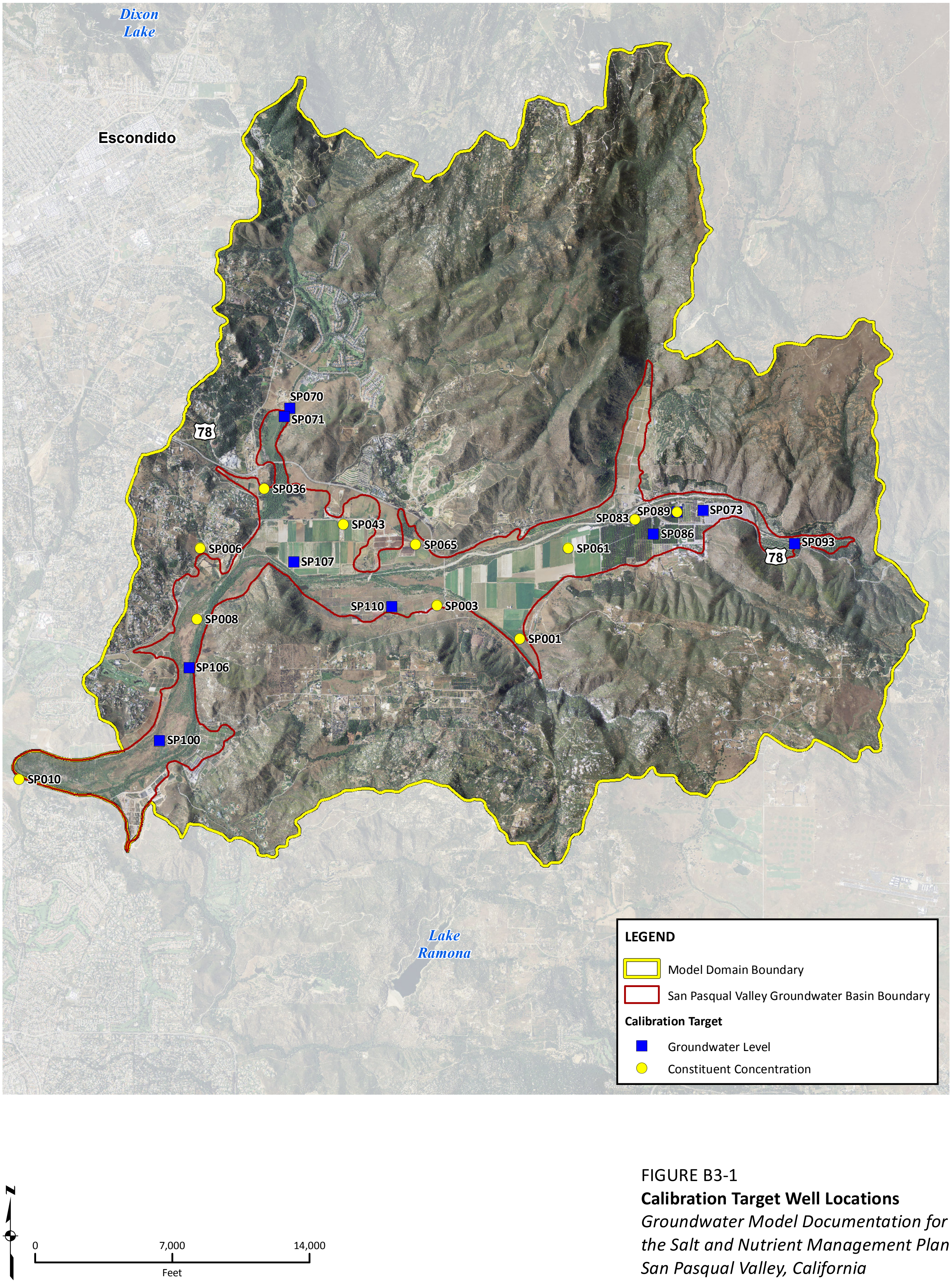

FIGURE B3-1
Calibration Target Well Locations
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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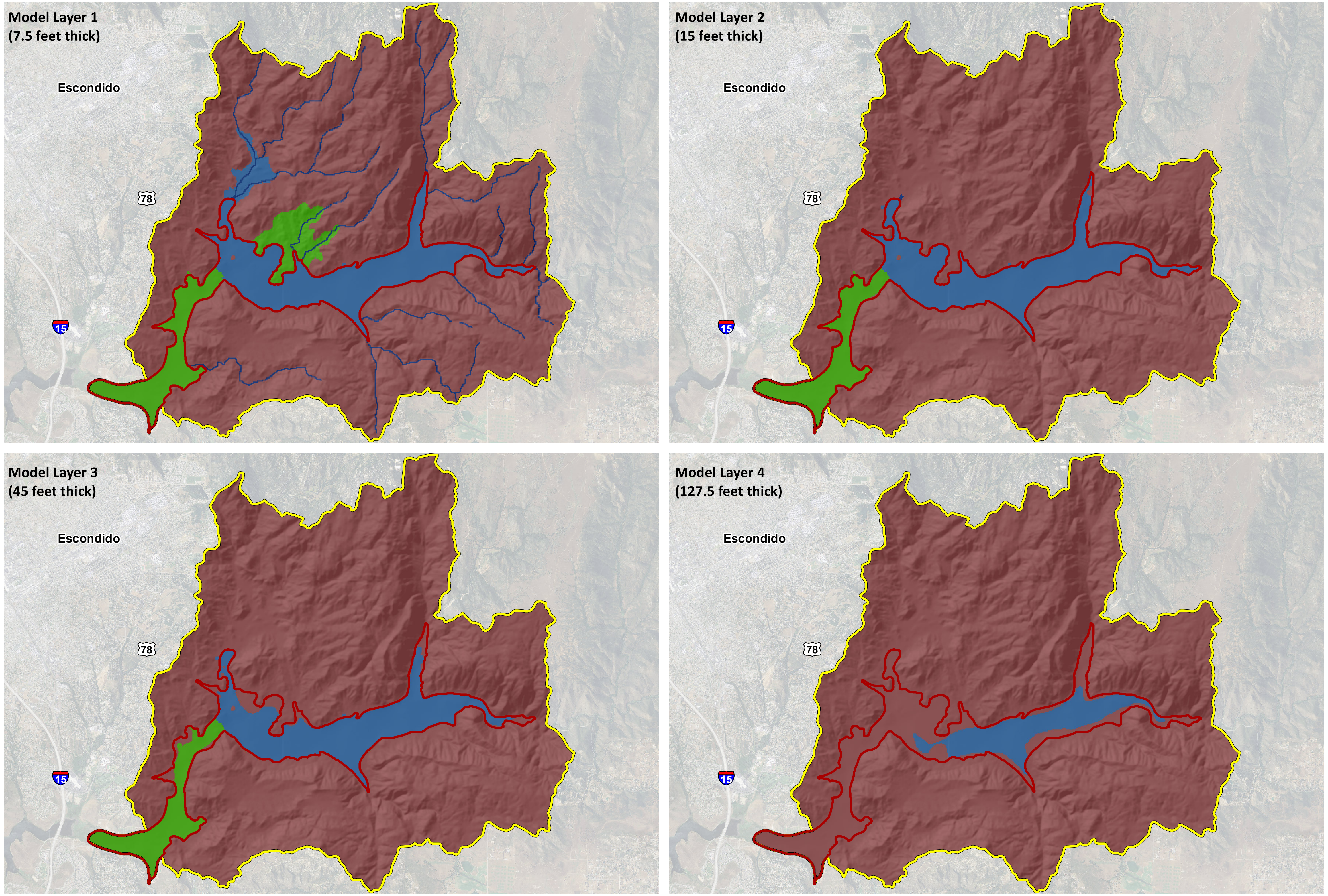


LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary

Horizontal Hydraulic Conductivity (feet/day)

- 100 to 250
- 50 to 100
- 10 to 50
- 5 to 10
- 1 to 5
- 0.015 to 1

NOTE:

Model Layer 5 has a uniform horizontal hydraulic conductivity of 0.015 feet/day and a uniform thickness of 255 feet.

FIGURE B3-2
Modeled Horizontal Hydraulic Conductivity
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

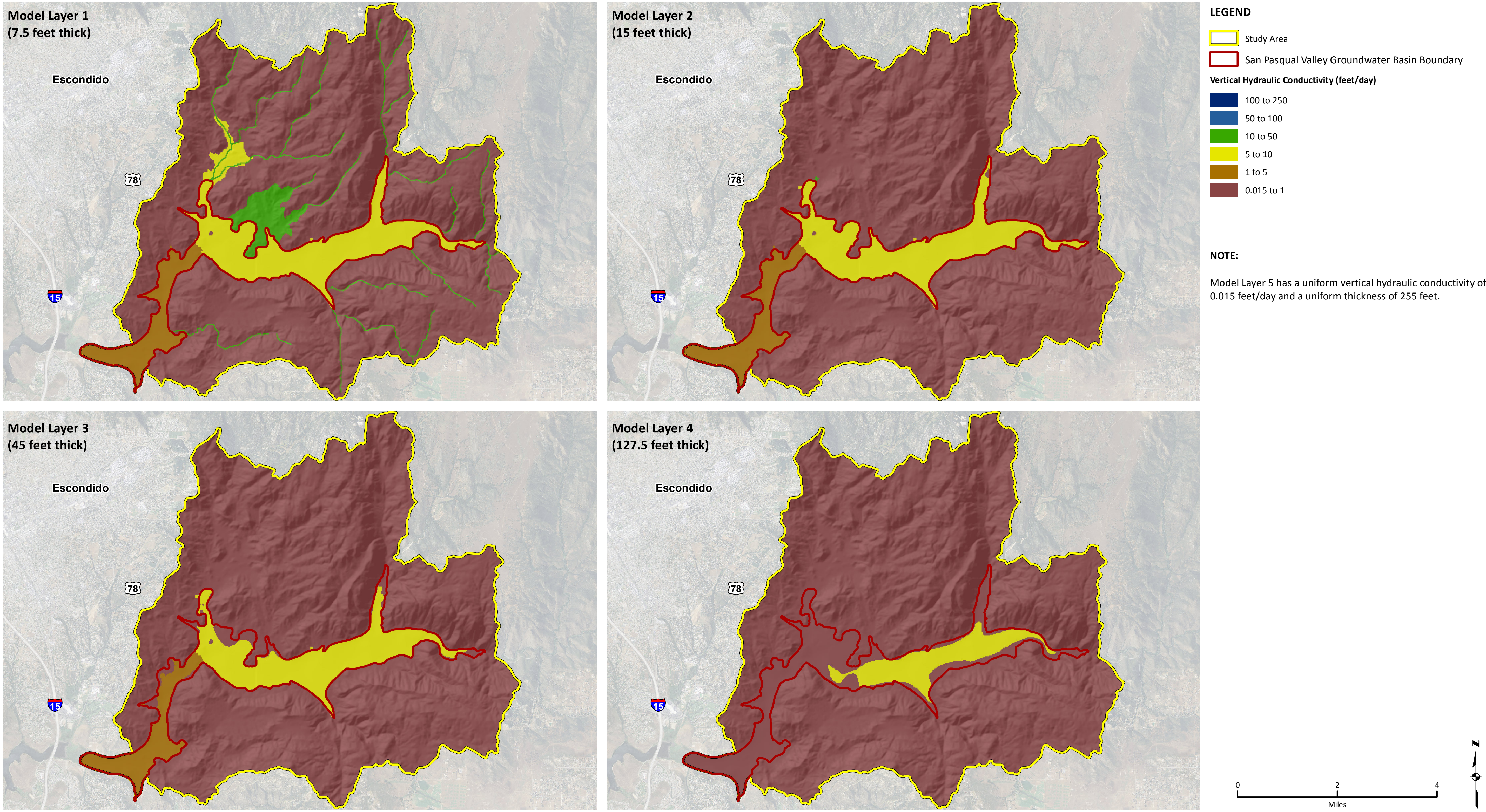
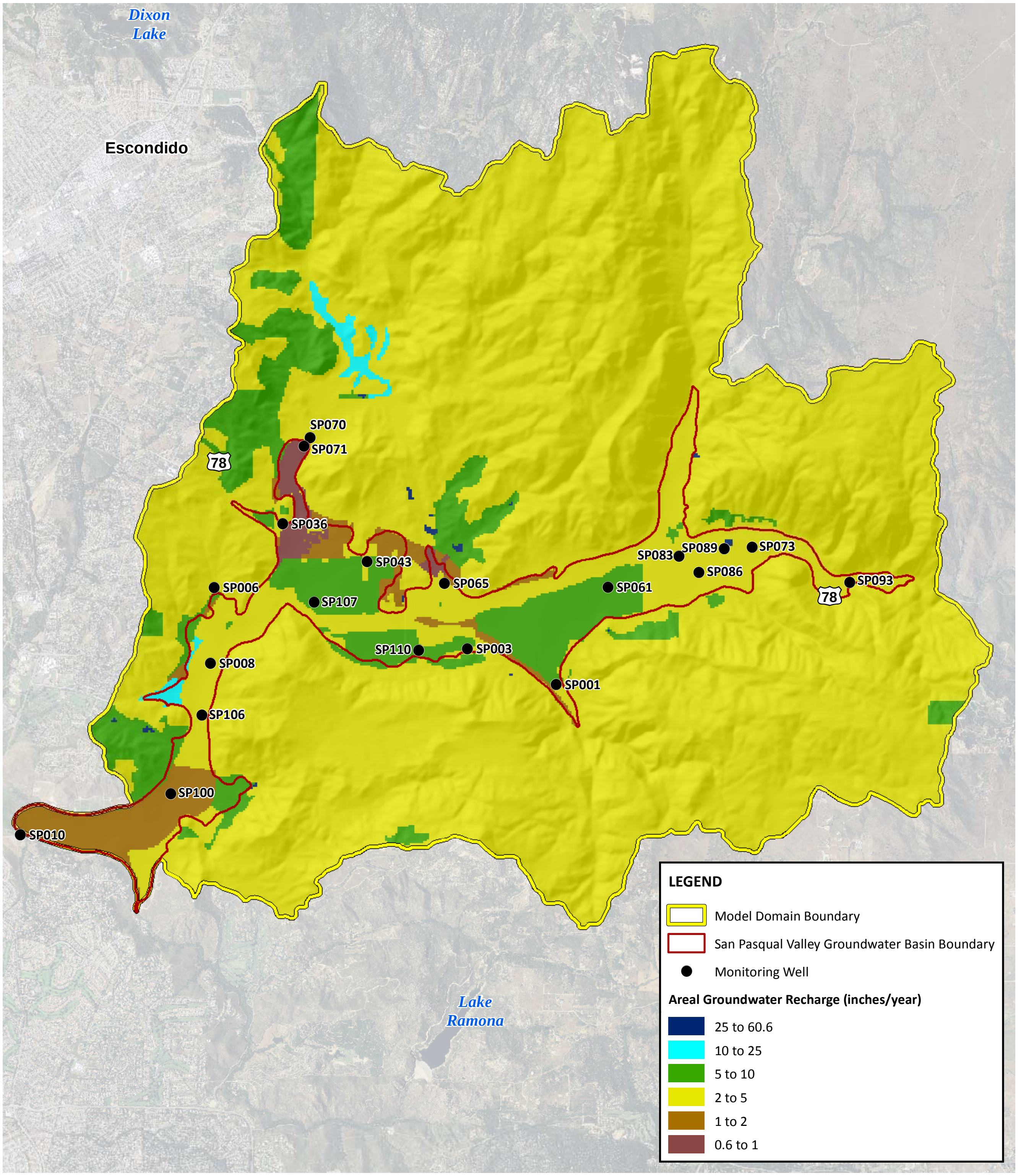


FIGURE B3-3
Modeled Vertical Hydraulic Conductivity
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



NOTE:

The areal groundwater recharge term represents the deep percolation of precipitation and applied water.

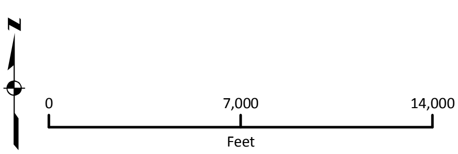


FIGURE B3-4
Modeled Areal Groundwater Recharge
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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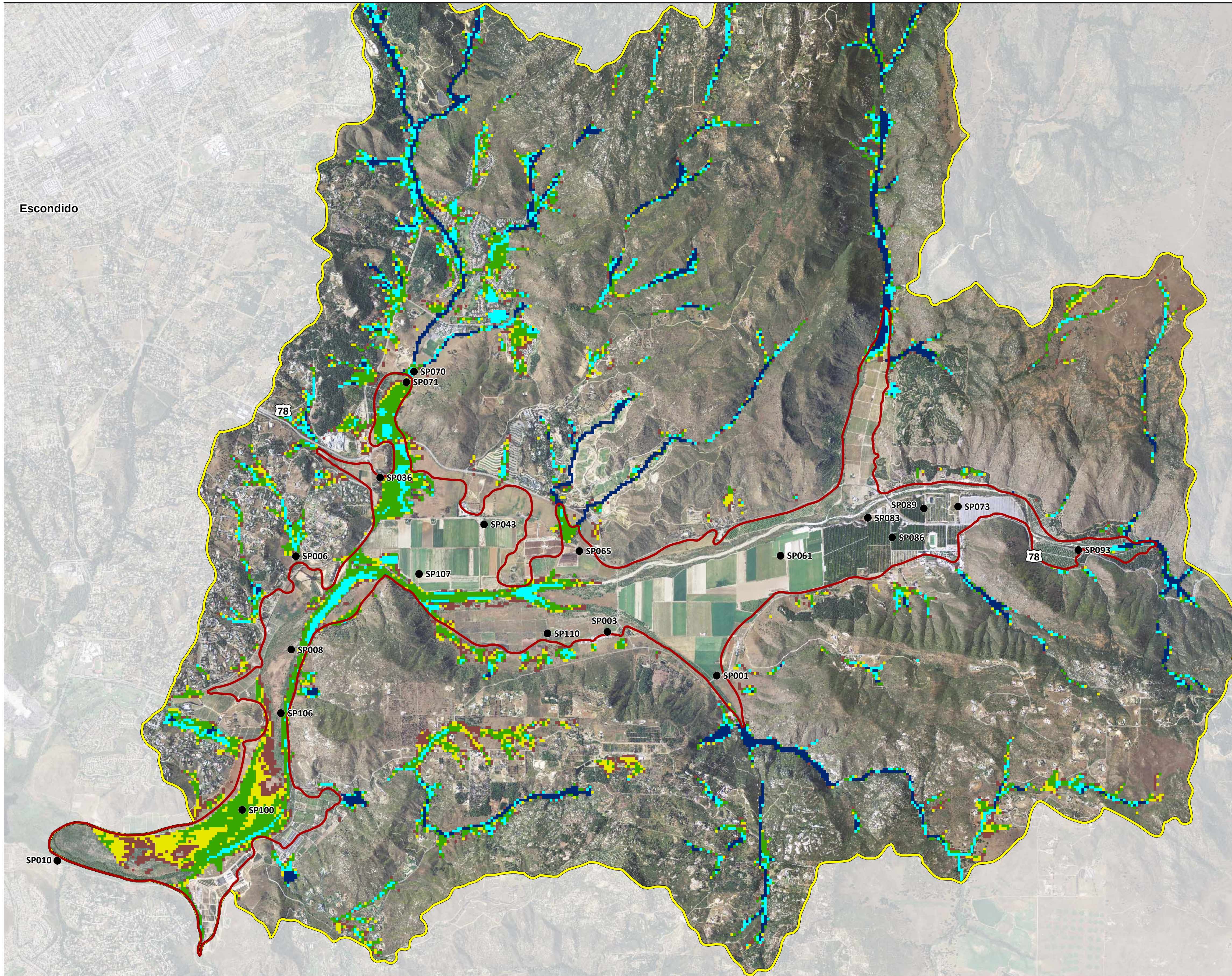

LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

Monitoring Well

Shallow Groundwater Evapotranspiration (inches/year)

50 to 109.6

25 to 50

10 to 25

5 to 10

0.001 to 5

NOTE:

Areas with no shallow groundwater ET only show the background aerial photograph.

0 4,000 8,000

Feet

FIGURE B3-5

Modeled Shallow Evapotranspiration

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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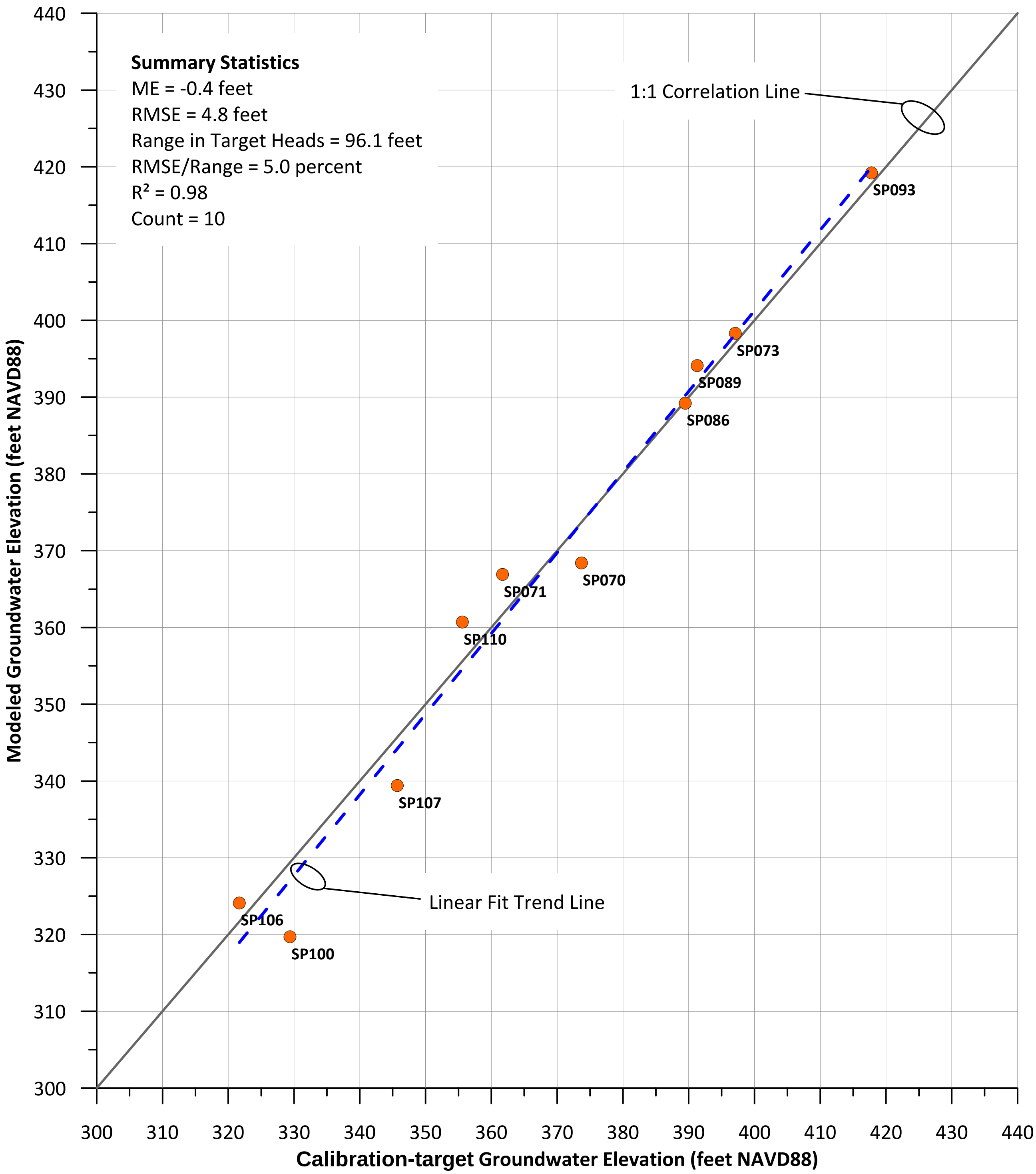
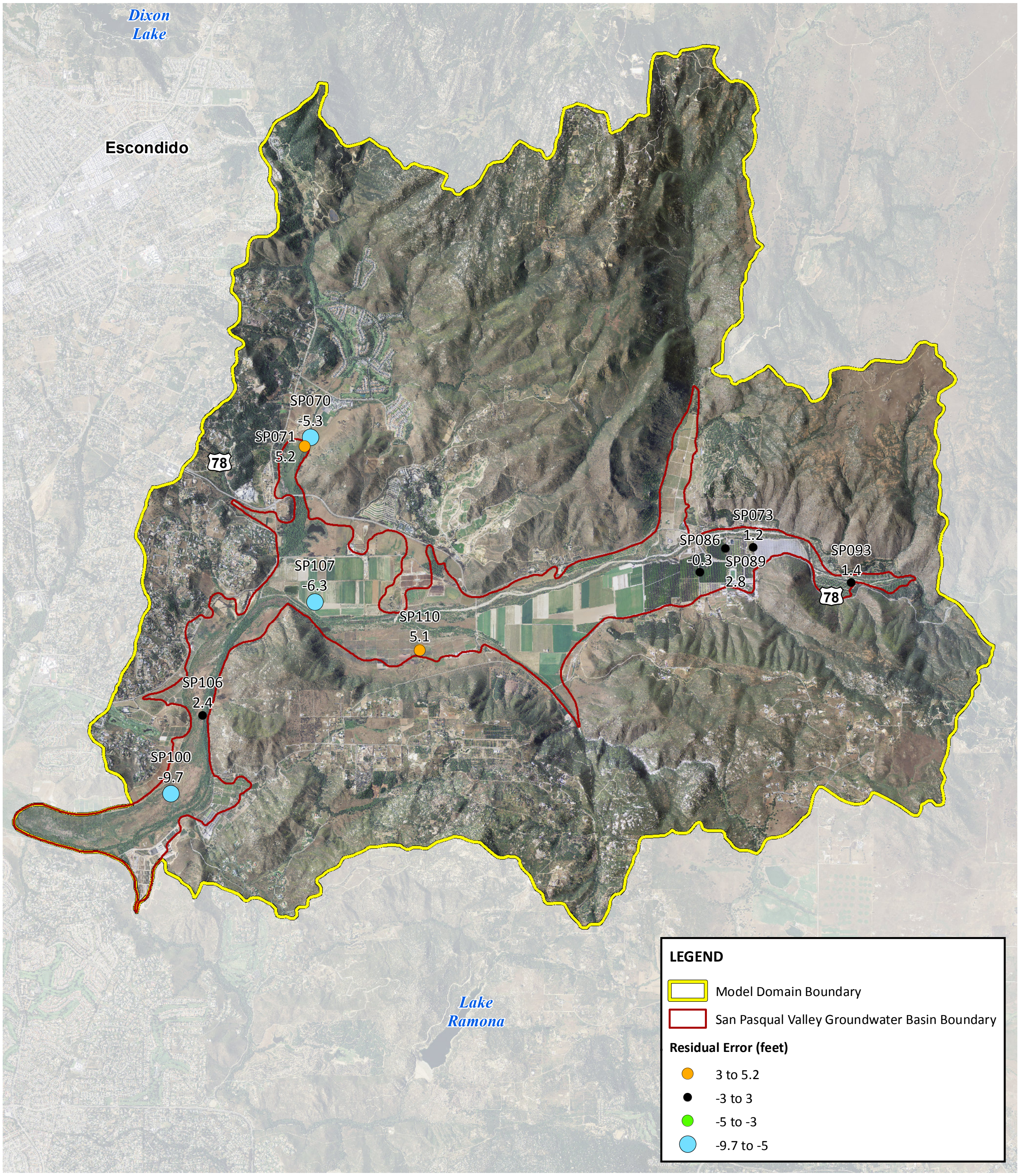


NOTES:

See Table B3-1 for a summary of the residual error for each target monitoring well.

NAVD88 = North American Vertical Datum of 1988.

FIGURE B3-6
Modeled versus Target Groundwater Elevations
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



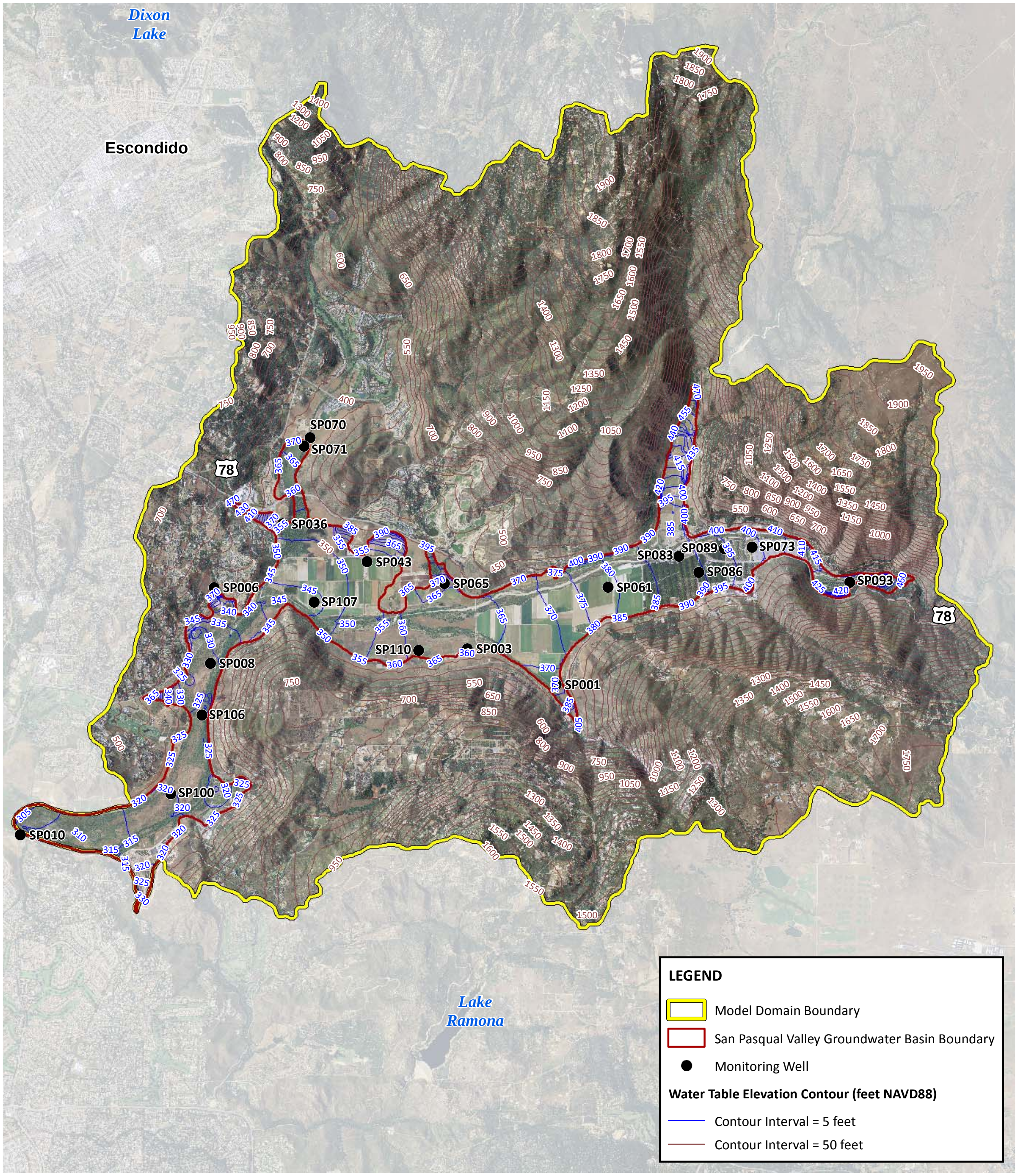
NOTE:

See Figure B3-6 for a plot of modeled versus calibration-target groundwater elevation.

FIGURE B3-7

Distribution of Residual Errors in Modeled Groundwater Elevations

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



NOTE:

NAVD88 = North American Vertical Dataum of 1988.

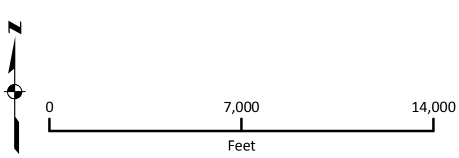
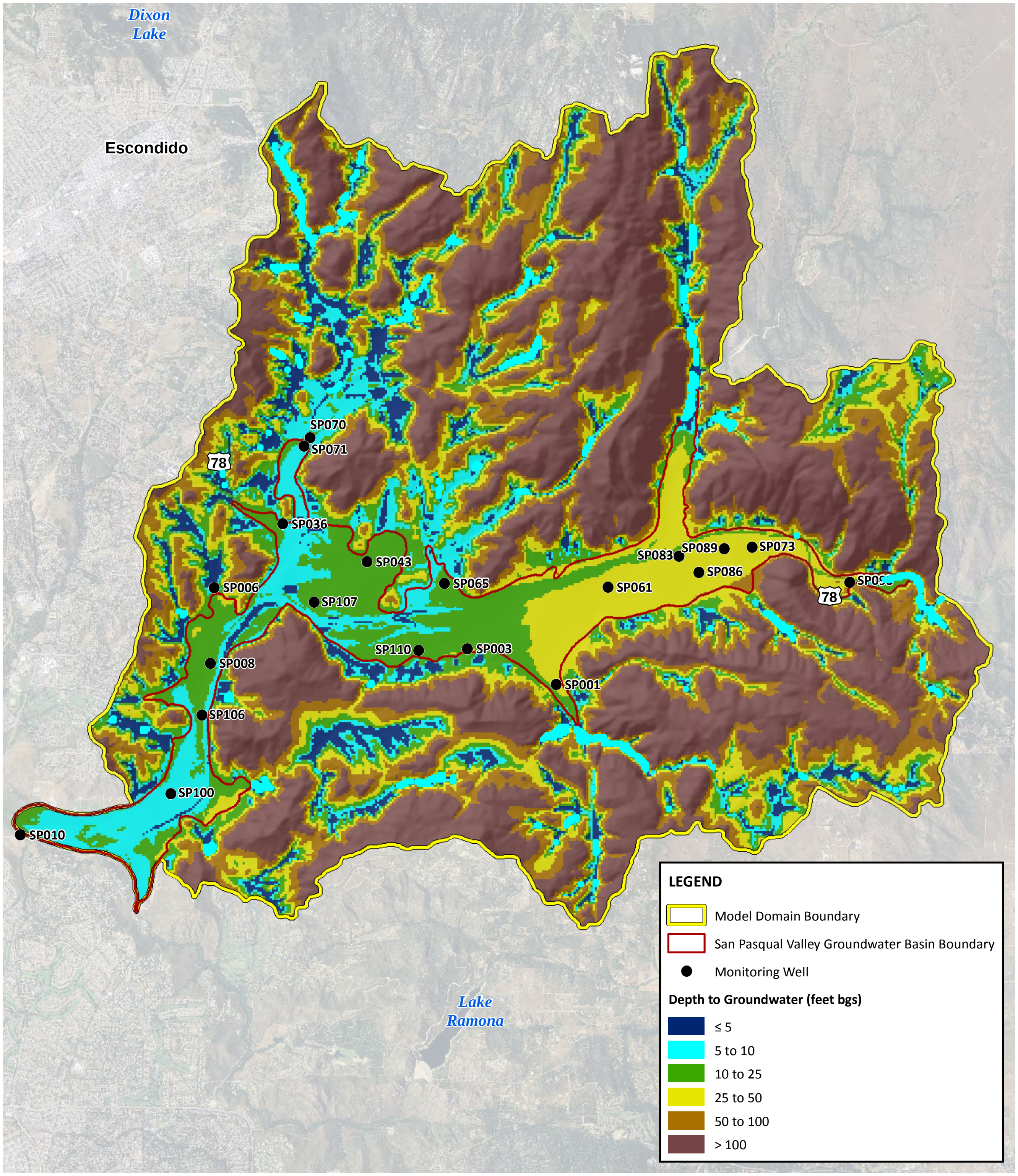


FIGURE B3-8

Modeled Water Table

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



NOTE:

bgs = Below ground surface.

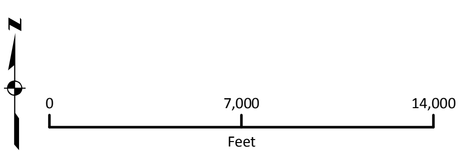
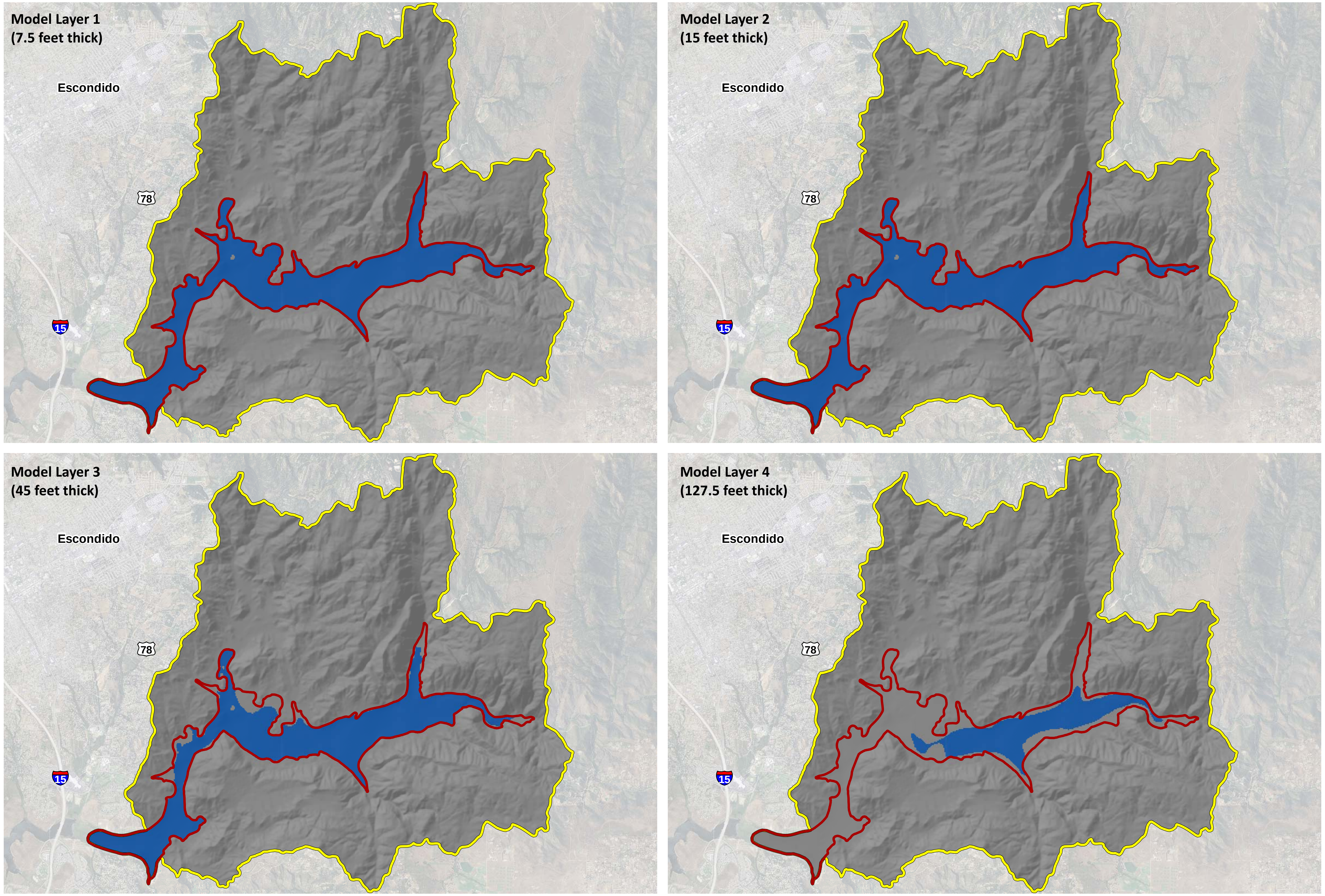


FIGURE B3-9

Modeled Depth to Groundwater

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary

Groundwater Balance Area

- Outside of Basin Alluvial Aquifer
- Inside of Basin Alluvial Aquifer

NOTE:

Model Layer 5 is Outside of the Basin Alluvial Aquifer with a Uniform Thickness of 255 Feet.

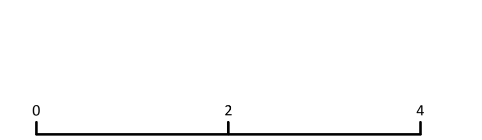
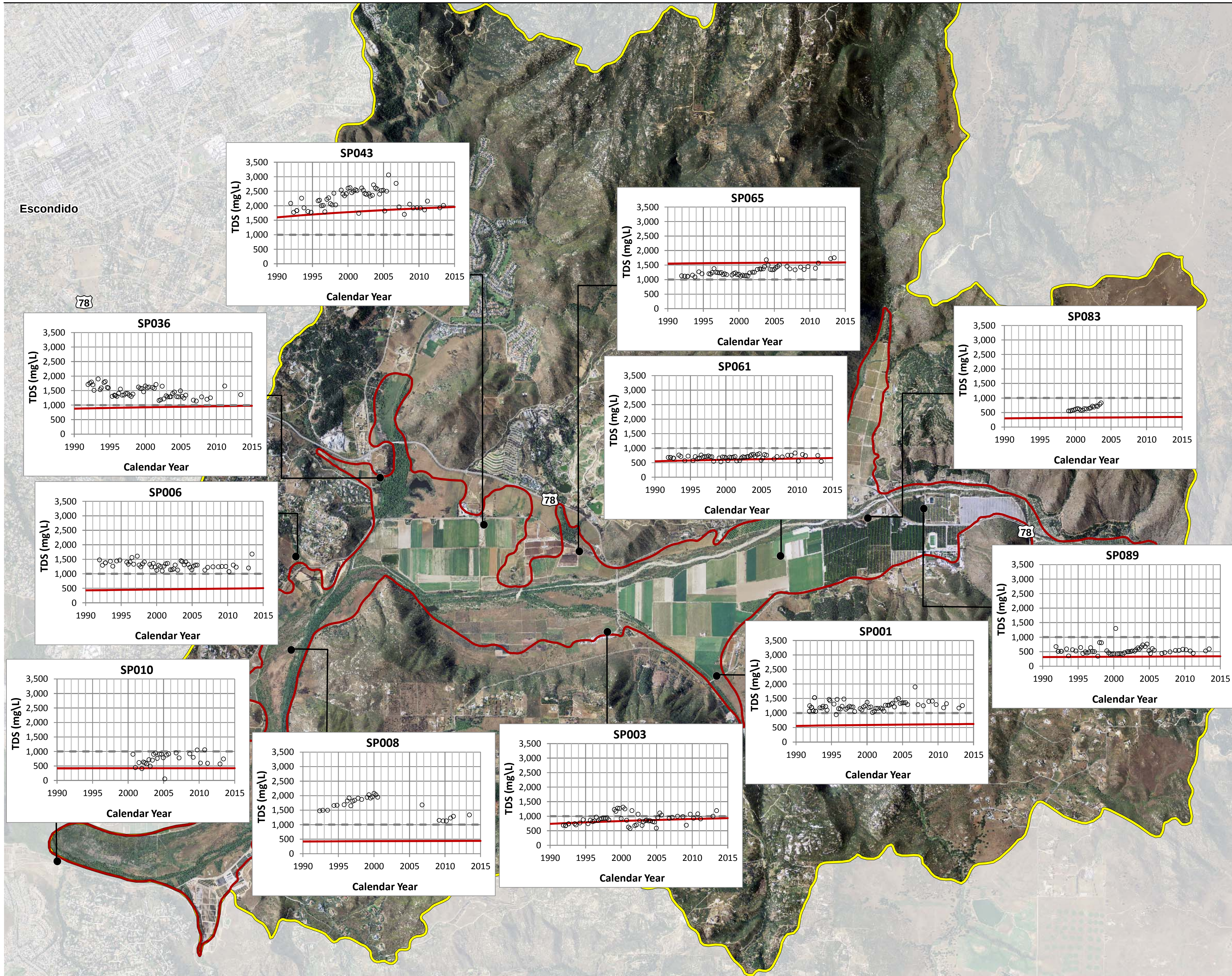


FIGURE B3-10
Modeled Basin Alluvial Aquifer Areas Used to Evaluate Groundwater Balances
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



MAP LEGEND

Study Area

San Pasqual Valley Groundwater Basin Boundary

Monitoring Well

PLOT LEGEND

Measured TDS Concentration (mg/L)

Modeled TDS Concentration (mg/L)

TDS Groundwater Water Quality Objective (1,000 mg/L)

NOTES:

mg/L = Milligrams per liter.

TDS = Total Dissolved Solids.

0 4,000 8,000

Feet

FIGURE B3-11

Modeled Time-series Total Dissolved Solids Concentrations

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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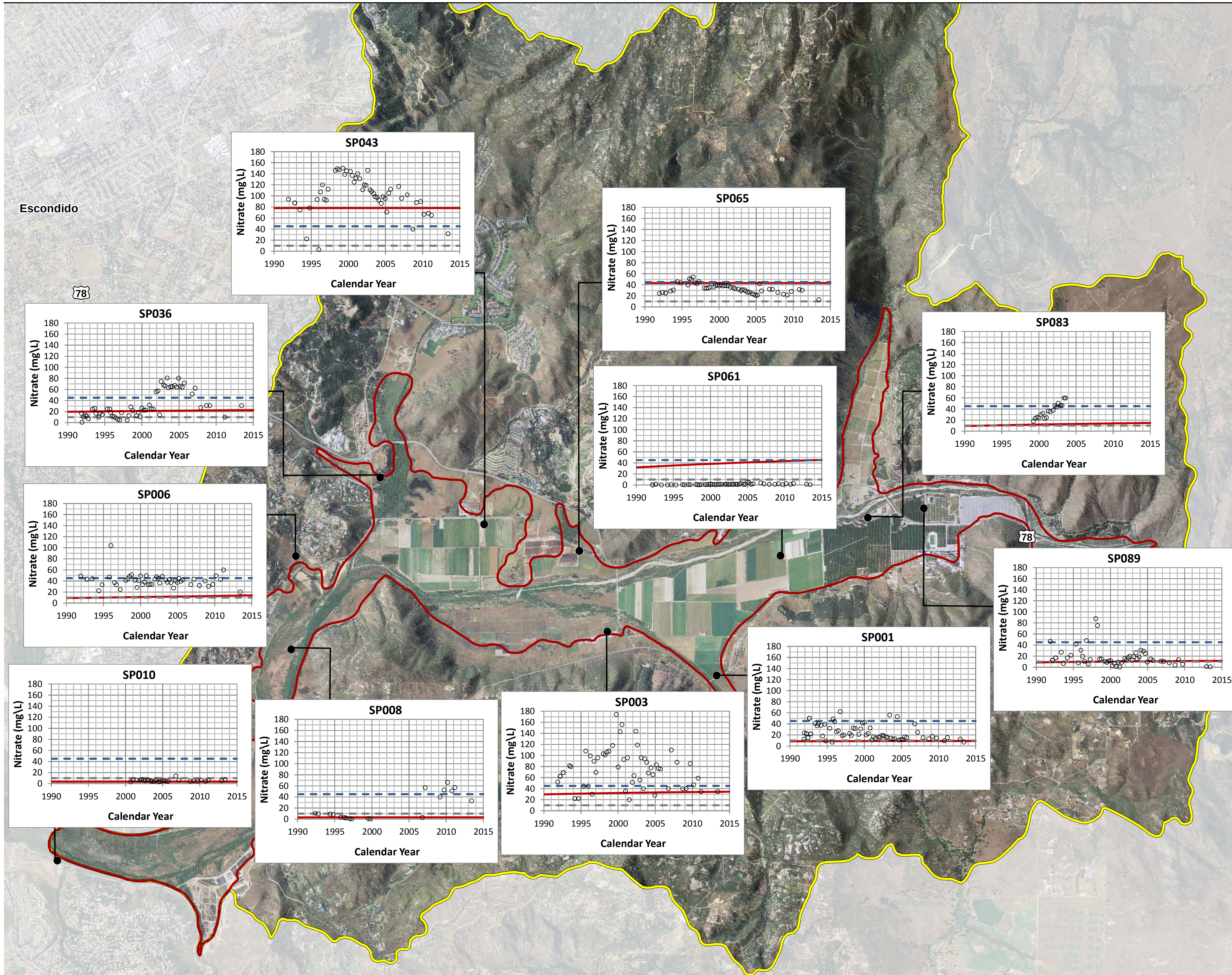

MAP LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- Monitoring Well

PLOT LEGEND

- Measured Nitrate Concentration (mg/L)
- Modeled Nitrate Concentration (mg/L)
- Nitrate Groundwater Water Quality Objective (10 mg/L)
- Nitrate USEPA Maximum Contaminant Level (45 mg/L)

NOTES:

Nitrate concentrations are expressed as NO_3.

mg/L = Milligrams per liter.

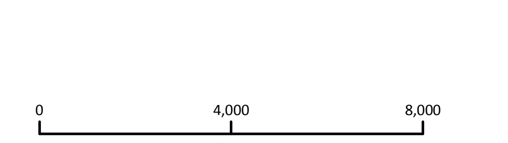

FIGURE B3-12

Modeled Time-series Nitrate Concentrations

Groundwater Model Documentation for
the Salt and Nutrient Management Plan
San Pasqual Valley, California

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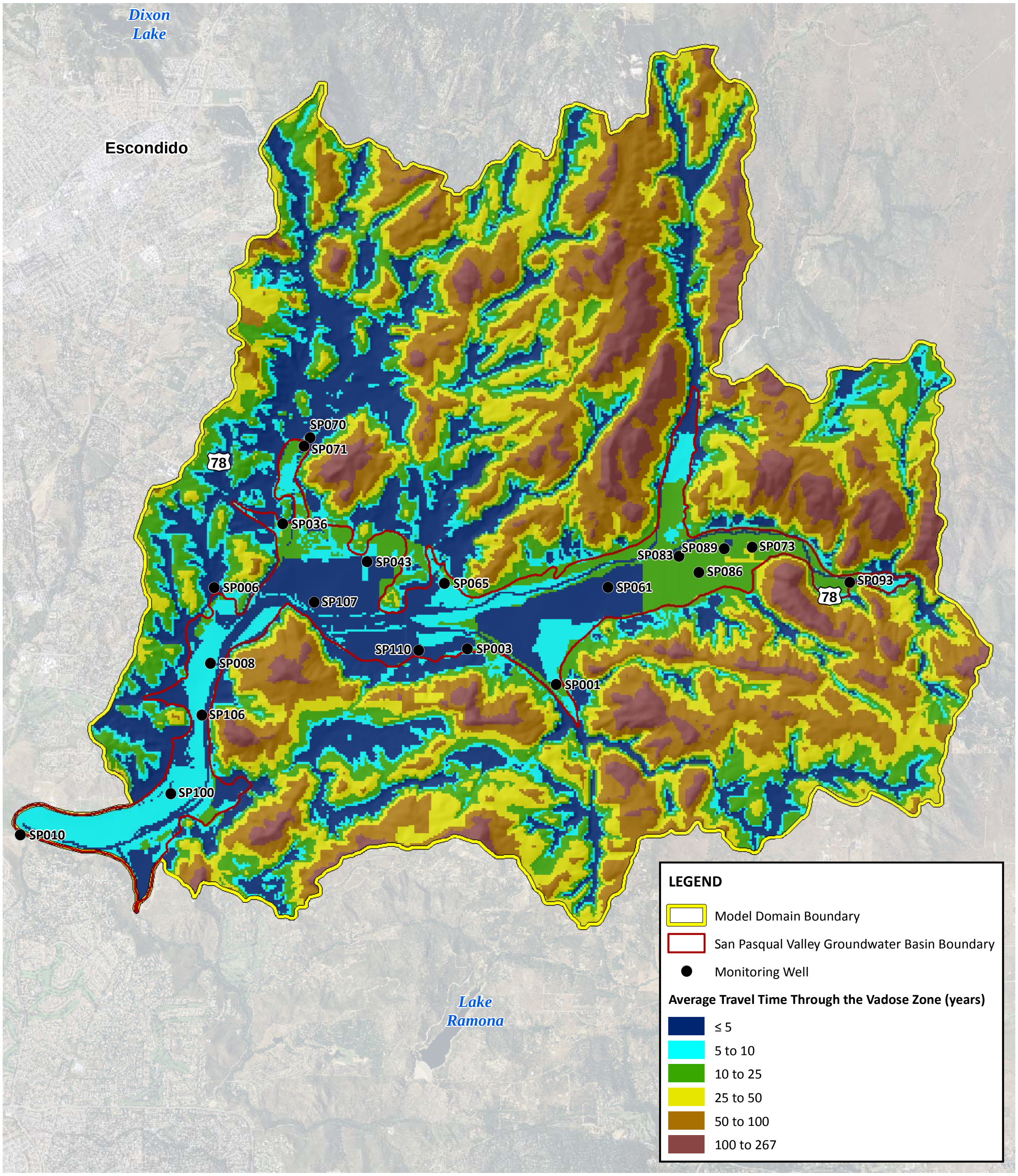

NOTE:

Travel time computed as the depth to water × 0.10 moisture content ÷ recharge rate.

FIGURE B3-13

Estimated Average Travel Time for Surface Constituents to Reach the Water Table

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

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SECTION B4

Model Application

The GFM and constituent transport models are tools that can help provide insight into the physical and chemical system in the Basin and surrounding subcatchment to help inform land management decisions. Although it is impossible to predict with certainty the future hydrology, availability and quality of imported and local water, land use, water use, and constituent conditions, these tools can forecast potential outcomes from hypothetical actions. Applications of these tools as described in this section are intended to provide insights into changes in Basin constituent concentrations from implementing changes in land management and ultimately support the development of the SNMP.

The City has not proposed land management changes that are aimed at reducing constituent concentrations in the Basin alluvial aquifer; however, four scenarios were evaluated using the calibrated GFM and constituent transport models. These scenarios were developed to help evaluate the impact of changed water and nutrient management within the Basin and, in some cases, were selected to evaluate the sensitivity of the Basin to extreme changes in land management rather than to represent any recommended actions. Table B4-1 summarizes these four scenarios.

TABLE B4-1
Summary of Predictive Modeling Scenarios
Groundwater Model Documentation for the Salt and Nutrient Management Plan, San Pasqual Valley, California

Scenario Name	Modeled Constituent	Description
Scenario 1– Baseline	TDS and Nitrate	Baseline scenario assumes current land and water uses in the study area will continue. Thus, model input values from calibration of the TDS and nitrate transport models are left unchanged.
Scenario 2– Reduced Irrigated Area	TDS	Scenario aimed at reducing TDS concentrations in the Basin alluvial aquifer by reducing irrigated areas served by Basin groundwater pumping, thereby reducing consumptive use and TDS loading from irrigated parcels represented in the model.
Scenario 3– Improved Nutrient Management	Nitrate	Scenario aimed at reducing nitrate concentrations in the Basin alluvial aquifer by implementing changes in nitrogen management throughout the subcatchment, thereby reducing nitrogen loading from agricultural and urban landscapes represented in the model.
Scenario 4– Conjunctive Use	TDS	Scenario aimed at reducing TDS concentrations in the Basin alluvial aquifer by implementing a conjunctive use project. Desalinization pumping would extract groundwater with elevated TDS near the central and western portions of the Basin. Extracted water would undergo ex situ treatment to remove some of the salts. The treated water would be used to irrigate selected parcels in lieu of using untreated local groundwater to irrigate these parcels, thereby removing TDS mass from the aquifer and reducing TDS loading from these irrigated parcels in the model.

Note:
All predictive modeling scenarios are simulated for a period of 50 years from 2015 through 2064.

Following is a discussion of how the calibrated models were modified to facilitate forecasting potential groundwater quality benefits from implementing each scenario summarized in Table B4-1.

B4.1 Model Setup for Predictive Simulations

All predictive modeling scenarios simulate conditions from 2015 through 2064. A multi-decade predictive period is necessary because changes in groundwater constituent concentrations would not occur for several decades after changes to land management practices are implemented, according to the models. Thus, a 50-year predictive simulation period was deemed adequate to gain insights into potential benefits from implementing each scenario.

The predictive simulations described herein maintain consistency among all GFM and constituent transport model parameters achieved during calibration unless otherwise noted.

B4.1.1 Scenario 1–Baseline

Scenario 1 assumes the current land and water uses in the study area would continue for another 50 years. Thus, no changes to the model input files were necessary for this particular scenario. Having baseline predictive scenarios for both TDS and nitrate provides predictive simulations against which other scenarios are compared.

B4.1.2 Scenario 2–Reduced Irrigated Area

Scenario 2 is was developed to evaluate the impact on TDS concentrations in the Basin alluvial aquifer from reducing irrigated areas and the associated groundwater pumping and consumptive use of groundwater. An aggressive assumption was selected to assume fallowing 50 percent of the irrigated areas that are currently served by Basin groundwater pumping. This reduction in the applied water demand resulted in a decrease in agricultural pumping in the Basin alluvial aquifer by approximately 2,900 AFY. Figure B4-1 shows the irrigated areas with reduced irrigation for Scenario 2, compared with Scenario 1.

The reduced deep percolation of applied water and agricultural pumping was incorporated into the appropriate recharge and well package cells of the GFM and TDS transport models used for Scenario 2.

B4.1.3 Scenario 3–Improved Nutrient Management

Scenario 3 was developed to evaluate the impact of reducing nitrate concentrations in the Basin alluvial aquifer by implementing changes in nitrogen management, thereby reducing nitrogen loading from agricultural and urban landscapes within the subcatchment. Conceptually, these management changes could be implemented in accordance with site-specific nutrient management plans for agriculture and public outreach programs for urban areas. To simplify implementing Scenario 3 in the GFM and nitrate transport model, the nitrate concentration associated with deep percolation recharge from all areas receiving fertilizer or manure applications were reduced by a set percentage, which varied for Scenarios 3a and 3b described below. No change in groundwater pumping or water use was assumed.

B4.1.3.1 Scenario 3a–95 Percent Reduction in Nitrate Loading to Groundwater

Scenario 3a was developed to evaluate the physical limit of potential groundwater nitrate improvements resulting from complete land conversion assuming surface nitrate loads to groundwater were reduced by 95 percent from current levels In addition to evaluating nitrate concentrations against the Basin groundwater WQO of 10 mg/L (as NO_3), comparisons of modeled nitrate concentrations were also made against the United States Environmental Protection Agency (USEPA) maximum contaminant level (MCL) of 45 mg/L (as NO_3).

B4.1.3.2 Scenario 3b–25 Percent Reduction in Nitrate Loading to Groundwater

Scenario 3b was developed to evaluate more practical reductions in nitrate loading to groundwater from changed fertilizer and manure management where associated nitrate loads to groundwater were reduced by 25 percent from current levels. Again, the reduced nitrate loading to groundwater was applied across all agricultural and urban landscapes within the subcatchment.

B4.1.4 Scenario 4–Conjunctive Use

Scenario 4 is aimed at reducing TDS concentrations in the Basin alluvial aquifer by implementing a conjunctive use project. Conceptually, this scenario includes desalinization pumping near selected central and western portions of the Basin where TDS concentrations are currently elevated (compare measured TDS concentrations in Figure B1-4 with desalinization well locations in Figure B4-2). Extracted groundwater would undergo ex situ treatment to remove salts. It is assumed that single-pass reverse osmosis would be the primary water treatment process to remove salts with an 80 percent water recovery and a treated TDS concentration of 345 mg/L. Groundwater would be extracted from 10 desalinization extraction wells in Scenario 4 at a combined rate of approximately 2,470 AFY (approximately 153 gpm per well), and this 2,470 acre-feet of desalinization pumping would replace approximately 1,974 acre-feet of local agricultural pumping. In other words, replacing 1,974 gpm of local agricultural pumping for irrigation with treated water is assumed to require 2,470 gpm of desalinization pumping (e.g., 2,470 gpm of water treatment influent × 80 percent recovery = 1,974 gpm treated water for irrigation). It is assumed that the brine by-product from the reverse osmosis treatment process would be disposed of outside the study area. The treated water would be used to irrigate selected parcels near the central and western portions of the Basin in lieu of using untreated local groundwater to irrigate these parcels, thereby removing TDS mass from the Basin alluvial aquifer and reducing TDS loading from these irrigated parcels. Figure B4-2 illustrates the general layout of Scenario 4.

B4.2 Model Application Results and Discussion

Considering the modeling objectives described in Section B1.1, output from each predictive simulation was evaluated using several methods, as follows:

- A color-flood map was prepared for each scenario that depicts the locations in the study area where constituent concentrations exceed groundwater WQOs at the end of the 50-year (i.e., 2015 through 2065) predictive simulation and compared with that presented for Scenario 1. This comparison is useful for gaining insights into potential areal improvements to the Basin assimilative capacity by implementing each scenario.
- The total constituent mass in the Basin alluvial aquifer was computed at the end of the 50-year predictive simulation for each scenario and compared with that presented for Scenario 1. This comparison is useful for gaining insights into the potential effectiveness of reducing overall constituent mass in the Basin alluvial aquifer by implementing each scenario.
- The constituent mass flux exiting the Basin alluvial aquifer as subsurface outflow was computed at the end of the 50-year predictive simulation for each scenario and compared with that presented for Scenario 1. This comparison is useful for gaining insights into the potential effectiveness of reducing constituent mass loading from the Basin alluvial aquifer to Lake Hodges by implementing each scenario.

B4.2.1 Overview of Model Application Summary Graphics

Figures B4-3 and B4-4 depict locations of the Basin alluvial aquifer where TDS and nitrate concentrations, respectively, are forecast to exceed the TDS and nitrate groundwater WQOs at the end of the 50-year simulation period of Scenario 1. Figure B4-5 depicts locations of the Basin alluvial aquifer where TDS concentrations are forecast to exceed the TDS groundwater WQOs at the end of the 50-year simulation period of Scenario 2. Figure B4-6 depicts locations of the Basin alluvial aquifer where nitrate concentrations exceed the nitrate groundwater WQOs at the end of the 50-year simulation period of Scenario 3a. Figure B4-7 depicts locations of the Basin alluvial aquifer where TDS concentrations exceed the TDS groundwater WQOs at the end of the 50-year simulation period of Scenario 4. Blue areas in Figures B4-3 through B4-7 coincide with modeled TDS and nitrate concentrations of less than 1,000 mg/L and 10 mg/L, respectively, and indicate locations and depths where some assimilative capacity for these constituents would remain at year 2065. Orange areas coincide with modeled TDS and nitrate concentrations greater than 1,000 mg/L and 10 mg/L, respectively, and indicate locations and depths where no assimilative capacity for these constituents would remain at year 2065. Portions of the study area that are not color-filled with blue or orange and show only the aerial photograph base map coincide with model cells representing unsaturated (i.e., vadose zone) locations.

Two-dimensional (i.e., footprint) areas were computed for model cells representing the saturated portions of the Basin alluvial aquifer (blue areas depicted in Figure B3-10) to help assess the modeled areal extent of Basin alluvial aquifer groundwater that exceeds the constituent groundwater WQOs. The upper plots in Figures B4-8 and B4-9 summarize these footprint areas exceeding the TDS and nitrate groundwater WQOs, respectively. These footprint areas are shown for all scenarios in 2015 (i.e., the beginning of the predictive simulation period) and for each individual scenario at the end of the predictive simulation period in 2065. The middle plots in Figures B4-8 and B4-9 summarize the modeled TDS and nitrate mass, respectively, in the model cells representing the saturated portions of the Basin alluvial aquifer at 2015 and 2065. The lower plots in Figures B4-8 and B4-9 summarize the modeled TDS and nitrate mass flux, respectively, from the Basin alluvial aquifer as subsurface outflow to Lake Hodges in 2015 and 2065. Values listed in parentheses at the tops of the 2065 bars in Figures B4-8 and B4-9 indicate the percent increase or decrease from the 2015 value.

B4.2.2 Interpretation of Results

Forecasts associated with Scenarios 2, 3a, and 4 indicate smaller footprint areas exceeding constituent groundwater WQOs and less constituent mass in the Basin alluvial aquifer than the 2065 forecast associated with Scenario 1 (see upper and middle plots in Figures B4-8 and B4-9). Implementation of Scenario 3b would help keep the footprint areas exceeding nitrate groundwater WQOs and the nitrate mass in the Basin alluvial aquifer similar to current conditions. Forecasts associated with Scenario 3a for nitrate and Scenario 4 for TDS are the only forecasts that indicate reductions in areas exceeding constituent groundwater WQOs and reductions in constituent mass in the Basin alluvial aquifer, compared with 2015 conditions. In other words, the modeling results suggests that continuing current land management practices under Scenario 1 conditions, or reducing the applied water demand in the study area by approximately 2,900 AFY (50 percent of current demands) under Scenario 2 conditions would both result in decreased assimilative capacity for TDS and nitrate or over the next 50 years.

Modeling results further suggest that under all scenarios described herein, subsurface mass fluxes of TDS and nitrate to Lake Hodges are expected to increase over time, compared with current conditions (see lower plots in Figures B4-8 and B4-9). This is due in part to the relatively large mass of nitrate already in the groundwater system near the outflow to Lake Hodges, the limited pumping of groundwater but high phreatophyte water use in this area, and the continued migration of nitrate mass in the groundwater system downgradient. Furthermore, increased constituent mass fluxes to Lake Hodges could result from increased groundwater elevations near the middle of the Basin relative to those in the lower San Pasqual Narrows under some scenarios, thereby increasing the overall Basin hydraulic gradient and volumetric groundwater flow into Lake Hodges. If there were an increase in the volumetric groundwater outflow from the Basin alluvial aquifer to Lake Hodges, then constituent loads could increase despite small decreases in constituent concentrations in the San Pasqual Narrows, according to the model.

The hydraulic restriction to groundwater outflow from the Basin caused by Lake Hodges limits the amount of groundwater outflow at the lower Basin boundary. The horizontal hydraulic gradient in the San Pasqual Narrows (i.e., 2×10^{-3} foot per foot, see Figure B3-8), coupled with the K_h values in that portion of the Basin (i.e., 37.5 ft/day, see Figure B3-2), indicate that the average groundwater “particle” not intercepted by pumping wells would take more than 100 years to move through the San Pasqual Narrows to the Basin boundary near Lake Hodges (approximately 20,000 feet), assuming an effective porosity of 0.16. This limited groundwater flushing through the San Pasqual Narrows is likely due in part to a backwater effect from Lake Hodges that flattens the hydraulic gradients near the downgradient end of the Basin. This backwater effect might also contribute to shallow groundwater levels and increased evapoconcentration of salts in lower portions of the San Pasqual Narrows. Thus, reductions in subsurface mass fluxes of TDS and nitrate to Lake Hodges in the lower San Pasqual Narrows in response to changes in land and water management in upgradient areas of the Basin could take several decades or never be manifest.

Modeling results also suggest that even an unrealistic reduction of 95 percent of the nitrate concentrations associated with nitrogen loading from fertilizer and manure management under Scenario 3a conditions would not decrease the footprint area where nitrate concentrations exceed the nitrate groundwater WQO by more than half ($2.1\ mi^2 \div 4.2\ mi^2$) of what would result under Scenario 1 conditions (see upper plot in Figure B4-9). Under current land use and current nutrient management practices, the assimilative capacity for nitrate will decrease over time, according to the model. However, implementation of Scenario 3b, which assumes a 25 percent reduction in nitrate loading from fertilizer and manure management, is projected to curb further increases in nitrate mass in the Basin alluvial aquifer over time.

For comparative purposes, in addition to evaluating modeled nitrate concentrations against the Basin groundwater WQO of 10 mg/L (as NO_3), comparisons also were made against the USEPA MCL of 45 mg/L (as NO_3). Figure B4-10 compares the footprint areas where modeled nitrate concentrations exceed both 10 mg/L and 45 mg/L. As expected, a greater portion of the Basin would have remaining assimilative capacity for nitrate if the nitrate groundwater WQO of the Basin were equal to the USEPA MCL, according to the model. Implementation of Scenario 3b would help keep the footprint areas exceeding nitrate groundwater WQOs and MCLs similar to current conditions, according to the model (Figure B4-10).

Scenario 4 was the only scenario evaluated that resulted in improved groundwater TDS conditions in the future relative to current conditions (see Figure B4-8). The model suggests that improvements could be made in different subareas of the Basin under Scenario 4 conditions, but the overall forecast suggests only limited improvements would occur within 50 years of implementing the conjunctive use project simulated. Conjunctive management scenarios that are more aggressive than those evaluated for the SNMP could be evaluated with future model updates, if needed.

A previous conjunctive use study for the Basin (Camp Dresser & McKee [CDM], 2010) examined aquifer storage and recovery scenarios that might, in concept, improve the overall reliability and flexibility of the City's water supply. The conjunctive use projects evaluated in that study were focused specifically on water supply objectives. Based on preliminary analysis using the GFM developed under this study, however, there may be potential to combine water supply objectives and WQOs in redesigning conjunctive use strategies and realize additional benefits from these projects in the future.

B4.3 Model Application Summary

The predictive versions of the GFM and constituent transport models described herein were developed to forecast steady-state groundwater flow fields, along with the transport of TDS and nitrate through these flow fields under hypothetical land use conditions. Although the City has not proposed land and water management changes in an attempt to reduce constituent concentrations in the Basin alluvial aquifer, four scenarios were evaluated to provide insights into potential benefits of implementing some changes in land and water management. All predictive modeling scenarios simulate conditions from 2015 through 2064. A 50-year predictive simulation period was deemed adequate to achieve the modeling objectives.

Modeling results indicate that continuing existing land management practices under Scenario 1 conditions or implementing any one of Scenarios 2 through 4 will not individually decrease all constituent concentrations to below the groundwater WQO in the Basin within the next 50 years. Site-specific flow dynamics in the Basin cause some subareas to pump and transmit groundwater and constituents more readily than in other subareas. Substantially improving overall groundwater quality in the Basin will require implementing not only an improved monitoring program but also a combination of strategies for land management and conjunctive use.

B4.4 Model Application Limitations

Models are imperfect in that they do not accurately describe all aspects of interrelated physical and chemical processes beneath a study area. The sparse hydraulic and chemical data, and data from well construction, limit the degree to which the model assumptions and results can be constrained. The modeling solutions discussed herein should be considered nonunique, meaning that different combinations of model parameter values could produce equally good fits to the calibration targets, but result in predictive results that are different. Groundwater flow and quality could vary in response to future changes in water policy, hydrology, land use, and water use in ways that were not accounted for with the four scenarios evaluated as part of this effort. Thus, groundwater flow and constituent migration pathways in the future will not necessarily follow those indicated with the GFM and constituent transport models. Although the forecasts described herein are considered plausible and reasonable, the fundamental assumptions inherent in these models and the adequacy of their input data should be considered when using model output to help make important land management decisions. Model output should be scrutinized and used in conjunction with observational data and professional judgment.

The existing versions of the GFM and constituent transport models do not include dynamic feedback loops between the transient groundwater quality being simulated at model cells representing agricultural wells and the cells representing parcels that are irrigated with the extracted groundwater. The water quality assigned to the water being applied for irrigation is based on current conditions or altered current conditions specific to a given scenario. This limitation with the current models may, in some cases, underestimate the benefit of implementing the scenarios described herein. Incorporating such feedback loops in these models is possible, but that would require resources beyond the current scope of work. Such an effort could be undertaken with future model updates, if needed.

Additional information related to the aquifer’s physical and chemical parameters and their spatial distributions would help constrain the model. As more hydraulic and chemical data become available, hydraulic and chemical parameter values should be evaluated periodically and compared with those assigned in the GFM and constituent transport models. Obtaining this information, along with detailed information on pumping and well construction in the study area, would provide the opportunity to improve the CSM and predictive capabilities of these models. It will also be important to update the GFM and constituent transport models periodically as additional data become available and as knowledge of groundwater conditions evolves.

B4.5 Other Potential Model Applications

Now that the GFM and constituent transport models have been developed, they could be used to aid in the following:

- Developing a surface water and groundwater monitoring program
- Forecasting potential outcomes from implementing other proposed actions not discussed herein
- Testing hypotheses about groundwater hydraulics and constituent transport processes in the Basin
- Supporting development of project documents such as feasibility studies, conceptual designs, water supply plans, and monitoring work plans
- Guiding capital investments for water supply and water quality projects
- Supporting the planning and implementation stages of project designs
- Guiding capital investments associated with environmental and water supply projects
- Providing technical graphics for public outreach efforts

Some of these potential applications are described in the SNMP.

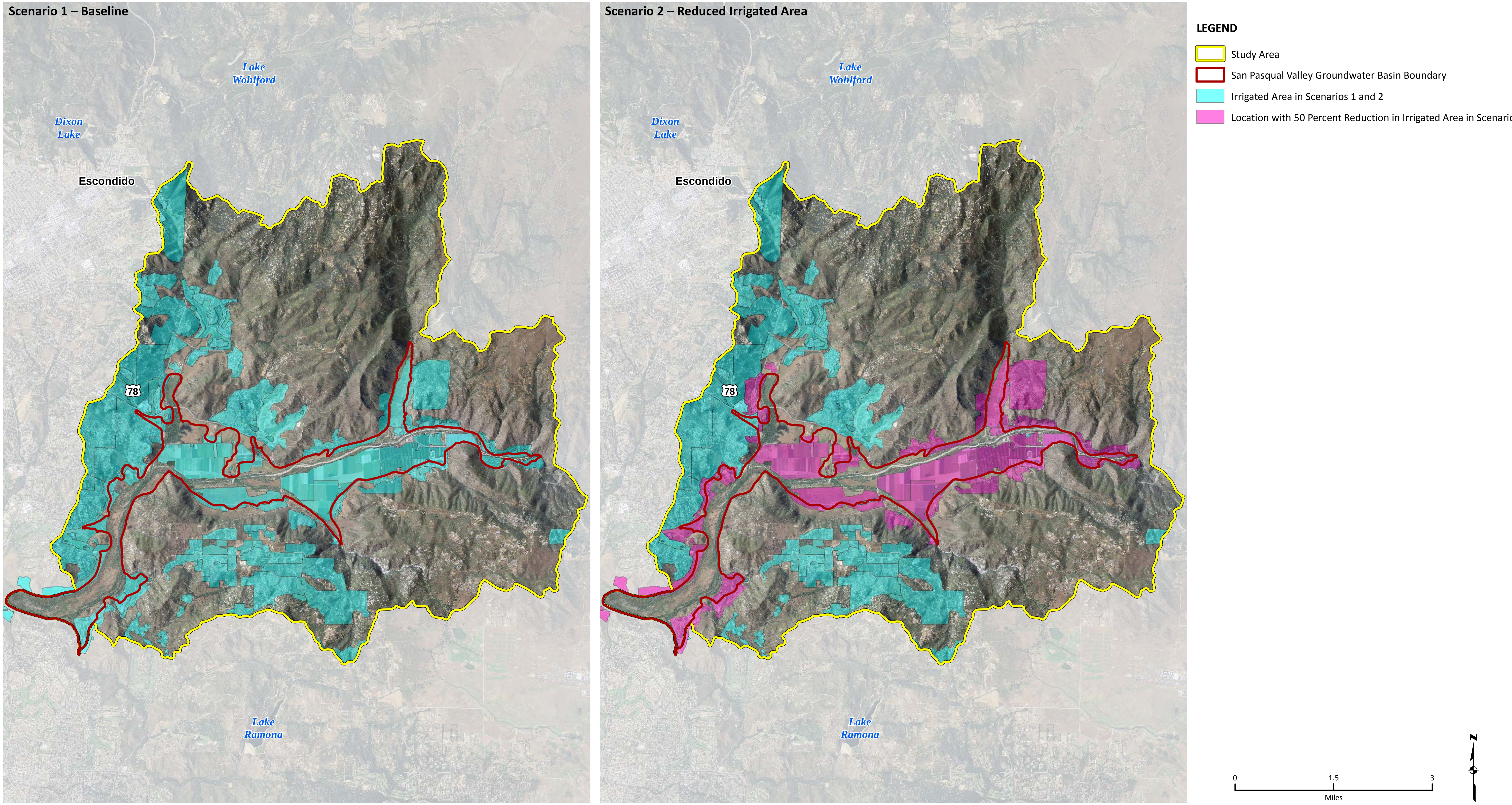
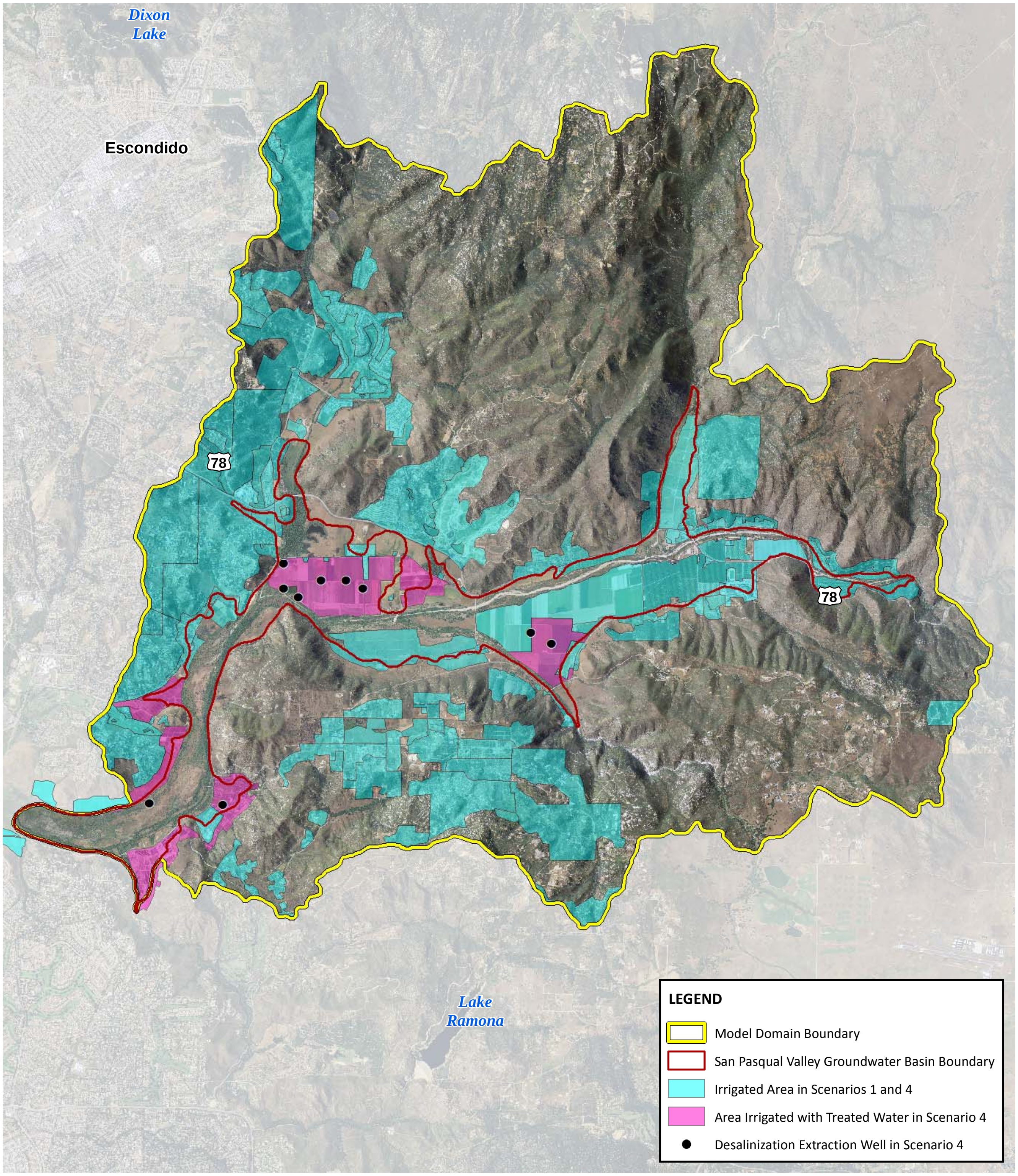


FIGURE B4-1
Comparison of Irrigated Areas:
Scenario 1 versus Scenario 2
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



NOTE:

Approximately 2,470 acre-feet of desalinization pumping is assumed from 10 extraction wells, each pumping approximately 153 gallons per minute.

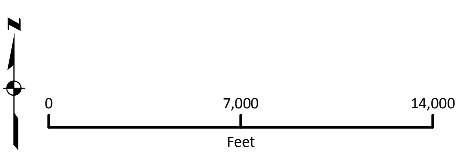
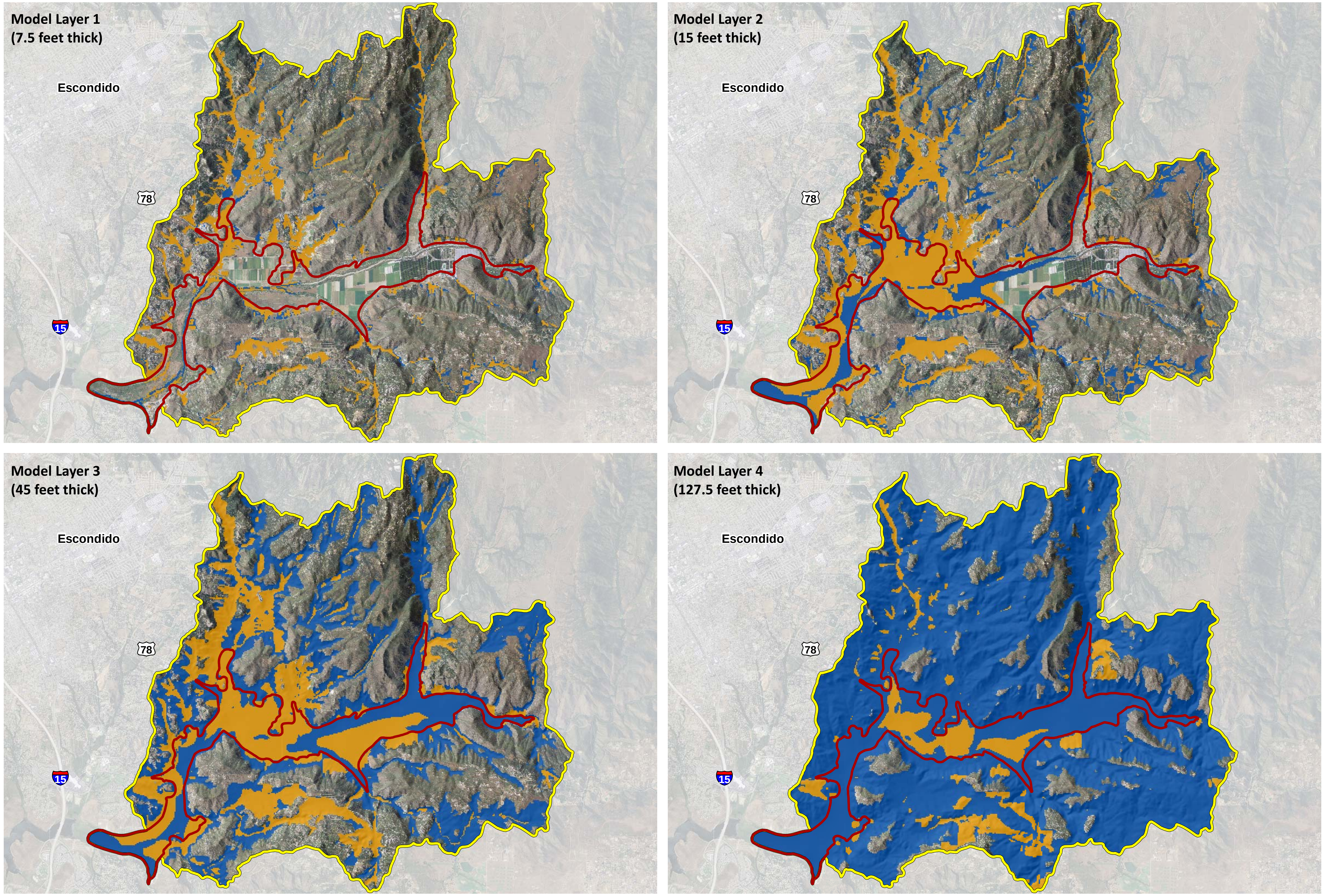


FIGURE B4-2

General Layout of Scenario 4 – Conjunctive Use

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

CH2MHILL.



LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- TDS Concentration < Groundwater Water Quality Objective (assimilative capacity remains)
- TDS Concentration ≥ Groundwater Water Quality Objective (no assimilative capacity remains)

NOTES:

The TDS groundwater Water Quality Objective for the Basin is 1,000 milligrams per liter (mg/L).

Model Layer 5 is below the Basin alluvial aquifer, so results for that 255-foot thick layer are not shown.

Results are taken from the end of the predictive simulation, which corresponds to year 2065 (i.e., 50 years after 2015).

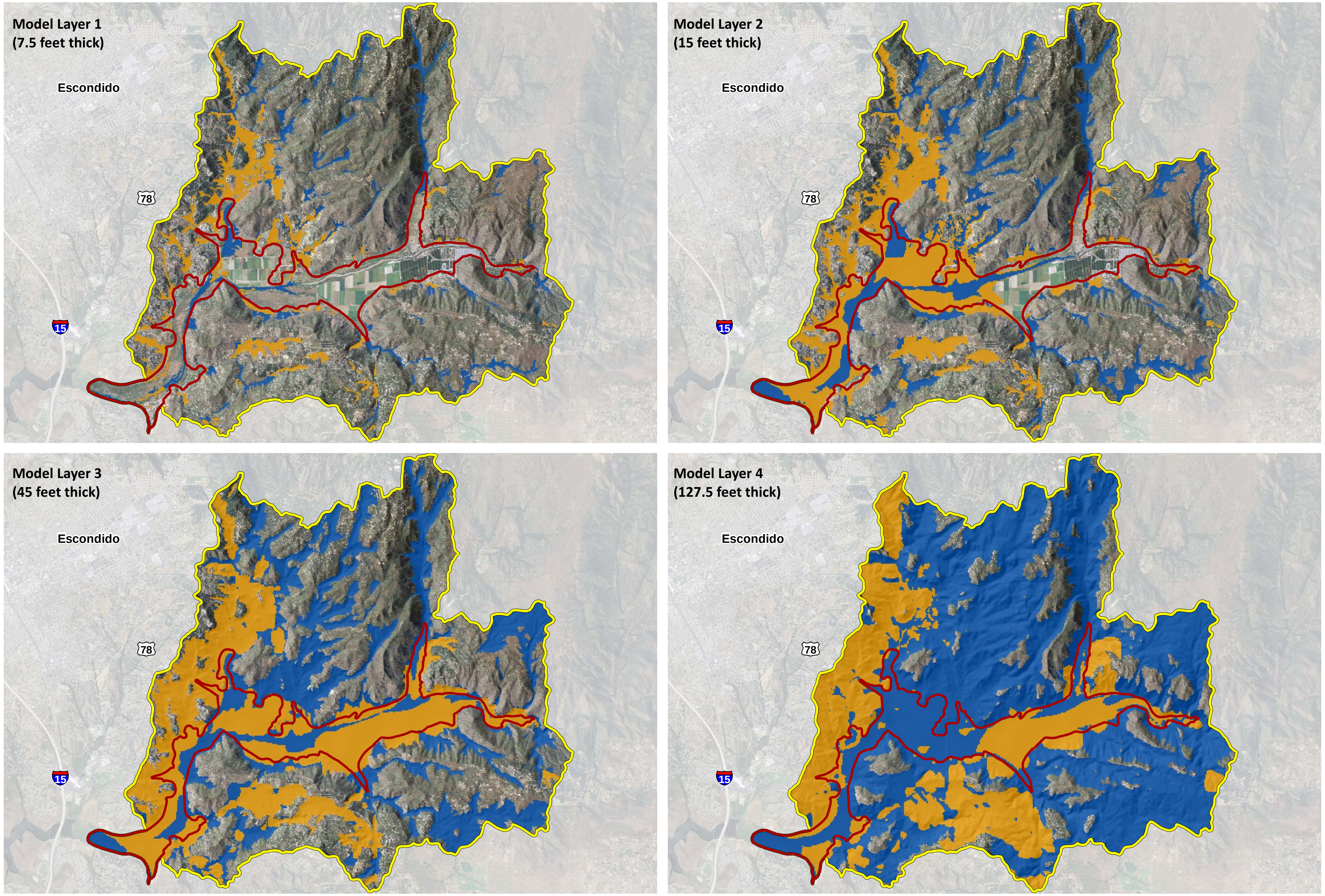
Areas showing the background aerial photograph within the study area correspond to dry model cells (vadose zone).

TDS = Total Dissolved Solids.

0 2 4
Miles

FIGURE B4-3
Assimilative Capacity Evaluation:
Scenario 1 – Total Dissolved Solids
Groundwater Model Documentation for the Salt and Nutrient Management Plan
San Pasqual Valley, California

CH2MHILL.



LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- Nitrate Concentration < Groundwater Water Qualtiy Objective (assimilative capacity remains)
- NitrateConcentration ≥ Groundwater Water Quality Objective (no assimilative capacity remains)

NOTES:

The nitrate groundwater Water Quality Objective for the Basin is 10 milligrams per liter (mg/L).

Model Layer 5 is below the Basin alluvial aquifer, so results for that 255-foot thick layer are not shown.

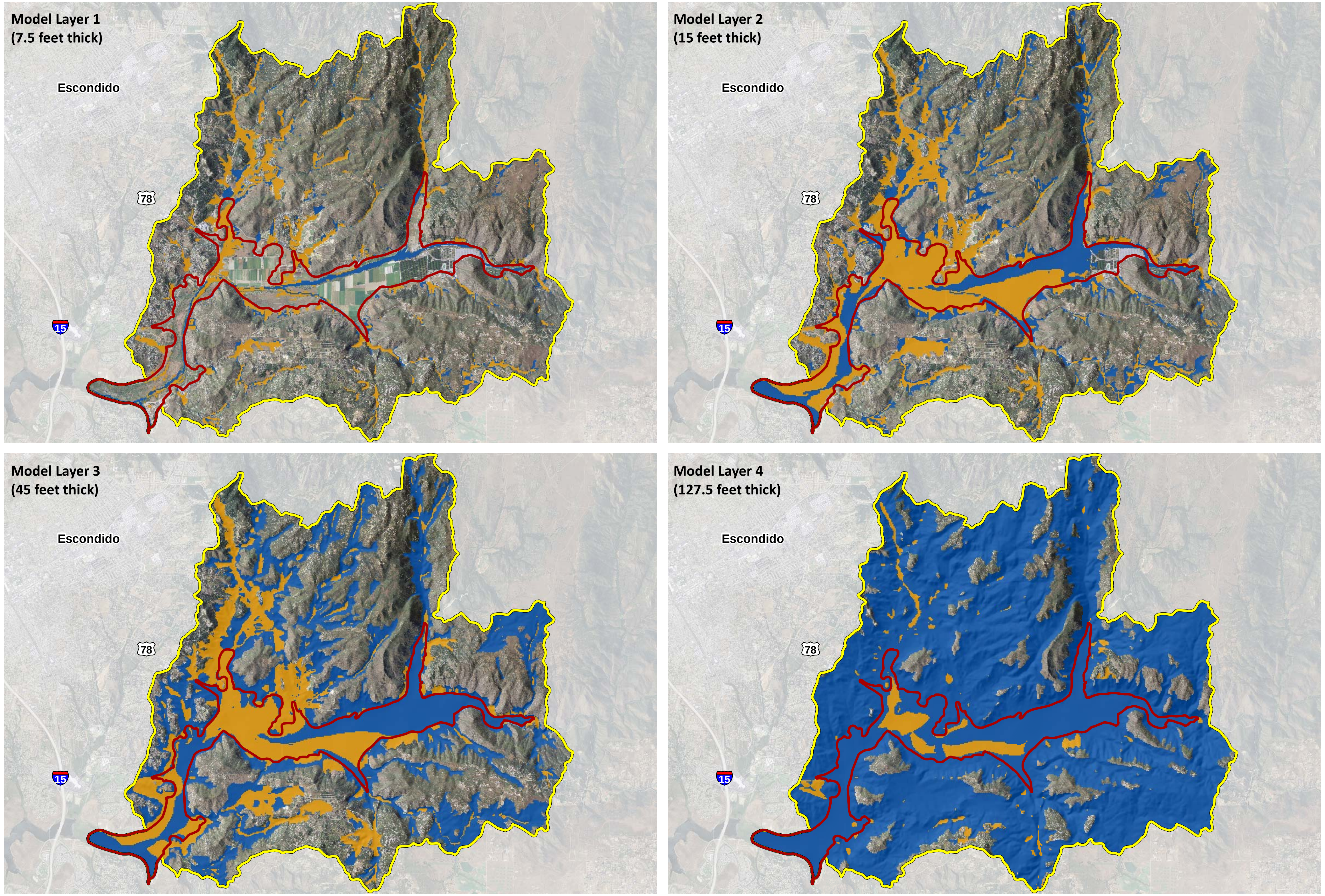
Results are taken from the end of the predictive simulation, which corresponds to year 2065 (i.e., 50 years after 2015).

Areas showing the background aerial photograph within the study area correspond to dry model cells (vadose zone).

Nitrate concentrations are expressed as NO3.

0 2 4
Miles

FIGURE B4-4
Assimilative Capacity Evaluation:
Scenario 1 – Nitrate
Groundwater Model Documentation for the Salt and Nutrient Management Plan
San Pasqual Valley, California



LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- TDS Concentration < Groundwater Water Quality Objective (assimilative capacity remains)
- TDS Concentration ≥ Groundwater Water Quality Objective (no assimilative capacity remains)

NOTES:

The TDS groundwater Water Quality Objective for the Basin is 1,000 milligrams per liter (mg/L).

Model Layer 5 is below the Basin alluvial aquifer, so results for that 255-foot thick layer are not shown.

Results are taken from the end of the predictive simulation, which corresponds to year 2065 (i.e., 50 years after 2015).

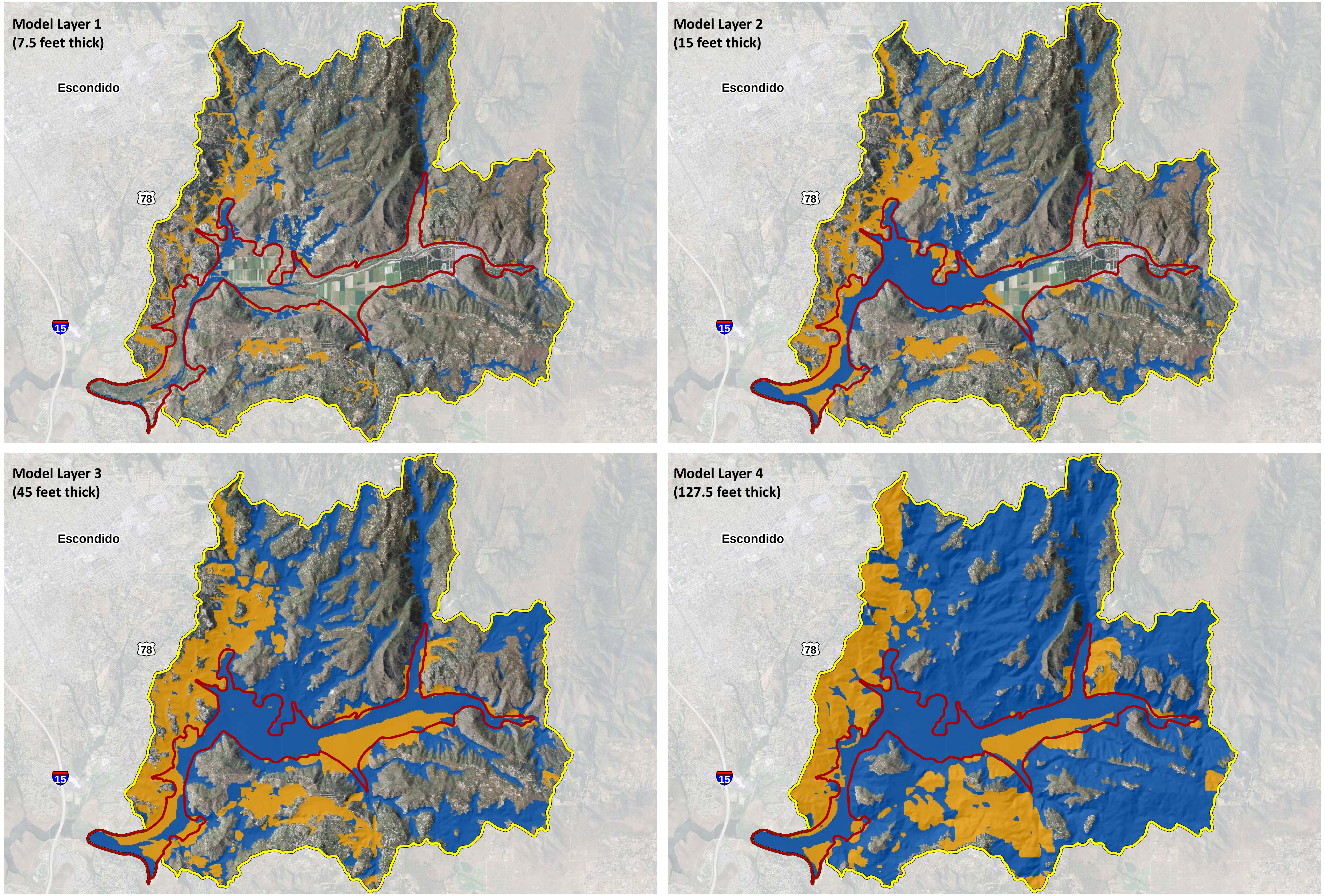
Areas showing the background aerial photograph within the study area correspond to dry model cells (vadose zone).

TDS = Total Dissolved Solids.

0 2 4
Miles

FIGURE B4-5
Assimilative Capacity Evaluation:
Scenario 2 – Total Dissolved Solids
Groundwater Model Documentation for the Salt and Nutrient Management Plan
San Pasqual Valley, California

CH2MHILL.



LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- Nitrate Concentration < Groundwater Water Qualtiy Objective (assimilative capacity remains)
- NitrateConcentration ≥ Groundwater Water Quality Objective (no assimilative capacity remains)

NOTES:

The nitrate groundwater Water Quality Objective for the Basin is 10 milligrams per liter (mg/L).

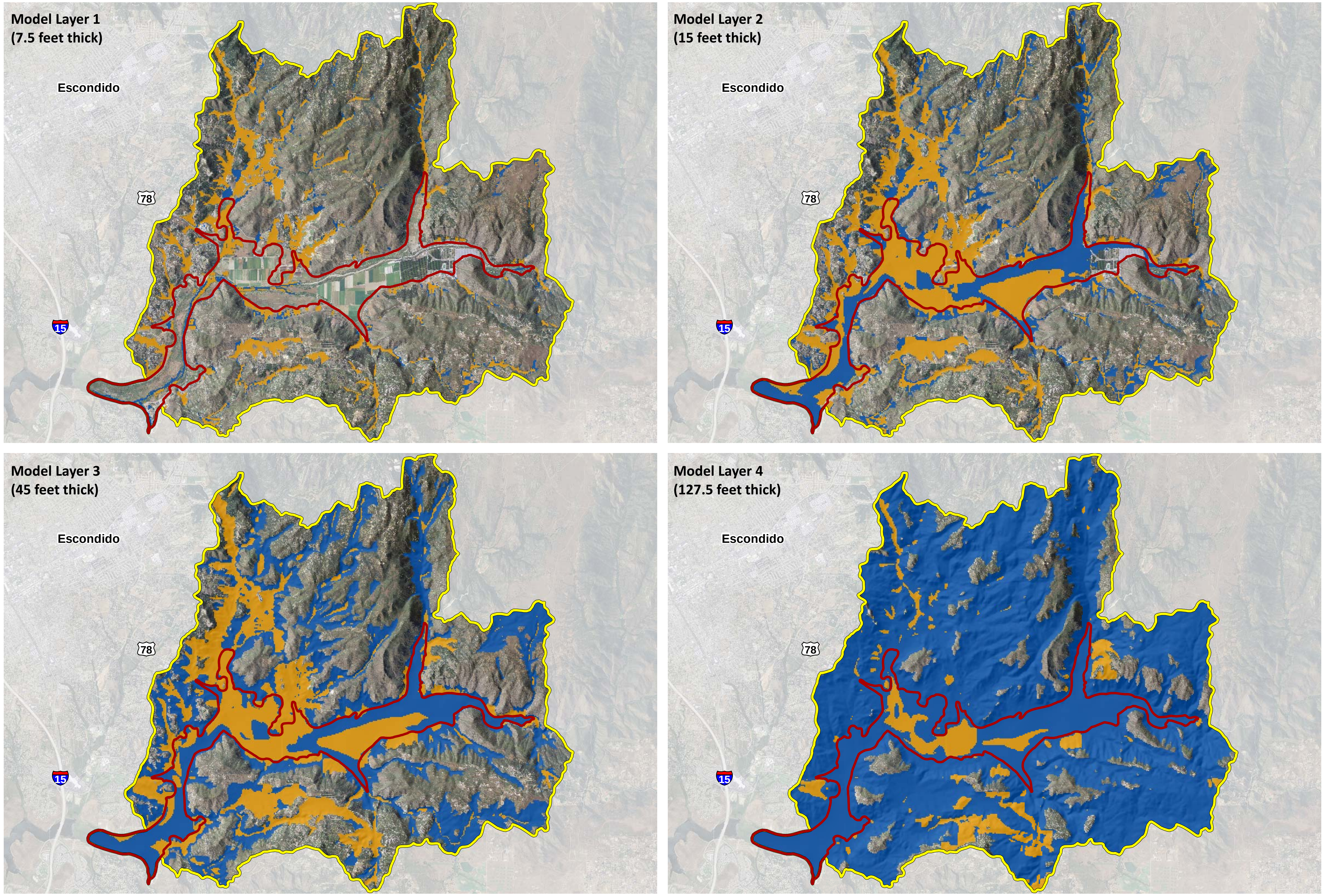
Model Layer 5 is below the Basin alluvial aquifer, so results for that 255-foot thick layer are not shown.

Results are taken from the end of the predictive simulation, which corresponds to year 2065 (i.e., 50 years after 2015).

Areas showing the background aerial photograph within the study area correspond to dry model cells (vadose zone).

Nitrate concentrations are expressed as NO3.

FIGURE B4-6
Assimilative Capacity Evaluation: Scenario 3a – Nitrate
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



LEGEND

- Study Area
- San Pasqual Valley Groundwater Basin Boundary
- TDS Concentration < Groundwater Water Quality Objective (assimilative capacity remains)
- TDS Concentration ≥ Groundwater Water Quality Objective (no assimilative capacity remains)

NOTES:

The TDS groundwater Water Quality Objective for the Basin is 1,000 milligrams per liter (mg/L).

Model Layer 5 is below the Basin alluvial aquifer, so results for that 255-foot thick layer are not shown.

Results are taken from the end of the predictive simulation, which corresponds to year 2065 (i.e., 50 years after 2015).

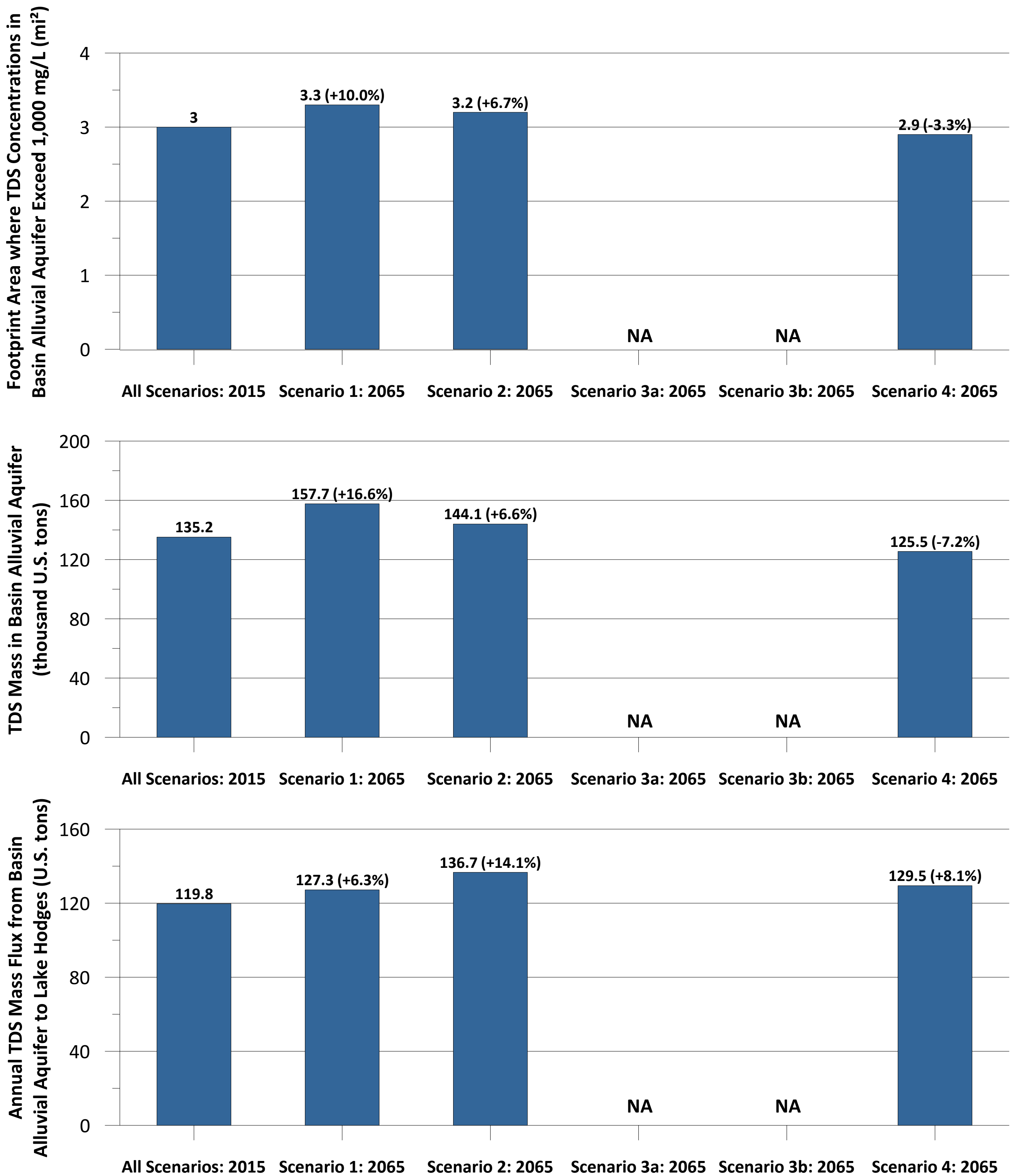
Areas showing the background aerial photograph within the study area correspond to dry model cells (vadose zone).

TDS = Total Dissolved Solids.

0 2 4
Miles

N

FIGURE B4-7
Assimilative Capacity Evaluation:
Scenario 4 – Total Dissolved Solids
Groundwater Model Documentation for the Salt and Nutrient Management Plan
San Pasqual Valley, California



NOTES:

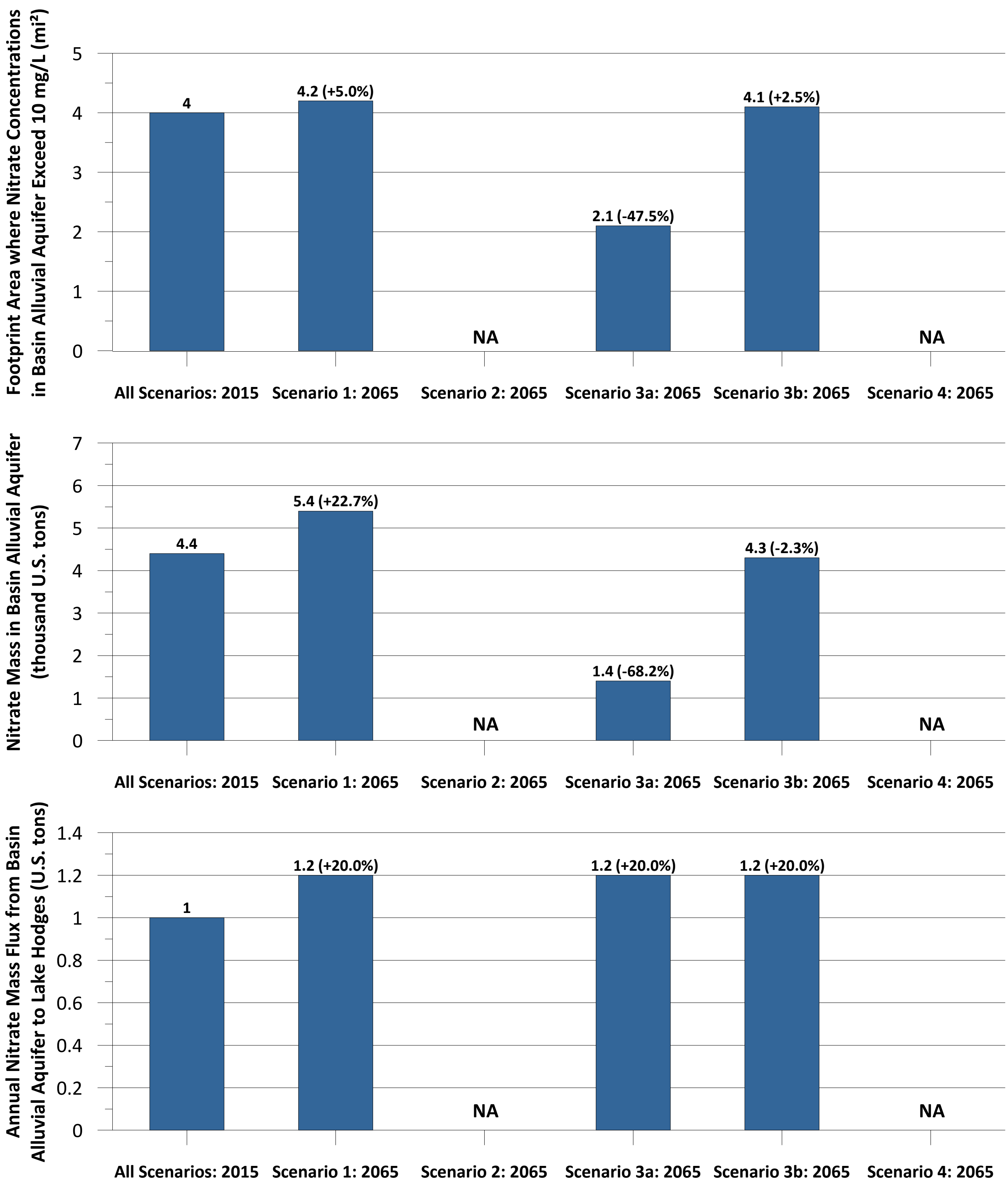
NA = Not applicable for Total Dissolved Solids.

Value in parentheses on top of each 2065 bar indicates the percent increase or decrease from the 2015 value.

mg/L = Milligrams per liter.

mi^2 = Square mile.

FIGURE B4-8
Comparison of Scenario Results: Total Dissolved Solids
Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



NOTES:

NA = Not applicable for nitrate.

Value in parentheses on top of each 2065 bar indicates the percent increase or decrease from the 2015 value.

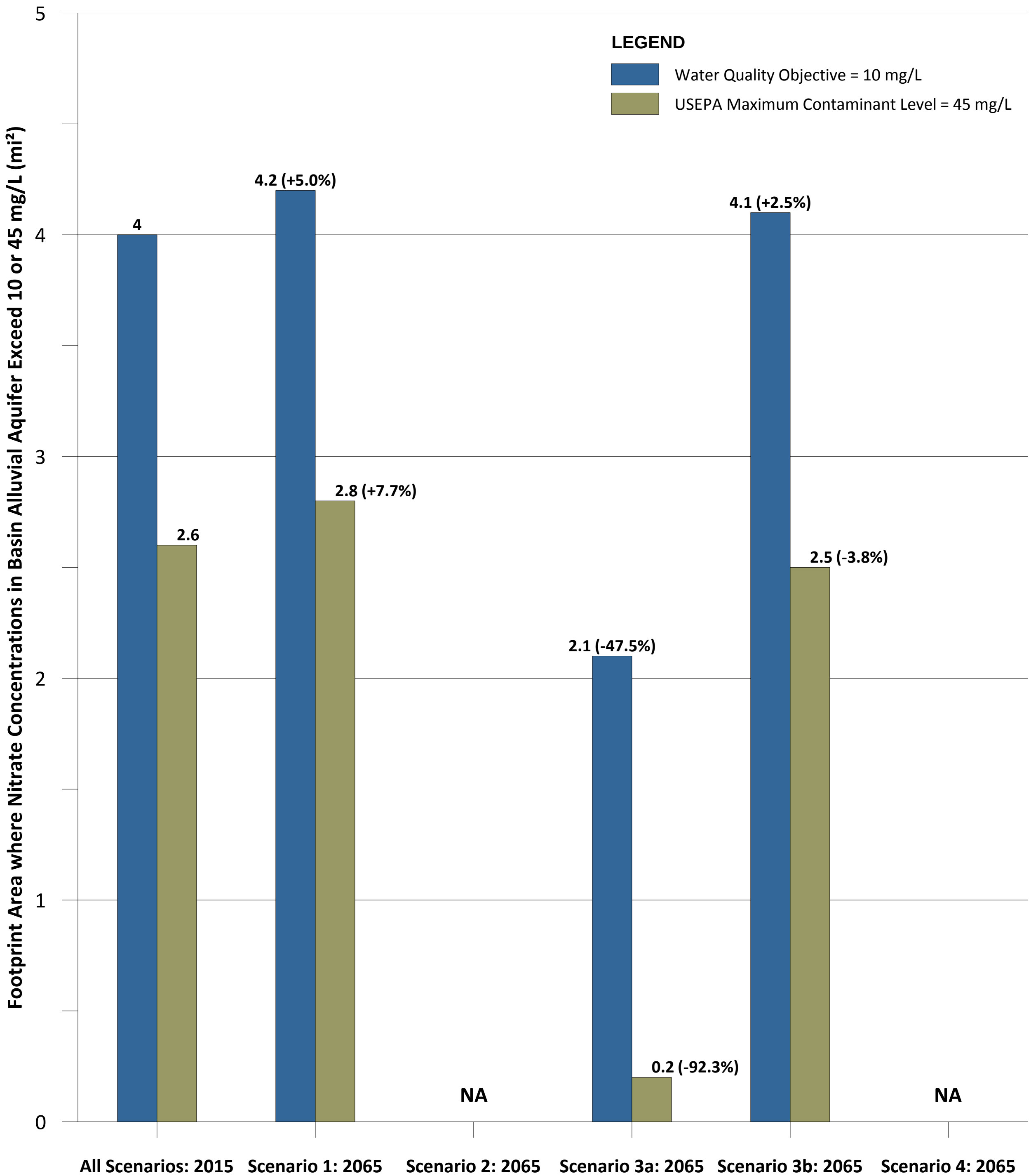
mg/L = Milligrams per liter.

mi^2 = Square mile.

FIGURE B4-9

Comparison of Scenario Results: Nitrate

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California



NOTES:

NA = Not applicable for nitrate.

Value in parentheses on top of each 2065 bar indicates the percent increase or decrease from the 2015 value.

Nitrate concentrations are expressed as NO_3.

mg/L = Milligrams per liter.

mi^2 = Square mile.

FIGURE B4-10

Nitrate Water Quality Objective Evaluation

Groundwater Model Documentation for the Salt and Nutrient Management Plan San Pasqual Valley, California

\\ODIN\PROJ\SANDIEGOCITYOF\437947\SANPASQUALGROUNDWATER\DOCS\MODELAPPENDIX\FIGURES\GRF\FIGB4-10_NO3_WQO45.GRF

SECTION B5

Works Cited

Allen, R.G., L.S. Pereira, D. Raes and M. Smith. 1998. *Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements.* Food and Agriculture Organization of the United Nations (FAO) Irrigation and Drainage Paper 56.

American Society for Testing and Materials. 1996. *Standard Guide for Calibrating a Ground-Water Flow Model Application*. D5981-96. Reapproved 2002.

Camp, Dresser, & McKee (CDM). 2010. *San Pasqual Groundwater Conjunctive Use Study – Final Study Report.* Appendix B. City of San Diego. May.

City of San Diego Water Department, MWH Americas, and Katz and Associates. 2007. *San Pasqual Basin Groundwater Management Plan*. November.

CH2M HILL. 2001. *Characterization of the San Pasqual Groundwater Basin.* Technical Memorandum prepared for Hatch & Parent. April.

Clement, T.P. 1997. *A Modular Computer Code for Simulating Reactive Transport in 3 Dimensional Groundwater Systems.* Pacific Northwest National Laboratory. PNNL-11720.

Doherty, J. 2010. *Addendum to the PEST Manual*. September.

Doherty, J. 2004. *PEST Model-Independent Parameter Estimation User Manual.* Fifth Edition. July.

Flach, G., S. Crisman, and F. Molz, F. 2004. “Comparison of Single-Domain and Dual-Domain Subsurface Transport Models.” *Ground Water.* Volume 42, Issue 6. Pp. 815-828.

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater.* Prentice Hall, Englewood Cliffs, New Jersey 07632. 604 p.

Harbaugh, A.W. 2005. *MODFLOW-2005, the U.S. Geological Survey Modular Ground-water Model -- the Ground-Water Flow Process.* U.S. Geological Survey Techniques and Methods 6 A16.

Harbaugh, A.W., E.R. Banta, M.C. Hill, and M.G. McDonald. 2000. *MODFLOW-2000, the U.S. Geological Survey Modular Ground-water Model -- User Guide to Modularization Concepts and the Ground-Water Flow Process*. U.S. Geological Survey Open-File Report 00-92, 121 pp.

Hill, M.C., E.R. Banta, A.W. Harbaugh, and E.R. Anderman. 2000. *MODFLOW-2000, the U.S. Geological Survey Modular Ground-water Model -- User Guide to the Observation, Sensitivity, and Parameter-Estimation Processes and Three Post-processing Programs.* U.S. Geological Survey Open-File Report 00-184, 210 pp.

HydroGeoLogic, Inc. (HGL). *2011. MODHMS/MODFLOW-SURFACT. A Comprehensive MODFLOW-Based Hydrologic Modeling System.* Reston, Virginia.

Izbicki, J. 1983. *Evaluation of the San Dieguito, San Elijo, and San Pasqual Hydrologic Subareas for Reclaimed Water Use, San Diego County, California*. Water-Resources Investigations Report 83-4044. Prepared in cooperation with the County of San Diego and the California Department of Water Resources. August.

McDonald, M.G., and A.W. Harbaugh. 1988. *A Modular Three-Dimensional Finite-Difference Groundwater Flow Model.* USGS Techniques for Water-Resources Investigation. Book 6, Chapter A1.

National Resources Conservation Service (NRCS). 2008. Comprehensive Nutrient Management Plan, Frank Konyn Dairy. Natural Resources Conservation Service (NRCS).

Orang, M.N., R.L. Snyder, and J.S. Maytec. 2004. CUP-E, Consumptive Use Program. Version 1.0. California Land and Water Use, Department of Water Resources and Department of Air, Land, and Water Resources, University of California, Davis.

Tesoriero, A., and L. Puckett. 2011. "O_2 Reduction and Denitrification Rates in Shallow Aquifers." Water Resources Research. 47, W12522, doi:10.1029/2011WR010471. December.

Tjosvold, S.A. 1999. *Effect of Nitrogen on Quality and Production of Field-Grown Field Flowers*. Kee Kitayama Research Foundation Final Report, December 1999. Santa Cruz County UC Cooperative Extension.

Viers, J.H., D. Liptzin, T.S. Rosenstock, V.B. Jensen, A.D. Hollander, A. McNally, A.M. King, G. Kourakos, E.M. Lopez, N. De La Mora, A. Fryjoff-Hung, K.N. Dzurella, H.E. Canada, S. Laybourne, C. McKenney, J. Darby, J.F. Quinn, and T. Harter. 2012. "Nitrogen Sources and Loading to Groundwater." Technical Report 2 in: *Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater*. Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis.

Zheng, C. 2010. *MT3DMS v5.3 Supplemental User's Guide.* Technical Report to the U.S. Army Engineer Research and Development Center, Department of Geological Sciences, University of Alabama. 51 pp.

Zheng, C. 1990. *MT3D, A Modular Three-dimensional Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems.* Report to the U.S. Environmental Protection Agency, 170 pp.

Zheng, C., and P. Wang. 1999. *MT3DMS, A Modular Three-dimensional Multi-species Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems: Documentation and User's Guide.* U.S. Army Engineer Research and Development Center Contract Report SERDP-99-1, Vicksburg, Mississippi. 202 pp.

ATTACHMENT B1

Soil Moisture Budget Model (Version 3.0) Documentation, January 2014

ATTACHMENT B1

Soil Moisture Budget Model (Version 3.0) Documentation, January 2014

B1.1 Introduction

The quantity and distribution of precipitation runoff, infiltration, and deep percolation to groundwater are governed by atmospheric conditions and topography, as well as by land use, vegetation, and soil characteristics. These parameters, while temporally and spatially highly variable, are important components of water balances. Deep percolation of infiltrated precipitation and applied irrigation water are often significant components of groundwater basin recharge. Runoff from precipitation is often the most significant contribution to stream flow. Applied water demands for uses such as agricultural crops, lawns, and landscaping often drive the use of both surface water and groundwater supplies. Direct measurement of each of these parameters is generally not possible at a basin scale and must be estimated. The Soil Moisture Budget (SMB) model described herein estimates direct runoff, infiltration, deep percolation, evapotranspiration (ET), and applied water from climatic inputs of precipitation and reference ET, along with geographic inputs of land use, vegetation, and soil characteristics.

B1.2 Soil Moisture Accounting

The SMB model performs an accounting of soil moisture in the root zone by estimating direct runoff, infiltration, deep percolation of precipitation and irrigation, ET, and irrigation applied water. The soil moisture accounting is currently performed on a monthly time step. Precipitation is first partitioned into direct runoff and infiltration. Infiltration contributes to soil moisture, interflow, or deep percolation to groundwater. Depending on the land use, soils, and climatic conditions, soil moisture is either held in storage or consumptively used through ET. In irrigated areas, additional water applied to the land for irrigation is also consumptively used through ET or held in soil moisture storage. Soil moisture in excess of the available water holding capacity (AWHC) of the root zone is assumed to contribute to deep percolation. The soil moisture accounting process is represented by Equation 1.

$$SM^t = SM^{t-1} + I_p^t + AW^t - R_{irr}^t - ET_a^t - DP^t \qquad \text{(Eq. 1)}$$

where

SM = soil moisture in the root zone (inches)

I_p = infiltration of precipitation (inches)

AW = irrigation applied water (inches)

R_{irr} = surface return flow of irrigation water (inches)

ET_a = actual evapotranspiration (inches)

DP = deep percolation of precipitation and applied water to groundwater (inches)

The superscripts used here and throughout this documentation represent the current time step (t) and the previous time step (t-1). Each of the parameters required for the solution of Equation 1 is described in more detail below.

B1.2.1 Direct Runoff

Direct runoff of precipitation is computed from the Soil Conservation Service (SCS) runoff curve number method (NRCS, 1986). The SCS method consists of determining a runoff curve number based on the land use, soil, and hydrologic condition of the area evaluated. The empirical relationship developed by the SCS (now the Natural Resources Conservation Services [NRCS]) was founded on field studies and relates daily precipitation and curve number to direct runoff on a daily basis.

$$R_p^t = (P^t - 0.2\,S)^2 / (P^t + 0.8\,S) \qquad \text{if } P > 0.2\,S \qquad \text{(Eq. 2a)}$$

$$R_p^t = 0 \qquad \text{if } P \leq 0.2\,S \qquad \text{(Eq. 2b)}$$

where R_p is the direct runoff of precipitation in inches, P is the precipitation in inches, and S is the retention parameter.

The curve number and retention parameter are related as shown in Equation 2c.

$$S = (1{,}000/CN) - 10 \qquad \text{(Eq. 2c)}$$

Curve numbers (CN) for the pervious areas and impervious areas are input separately into the model. Composite curve numbers should not be used. Currently, it is assumed that impervious areas have a curve number of 98.

When the SMB model is run with monthly input data, Equations 2a through 2c are no longer valid, and empirical fitting equations are used to estimate monthly runoff as a percentage of monthly precipitation depths. This is accomplished by running Equations 2a through 2c using daily precipitation data over a wide range of CN values and then fitting an empirical equation to relate CN to the monthly precipitation runoff percentage. The following relationship is utilized in the SMB model for monthly runoff estimation.

$$R_p^t = P^t\,[a \cdot \exp(b \cdot CN)] \qquad \text{(Eq. 2d)}$$

For application in the San Pasqual Valley Groundwater Basin near Escondido, CA, values of a = $7.0\text{x}10^{-7}$ and b = 0.14 provided reasonable results over a 13-year calibration period with 0.02 inches average annual runoff error.

B1.2.2 Infiltration

Infiltration of precipitation is estimated as the difference between precipitation and direct runoff.

$$I_p^t = P^t - R_p^t \qquad \text{(Eq. 3)}$$

B1.2.3 Evapotranspiration

Evapotranspiration by the crop, or other vegetative cover, causes depletion of soil moisture. Methods used in the SMB for determining ET are based on Allen et al. (1998) and DWR (2004). These methods utilize the Penman-Monteith equation and weather station data to determine the ET rate of a reference crop of closely clipped and fully irrigated grass (ETo). The crop evapotranspiration rates (ETc) for all other crops are related to ETo through a crop coefficient (Kc) and are based upon the crop phenological development stages and dates. The general equation used in this SMB model is shown in Equation 4a.

$$ET_c^t = ET_o^t\;K_c^t \qquad \text{(Eq. 4a)}$$

Note that ET_c is the potential crop ET for a particular vegetation cover under conditions of full water supply. However, the actual ET (ET_a) is often less under rain-fed conditions or under deficit irrigation management and is limited by the soil moisture available to the vegetation (Allen et al., 1998). With sufficient soil moisture supply, ETa proceeds at a rate of ET_c. However, as soil moisture is depleted below the readily available water level, ET_a is reduced due to plant water stress until soil moisture is depleted to the permanent wilting point, at which point ET is zero. This relationship is described in Equations 4b and 4c.

$$ET_a^t = K_{sw}^t\,ET_c^t \qquad \text{(Eq. 4b)}$$

where K_{sw} is the water stress factor due to water shortage and is described by:

$$K_{sw}^t = \min\,[(TAW - D_r^{t-1}) / (TAW - RAW),\,1] \qquad \text{(Eq. 4c)}$$

and where the soil factors are described by

D_r = Root zone depletion (inches)

$$D_r^{t-1} = Z_r\,FC - SM^{t-1} \qquad \text{(Eq. 4d)}$$

Z_r = Root zone depth (inches)

FC = Soil water content at field capacity (inches water per inch depth of soil)

TAW = Total available soil water in the root zone (inches)

$$TAW = (FC - PWP)\ Z_r \quad \text{(Eq. 4e)}$$

PWP = Soil water content at the permanent wilting point (inches water per inch depth of soil)

RAW = Readily available soil water content in the root zone (inches)

$$RAW = MAD\ (TAW) \quad \text{(Eq. 4f)}$$

MAD = Maximum allowable depletion, which is the average fraction of total available soil water that can be depleted from the root zone before moisture stress resulting in ET reduction occurs. This factor varies between 0.20 and 0.80, but the vast majority of crops have values between 0.30 and 0.60.

For impervious surfaces, the evapotranspiration component ($ET_{impervious}{}^t$) is calculated separately simply as

$$ET_{impervious}{}^t = P^t - R_{p\text{-}impervious}{}^t \quad \text{(Eq. 5)}$$

This assumes that any precipitation that does not run off is evaporated.

B1.2.4 Effective Precipitation

Effective precipitation (P_e) is the amount of precipitation that is available for crop consumptive use. The computation is based on the SCS method that relates monthly precipitation and consumptive use to an estimate of monthly effective precipitation (NRCS, 1986). This empirical method was developed from a comprehensive analysis of precipitation and climatic conditions, and computed soil moisture balances at various locations. Monthly effective precipitation is computed as follows:

$$P_e{}^t = SF\ (0.70917\ P^{t\ 0.82416} - 0.11556)\ 10^{0.02426\ ETc} \quad \text{(Eq. 6a)}$$

where

P = monthly precipitation (inches)

ETc = average monthly consumptive use (inches)

SF = soil water storage factor

and where the soil water storage factor, SF, is computed as

$$SF = 0.531747 + 0.295164\ RAW - 0.057697\ RAW^2 + 0.003804\ RAW^3 \quad \text{(Eq. 6b)}$$

Effective precipitation must be limited to be no greater than the monthly actual precipitation or the monthly crop evapotranspiration and must be zero or greater as follows

$$P_e{}^t = \max\ (\min\ (P^t\ ,\ ET_c{}^t\ ,\ P_e{}^t{}_{\text{initial estimate}}),\ 0) \quad \text{(Eq. 6c)}$$

The effective precipitation is used in the SMB model for the calculation of irrigation water requirements and estimation of irrigation applied water but is not used in the calculation of deep percolation.

B1.2.5 Applied Water

For irrigation-applied water to agricultural crops and urban landscapes, a computation is included in the SMB model to estimate the amount of water that is required to satisfy the ET demand and minimum soil moisture requirements associated with normal irrigation practices. The model first determines the soil moisture deficit (SMD), which is the amount of water needed to bring the soil moisture to the minimum specified monthly values after accounting for effective precipitation. ET demand that cannot be met by precipitation and carryover soil moisture are then assumed to be satisfied through irrigation. These terms are computed as:

$$SMD^t = FC\ Z_r - RAW - (SM^{t-1} + P_e{}^t) \quad \text{(Eq. 7a)}$$

$$AW^t = \max[(ET_c{}^t + SMD^t)/IE,\ 0] \quad \text{(Eq. 7b)}$$

where IE is the irrigation application efficiency

B1.2.6 Surface Irrigation Return Flow

Under most flood irrigation applications, a portion of the applied water on each field is typically lost to surface return flows from tailwater production. Tailwater is often collected in drain ditches where it may be reused for irrigation, or tailwater is uncontrolled and discharged to surface water. This model assumes all tailwater produced within flood irrigated areas is discharged directly to surface water and not reused. Surface return flow of irrigation water (R_{irr}) is described as

$$R_{irr}^{t} = AW^{t} F_{rf} \qquad \text{(Eq. 8)}$$

where

F_{rf} = the fraction of applied water typically lost to surface return flow

B1.2.7 Deep Percolation

Deep percolation of precipitation and applied water is computed as the last step of the SMB. When the calculated ending soil moisture exceeds field capacity, deep percolation results, thereby reducing the ending soil moisture to field capacity. This is calculated in a one-step process as follows:

$$DP^{t} = \max(SM^{t-1} + I_{p}^{t} + AW^{t} - R_{irr}^{t} - ET_{a}^{t} - FC\,Z_{r}, 0) \qquad \text{(Eq. 9)}$$

B1.2.8 Final Soil Moisture Accounting

Following the evaluation of Equations 2 through 9, Equation 1 is evaluated to determine the resulting soil moisture at the end of the current time step. Under dry-land conditions (i.e., no irrigation), the soil moisture can evaluate to negative values. A final correction step is taken to limit the soil moisture to no less than a value of zero and to correct the actual transpiration for that time step by the same adjustment made to the soil moisture value.

B1.2.9 Final Water Budget Summary

After all of the SMB factors have been evaluated for the time step, these values are written to a data file and stored for use in the next time step calculations and for final data file reporting. The water budget factors that are written to output for each polygon at each time step include:

- Precipitation (acre-feet)
- Runoff-pervious (acre-feet)
- Runoff-impervious (acre-feet)
- Runoff-irrigation (acre-feet)
- Evapotranspiration (acre-feet)
- Evapotranspiration-impervious (acre-feet)
- Applied water-urban (acre-feet)
- Applied water-agricultural (acre-feet)
- Deep percolation (acre-feet)
- Soil moisture (acre-feet)

The runoff and ET from pervious and impervious surfaces are calculated separately within the model, based upon the user input of impervious surface area within each polygon. The runoff from irrigation is determined using Equation 8 for the surface return flow of irrigation water. Applied water for irrigation is separated into urban and agricultural components based upon the user input urban or agricultural irrigation factors. The purpose of this input and separation of terms is to allow for separation and tracking of different water sources utilized for irrigation within the study area.

B1.3 Input Data Requirements

The SMB model has been developed at a level of detail appropriate for basin-scale analyses and for which data are commonly available. In general, the model is designed to work with geographic information system (GIS) spatial data, time-series climatic data, and relational tables that define characteristics of the spatial attributes. This section describes the input data requirements and data sources that have proved valuable.

B1.3.1 Spatial Data

Spatial data requirements for the SMB model include delineation of study area boundaries, distribution of soils, and land use information. The basic requirement is that each unique combination of soil type and land use should be delineated as a polygon and acreage computed. The polygons serve as the computational unit for the soil moisture accounting. Soil information for many counties in the United States can be obtained from the United States Department of Agriculture (USDA) NRCS Soil Survey Geographic Database (SSURGO) GIS Database (*http://www.ftw.nrcs.usda.gov/ssur_data.html*). Land use information can generally be obtained from local planning agencies and/or state water planning agencies. In California, the Department of Water Resources (DWR) Division of Planning, with local assistance, performs county land and water use surveys for statewide planning purposes (*http://www.waterplan.water.ca.gov/landwateruse/landuse/ludataindex.htm*). An intersection of the soils and land use information is usually sufficient for generating the unique computational polygons.

B1.3.2 Time Series Data

Climatic data are input in the SMB model as monthly time-series information. Precipitation and reference ET at any number of representative stations are included. These data can be obtained from local cities, state water planning agencies, or the National Oceanic and Atmospheric Administration (*http://www.noaa.gov/*). For the western United States, the Western Regional Climate Center (*http://www.wrcc.dri.edu/*) maintains a database of historical climate information. In California, the California Irrigation Management Information System maintains weather stations throughout the state and houses a database of the detailed climate information generated from these stations, including reference ET (*http://www.cimis.water.ca.gov/*). Note that pan evaporation is not equal to reference ET and that values from other data sources may need to be scaled appropriately.

B1.3.3 Relational Data

A number of soil, crop/irrigation, runoff, and other hydrologic characteristics are necessary to perform the soil moisture budget and are related to the spatial data. The key soil characteristics are the hydrologic soil group (needed for the computation of direct runoff) and available water capacity, both of which are available through the SSURGO database. The ET crop coefficients, rooting depths, and soil moisture minimums for various crops and landscaping can be obtained from DWR (2004) or Allen et al. (1998). Irrigation efficiency and return flow distributions can be estimated based on knowledge of local irrigation practices. Runoff curve numbers can be estimated from the tables in NRCS (1986) or county hydrology manuals. Percent imperviousness is best estimated from aerial photos.

B1.3.4 Limitations

The SMB model has been developed with the primary purpose to estimate deep percolation of precipitation and applied water on a basin or sub-basin scale to assist in estimating groundwater basin budget components. Direct runoff and applied water demands are also important outputs from the model and may be used in estimating surface runoff and agricultural demands supplied by groundwater pumping, surface water diversions, or imported supplies. Simplifying assumptions have been made to accommodate monthly model time steps and general availability of data. The estimation of direct runoff as a fraction of precipitation related through curve numbers is an example. Typically, runoff curve numbers are also calibrated for surface water flow evaluations where it is possible to measure the outflow of a watershed or sub-watershed. Sensitivity analysis should be performed for areas in which it is not possible to calibrate surface flows. Likewise, the input data assumptions for root depth, minimum soil moisture requirement, and irrigation efficiency should be screened for appropriateness. The use of these parameters represents a simplification of complex soil-water processes and agricultural practices.

The SMB model estimates deep percolation of precipitation that falls directly on pervious surfaces only. Runoff from each polygon is not routed to streams or ponds/lakes where additional groundwater recharge may occur.

Likewise, indoor water use and water used for purposes other than irrigation are not accounted. Other methods for estimation of these types of water demands and associated recharge are likely more appropriate.

B1.4 References

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. *Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements.* FAO Irrigation and Drainage Paper No. 56. Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.

Department of Water Resources (DWR). 2004. *Consumptive Use Program – CUP Version 1.0*. California Department of Water Resources, Sacramento, CA.

Natural Resources Conservation Service (NRCS). 1993. “Irrigation Water Requirements.” Part 623 *National Engineering Handbook*, Chapter 2. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C.

Natural Resources Conservation Service (NRCS). 1986. *Urban Hydrology for Small Watersheds.* Technical Release No. 55. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C.

Appendix C
NRCS Conservation Practice Materials

Nutrient Management Plan
Criteria - Practice/Activity Code (104)(No.)

1. **Definition**

Nutrient management plans are documents of record of how nutrients will be managed for plant production and to address the environmental concerns with the offsite movement of nutrients. These plans are prepared in collaboration with producer and/or landowner and are designed to help the producer with implementation and maintenance activities associated with the plan.

A Nutrient Management conservation activity plan must:

a. Meet NRCS quality criteria for soil erosion (sheet, rill, wind, and ephemeral/concentrate flow erosion), water quality and quantity, and other identified resource concerns;
b. Be developed in accordance with technical requirements of the NRCS Field Office Technical Guide (FOTG) and policy requirements of General Manual, Title 190, Part 402, Nutrient Management; and guidance contained in the National Agronomy Manual, Subpart 503C.
c. Comply with federal, state, tribal, and local laws, regulations and permit requirements; and
d. Satisfy the operator's objectives.

2. Nutrient Management Plan Technical Criteria

This section establishes the minimum criteria to be addressed in the development of Nutrient Management Plans.

A. General Criteria

The "Nutrient Management Plan" must be developed by certified Technical Service Providers (TSPs). In accordance with Section 1240 (A), the Environmental Quality Incentive Program (EQIP) program provides funding support through contracts with eligible producers to obtain services of certified TSPs for development of Nutrient Management Plans. The specific TSP criteria required for Nutrient Management Plan development is located on the TSP website http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical/tsp.

B. Nutrient Management Specific Element Criteria

The Nutrient Management Plan must include, but not be limited to, the following components:

1. Background and Site Information
   - Name of owner/operator;
   - Farm location and mailing address;
   - Soil map units;

- Conservation plan map;
- Field names or codes;
- List of crops grown on the parcel, with acreage for each crop
- Description of the concerns related water quality, soil erosion (wind and water) or other local concerns, etc.

2. Land Treatment

   Land Treatment must address the need for and implementation of appropriate conservation practices for land treatment areas. On fields where nutrients (manure, organic by-products, and commercial fertilizer) are applied, it is essential that runoff and soil erosion (sheet, rill, wind, and ephemeral/concentrate flow erosion) as close as possible, and that plant uptake of applied nutrients be maximized to prevent nutrients from reaching surface and/or groundwater or being volatilized to the air. Therefore, the planner must develop a conservation system that will reduce runoff and control soil erosion from the field to the level specified in Section III of the FOTG. Criteria for land treatment practices element:

   (i) GIS Map(s) documenting fields and conservation practices:

   - Aerial maps of land application areas including soil maps;
   - Fields delineated to show setbacks, buffers, waterways, conservation practices planned or other site specific features important to nutrient management planning (risers, inlets, wells);
   - Identification of sensitive areas such as sinkholes, streams, springs, lakes, ponds, wells, gullies, and drinking water sources; and
   - Other site information features of significance, such as property boundaries or occupied dwellings.

   (ii) Land treatment conservation practices planned or applied to meet the quality criteria for soil erosion (sheet, rill, wind, and ephemeral/concentrate flow erosion), water quality, and quantity. Include the practice narrative and the O&M requirements for each practice. Design specifications (job sheets, engineering plans) and information associated with planning and implementation of the included conservation practices must be maintained.

   (iii) To achieve the desired soil erosion, water and air quality improvements on land treatment areas, adjacent fields may also require conservation treatment.

   (iv) Additional natural resource concerns may need to be addressed to meet an acceptable treatment level for erosion, water quality, and air quality, for example, managing the plant resource on pasture lands.

   (v) If it is determined that excessive negative impacts to air quality resource concerns arise from existing or planned land treatment activities, identified in the plan, then air quality impact mitigation is required in the nutrient plan.

3. Nutrient Management

Nutrient Management plans must meet the technical criteria for the Nutrient Management conservation practice (code 590) standard, and address the use and management of all nutrients applied on cropland, hayland, or pastureland (animal manure, wastewater, commercial fertilizers, crop residues, legume credits, irrigation water, organic by-products). Planners must document the rationale when using custom recommendations in the nutrient plan.

C. Practice Standards

The Nutrient Management Plan must address the resource concerns identified and the conservation practices needed to comprise a conservation system. Document the planned conservation practices, the site specific specifications for the practice, the amount to be applied, and schedule of application.

D. References

- USDA Natural Resource Conservation Service National Agronomy Manual, Parts 507 and 503C.
- General Manual, Title 190, Part 402, Nutrient Management

E. Deliverables for the Client – a hardcopy of the plan that includes:

- Cover page – name, address, phone of client and TSP; Total Acres of the Plan, signature blocks for the TSP, producer, and a signature block for the NRCS acceptance.
- Soils map and appropriate soil descriptions
- Resource assessment results (wind and water erosion, water availability, soil fertility, and others that may be needed)
- Complete Hardcopy of the client's plan (MsWord copy). Document the planned conservation practices showing the planned amount, the fields where the practice is to be applied, and the planned year of application.
- When the following practices are planned include the appropriate Jobsheet or Implementation Requirements (founding in Section IV of the State eFOTG):

Code	Practice Name
328	Conservation Crop Rotation
329	Residue and Tillage Management, No-Till/Strip-Till/Direct Seed
330	Contour Farming
332	Contour Buffer Strips
340	Cover Crops
344	Residue Management, Seasonal
345	Residue and Tillage Management, Mulch Till
346	Residue and tillage Management, Ridge-Till
386	Field Boarder
390	Riparian Herbaceous Cover
391	Riparian Forest Buffer

Code	Practice Name
393	Filter Strip
585	Strip-Cropping
590	Nutrient Management
601	Vegetative Barrier
635	Vegetated Treatment Area

- The plans and specifications as stated in the 590 Nutrient Management Standard.

F. Deliverables for NRCS Field Office:

- Complete Hardcopy and Electronic copy of the client's plan (MsWord or other appropriate digital format copy).
- Digital Conservation Plan Map with fields, features, and structural practices located.
- Digital Soils Map.

United States Department of Agriculture
Natural Resources Conservation Service

Date Received: **Control No:**

Field Office Checklist and TSP Certification Sample Plan Review

Conservation Activity Plan – Nutrient Management Plan
Practice Activity Code (104)
(Refer to National Bulletin 450-11-1 for a complete listing of CAP Criteria)

Purpose: The purpose of this checklist is to provide guidance for components that need to be addressed or included in a Nutrient Management Plan. This checklist is designed for use by NRCS staff as well as Technical Service Providers. Please refer to CAP Development Criteria for specific elements to be addressed.
Instructions: Note: The NMP CAP sample plan should be reviewed at the State level and is not required to be reviewed by National Headquarters. However, should the State not have the technical specialist to conduct the review, requests can be submitted (by the State Office) to NHQ for review. Submit the completed checklist and sample plan by mail or email to Tim Pilkowski, Natural Resources Specialist, TSP Team. See below for address info.

Nutrient Management Plan	
State/County:	**Date Plan Submitted:**
Producer/Owner:	**Technical Service Provider:**

A Nutrient Management Plan (NMP) is a document of record of how nutrients will be managed for plant production. The plan is designed to help the producer with implementation and maintenance activities associated with the plan.

Technical Guidance, Criteria, and Content for the NMP is found at the URL: eDirectives http://directives.sc.egov.usda.gov/. Navigate to: General Manual Title 190 Part 402 – Nutrient Management
Minimum components of a NMP shall include:

1.	**Background and site information:**
☐	a. Name of owner/operator; b. Farm location, mailing address and operator phone; c. Soil Map Units; d. Conservation plan map; e. Field names and/or codes including acres; f. List of crops grown on the parcel; g. Description of concerns related to water quality, soil erosion (wind & water) or other local concerns

2.	**Land Treatment: On all fields where nutrients are applied**
☐	1. GIS Map(s) documenting fields and conservation practices including: a. Aerial maps and soil maps of land application area; b. Fields delineated to show setbacks, buffers, conservation practices planned, etc.; c. Identification of sensitive areas such as sinkholes, streams, wells, water sources, etc.
☐	2. Land treatment conservation practices planned or applied including: a. Practice narrative, O&M, design specifications, job sheets, etc.; b. Recommended conservation practices on adjacent fields; c. Any additional resource concerns addressed for erosion, water quality and air quality
3.	**Nutrient Management: Must meet technical criteria for NM Practice Standard (590)**
☐	1. Soil test data, Manure analysis and nutrient content from biosolids; 2. Field information (field names, total acres and spreadable acres); 3. Planned management and engineering practices (when, where and how practice will be applied); 4. Planned crops and nutrient recommendations for all sources; 5. Manure application planning calendar; 6. Planned nutrient applications; 7. Farm/Field Nutrient Balance; 8. Manure/Fertilizer annual summary

Yes	**No**	**Checklist Approval**	
◯	◯	I have reviewed this Nutrient Management Plan (NMP) and it meets all the criteria of the Conservation Activity Plan 104 in accordance with Section 2508 of the Food, Conservation and Energy Act of 2008.	
NRCS Representative Name and Title (print or type):			
NRCS Representative Signature			Date:
Notes (If "No" is checked, include reasons for denial, comments, missing items that need to be added, etc.):			

e-mail: **RA.dcwashing4.TSP. tim.pilkowski@wdc.usda.gov.**

Mailing Address: **Tim Pilkowski, Natural Resources Specialist**
Technical Service Provider Team
USDA - Natural Resources Conservation Service
1400 Independence Ave SW, Room 5232
Washington, DC 20250

Comprehensive Nutrient Management Plan Criteria

Practice Activity Code (102) (No.)

1. **Definitions**

A. A comprehensive nutrient management plan (CNMP) is a conservation plan for an animal feeding operation (AFO) that:

(1) Typically include the following two components:

(i) **The production area**, including the animal confinement, feed, and other raw materials storage areas, animal mortality facilities, and the manure handling containment or storage areas; and

(ii) **The land treatment area**, including any land under control of the AFO owner or operator, whether it is owned, rented, or leased, and to which manure or process wastewater is, or might be, applied for crop, hay, pasture production, or other uses.

Note: Operations that confine animals and export all manure and litter offsite; or operations that do not confine animals, but do import sufficient quantities of manure, wastewater, animal by-products, etc. to require structural facilities for storage, handling or transfer, would also need a CNMP.

(2) Meets Natural Resources Conservation Service (NRCS) quality criteria for water quality (nutrients, organics, and sediments in surface and groundwater) and soil erosion (sheet and rill, wind, ephemeral gully, classic gully, and irrigation induced natural resource concerns on the production area and the land treatment area).

(3) Mitigates, if feasible, any excessive air emissions and/or negative impacts to air quality resource concerns that may result from practices identified in the CNMP or from existing on-farm areas/activities.

(4) Complies with Federal, Tribal, State, and local laws, regulations, and permit requirements.

(5) Satisfies the owner/operator's production objectives.

Note: If it is probable that the producer will forward the CNMP to the State regulatory agency in pursuit of a National Pollutant Discharge Elimination System (NPDES) permit, the planner should include all farm acreage that could foreseeably receive manure. This additional acreage, when included in the CNMP, will increase planning options should the plan need to be altered after it becomes a regulatory plan. Planning flexibility makes it less likely that the NPDES permit will need to be revised.

B. The Producer Activity Document (PAD) is an abbreviated CNMP document for the producer's use that summarizes the day-to-day activities to implement the CNMP. A template for a PAD is available in the Manure Management Planner (MMP) software.

C. Miscellaneous Definitions:

Internal transfers. These are on-the-farm relocations (transfers) of manure, litter, wastewater, by-products, etc.

CNMP Criteria

This section establishes the minimum criteria the planner must address in the development and implementation of CNMPs.

A. General Criteria

1) A CNMP must be designed to assist owners/operators in taking voluntary actions to minimize potential pollutants from animal confinement facilities and land application of manure and organic by-products.

2) Information in the CNMP must document the landowner(s) decisions.

3) The CNMP must be developed in accordance with all applicable Federal, Tribal, State and local water quality goals or regulations.

4) The CNMP must require evaluation and documentation of compliance with the National Environmental Policy Act, the Endangered Species Act, the National Historic Preservation Act, and other effects on the environment. This evaluation and documentation process WILL BE COMPLETED BY NRCS.

5) A CNMP must be developed by persons who meet NRCS certification requirements. The specific criteria for certification of NRCS employees and conservation partners can be found in NRCS General Manual 180 Part 409. The specific criteria for certification for Technical Service Providers (TSP) is available via the TSP website http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical/tsp

6) All CNMPs must be developed through utilization of the national CNMP development templates as adopted by the State in which the operation is located.

7) A CNMP must be developed in accordance with the State nutrient management conservation practice standard (code 590).

8) The NRCS review and approval process for CNMPs must be followed. The CNMP planner submits the following to NRCS and/or regulatory agency for review and signatures:

   (i) Printed copy of the CNMP document;

   (ii) CNMP document file (If using MMP, include the ".nat-cnmp.doc" file);

   (iii) PAD document file (If using MMP, include the ".nat-prd.doc" file);

   (iv) Nutrient Management planning tool plan file (If using MMP, include the ".mmp" file);

   (v) Revised Universal Soil Loss Equation (RUSLE2) database file (.gdb extension);

   (vi) Conservation plan xml file from Customer Service Toolkit (.consplan.xml extension); and

   (vii) If requested, the Geographic Information Systems (GIS) shapefiles created for the operation.

9) Delivery of the CNMP - A CNMP must be signed by the producer, certified planner, and appropriate specialist(s), and include other signatures as required. Once the CNMP has been reviewed and signed by the planner(s) and reviewer(s), copies of the CNMP and PAD document(s) are delivered to the producer for signature. The planner returns one copy of the finalized and signed documents to the NRCS Field Service Center, the producer retains a signed copy, as well.

   All electronic files supporting the CNMP shall be delivered to the respective field office to be saved in the client's NRCS file.

10) Archiving of the CNMP document and associated data.

   (i) Once the CNMP has been completed and delivered to the producer, the NRCS archives the signed hard copy and sufficient electronic documentation (see "Submit the CNMP" list above), technical references, software versioning, etc., to facilitate recreation of the CNMP documents for future reference as part of the CNMP review/revision cycle. (See CNMP Handbook Section IV Developing a CNMP, item 8 Submit, Review, Archive CNMP data and document(s).)

   (ii) Before TSPs can check conservation practice information back into the NRCS National Conservation Practice Database (NCPdb), the data will need to be reviewed and accepted by NRCS designated Field Service Center staff. Procedures are being developed to enable and accommodate this review.

11) In most situations, addressing the CNMP Criteria will require a combination of conservation practices and management activities to meet the production needs of the AFO owner/operator, and resource concerns associated with the production and land treatment areas. The Field Office Technical Guide (FOTG) Section III and National Planning Procedures Handbook contain additional information and guidance.

CNMP

A. Specific CNMP Elements.

   (1) Minimum specific elements for a CNMP include:

   (i) Background and Site Information;

   (ii) Manure and Wastewater Handling and Storage;

   (iii) Farmstead Safety and Security;

   (iv) Land Treatment Practices;

   (v) Soil and Risk Assessment Analyses;

   (vi) Nutrient Management according to the criteria in the Nutrient Management Conservation Practice (Code 590);

   (vii) Feed Management (Optional);

   (viii) Other Utilization Options (Optional);

   (ix) Recordkeeping; and

   (x) References.

Note: "Feed Management" and "Other Utilization Options" are not required elements of a CNMP. However, the "Feed Management Element" and/or "Other Utilization Options" should be included in the CNMP, if used, to help manage the farm nutrient balance.

Note: Where air quality has been identified as a resource concern due to agricultural operations, an air quality element may be needed.

B. Specific CNMP Element Criteria.

Note: Each of the CNMP elements must address specific criteria. The degree to which these elements are addressed in the development and implementation of a site-specific CNMP is determined by General Criteria contained in NI-190-304, Section 304.1A (http://directives.sc.egov.usda.gov/) and the specific criteria provided for each element of the CNMP below:

(1) Background and Site Information Element – This element provides a brief description of:

(i) Name of owner/operator in control of the site;

(ii) Facility location and mailing address;

(iii) Latitude and longitude of the production area entrance;

(iv) The type and size of the AFO;

(v) Resource concerns, including those that may arise from the implementation of the CNMP (air quality); and

(vi) The producer's manure management objectives.

(2) Manure and Wastewater Handling and Storage Element:

(i) This element must address the components and activities associated with the production facility, including feed management decisions made to reduce the nutrient content of manure, feedlot or animal loafing facilities, manure and wastewater storage and treatment structures and areas, animal mortality facilities, feed and other raw material storage areas, and any areas used to facilitate transfer of manure and wastewater.

(ii) The manure and wastewater handling and storage facilities will provide for adequate collection, handling, storage, and/or treatment of manure and organic by-products that facilitate application during favorable weather conditions and is compatible with crop management strategies, including the application of nutrients at agronomic rates.

(iii) Practices planned for the collection, storage, treatment, and/or transfer practices will meet the minimum criteria and documentation as addressed in the NRCS conservation practice standards, contained in Section IV of the NRCS FOTG. Existing structures will function in accordance with the planned manure and waste water handling system.

(iv) If it is determined that excessive negative impacts to air quality resource concerns arise from existing or planned production activities identified in the

CNMP, then air quality impact mitigation is required in the CNMP.

(v) The Manure and Wastewater Handling and Storage element will include:

- Map(s) of production area: Accurate scaled drawing or aerial photo of the confinement areas, production buildings, manure storage, and treatment locations, and feed storage areas;
- Production area conservation practices (including air quality impact mitigation [if required]): document the conservation practice decisions and operation and maintenance (O&M) requirements;
- Manure collection, transfer, storage, and treatment: type, operational capacity, annual requirement, maximum days of storage, manure on-hand at start of the plan, management of silage leachate, scraping lots, etc;
- Animal inventory: group name, type, number, weight, confinement period, percentage of manure collected (days of confinement/365 × 100), additional bedding or washwater, facility identification where manure will be stored (pad, house/building/barn, lagoon);
- Mortality Management: description of how the normal mortality will be managed in an environmentally acceptable manner (burial requirements, incineration, composting, hauled away to rendering);
- Planned Manure Exports off the Farm: month/year, amount;
- Planned Manure Imports onto the Farm: month/year, manure type, amount, source; and
- Planned Internal Transfers of Manure: month/year, manure source, amount, and manure destination.

(3) Farmstead Safety and Security element – This element will address the need for onsite guidance and procedures to be followed in the event of a leak or spill emergency, catastrophic mortality, or other biosecurity concern.

(i) General emergency procedures to follow in response to leaks or spills of manure, chemical, fuel, or other substance that may pose a threat to the environment, and appropriate contact information.

(ii) Procedures for biosecurity, including protocol for farm visitors, and disposal of animal veterinary waste.

(iii) Procedures to follow in the event of catastrophic mortalities.

(iv) The Chemical Handling Checklist must be included in the CNMP document when the CNMP will be utilized for an NPDES permit.

(4) Land Treatment Practices Element – This element will address the need for and implementation of appropriate conservation practices for land treatment areas. On fields where manure and organic by-products are applied, it is essential that runoff and soil erosion be reduced to acceptable levels, and that plant uptake of applied nutrients be maximized to prevent manure nutrients from reaching surface and/or

groundwater or being volatilized to the air. Therefore, the planner must develop a conservation system that will reduce runoff and control soil erosion from the field to the level specified in Section III of the FOTG. Criteria for land treatment practices element:

(i) Map(s) documenting fields and conservation practices (a GIS-developed map product is preferred):

- Aerial maps of land application areas including soil maps;
- Fields delineated to show setbacks, buffers, waterways, conservation practices planned or other site specific features important to nutrient management planning (risers, inlets, wells);
- Identification of sensitive areas such as sinkholes, streams, springs, lakes, ponds, wells, gullies, and drinking water sources; and
- Other site information features of significance, such as property boundaries or occupied dwellings.

(ii) Land treatment conservation practices planned or applied to meet the quality criteria for soil erosion, air and water quality. Include the practice narrative and the O&M requirements for each practice. Design specifications (job sheets, engineering plans) and information associated with planning and implementation of the included conservation practices must be maintained.

(iii) To achieve the desired soil erosion, water and air quality improvements on land treatment areas, adjacent fields may also require conservation treatment.

(iv) Additional natural resource concerns may need to be addressed to meet an acceptable treatment level for erosion, water and air quality, for example, managing the plant resource on pasture lands.

(v) If it is determined that excessive negative impacts to air quality resource concerns arise from existing or planned land treatment activities, identified in the CNMP, then air quality impact mitigation is required in the CNMP.

(5) Soil and Risk Assessment Analyses Element – This element will document the results of the predicted average annual soil erosion from wind and/or water as a result of the planned treatment(s) and nitrogen and/or phosphorus risk assessments as required by the State. Any State required risk assessment necessary for CNMP development will be included to document the relative risk of nutrient loss to the environment. Refer to the State-specific Nutrient Management conservation practice standard (code 590) for further guidance.

(6) Nutrient Management Element – This element must meet the technical criteria for the Nutrient Management conservation practice (code 590) standard, and address the use and management of all nutrients applied on cropland, hayland, or pastureland (animal manure, wastewater, commercial fertilizers, crop residues, legume credits, irrigation water, organic by-products). Planners must document the rationale when using custom recommendations in the CNMP.

(i) Some data necessary to develop a CNMP will come from chemical analyses of soils, plant tissue, manure, water, and feed. Soil test analyses must be performed by laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program (NAPT) under the auspices of the Soil Science Society of America, or the Agricultural Laboratory Proficiency Program (APL), or other state approved program that considers laboratory performance and proficiency to assure accuracy of test results.

(ii) Manure analyses must be performed by laboratories successfully meeting the requirements and performance standards of the Manure Testing Laboratory Certification Program (MTLCP) http://www.mda.state.mn.us/licensing/pestfert/manurelabs.htm under the auspices of the Minnesota Department of Agriculture, or State-recognized program that considers laboratory performance and proficiency to assure accuracy of test results. States are encouraged to adopt the MTLCP or State Conservationists can establish State proficiency criteria that meet or exceed the MTLCP program criteria.

(iii) Nutrients from biosolids must be included in nutrient management planning when applied on farms for which CNMPs are being developed. Biosolids (sewage sludge) applications are regulated by the U.S. Environmental Protection Agency (EPA) and, therefore, must be applied in accordance with EPA regulations (40 C.F.R. Parts 403 Pretreatment and 503 Biosolids) and other State and/or local regulations regarding the use of biosolids as a nutrient source.

(iv) Criteria for the CNMP Nutrient Management Element must include all proposed applications of manure and other needed nutrients to meet the Nutrient Management conservation practice standard (code 590). This would include all fields that may receive manure applications from any manure source. The plans and specifications must include the following tables:

- Field information—identify field names, total acres, and spreadable acres in a table format;
- Manure application setback distances—identify setbacks for each field on the map and in a table format;
- Soil test data—soil test data for each field displayed in a table;
- Irrigation water test data (if applicable);
- Manure nutrient analysis—document most recent manure analysis in a table;
- Planned crops and fertilizer recommendations—list fields, crops, yield goals, and fertilizer recommended;
- Manure application planning calendar—display manure applications planned, when crops are grown, and restrictions that would prevent nutrient/manure applications, for example, winter spreading or high potential for nitrate leaching;
- Planned nutrient applications—the timing, rate, source(s), and methods of application by field;

- Field nutrient balance—the recommended nutrient amounts, nutrients applied, and balance after recommendation, and balance after crop removal;
- Manure inventory annual summary—annual manure production by source and storage facility; and
- Farm nutrient balance (acres planned for nutrient application) – summary of primary nutrients applied from all nutrient sources, by crop, year, and field. The net excess or shortage of nitrogen, phosphorus, and potassium must be displayed by crop year and field.

Note: The fertilizer material annual summary documents the amount of commercial fertilizer needed each crop year. While not required, it can be very useful to the producer for planning purposes.

(7) Feed Management Element (optional) – Include only if a Feed Management Plan is required to reduce the total nutrients excreted by the livestock on the farm. Do not include discussions of optional feed management.

When Feed Management conservation practice (code 592) is included in the CNMP, diets and feed management strategies must be developed by professional animal scientists, independent professional nutritionists, or other comparably qualified individuals. When required by State policy or regulation, animal nutritionists must be certified through any certification program recognized within the State.

(8) Other Utilization Options Element (optional) – Include only if utilization options other than land application are planned.

Note: Criteria are not offered for Feed Management and for Other Utilization Options because they are not always required CNMP elements. Technical criteria used to implement these elements are found in Section IV of the Field Office Technical Guide (FOTG).

(9) Recordkeeping Element – It is important that accurate records are kept to effectively document and demonstrate implementation activities associated with the CNMP, and to meet the documentation requirements of regulatory agencies. Recordkeeping includes appropriate management and maintenance of practices and structures. AFO owners/operators have responsibilities to maintain records that document the implementation of CNMPs in accordance with conservation practice standards, including the State nutrient management conservation practice (code 590), including:

i. Producer activity checklist;

ii. Inspection/monitoring records (taken from the O&M requirements contained in each conservation practice under CNMP Elements 2 and 4);

iii. Annual crop records—crop, yield by field;

iv. (iv) Manure application records—date, rate, timing, weather, setbacks, by manure type, manure source, storage facility, by fields receiving manure, etc.;

v. (v) Other nutrient applications (e.g. commercial fertilizer and irrigation water application) records—nutrient content analysis, application rate/acre, amount of water applied, nutrient content of irrigation water, etc.;

vi. Manure exports off the farm—date(s) and amount(s);

vii. Manure imports onto the farm—date(s), amount(s), and analysis (prior to application);

viii. Internal transfers of manure—date(s), amount(s), initial location(s) and final location(s); and

ix. Other records required by State and/or local regulations: manure analysis—by date, type, and storage facility, soil testing—by field or conservation management unit, etc.

- Recordkeeping responsibilities are reviewed with producers when the CNMP is planned and during the implementation follow-up visits. Electronic copies of the CNMP and PAD must be maintained at the operation headquarters for future review and potential revision.
- When Federal funds are used (i.e. Environmental Quality Incentives Program) to develop the CNMP, follow-up for implementation and O&M of the CNMP is the responsibility of NRCS employees or United States Department of Agriculture (USDA)-authorized third party vendors. When the CNMP is used for regulatory purposes (i.e. NPDES permit), the farmer is responsible for follow-up and O&M of the CNMP, including recordkeeping. NRCS employees or other USDA-authorized providers of technical assistance will provide guidance to farmers that ensure the farmer knows which records they need to keep and how to maintain those records.

(10) References Element – This element must document all technical sources important to understanding the contents or implementation of the CNMP. This element should include reference sites where useful information pertinent to the CNMP can be obtained. To avoid unnecessary expansion of the CNMP document, planners must minimize inclusion of hard copies of supporting documentation.

CNMP Format and Template

A. The CNMP and PAD national templates provide a basic format and content framework that is consistent across all States. The national templates are the required format of a CNMP. States are permitted to make additions to meet State-specific code.

B. The CNMP is an important part of the conservation system for the AFO. The CNMP documents the planning decisions and O&M activities for the AFO. In addition, the CNMP includes background information and guidance, and reference Web sites where up-to-date information can be obtained. The PAD is a subset of the CNMP and provides the information about day-to-day management activities and required recordkeeping. Electronic copies of both the CNMP and the PAD must remain in the possession of the producer/landowner to facilitate future revision(s).

C. Planners must submit electronic files .AWM; .MMP; and .Doc (the State-adapted national template) to the reviewer.

D. The CNMP elements are represented in the national template as sections.

CNMP National Template

A. At a minimum, the following sections and format will be required in the template:

a) Cover and Signature Page:

i) Name of owner/operator;

ii) Facility location (physical address) and mailing address;

iii) Latitude and longitude of the production area entrance;

iv) Type and size of the AFO;

v) Plan period; and

vi) All required signatures for acceptance of a CNMP in the State.

b) Section 1 – Background and Site Information:

i) 1.1 General description of the operation;

ii) 1.2 Sampling, calibration, and other statements; and

iii) 1.3 Natural Resource Concerns.

c) Section 2 – Manure and Wastewater Handling and Storage:

i) 2.1 Map(s) of Production Area;

ii) 2.2 Production Area Conservation Practices (Including air quality impact mitigation, if required);

iii) 2.3 Manure Storage;

iv) 2.4 Animal Inventory;

v) 2.5 Normal Animal Mortality Management;

vi) 2.6 Planned Manure Exports off the Farm;

vii) 2.7 Planned Manure Imports onto the Farm; and

viii) 2.8 Planned Internal Transfers of Manure.

d) Section 3 – Farmstead Safety and Security:

i) 3.1 Emergency Response Plan;

ii) 3.2 Biosecurity Measures, including Biosecurity Protocol for Farm Visitors and Disposal of Animal Veterinary Waste;

iii) 3.3 Catastrophic Animal Mortality Management; and

iv) 3.4 The EPA agreed-to Chemical Handling Check List must be included when the CNMP will be utilized for an NPDES permit.

e) Section 4 – Land Treatment.

i) 4.1 Map(s) of fields and conservation practices:

- Aerial maps of land application areas;
- Fields delineated with setbacks, buffers, waterways, conservation practices planned or other site-specific features important to nutrient management planning, (risers, inlets, wells, etc.);
- Identification of sensitive areas such as sinkholes, streams, springs, lakes, ponds, wells, gullies, and drinking water sources; and
- Other site information or features of significance to nutrient management planning, such as property boundaries and occupied dwellings.

(ii) 4.2 Land Treatment Conservation Practices:

- Land treatment conservation practices are planned and installed to the land treatment area and must be in accordance with NRCS conservation practice standards. The objective of these practices is to prevent, minimize, or mitigate the impact of potential contaminants to water and air resources near agricultural fields.
- MMP will automatically generate State-approved conservation practice narratives in the CNMP document. Design specifications information associated with planning and implementation of the conservation practices, job sheets, engineering plans, if essential, will be placed in the customer's file to minimize the content of the CNMP. When job sheets are used, they must not conflict with information automatically generated by MMP and content must be agreed-to by State-based partners.

f) Section 5 – Soil and Risk Assessment Analyses:

i) 5.1 Soil information;

ii) 5.2 Predicted soil erosion;

iii) 5.3 Nitrogen and phosphorus risk analyses; and

iv) 5.4 Additional field data required by risk assessment procedure(s).

g) Section 6 – Nutrient Management - Meets the Nutrient Management Conservation Practice (Code 590):

i) 6.1 Field information;

ii) 6.2 Manure application setback distances;

iii) 6.3 Soil test data;

iv) 6.4 Manure nutrient analyses;

v) 6.5 Planned crops and fertilizer recommendations;

vi) 6.6 Manure application planning calendar;

vii) 6.7 Planned nutrient applications;

viii) 6.8 Field nutrient balance;

ix) 6.9 Manure inventory annual summary;

x) 6.10 Fertilizer material annual summary; and

xi) 6.11 Farm nutrient balance.

h) Section 7 – Feed Management

i) (Include only if a Feed Management Plan is required to reduce the total nutrients excreted by the livestock on the farm. Do not include discussions of optional feed management strategies.)

ii) When Feed Management conservation practice (code 592) is included in the CNMP, diets and feed management strategies must be developed by professional animal scientists, independent professional nutritionists, or other comparably qualified individuals. When required by State policy or regulation, animal nutritionists must be certified through any certification program recognized within the State.

i) Section 8 – Other Utilization Options - Include only if utilization options other than land application are planned.

j) Section 9 – Recordkeeping - Recordkeeping information is contained in the PAD for specific recordkeeping items, including tables and forms. Planners must work with the producer and provide guidance regarding recordkeeping.

k) Section 10 – References

i) 10.1 Publications.

ii) 10.2 Software and Data Sources, including pertinent version information.

b) CNMP Producer Activity Document (PAD) National Template

a) A document will be prepared to assist the producer in understanding and managing the CNMP. This document must be readily available to the producer. The PAD national template below provides the basic format and content for a PAD. Typically, the PAD will not contain sufficient information for operations choosing to seek a permit.

b) At a minimum, the following sections and format will be required in the template: (Specific sections in the PAD below refer to maps or tabular information.)

i) Cover Page:

- Name of Owner/Operator;
- Facility Location (physical address) and Mailing Address;
- Latitude and Longitude of the Production Area Entrance;
- Type and Size of the AFO;
- Plan period; and

- Includes all required signatures for acceptance of a CNMP in the State.

ii) Section 1 – Background and Site Information. Background and Site Information is contained in the CNMP document.

iii) Section 2 – Manure and Wastewater Handling and Storage

- 2.1. Map(s) of Production Area: sketch or aerial photo of the confinement areas, production buildings, manure storage and treatment locations, and feed storage areas.
- 2.2. Production Area Conservation Practices: documentation of the conservation practice decisions and O&M requirements.
- 2.6. Planned Manure Exports off the Farm.
- 2.7. Planned Manure Imports onto the Farm.
- 2.8. Planned Internal Transfers of Manure.

iv) Section 3 – Farmstead Safety and Security

- 3.1 Emergency Response Plan (Sample).
- 3.2 Biosecurity measures, including biosecurity protocol for farm visitors and disposal of animal veterinary waste.
- 3.3 Catastrophic mortality management including State required procedures and contact information.

v) Section 4 – Land Treatment Practices

- 4.1 Map(s) of Fields including land treatment conservation practices.
- 4.2 Land Treatment Practices: documentation of the conservation practice decisions and O&M requirements.

vi) Section 5 – Soil and Risk Assessment Analyses

- Soil and Risk Assessment Analyses are contained in the CNMP document.

vii) Section 6 – Nutrient Management – Meets the Nutrient Management Conservation Practice (Code 590).

- 6.1 Field information.
- 6.2 Manure application setback distances.
- 6.6 Manure application planning calendar.
- 6.7 Planned nutrient applications.
- 6.10 Fertilizer material annual summary.

viii) Section 7 – Feed Management

- Feed Management is contained in the CNMP document.

ix) Section 8 – Other Utilization Options

- Other Utilization Options are contained in the CNMP document

x) Section 9 – Recordkeeping

- Planners must work with the producer and provide guidance regarding advantageous and required recordkeeping. The PAD Recordkeeping items include the following tables and forms:

  -- 9.1 Producer activity checklist;

  -- 9.2 Inspection/monitoring records;

  -- 9.3 Crop records;

  -- 9.4 Manure application records;

  -- 9.5 Other nutrient applications (commercial fertilizer and irrigation water application records);

  -- 9.6 Manure exports off the farm;

  -- 9.7 Manure imports onto the farm;

  -- 9.8 Internal transfers of manure; and

  -- 9.9 Other records required by State and/or local regulations.

xi) Section 10 – References

- References include State-based technical information in support of farming activities. Also see CNMP document for additional references.

  -- 10.1 Publications—provide a list of electronically executable reference materials (url).

United States Department of Agriculture
Natural Resources Conservation Service

Date Received: **Control No:**

Field Office Checklist and TSP Certification Sample Plan Review

Conservation Activity Plan – Comprehensive Nutrient Management Plan Practice Activity Code (102)

(Refer to National Bulletin 450-11-1 for a complete listing of CAP Criteria)

Purpose: The purpose of this checklist is to provide guidance for components that need to be addressed or included in a Comprehensive Nutrient Management Plan. This checklist is designed for use by NRCS staff as well as Technical Service Providers. Please refer to CAP Development Criteria for specific elements to be addressed.
Instructions: Note: The CNMP CAP sample plan should be reviewed at the State level and is not required to be reviewed by National Headquarters. However, should the State not have the technical specialist to conduct the review, requests can be submitted (by the State Office) to NHQ for review. Submit the completed checklist and sample plan by mail or email to Tim Pilkowski, Natural Resources Specialist, TSP Team. See below for address info.

Comprehensive Nutrient Management Plan	
State/County:	**Date Plan Submitted:**
Producer/Owner:	**Technical Service Provider:**

A Comprehensive Nutrient Management Plan (CNMP) is a conservation plan that is unique to animal feeding operations. It is a grouping of conservation practices and management activities which, when implemented as part of a conservation system, will help to ensure that both production and natural resource protection goals are achieved.

Technical Guidance, Criteria, and Content for the CNMP is found at the URL: eDirectives http://directives.sc.egov.usda.gov/. Navigate to: General Manual Title 190 Part 405 – Comprehensive Nutrient Management Plans; Handbooks Title 190 Part 620 Comprehensive Nutrient Management Planning; National Instructions Title 190 NI_190_304, Comprehensive Nutrient Management Plan Technical Criteria.
Minimum components of a CNMP shall include:

☐	**Production Area**
	Production area shall include animal confinement, feed and other raw material storage areas, animal mortality facilities, and the manure handling containment or storage areas and;
☐	**Land Treatment Area**
	Land Treatment area shall include any land under control of the AFO owner or operator, whether it is owned, rented or leased, and to which manure or process wastewater is, or might be, applied for crop, hay, pasture production or other uses.

1.	**Cover and Signature Page:**
☐	a. Name of operator, facility location and mailing address; b. Latitude and longitude of the production address; c. Type and size of the AFO; d. Plan period and all required signatures for the State
2.	**Background and Site Information:**
☐	a. General description of Operation; b. Sampling, calibration and other statements; c. Identified Natural Resource Concerns
3.	**Manure and Wastewater Handling and Storage Element:**
☐	a. Map(s) of the production area; b. Production area conservation practices; c. Animal Inventory and Manure storage; d. Normal animal mortality management; e. Planned manure exports/imports and internal transfers
4.	**Farmstead Safety and Security:**
☐	a. Emergency response plan; b. Biosecurity measures including protocol for visitors & disposal of animal veterinary waste c. Castastrophic animal mortality management; d. EPA agreed-to Chemical Handling checklist
5.	**Land Treatment:**
☐	a. Maps documenting fields and conservation practices including: 1. Aerial maps of land application areas; 2. Fields delineated with setbacks, buffers, waterways and conservation practices planned; 3. Sensitive areas such as sinkholes, streams, springs, ponds and drinking water sources; 4. Property boundaries and occupied dwellings; b. Land Treatment Conservation Practices in accordance with NRCS conservation practice standards
6.	**Soil and Risk Assessment Analysis:**
☐	a. Soil information; b. Predicted Soil Erosion; c. Nitrogen and Phosphorus Risk Analysis including any additional field data required by risk assessment
7.	**Nutrient Management:**
☐	a. This element shall meet the technical criteria for the Nutrient Management conservation practice code (590) standard including: 1. Field information, manure application setback distances, soil test data, manure nutrient analysis; 2. Planned crops and fertilizer recommendations, manure application planning calendar, planned nutrient applications, field nutrient balance, manure inventory and annual summary, fertilizer material annual summary, and farm nutrient balance

8.	**Feed Management (Optional):**
☐	Include only if Feed Management Plan is required to reduce the total nutrients excreted by the Livestock on the Farm. Should not include discussions of optional feed management strategies. Feed Management element should be developed by a professional animal scientist, independent professional nutritionists, or other comparably qualified individual. Nutritionist shall be State certified if required by Policy or Regulation.
9.	**Other Utilization Options (Optional):**
☐	Included if manure utilization is different from land application.
10.	**Recordkeeping:**
☐	a. At a minimum, recordkeeping shall include: Producer activity checklist, Inspection/monitoring records, Annual crop records, Manure application records, Other nutrient applications (commercial fertilizer), Manure exports and imports to the farm and Internal transfers of manure; b. Other records required by State and/or local regulations
11.	**References:**
☐	a. Publications; b. Software and Data Sources, including pertinent version information

Yes	**No**	**Checklist Approval**	
○	○	I have reviewed this Comprehensive Nutrient Management Plan (CNMP) and it meets all the criteria of the Conservation Activity Plan 102 in accordance with Section 2508 of the Food, Conservation and Energy Act of 2008.	
NRCS Representative Name and Title (print or type):			
NRCS Representative Signature			Date:
Notes (If "No" is checked, include reasons for denial, comments, missing items that need to be added, etc.):			

e-mail: **RA.dcwashing4.TSP. tim.pilkowski@wdc.usda.gov.**

Mailing Address: **Tim Pilkowski, Natural Resources Specialist**
Technical Service Provider Team
USDA - Natural Resources Conservation Service
1400 Independence Ave SW, Room 5232
Washington, DC 20250

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

NUTRIENT MANAGEMENT

(Ac.)

CODE 590

DEFINITION

Managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments.

PURPOSE

- To budget, supply, and conserve nutrients for plant production.
- To minimize agricultural nonpoint source pollution of surface and groundwater resources.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates.
- To maintain or improve the physical, chemical, and biological condition of soil.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all lands where plant nutrients and soil amendments are applied. This standard does not apply to one-time nutrient applications to establish perennial crops.

CRITERIA

General Criteria Applicable to All Purposes

Develop a nutrient budget for nitrogen, phosphorus, and potassium that considers all potential sources of nutrients including, but not limited to, green manures, legumes, crop residues, compost, animal manure, organic by-products, biosolids, waste water, organic matter, commercial fertilizer, and irrigation water.

Enhanced efficiency fertilizers, used in the State must be defined by the Association of American Plant Food Control Officials (AAPFCO) and be accepted for use by California Department of Food and Agriculture Fertilizing Materials Program (https://apps4.cdfa.ca.gov/fertilizerproducts/).

For nutrient risk assessment policy and procedures see Title 190, General Manual (GM), Part 402, Nutrient Management, and Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation.

Nitrate transport risk assessment must be completed whenever Nutrient Management is planned.

Two nitrogen loss risk assessment tools are available for use in California. The Nitrate Groundwater Pollution Hazard Index can be accessed at http://ucanr.edu/sites/wrc/Programs/Water_Quality/Nitrate_Groundwater_Pollution_Hazard_Index/. The other accepted method for evaluating potential loss of nitrogen in California is the USDA-ARS Nitrogen Index. See Nutrient Loss Risk Assessment supplement.

The California P-index risk assessment for potential movement of phosphorus must be completed when Nutrient Management is planned. See Nutrient Loss Risk Assessment supplement.

On organic operations, the nutrient sources and management must be consistent with the USDA's National Organic Program.

Areas contained within minimum application setbacks (e.g., sinkholes, wellheads, gullies, ditches, or surface inlets) must receive nutrients consistent with the setback restrictions.

Applications of irrigation water must minimize the risk of nutrient loss to surface and groundwater (Refer to 449-Irrigation Water Management).

Soil pH must be maintained in a range that allows adequate crop nutrient availability.

Soil, Manure, Amendment, and Tissue Sampling and Laboratory Analyses.

Nutrient planning must be based on current soil, manure, and when used, tissue test results developed in accordance with land-grant university guidance, or industry practice, if recognized by the university.

Analyze other amendments used as a nutrient source, and include the results in nutrient management planning.

Soil tests should be no older than 3 years. However, cropping history and intensity of production can justify a requirement for more frequent and current test results..

The area represented by a soil test should have a similar soil type and the same management throughout.

Where a conservation management unit (CMU) is used as the basis for a sampling unit, all acreage in the CMU must have similar soil type, cropping history, and management practice treatment.

The soil and tissue tests must include analyses pertinent to monitoring or amending the annual nutrient budget, e.g., pH, electrical conductivity (EC) and sodicity where salts are a concern, soil organic matter, phosphorus, potassium, or other nutrients and test for nitrogen where applicable. Follow land-grant university guidelines regarding required analyses.

Soil test analyses must be performed by laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program-Performance Assessment Program (NAPT-PAP) under the auspices of the Soil Science Society of America (SSSA) and NRCS, or other NRCS-approved program that considers laboratory performance and proficiency to assure accuracy of soil test results. Alternate proficiency testing programs must have solid stakeholder (e.g., water quality control entity, NRCS State staff, growers, and others) support and be regional in scope.

Nutrient values of manure, biosolids, and other organic by-products must be determined prior to land application.

Manure analyses must include, at minimum, total nitrogen (N), ammonium N, total phosphorus (P) or P_2O_5, total potassium (K) or K_2O, and percent solids, or follow land-grant university guidance regarding required analyses.

Manure, biosolids, and other organic by-product samples must be collected and analyzed at least annually, or more frequently if needed to account for operational changes (feed management, animal type, manure handling strategy, etc.) impacting manure nutrient concentrations. If no operational changes occur, less frequent manure testing is allowable where operations can document a stable level of nutrient concentrations for the preceding three consecutive years, unless federal, State, or local regulations require more frequent testing.

Samples must be collected, prepared, stored, and shipped, following land-grant university guidance or industry practice.

When planning for new or modified livestock operations, acceptable "book values" recognized by the NRCS (e.g., NRCS Agricultural Waste Management Field Handbook) and the land-grant university, or analyses from similar operations in the geographical area, may be used if they accurately estimate nutrient output from the proposed operation.

Manure testing analyses must be performed by laboratories successfully meeting the requirements and performance standards of the Manure Testing Laboratory Certification program (MTLCP) under the auspices of the Minnesota Department of Agriculture, or other NRCS-approved program that considers laboratory performance and proficiency to assure accurate manure test results.

Nutrient Application Rates.

Planned nutrient application rates for nitrogen, phosphorus, and potassium must not exceed land-grant university guidelines or industry practice when recognized by the university.

At a minimum, determination of rate must be based on crop/cropping sequence, current soil test results, realistic yield goals, and nitrogen and phosphorus loss risk assessments.

In the absence of crop-specific nutrient requirement values, application rates must be based on plans that consider realistic yield goals and associated plant nutrient uptake rates.

Realistic yield goals must be established based on historical yield data, soil productivity information, climatic conditions, nutrient test results, level of management, and local research results considering comparable production conditions.

Estimates of yield response must consider factors such as poor soil quality, drainage, pH, salinity, etc., prior to assuming that nitrogen and/or phosphorus are deficient.

For new crops or varieties, industry-demonstrated yield, and nutrient utilization information may be used until land-grant university information is available.

Lower-than-recommended nutrient application rates are permissible if the grower's objectives are met.

Applications of biosolids, starter fertilizers, or pop-up fertilizers must be accounted for in the nutrient budget.

Nutrient Sources.

Nutrient sources utilized must be compatible with the application timing, tillage and planting system, soil properties, crop, crop rotation, soil organic content, and local climate to minimize risk to the environment.

Nutrient Application Timing and Placement.

Application timing and placement of nutrients must correspond as closely as practical with plant nutrient uptake (utilization by crops), and consider nutrient source, cropping system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment results.

Nutrients must not be surface-applied if nutrient losses offsite are likely. This precludes spreading on:

- frozen and/or snow-covered soils, and
- when the top 2 inches of soil are saturated from rainfall or snow melt.

Exceptions for the above criteria can be made for surface-applied manure when specified conditions are met and adequate conservation measures are installed to prevent the offsite delivery of nutrients. The adequate treatment level and specified conditions for winter applications of manure must be defined by NRCS in concurrence with the water quality control authority in the State. At a minimum, the following site and management factors must be considered:

- slope,
- organic residue and living covers,
- amount and form of nutrients to be applied, and
- adequate setback distances to protect local water quality.

<u>Additional Criteria to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater</u>

Nutrients must be applied with the right placement, in the right amount, at the right time, and from the right source to minimize nutrient losses to surface and groundwater. The following nutrient use efficiency strategies or technologies should be considered:

- slow and controlled release fertilizers
- nitrification and urease inhibitors
- enhanced efficiency fertilizers
- incorporation or injection
- timing and number of applications
- soil nitrate and organic N testing
- coordinate nutrient applications with optimum crop nutrient uptake
- Corn Stalk Nitrate Test (CSNT), Pre-Sidedress Nitrate Test (PSNT), and Pre-Plant Soil Nitrate Test (PPSN)
- tissue testing, chlorophyll meters, and spectral analysis technologies
- other land-grant university recommended technologies that improve nutrient use efficiency and minimize surface or groundwater resource concerns.

Planners must use the current NRCS-approved nitrogen, phosphorus, and soil erosion risk assessment tools to assess the risk of nutrient and soil loss. Identified resource concerns must be addressed to meet current planning criteria (quality criteria). Technical criteria for risk assessments can be found in NI-190-302.

When there is a high risk of transport of nutrients, conservation practices must be coordinated to prevent loss of nutrients from the field by surface or subsurface flow.

Additional Criteria Applicable to Properly Utilize Manure or Organic By-Products as a Plant Nutrient Source

When manures are applied, and soil salinity is a concern, salt concentrations must be monitored to prevent potential crop damage and/or reduced soil quality.

The total single application of liquid manure must:

- not exceed the soil's infiltration or water holding capacity
- be based on crop rooting depth
- be adjusted to avoid runoff or loss to subsurface tile drains.

Utilize results of nitrogen and phosphorus loss risk assessment tools.

For fields receiving manure or other organic P sources:

When P-index is LOW, additional phosphorus can be applied at rates greater than crop requirement up to that which will cause the nitrogen applied to meet the N needs of the succeeding crop.

When P-index is MEDIUM, additional phosphorus may be applied at the rate required for the planned crops in the rotation.

When P-index is HIGH or VERY HIGH, additional phosphorus may be applied at phosphorus crop removal rates. However, when index is VERY HIGH, no additional manure or other form of organic P can be applied. At HIGH or VERY HIGH the following requirements must be met:

- a soil phosphorus drawdown strategy has been implemented, and
- a site assessment for nutrients and soil loss has been conducted to determine if mitigation practices are required to protect water quality.
- any deviation from these high risk requirements must have the approval of the Chief of the NRCS.

Manure or organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass.

Manure may be applied at a rate equal to the recommended phosphorus application, or estimated phosphorus removal in harvested plant biomass for the crop rotation, or multiple years in the crop sequence at one time. The application rate:

- must not exceed the acceptable phosphorus risk assessment criteria,
- must not exceed the recommended nitrogen application rate during the year of application or harvest cycle, and
- no additional phosphorus can be applied in the current year and any additional years for which the single application of phosphorus is intended to supply nutrients.

Additional Criteria to Protect Air Quality by Reducing Odors, Nitrogen Emissions and the Formation of Atmospheric Particulates

To address air quality concerns caused by odor, nitrogen, sulfur, and/or particulate emissions; the source, timing, amount, and placement of nutrients must be adjusted to minimize the negative impact of these emissions on the environment and human health. One or more of the following may be used:

- slow or controlled release fertilizers
- nitrification inhibitors
- urease inhibitors
- nutrient enhancement technologies
- incorporation
- injection
- stabilized nitrogen fertilizers
- residue and tillage management
- no-till or strip-till
- other technologies that minimize the impact of these emissions

Do not apply poultry litter, manure, or organic by-products of similar dryness/density when there is a high probability that wind will blow the material offsite.

Additional Criteria to Improve or Maintain the Physical, Chemical, and Biological Condition of the Soil to Enhance Soil Quality for Crop Production and Environmental Protection

Time the application of nutrients to avoid periods when field activities will result in soil compaction.

In areas where salinity is a concern, select nutrient sources that minimize the buildup of soil salts.

Avoid high concentrations of anhydrous ammonia and other chemicals that can adversely affect the biological condition of the soil.

CONSIDERATIONS

Use no-till/strip-till in combination with cover crops to sequester nutrients, increase soil organic matter, increase aggregate stability, reduce compaction, improve infiltration, and enhance soil biological activity to improve nutrient use efficiency.

Use nutrient management strategies such as cover crops, crop rotations, and crop rotations with perennials to improve nutrient cycling and reduce energy inputs.

Use variable-rate nitrogen application based on expected crop yields, soil variability, soil nitrate or organic N supply levels, or chlorophyll concentration.

Use variable-rate nitrogen, phosphorus, and potassium application rates based on site-specific variability in crop yield, soil characteristics, soil test values, and other soil productivity factors.

Develop site-specific yield maps using a yield monitoring system. Use the data to further diagnose low- and high- yield areas, or zones, and make the necessary management changes. See Title 190, Agronomy Technical Note (TN) 190.AGR.3, Precision Nutrient Management Planning.

Use manure management conservation practices to manage manure nutrients to limit losses prior to nutrient utilization.

Apply manure at a rate that will result in an “improving” Soil Conditioning Index (SCI) without exceeding acceptable risk of nitrogen or phosphorus loss.

Use legume crops and cover crops to provide nitrogen through biological fixation and nutrient recycling.

Modify animal feed diets to reduce the nutrient content of manure following guidance contained in Conservation Practice Standard (CPS) Code 592, Feed Management.

Soil test information should be no older than 1 year when developing new plans.

Excessive levels of some nutrients can cause induced deficiencies of other nutrients, e.g., high soil test phosphorus levels can result in zinc deficiency in corn.

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or availability of the primary nutrients.

Use the adaptive nutrient management learning process to improve nutrient use efficiency on farms as outlined in the NRCS’ National Nutrient Policy in GM 190, Part 402, Nutrient Management.

Potassium should not be applied in situations where an excess (greater than soil test potassium recommendation) causes nutrient imbalances in crops or forages.

Workers should be protected from and avoid unnecessary contact with plant nutrient sources. Extra caution must be taken when handling anhydrous ammonia or when dealing with organic wastes stored in unventilated enclosures.

Material generated from cleaning nutrient application equipment should be utilized in an environmentally safe manner. Excess material should be collected and stored or field applied in an appropriate manner.

Nutrient containers should be recycled in compliance with State and local guidelines or regulations.

Considerations to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration, e.g., filter strip, contour farming, or contour buffer strips. These practices can also reduce the loss of nitrates or soluble phosphorus.

Use application methods and timing strategies that reduce the risk of nutrient transport by ground and surface waters, such as:

- split applications of nitrogen to deliver nutrients during periods of maximum crop utilization,
- banded applications of nitrogen and/or phosphorus to improve nutrient availability,
- drainage water management to reduce nutrient discharge through drainage systems, and
- incorporation of surface-applied manures or organic by-products if precipitation capable of

producing runoff or erosion is forecast within the time of planned application.

Use the agricultural chemical storage facility conservation practice to protect air, soil, and water quality.

Use bioreactors and multistage drainage strategies when approved by the land-grant university.

Considerations to Protect Air Quality by Reducing Nitrogen and/or Particulate Emissions to the Atmosphere.

Avoid applying manure and other by-products upwind of inhabited areas.

Use high-efficiency irrigation technologies (e.g., reduced-pressure drop nozzles for center pivots) to reduce the potential for nutrient losses.

PLANS AND SPECIFICATIONS

The following components must be included in the nutrient management plan:

- aerial site photograph(s)/imagery or site map(s), and a soil survey map of the site,
- soil information including: soil type surface texture, pH, drainage class, permeability, available water capacity, depth to water table, restrictive features, and flooding and/or ponding frequency,
- location of designated sensitive areas and the associated nutrient application restrictions and setbacks,
- for manure applications, location of nearby residences, or other locations where humans may be present on a regular basis, and any identified meteorological (e.g., prevailing winds at different times of the year), or topographical influences that may affect the transport of odors to those locations,
- results of approved risk assessment tools for nitrogen, phosphorus, and erosion losses,
- documentation establishing that the application site presents low risk for phosphorus transport to local water if phosphorus is applied in excess of crop requirement.
- current and/or planned plant production sequence or crop rotation,
- soil, water, compost, manure, organic by-product, and plant tissue sample analyses applicable to the plan,
- when it is known that soil phosphorus levels are increasing, include a discussion of the risk associated with phosphorus accumulation and a proposed phosphorus draw-down strategy,
- realistic yield goals for the crops,
- complete nutrient budget for nitrogen, phosphorus, and potassium for the plant production sequence or crop rotation,
- listing and quantification of all nutrient sources and form,
- all enhanced efficiency fertilizer products that are planned for use,
- in accordance with the nitrogen and phosphorus risk assessment tool(s), specify the recommended nutrient application source, timing, amount (except for precision/variable rate applications specify method used to determine rate), and placement of plant nutrients for each field or management unit, and
- guidance for implementation, operation and maintenance, and recordkeeping.

In addition, the following components must be included in a precision/variable rate nutrient management plan:

- Document the geo-referenced field boundary and data collected that was processed and analyzed as a GIS layer or layers to generate nutrient or soil amendment recommendations.
- Document the nutrient recommendation guidance and recommendation equations used to convert the GIS base data layer or layers to a nutrient source material recommendation GIS layer or layers.
- Document if a variable rate nutrient or soil amendment application was made.
- Provide application records per management zone or as applied map within individual field boundaries (or electronic records) documenting source, timing, method, and rate of all applications that resulted from use

of the precision agriculture process for nutrient or soil amendment applications.

- Maintain the electronic records of the GIS data layers and nutrient applications for at least 5 years.

If increases in soil phosphorus levels are expected (i.e., when N-based rates are used), the nutrient management plan must document:

- the soil phosphorus levels at which it is desirable to convert to phosphorus based planning,
- the potential plan for soil test phosphorus drawdown from the production and harvesting of crops, and
- management activities or techniques used to reduce the potential for phosphorus transport and loss,
- for AFOs, a quantification of manure produced in excess of crop nutrient requirements, and
- a long-term strategy and proposed implementation timeline for reducing soil P to levels that protect water quality,

OPERATION AND MAINTENANCE

Conduct periodic plan reviews to determine if adjustments or modifications to the plan are needed. At a minimum, plans must be reviewed and revised, as needed with each soil test cycle, changes in manure volume or analysis, crops, or crop management.

Fields receiving animal manures and/or biosolids must be monitored for the accumulation of heavy metals and phosphorus in accordance with land-grant university guidance and State law.

Significant changes in animal numbers, management, and feed management will necessitate additional manure analyses to establish a revised average nutrient content.

Calibrate application equipment to ensure accurate distribution of material at planned rates.

Document the nutrient application rate. When the applied rate differs from the planned rate, provide appropriate documentation for the change.

Records must be maintained for at least 5 years to document plan implementation and maintenance. As applicable, records include:

- soil, plant tissue, water, manure, and organic by-product analyses resulting in recommendations for nutrient application,
- quantities, analyses and sources of nutrients applied,
- dates, and method(s) of nutrient applications, source of nutrients, and rates of application,
- weather conditions and soil moisture at the time of application; lapsed time to manure incorporation; rainfall or irrigation event,
- crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass, and crop residues removed,
- dates of plan review, name of reviewer, and recommended changes resulting from the review, and
- all enhanced efficiency fertilizer products used.

Additional records for precision/variable rate sites must include:

- maps identifying the variable application source, timing, amount, and placement of all plant nutrients applied, and
- GPS-based yield maps for crops where yields can be digitally collected.

REFERENCES

Association of American Plant Food Control Officials (AAPFCO). 2011. AAPFCO Official Publication no. 64. AAPFCO Inc., Little Rock, AR.

Follett, R.F. 2001. Nitrogen transformation and transport processes. *In* Nitrogen in the environment; sources, problems, and solutions, (eds.) R.F. Follett and J. Hatfield, pp. 17-44. Elsevier Science Publishers. The Netherlands. 520 pp.

Schepers, J.S., and W.R. Ruan, (eds.) 2008. Nitrogen in agricultural systems. Agron. Monogr. no. 49, American Society of Agronomy (ASA), Crop Science Society of America (CSSA), Soil Science Society of America (SSSA). Madison, WI.

Sims, J.T. (ed.) 2005. Phosphorus: Agriculture and the environment. Agron. Monogr. no. 46. ASA, CSSA, and SSSA, Madison, WI.

Stevenson, F.J. (ed.) 1982. Nitrogen in agricultural soils. Agron. Series 22. ASA, CSSA, and SSSA, Madison, WI.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2010. Agronomy Technical Note, (TN) 190-AGR-3, Precision Nutrient Management Planning. Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2011. Title 190, General Manual, (GM), Part 402, Nutrient Management. Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2011, Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation. Washington, DC.

IRRIGATION WATER MANAGEMENT PLAN CRITERIA
PRACTICE/ACTIVITY CODE (118) (NO.)

1. Definition of an Irrigation Water Management Plan

The objective of Irrigation Water Management (IWM) is to control the volume, frequency, and rate of water for efficient irrigation, and for the following purposes:

- Promote desired crop response.
- Optimize the use of available water supplies.
- Improve water quality, by reducing irrigation sources of surface and ground water contamination.
- Minimize irrigation induced soil erosion.
- Improve soil environment for vegetative growth.
- Manage salts in the root zone.
- Improve air quality, by reducing movement of particulate matter.
- Provide appropriate and safe fertigation and chemigation.
- Reduce energy consumption.

The objective of an Irrigation Water Management Plan (IWMP) is to provide the producer a guide for the proper management and application of irrigation water resources. The potential benefits of IWM can be effectively determined by interviewing the producer to identify fields, soils, crops, climate, and available water supply; measuring the volumes of water withdrawn or applied; determining irrigation system uniformity, selecting a method to schedule irrigations, and then combining these components to produce an IWMP for the farm.

2. IWMP Criteria

This section establishes the minimum criteria to be addressed in the development of Irrigation Water Management Plans.

A. General Criteria:

1. Irrigation Water Management Plans shall be developed by certified Technical Service Providers (TSPs). In accordance with Section 1240 (A), the Environmental Quality Incentive Program (EQIP) program provides funding support through contracts with eligible producers to obtain services of certified TSPs for development of Irrigation Water Management Plans. The specific TSP criteria required for Irrigation Water Management Plan development is located on the TSP registry (TechReg) web site at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical/tsp.
2. The IWMP should address the resource concerns identified, and the conservation practices needed to comprise a conservation system for IWM. In addition, the IWMP should be based on the economics of water use, energy consumption, and crop yield. Management may be limited by water (deficit irrigation), or limited by land (unlimited water). The two general management schemes for irrigation water conservation in agriculture are: Demand Management (reducing withdrawals or reducing crop requirements), and Supply Management (increasing water storage, yield, or supplies).

Technologies available for Demand Management include:

- Irrigation scheduling.
- Increased system uniformity.
- Increased irrigation efficiency.
- Reduced water evaporation.
- Reduced soil evaporation (utilize crop residue or mulch).
- Reduced water use by non-beneficial vegetation.
- Limited irrigation (applying less than maximum ET_C).
- Crop selection (lower ET_C or drought resistant strains).
- Decision-making models (optimize water, energy, and nutrient use).
- Conversion of irrigated cropland to dry land farming.

Technologies available for Supply Management include:

- Increased water storage capacity.
- Groundwater recharge.
- Water harvesting.
- Vegetative management for increased watershed runoff.
- Reuse of waste or drainage water.
- Water transfers

B. IWMP Technical Criteria. The IWMP should include, but not be limited to, the following components:

1. Farm and field information:
   a. Name of producer.
   b. Farm number.
   c. Field and/or tract number.
   d. Crops grown, and planned rotation by field.
   e. Name of contractor or consultant developing plan.
   f. Date of plan development.

2. The objectives of the producer, which should involve one of the purposes listed in Conservation Practice Standard (CPS) 449, Irrigation Water Management.

3. A map that includes field boundaries, and a soils map with the predominant soils listed and area quantified. If the qualifying acres for the plan are a subset of fields, the boundaries of the IWMP acreage should also be delineated.

4. An irrigation system map that includes the size, materials, and locations of the mains, laterals, and application systems.

5. Documentation of past water withdrawals and applications, by crop.

6. The methods planned to measure or quantify future water withdrawals and irrigation applications.

7. Planned water application volumes, on a seasonal and/or annual basis, and by crop.

8. Soil tests, to include nutrient levels and salinity. Water tests, to include nutrients, pathogens, salinity, pH, and trace elements.

9. Estimates of irrigation system uniformity, based on testing, evaluation, or observation. Distribution Uniformity (DU) should be based on the ratio of the average depth infiltrated in the low one-quarter of the field, to the average depth infiltrated over the entire field.

10. Documentation of the scientific method planned for scheduling the timing and amount of irrigation applications, based on the measurement or estimation of soil moisture, and the measurement or prediction of evapotranspiration (ET_C) of the crop(s). The proposed irrigation scheduling method should include:

    a. Estimated volume of water applied, by field, irrigation event, season, and/or year.

    b. Estimated frequency or timing of irrigation applications, by field.

    c. Estimated application rates and depths of irrigation events.

11. An Operation and Maintenance plan, to include a check list of items to eliminate non-beneficial system losses.

12. A signature page, with names, dates and signatures of all contract holders and the person who prepared the plan. The signature page should also contain a space for approval by NRCS.

13. The IWMP components shall be assembled into one complete plan.

C. Associated Practice Standards. The IWMP should address the resource concerns identified, and the conservation practices needed to comprise a conservation system for IWM. In addition to the information required in CPS 449, Irrigation Water Management, existing irrigation systems and conveyance facilities may require modification, augmentation, or replacement of components. NRCS Conservation Practice Standards to be incorporated in the IWMP could include:

Code	Practice name
449	Irrigation Water Management
441	Irrigation System, Micro
442	Irrigation System, Sprinkler
443	Irrigation System, Surface & Subsurface
430	Irrigation Pipeline
428	Irrigation Ditch Lining
388	Irrigation Field Ditch
320	Irrigation Canal or Lateral
587	Structure for Water Control
436	Irrigation Reservoir
447	Irrigation System, Tailwater Recovery
533	Pumping Plant
464	Irrigation Land Leveling
450	Anionic Polyacrylamide (PAM) Application
610	Salinity and Sodic Soil Management
590	Nutrient Management

D. References

- USDA-NRCS, National Engineering Handbook, Part 623, Section 15, Irrigation.
- USDA-NRCS, National Engineering Handbook, Part 652, National Irrigation Guide.

3. Deliverables for the Client – a hardcopy of the IWMP that includes:

- Cover page – name, address, and phone number of producer and TSP; Total Acres of the Plan, signature blocks for the TSP, producer, and a signature block for the NRCS acceptance.
- Soils map and appropriate soil descriptions.
- Resource assessment results (wind and water erosion, water availability, soil fertility, and others that may be needed).
- Complete Hardcopy of the client's plan (MsWord copy). Document the planned conservation practices showing the planned amount, the fields where the practice is to be applied, and the planned year of application.

4. Deliverables for the NRCS Field Office:

- Complete Hardcopy and Electronic copy of the client's plan (MsWord and/or other appropriate digital copies).
- Digital Conservation Plan Map with fields, features, and structural practices located.
- Digital Soils Map.

United States Department of Agriculture
Natural Resources Conservation Service

Date Received: **Control No:**

Field Office Checklist and TSP Certification Sample Plan Review

Conservation Activity Plan – Irrigation Water Management Plan
Practice Activity Code (118)
(Refer to National Bulletin 450-11-1 for a complete listing of CAP Criteria)

Purpose: The purpose of this checklist is to provide guidance for components that need to be addressed or included in a Irrigation Water Management Plan. This checklist is designed for use by NRCS staff as well as Technical Service Providers. Please refer to CAP Development Criteria for specific elements to be addressed.
Instructions: Note: The IWMP CAP sample plan should be reviewed at the State level and is not required to be reviewed by National Headquarters. However, should the State not have the technical specialist to conduct the review, requests can be submitted (by the State Office) to NHQ for review. Submit the completed checklist and sample plan by mail or email to Tim Pilkowski, Natural Resources Specialist, TSP Team. See below for address info.

Irrigation Water Management Plan	
State/County:	**Date Plan Submitted:**
Producer/Owner:	**Technical Service Provider:**

A Irrigation Water Management Plan (IWMP) provides the producer with a guide for the proper management and application of irrigation water resources. The objective of Irrigation Water Management is to control the volume, frequency and rate of water for efficient irrigation.

Technical Guidance, Criteria, and Content for the NMP is found at the URL: eDirectives http://directives.sc.egov.usda.gov/. Navigate to: Handbooks Title 210 Engineering, Section 15 – Irrigation

Minimum components of a IWMP shall include:

1.	**General Criteria: IWMP plans should address:**
☐	a. Resource concerns identified, and; b. Conservation practices needed to comprise a conservation system for IWM; c. Economics of water use; d. Energy consumption; e. Crop yield.

2.	**Technical Criteria: Minimum criteria to be addresses in development and implementation of IWM Plan**
☐	1. Farm and field information: a. Name of producer; b. Farm number, field and/or Tract number; c. Crops grown, and planned rotation by field; d. Name of contractor or consultant developing plan; e. Date of plan development
☐	2. The objectives of the producer, which should involve one of the purposes listed in CPS 449, Irrigation Water Management.
☐	3. A soils map that includes field boundaries, with the predominant soils listed and area quantified.
☐	4. An irrigation system map that includes the size, materials, and locations of mains, laterals and application systems.
☐	5. Documentation of past water withdrawals and applications, by crop.
☐	6. The methods planned to measure or quantify future water withdrawals and irrigation applications.
☐	7. Planned water application volumes, on a seasonal and/or annual basis, and by crop.
☐	8. Soil tests, to include nutrient levels and salinity. Water tests, to include nutrients, pathogens, salinity, pH, and trace elements.
☐	9. Estimates of irrigation system uniformity, based on testing, evaluation, or observation
☐	10. Documentation of the scientific method planned for scheduling the timing and amount of irrigation applications, based on the measurement or estimation of soil moisture, and the measurement or prediction of evapotranspiration (Et_c) of the crop(s). The proposed irrigation scheduling method should include: a. Estimated volume of water applied by field, irrigation event, season, and/or year; b. Estimated frequency or timing of irrigation applications, by field; c. Estimated application rates and depths of irrigation events.
☐	11. An operation and maintenance plan, to include a check list of items to eliminate non-beneficial system losses.
☐	12. A signature page, with names, dates and signatures of all contract holders and the person who prepared the plan.
☐	13. The IWMP components shall be assembled into one complete plan.
☐	14. Conservation Plan which includes planned practices, schedule of implementation, appropriate site specific specifications and job sheet for each practice.
☐	15. References

Yes	No	Checklist Approval	
◯	◯	I have reviewed this Irrigation Water Management Plan (IWMP) and it meets all the criteria of the Conservation Activity Plan 118 in accordance with Section 2508 of the Food, Conservation and Energy Act of 2008.	
NRCS Representative Name and Title (print or type):			
NRCS Representative Signature			Date:
Notes (If "No" is checked, include reasons for denial, comments, missing items that need to be added, etc.):			

e-mail: **RA.dcwashing4.TSP. tim.pilkowski@wdc.usda.gov.**

Mailing Address:
Tim Pilkowski, Natural Resources Specialist
Technical Service Provider Team
USDA - Natural Resources Conservation Service
1400 Independence Ave SW, Room 5232
Washington, DC 20250

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER MANAGEMENT

(Ac.)

CODE 449

DEFINITION

The process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner.

PURPOSE

This practice may be applied as part of a resource management system to achieve one or more of the following purposes:

- Manage soil moisture to promote desired crop response
- Optimize use of available water supplies
- Minimize irrigation induced soil erosion
- Decrease non-point source pollution of surface and groundwater resources
- Manage salts in the crop root zone
- Manage air, soil, or plant micro-climate
- Proper and safe chemigation or fertigation
- Improve air quality by managing soil moisture to reduce particulate matter movement
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable to all irrigated lands.

An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, air quality, etc.) must be available and capable of efficiently applying water to meet the intended purpose(s).

CRITERIA

General Criteria Applicable to All Purposes

Irrigation water shall be applied in accordance with federal, state, and local rules, laws, and regulations. Water shall not be applied in excess of the needs to meet the intended purpose.

Measurement and determination of flow rate is a critical component of irrigation water management and shall be a part of all irrigation water management purposes.

The irrigator or decision-maker must possess the knowledge, skills, and capabilities of management coupled with a properly designed, efficient and functioning irrigation system to reasonably achieve the purposes of irrigation water management.

An "Irrigation Water Management Plan" shall be developed to assist the irrigator or decision-maker in the proper management and application of irrigation water.

Irrigator Skills and Capabilities. Proper irrigation scheduling, in both timing and amount, control of runoff, minimizing deep percolation, and the uniform application of water are of primary concern. The irrigator or decision-maker shall possess or obtain the knowledge and capability to accomplish the purposes which include:

A. General

1. How to determine when irrigation water should be applied, based on the rate of water used by crops and on the stages of plant growth and/or soil moisture monitoring.

2. How to determine the amount of water required for each irrigation, including any leaching needs.
3. How to recognize and control erosion caused by irrigation.
4. How to measure or determine the uniformity of application of an irrigation.
5. How to perform system maintenance to assure efficient operation.
6. Knowledge of "where the water goes" after it is applied considering soil surface and subsurface conditions, soil intake rates and permeability, crop root zones, and available water holding capacity.
7. How to manage salinity and shallow water tables through water management.
8. The capability to control the irrigation delivery.

B. Surface Systems

1. The relationship between advance rate, time of opportunity, intake rate, and other aspects of distribution uniformity and the amount of water infiltrated.
2. How to determine and control the amount of irrigation runoff.
3. How to adjust stream size, adjust irrigation time, or employ techniques such as "surge irrigation" to compensate for seasonal changes in intake rate or to improve efficiency of application.

C. Subsurface Systems

1. How to balance the relationship between water tables, leaching needs, and irrigation water requirements.
2. The relationship between the location of the subsurface system to normal farming operations.
3. How to locate and space the system to achieve uniformity of water application.
4. How to accomplish crop germination in arid climates and during dry periods.

D. Pressurized Systems

1. How to adjust the application rate and/or duration to apply the required amount of water.
2. How to recognize and control runoff.
3. How to identify and improve uniformity of water application.
4. How to account for surface storage due to residue and field slope in situations where sprinkler application rate exceeds soil intake rate.
5. How to identify and manage for weather conditions that adversely impact irrigation efficiency and uniformity of application.

System Capability. The irrigation system must be capable of applying water uniformly and efficiently and must provide the irrigator with adequate control over water application.

Additional Criteria to Manage Soil Moisture to Promote Desired Crop Response

The following principles shall be applied for various crop growth stages:

- The volume of water needed for each irrigation shall be based on plant available water-holding capacity of the soil for the crop rooting depth, management allowed soil water depletion, irrigation efficiency and water table contribution.
- The irrigation frequency shall be based on the volume of irrigation water needed and/or available to the crop, the rate of crop evapotranspiration, and effective precipitation.
- The application rate shall be based on the volume of water to be applied, the frequency of irrigation applications, soil infiltration and permeability characteristics, and the capacity of the irrigation system.

Appropriate field adjustments shall be made for seasonal variations and field variability.

Additional Criteria to Optimize Use of Water Supplies

Limited irrigation water supplies shall be managed to meet critical crop growth stages.

When water supplies are estimated to be insufficient to meet even the critical crop growth stage, the irrigator or decision-maker shall modify plant populations, crop and variety selection, and/or irrigated acres to match available or anticipated water supplies.

Additional Criteria to Minimize Irrigation-Induced Soil Erosion

Application rates shall be consistent with local field conditions for long-term productivity of the soil.

Additional Criteria to Decrease Non-Point Source Pollution of Surface and Groundwater Resources

Water application shall be at rates that minimize transport of sediment, nutrients, and chemicals to surface waters and that minimize transport of nutrients and chemicals to groundwater.

Additional Criteria to Manage Salts in the Crop Root Zone

The irrigation application volume shall be increased by the amount required to maintain an appropriate salt balance in the soil profile.

The requirement shall be based on the leaching procedure contained in NRCS National Engineering Handbook (NEH) Part 623, Chapter 2, Irrigation Water Requirements, and NEH, Part 652, National Irrigation Guide, Chapters 3 and 13.

Additional Criteria to Manage Air, Soil, or Plant Micro-Climate

The irrigation system shall have the capacity to apply the required rate of water for cold or heat protection as determined by the methodology contained in NEH Part 623, Chapter 2, Irrigation Water Requirements.

Additional Criteria for Proper and Safe Chemigation or Fertigation

Chemigation or fertigation shall be done in accordance with all local, state and federal laws.

The scheduling of nutrient and chemical application should coincide with the irrigation cycle in a manner that will not cause excess leaching of nutrients or chemicals below the root zone to the groundwater or to cause excess runoff to surface waters.

Chemigation or fertigation should not be applied if rainfall is imminent. Application of chemicals or nutrients will be limited to the minimum length of time required to deliver them and flush the pipelines. Irrigation application amount shall be limited to the amount necessary to apply the chemicals or nutrients to the soil depth recommended by label. The timing and rate of application shall be based on the pest, herbicide, or nutrient management plan.

The irrigation and delivery system shall be equipped with properly designed and operating valves and components to prevent backflows into the water source(s) and/or contamination of groundwater, surface water, or the soil.

Additional Criteria to Reduce Particulate Matter Movement

Sprinkler irrigation water shall be applied at a rate and frequency sufficient to reduce the wind erodibility index (I Factor) of the soil by one class.

Additional Criteria Applicable to Reduce Energy Use

Provide analysis to demonstrate reduction of energy use from practice implementation.

Reduction of energy use is calculated as average annual or seasonal energy reduction compared to previous operating conditions.

CONSIDERATIONS

The following items should be considered when planning irrigation water management:

- Consideration should be given to managing precipitation effectiveness, crop residues, and reducing system losses.
- Consider potential for spray drift and odors when applying agricultural and municipal waste waters. Timing of irrigation should be based on prevailing winds to reduce odor. In areas of high visibility, irrigating at night should be considered.
- Consider potential for overspray from end guns onto public roads.

- Equipment modifications and/or soil amendments such as polyacrylamides and mulches should be considered to decrease erosion.
- Consider the quality of water and the potential impact to crop quality and plant development.
- Quality of irrigation water should be considered relative to its potential effect on the soil's physical and chemical properties, such as soil crusting, pH, permeability, salinity, and structure.
- Avoid traffic on wet soils to minimize soil compaction.
- Consider the effects that irrigation water has on wetlands, water related wildlife habitats, riparian areas, cultural resources, and recreation opportunities.
- Management of nutrients and pesticides.
- Schedule salt leaching events to coincide with low residual soil nutrients and pesticides.
- Water should be managed in such a manner as to not drift or come in direct contact with surrounding electrical lines, supplies, devices, controls, or components that would cause shorts in the same or the creation of an electrical safety hazard to humans or animals.
- Consideration should be given to electrical load control/interruptible power schedules, repair and maintenance downtime, and harvest downtime.
- Consider improving the irrigation system to increase distribution uniformity or application efficiency of irrigation water applications.

PLANS AND SPECIFICATIONS

Application of this standard may include job sheets or similar documents that specify the applicable requirements, system operations, and components necessary for applying and maintaining the practice to achieve its intended purpose(s).

OPERATION AND MAINTENANCE

The operation and maintenance (O&M) aspects applicable to this standard consist of evaluating available field soil moisture, changes in crop evapotranspiration rates and changes in soil intake rates and adjusting the volume, application rate, or frequency of water application to achieve the intended purpose(s). Other necessary O&M items are addressed in the physical component standards considered companions to this standard.

REFERENCES

USDA-NRCS National Engineering Handbook, Part 623, Chapter 2, Irrigation Water Requirements.

USDA-NRCS, National Engineering Handbook, Part 652, National Irrigation Guide

Appendix D
Groundwater Management Actions

Appendix D
Status of Groundwater Management Actions in San Pasqual Basin (December 2010)

Implementation Status
Not started
In progress
Completed

Basin Management Objectives (BMO's)	
No. 1	*Protect and enhance groundwater quality.*
No. 2	*Sustain a safe, reliable local groundwater supply.*
No. 3	*Reduce dependence on imported water.*
No. 4	*Improve understand-ing of groundwater elevation, basin yield and hydrogeology*
No. 5	*Partner with agricultural and residential communities to continue to improve implementation of best management practices.*

	Management Actions	**BMO No. 1.**	**BMO No. 2.**	**BMO No. 3.**	**BMO No. 4.**	**BMO No. 5.**	**Comments**
	Component No. 1 Stakeholder Involvement						
	Involving the Public				✓	✓	
1	Update Public Outreach Plan Every Five Years.						To be completed in 2012 - San Pasqual GMP Update presentation to the San Pasqual Hodges Planning Group, August 5, 2010
2	Implement Public Outreach Plan Developed for the San Pasqual GMP.						San Pasqual GMP Update presentation to the San Pasqual Hodges Planning Group, August 5, 2010
3	Provide biannual briefings to the Policy Advisory Committee (PAC) and invite stakeholders listed in**Attachment A,** including the domestic and agricultural groundwater users, on San Pasqual GMP implementation progress.						Lead Public Meeting 3rd Qtr 2010 to report on Status of GMP Implementation. State of the Basin Report 2010 being developed
4	Create a new GMP website or use an existing San Diego website to display San Pasqual GMP information. Relevant website content may include outreach material, groundwater levels, groundwater quality and project updates.						Considered for 2nd Quarter 2010, launch in April or May to coincide with completion of "State of the Basin" Report. Ground Water Reports and Fact Sheets are available through the City's website:http://www.sandiego.gov/water/gen-info/watersupply.shtml
5	Annually review list of stakeholders and update as necessary.						List updated in October 2010
	Involving Other Agencies Within & Adjacent to the San Pasqual GMP Area	✓	✓		✓	✓	
6	Contact the land use authority in the watershed such as the Cities of Escondido, Poway, and the County of San Diego, to determine interests in considering improved standard to protect water quality.						Review current actions to protect water quality within watersheds. Develop recommendations for how to improve current situation. Meet with municipal and County staff to present recommendations. Work with municipal and County staff to implement recommendations. August 30, 2010: For the Escondido General Plan Update (Case No.: PHG 09-0020) and Climate Action Plan (Case No.: PHG 10-0016), the City reviewed and provided comments to the Program Environmental Impact Report (PEIR) dated July 22, 2010.
7	Monitor and review new development proposals and projects within the watershed to ensure that these proposals incorporate appropriate measures to protect downstream water quality and water quantity, as described in the Watershed Management Plan.						Need commitment from cities and county to further protect water quality.
8	Provide copies of the adopted San Pasqual GMP and subsequent bi-annual state of the basin assessments to representatives from City of Escondido, San Diego County Water Authority and the County of San Diego and other interested parties.						2nd Quarter 2010. Invite them to download from new website. San Pasqual GMP, Ground Water Reports and Fact Sheets are available through the City's website:http://www.sandiego.gov/water/gen-
	Developing Relationships with Local, State and Federal Agencies	✓	✓		✓		

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Implementation Status	
(red)	Not started
(yellow)	In progress
(green)	Completed

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No.	Management Actions	BMO No. 1.	BMO No. 2.	BMO No. 3.	BMO No. 4.	BMO No. 5.	Comments
9	Establish a formal process whereby jurisdictions in the watershed will notify the Water Department of any new residential, commercial, or agricultural development proposals or projects in the watershed; thus providing an opportunity for the Water Department to review and comment on the development, and verify that measures to protect water quality, as described in the SDWMP are being incorporated into the designs.						To be initiated
10	Partner with local, state and federal regulatory agencies to ensure that non-compliance fees are returned to the City of San Diego to fund water resource improvement programs in San Pasqual Basin.						To be initiated
11	Establish a point of contact within local, state, and federal regulatory agencies that have responsibility for resource management within San Pasqual Basin. Important resource agencies include: DWR, DEH, RWQCB, U.S. Fish and Wildlife Service, California Dept of Fish and Game, JPA, USDA / Forest Service						DWR and JPA are listed as PAC Advisory Committee. Finalized an Agreement, Aug 2010, with DWR for Hydrological Investigations. Task Order #1 Monitoring Equipment Installation, Nov 2010.
	Pursuing Partnership Opportunities	✓	✓	✓	✓	✓	
12	Continue to promote partnerships with water purveyors and municipalities to achieve regional water supply reliability for the City of San Diego in San Pasqual Basin.						In progress with the Desal and Conjunctive Use projects and IRWMP activities.
13	Continue to track and apply for grant opportunities to fund GMP activities and local water management/development projects.						Have applied for and received 1 AB303 grant. Next application expected out in late 2010. 2 AB 303, 1 USBOR, 1 LISA
	Component No. 2 Monitoring Program and Basin Understanding						
	Groundwater Elevation Monitoring		✓		✓		
14	Identify and select production/monitoring well locations for installation of groundwater elevation data loggers.						Completed this with input from City Staff. DWR Agreement, Aug 2010, Hydrological Investigations. Task Order #1 Monitoring Equipment Installation, Nov 2010.
15	Continue to collect and evaluate groundwater elevation data from existing production and monitoring wells.						Effort is ongoing
	Surface Water Flow Monitoring				✓		
16	Continue to collect, evaluate and archive stream flow data from the creeks and streams entering and exiting the basin.						Identified as a priority for funding in 2011
	Groundwater Quality Monitoring	✓	✓		✓		
17	Continue to collect and evaluate relevant existing production and monitoring well groundwater quality data and further identify water quality constituents of concern.						According to monitoring matrix
18	Evaluate the potential mobilization of water quality contaminants as a result of rising groundwater elevations in response to implementation of a conjunctive use within the groundwater basin.						First need solid baseline of monitoring data by implementing the plan outlined in the monitoring matrix

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	Management Actions	BMO No. 1.	BMO No. 2.	BMO No. 3.	BMO No. 4.	BMO No. 5.	Comments
19	Periodically collaborate with the U.S. Geological Survey (USGS) and the State Water Resources Control Board (SWRCB) to include monitoring results from the Groundwater Ambient Monitoring and Assessment (GAMA) program in updates to the bi-annual state of the basin assessment.						Ongoing activity of City Staff. USGS San Pasqual Multilevel Monitoring Well project to be completed by Dec 2010, Project has DWR Grant Agreement w/ scope to update GAMA.
	Surface Water Quality Monitoring	✓	✓		✓		
20	Archive the analytical results of surface water sampling in the SPGMP						Need to verify with watershed group that we have all available data in the DMS. Data received from lab for 2006 to present has been added to DMS
21	Collect and analyze surface water samples for stable isotopes to better understand surface water/groundwater interaction.						Surface water data has been received from lab
	Surface Water Groundwater Interaction	✓	✓		✓		
22	Regularly summarize groundwater and Lake Hodges water quality in the bi-annual state of the basin assessments.						To be included in state of the basin report in 2010
23	Summarize surface water quality data from existing City of San Diego monitoring points in the Bi-annual State of the Basi assessments.						To be included in state of the basin report in 2010
	Protocols for Collection of Groundwater Data	✓	✓		✓		
24	Determine monitoring network adequacy and periodically review and expand as appropriate to meet the needs of the GMP on a 5 year frequency or on a special project need basis.						Should be covered under SBX7.6 Drafting a letter to DWR to meet the Jan 2011 target date to identify monitoring entity
25	Establish protocols for methods and frequency of collection, storing, and disseminating data. These protocols will be documented in the GMP and may be updated in the bi-annual state of the basin assessments.						To be included in state of the basin report in 2010
	Groundwater Reporting and Modeling				✓		
26	Determine the need for a numerical groundwater model and re-evaluate the need during development of the bi-annual state of the basin assessment. If deemed necessary, provide resources for maintaining, updating and utilizing a groundwater model. A potential application of a numerical model may be to assist in the development of a basin wide salt balance.						Groundwater model completed for Conjunctive Use Study
27	Develop and present a bi-annual state of the basin assessment.						Target date is December 2010
28	Review and update of GMP action items bi-annually. This information may be included bi-annual state of the basin reports.						Target date is December 2010
	Evaluate Bedrock Underlying San Pasqual Valley	✓	✓		✓		
29	Review well construction information to identify groups of wells screened within alluvial formations and groups screened within underlying bedrock. If information is available, evaluate grouped well data (quality and elevations) to determine if groundwater within the bedrock system is a viable groundwater water supply resource.						MWH began this process for the GMP, Antero has continued the well evaluation. Evaluation of bedrock was proposed by USGS in the San Pasqual workshop in Feb 2009. This could also be evaluated by DWR under their new contract.
	Data Management System	✓	✓		✓		

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In progress (yellow)
Completed (green)

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	Management Actions	BMO No. 1.	BMO No. 2.	BMO No. 3.	BMO No. 4.	BMO No. 5.	Comments
30	Bi-annual update Data Management System (DMS) with future groundwater elevation and quality, well construction and lithology, borehole geophysical data and surface water stream gauge data.						MWH has worked with City staff to accomplish this under the GMP implementation contract. DMS to be manage by the Water Reliability Section, Long Range Planning and Water Resources Division.
31	Provide City's available resources for maintaining and updating the DMS.						Contact person within City required
	Component No. 3 Groundwater Resource Protection						
	Well Construction Policies	✓	✓				
32	Ensure that future production and monitoring wells are constructed per the County DEH well ordinance and City of San Diego staff understands the proper well construction procedures.						To be included in state of the basin report in December 2010
33	Inform lessees and other groundwater users who are constructing production and monitoring wells of available information related to water quality concerns to assist with proper well siting. This information may be included on the GMP website.						Potential Implementation Action in 2010-2011
34	Provide lessees and other groundwater users with guidance on the importance and use of exploratory borehole information (lithologic descriptions and geophysical data) in the design and construction of production and monitoring wells. This guidance information may be included on the GMP website.						Potential Implementation Action in 2010-2011
	Well Abandonment and Destruction Policies	✓	✓				
35	Document well status (active, operational, and currently in use), inactive (not currently being used, but operational, with potential for future use), or abandoned (inoperable, or permanently inactive, with no potential for future use) as part of the well inventory survey completed during the development of the GMP. Based on survey results, if wells are classified as inactive, then resurvey every 5 years to establish current well classification and follow appropriate protocols based on well status change. Abandoned wells, not included in the groundwater monitoring program, should be properly destroyed. Based on survey results, if wells are classified as abandoned, develop phased schedule for well destruction following DWR and/or County DEH standards.						Consider requesting AB303 funds in 2010 to destroy known abandoned wells
36	Ensure that land lessees are provided a copy of the County DEH's code and understanding the proper destruction procedures and support implementation of these procedures. A link to this information shall be provided on the "GMP" website.						Potential Implementation Action in 2011-2012
37	Follow up with the County DEH on the reported abandoned and destroyed wells to confirm the information has been provided to the DWR and visa versa. The City of San Diego will also keep a record of well status in the groundwater Data Management System.						Potential Implementation Action in 2011-2012
	Protection of Recharge Areas	✓	✓				

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	Management Actions	BMO No. 1.	BMO No. 2.	BMO No. 3.	BMO No. 4.	BMO No. 5.	Comments
38	If groundwater quality monitoring data indicate groundwater contamination, review current and past land use practices to determine adverse impacts on groundwater quality. If correlations between land use and groundwater contamination are observed, then implement Best Management Practices (BMPs) or report to appropriate enforcement agency.						City has completed a Salt Balance Study to better understand sources of high TDS and nitrates in the basin The City is currently in the process to modify Ag lease contracts to address these concerns.
	Wellhead Protection Measures	✓	✓				
39	If a conjunctive use project is implemented, contact groundwater basin managers in other areas of the state for technical advice, effective management practices, and "lessons learned", regarding establishing wellhead protection areas.						Information being collected as part of the conjunctive use study will be considered before implementing this action
	Control of the Migration and Remediation of Contaminated Groundwater	✓	✓				
40	Continue reviewing groundwater quality data collected for potential presence of contamination and include status in bi-annual state of the basin assessment or every 5 years.						To be included in state of the basin report in 2010
41	If contaminant detections occur take the appropriate action to implement groundwater protection BMP or report to appropriate enforcement agency (i.e. Regional Water Quality Control Board).						The City continues to monitor water quality and elevations in the basin. Based on the findings in the Salinity Report recommendation for additional BMPs, the City may move forward to implement BMPs.
42	If contaminant detection occurs, provide the County DEH and others with all information on mapped contaminant polluters and Leaky Underground Storage Tank (LUST) sites for their information in developing groundwater extraction patterns and in the siting of future production or monitoring wells.						To be completed be City Staff. Contaminant and pollutants require notification to the appropriate authority as standard practices.
43	If contaminant detection occurs, identify point and non-point sources of groundwater contamination.						Salinity assessment is helping characterize non-point sources
	Component No. 4 Groundwater Sustainability						
	Conjunctive Management Activities			✓			
44	Continue to investigate conjunctive use opportunities and implement technically, economically environmentally feasible projects. Consideration should be given to improving the understanding of potential contaminant mobilization during recharge and rising groundwater elevations.						Ongoing and status will be reported in 2010 state of basin report. SP Groundwater Conjunctive Use Study completed May 2010, follow-on studies to be completed in 2012
45	Investigate groundwater desalination opportunities on the west side of the basin.						Ongoing and status will be reported in 2010 state of basin report. City to investigate alternatives to recharge the basin.
	Component No. 5 Planning Integration						

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	Management Actions	BMO No. 1.	BMO No. 2.	BMO No. 3.	BMO No. 4.	BMO No. 5.	Comments
	IRWMP, UWMP, Land Use Planning, and Groundwater Modeling	✓	✓	✓	✓		
46	Establish a point of contact with the San Diego Integrated Regional Water Mgt. Planning process and be involved in preparing grant application for Prop 50, Prop 84, and future funding, through the IRWMP effort.						The City participated in reviewing and commenting on the IRWMP guidelines. Cathy Perroni is the representative for the City. The City participated in the first round and several projects were submitted and subsequently pulled due to the anticipated project schedule.
47	Participate in Vision Plan updates, other relevant planning documents (i.e. UWMP, Land Use Planning, etc.) and water resources management activities.						Water Reliability Section is currently reviewing the UWMP and it is to be finalize early 2011 and Council approval of the plan is anticipated by mid to late 2011
48	The City of San Diego will include a requirement in its Source Water Protection Plan that the City Water Department will review and comment on proposals for development in the San Pasqual/Hodges watershed.						Item to be investigated further and formalized; action plan to be determined.
49	City of San Diego will seek an agreement with all jurisdictions in the drinking water source watershed. This agreement will ensure that those jurisdictions notify the City Water Department for comment on all land use proposals within the drinking water source watershed. Alternatively, the City could initiate legislation to add language to CEQA requiring jurisdictions in a drinking water source watershed to notify the water agency responsible for the drinking water source for comment on all land use proposals within the drinking water source watershed.						Item to be investigated further and formalized; action plan to be determined.






May 2014

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