Appendix A – Technical Memorandum No. 1 - Preliminary Data Review and Documentation of Technical Methods

TECHNICAL MEMORANDUM

To:	Coachella Valley Salt and Nutrient Management Plan Technical Group	**Date:**	October 16, 2014
From:	MWH	**Reference:**	10505158
Subject:	Technical Memorandum No.1 Preliminary Data Review and Documentation of Technical Methods		

1 Introduction

The Coachella Valley Water District (CVWD), Coachella Water Authority (CWA), Desert Water Authority (DWA), and Indio Water Authority (IWA) have initiated the preparation of a Salt and Nutrient Management Plan (SNMP) for the Whitewater (Indio), Mission Creek, Garnet Hill, and Desert Hot Springs Groundwater Subbasins in response to the requirements of the California Recycled Water Policy (Policy). This technical memorandum (TM-1) is the first in a series to document the development of the SNMP. TM-1 summarizes the purpose of the SNMP, reviews the areas for which the plan will cover, summarizes a preliminary data review conducted to assess technical methods, and proposes technical methods to develop the SNMP. Technical Memorandum No. 2 (TM-2) will document the calculated ambient water quality (AWQ), salt and nutrient sources and sinks, and the tool used to evaluate future projects. Following these technical memorandums, the SNMP will be prepared that includes summaries from these technical memorandums, salt and nutrient source identification, assimilative capacity and loading estimates; anti-degradation analysis, water recycling and stormwater recharge/use goals and objectives, and monitoring plans.

A draft of this TM-1 was submitted to the stakeholders on August 29, 2014. Comments were solicited and responses to comments were documented. These are attached at the end of this TM-1 as **Addendum: Stakeholder Comments and Responses**.

1.1 BACKGROUND

The State Water Resources Control Board (SWRCB) adopted Resolution No. 2009 011 in February 2009 that established the Recycled Water Policy (Policy). It requires the SWRCB and the nine Regional Water Quality Control Boards (RWQCBs) to exercise the authority granted to them by the Legislature to encourage the use of recycled water, consistent with state and federal water quality laws. To achieve this goal, the Policy provides direction to California's nine RWQCBs on appropriate criteria to be used in regulating recycled water projects (SWRCB, 2009). One objective of the Policy is that salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis that ensures meeting water quality objectives and protection of beneficial uses. The Policy states that the SWRCB finds the most appropriate way to address salt and nutrient issues is through the development of regional salt and nutrient management plans, as opposed to establishing requirements solely on individual recycled water projects.

1.2 PURPOSE OF PLAN

The Policy identifies the requirements of a SNMP, along with requirements for recycled water projects. Tabulated in **Table 1-1** below is each requirement in the Policy related to SNMPs, and a brief description. Declining imported water supply conditions in California has led to the need to increase local water supplies. The Coachella Valley (Valley) is dependent upon the Coachella Valley groundwater system as a reservoir for reliable municipal and irrigation water supply, and therefore the protection of this resource is important. Recycled water projects provide an alternative to augment and secure groundwater resources. This SNMP presents an opportunity to evaluate recycled water projects for the protection of long-term water supplies and to ensure reliability.

Table 1-1
Salt and Nutrient Management Plan Requirements

Policy Section	Component
6(b)(3)(a)	Basin/subbasin wide monitoring plan including an appropriate network of monitoring locations
6(b)(3)(a)(i)	Plan must focus on water quality near supply wells and areas near large water recycling projects (e.g., groundwater recharge); monitoring locations should target areas of groundwater/surface water connectivity, where appropriate
6(b)(3)(a)(iii)	Identify stakeholders responsible for conducting, compiling, and reporting monitoring data
6(b)(3)(b)	Provision for annual monitoring of Constituents of Emerging Concern (CECs)[1]
6(b)(3)(c)	Water recycling and stormwater recharge/use goals and objectives
6(b)(3)(d)	Salt and nutrient source identification; basin/sub-basin assimilative capacity and loading estimates; and fate and transport of salts and nutrients
6(b)(3)(e)	Implementation measures to manage salt and nutrient loading in the basin on a sustainable basis
6(b)(3)(f)	Anti-degradation analysis demonstrating that projects within the plan will, collectively, satisfy the requirements of Resolution No. 68-16[2]

1. Includes human health-based CECs (e.g., NDMA, 17β-estradiol), performance indicator CECs (e.g., DEET, sucralose), and surrogates (e.g., ammonia, TOC, electrical conductivity).
2. Resolution No. 68-16 concerned with maintenance of high-quality waters consistent with maximum benefit to the people of the state.

Numerous areas within the Valley, such as Desert Hot Springs, Sky Valley, Indio Hills, Oasis, Salton City, and areas adjacent to the San Andreas fault system have naturally-occurring high salinity groundwater as a result of local geologic conditions. If water resources in the Valley are not managed, long-term water quality degradation of the groundwater basin underlying the

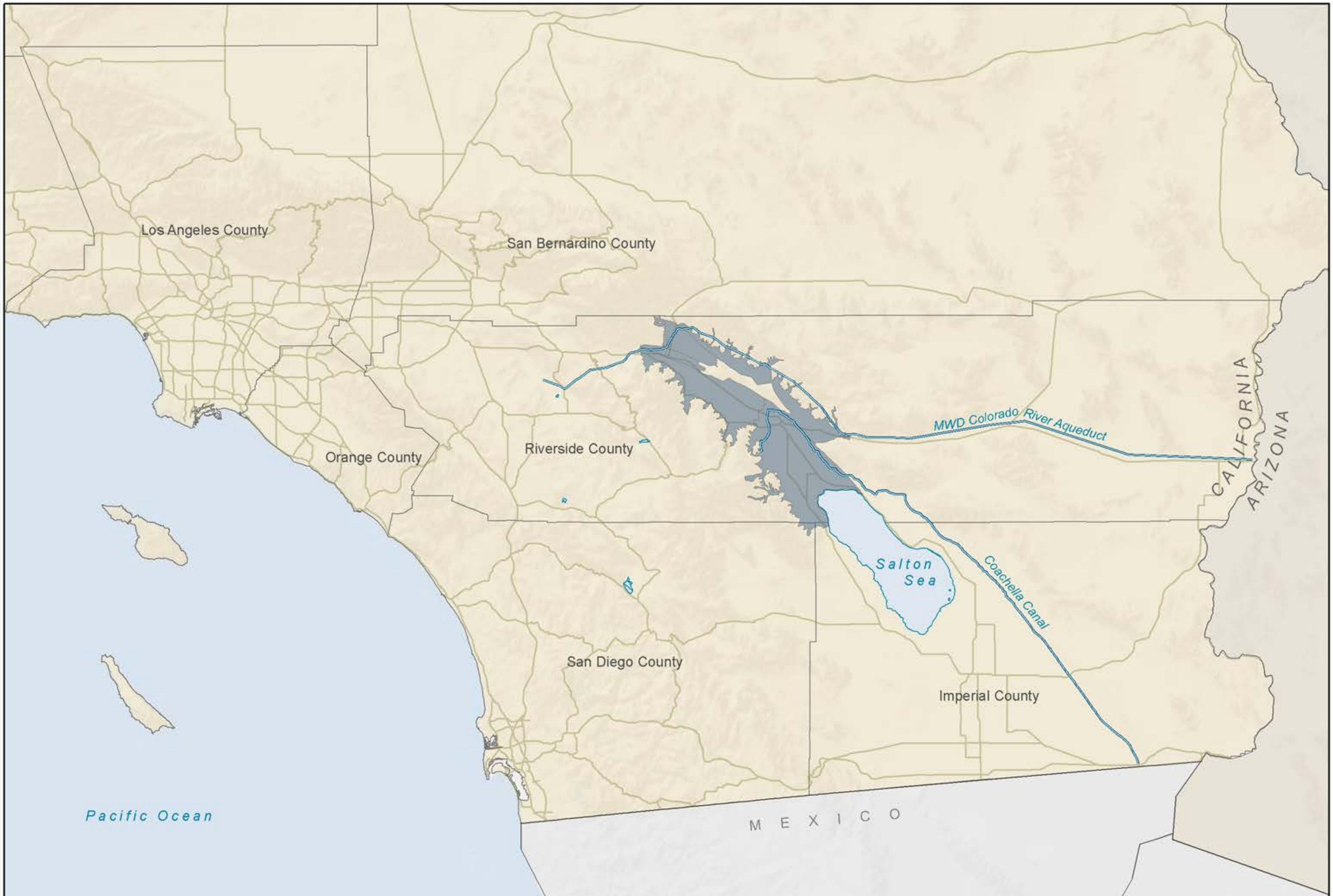
Valley could occur, potentially impacting the beneficial use of groundwater. The Coachella Valley SNMP seeks to achieve the following objectives:

- Fulfill the requirements of the Recycled Water Policy;
- Identify and evaluate potential projects, policies, and opportunities to protect groundwater quality in the Valley;
- Help to promote a sustainable water supply;
- Develop a comprehensive monitoring strategy to better understand the Coachella Valley Groundwater Basin (Basin) and ensure protection of the beneficial uses of groundwater; and
- Recommend beneficial use designation corrections for Coachella Valley groundwaters.

1.3 SALT AND NUTRIENT MANAGEMENT PLANNING AREA

The Coachella Valley Groundwater Basin lies in the northwestern portion of the Salton Trough, which extends from the Gulf of California in Mexico northwesterly to the Banning-Beaumont area. The California Department of Water Resources designated the Coachella Valley Groundwater Basin as Basin 7-21 in Bulletin 118 (1975). The Basin is located approximately 100 miles east of Los Angeles in Riverside County and portions of Imperial County. The Basin encompasses the area below much of the Valley floor. Geologic faults and structures divide the basin into five subbasins: San Gorgonio Pass, Whitewater River (Indio), Garnet Hill, Mission Creek, and Desert Hot Springs subbasins. A map of the regional setting of the Coachella valley is shown on **Figure 1-1.**

The planning area for the SNMP includes most of the Coachella Valley Groundwater Basin as shown on **Figure 1-2**. The study area is defined as the Coachella Valley floor and underlying groundwater basins, extending from the Riverside County boundary on the north to the Salton Sea at the southeast. The planning area is bounded on the west by the jurisdictional boundary separating DWA and Mission Springs Water District (MSWD) from the San Gorgonio Pass Water Agency. This location also corresponds to the boundary between the Whitewater River and the San Gorgonio Pass subbasins. The planning area is bounded on the northeast by the Little San Bernardino Mountains and on the southwest by the San Jacinto and Santa Rosa mountain ranges. This area is coincident with the planning area of the Coachella Valley Integrated Regional Water Management Plan. **Figure 1-3** shows the subbasins and subareas that comprise the Coachella Valley Groundwater Basin.



Key to Features

Highway

Water Bodies

Coachella Valley Groundwater Basin

Counties

Canal / Aqueduct

N 0 15 30 Miles

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Date: Aug 2014

Regional Map

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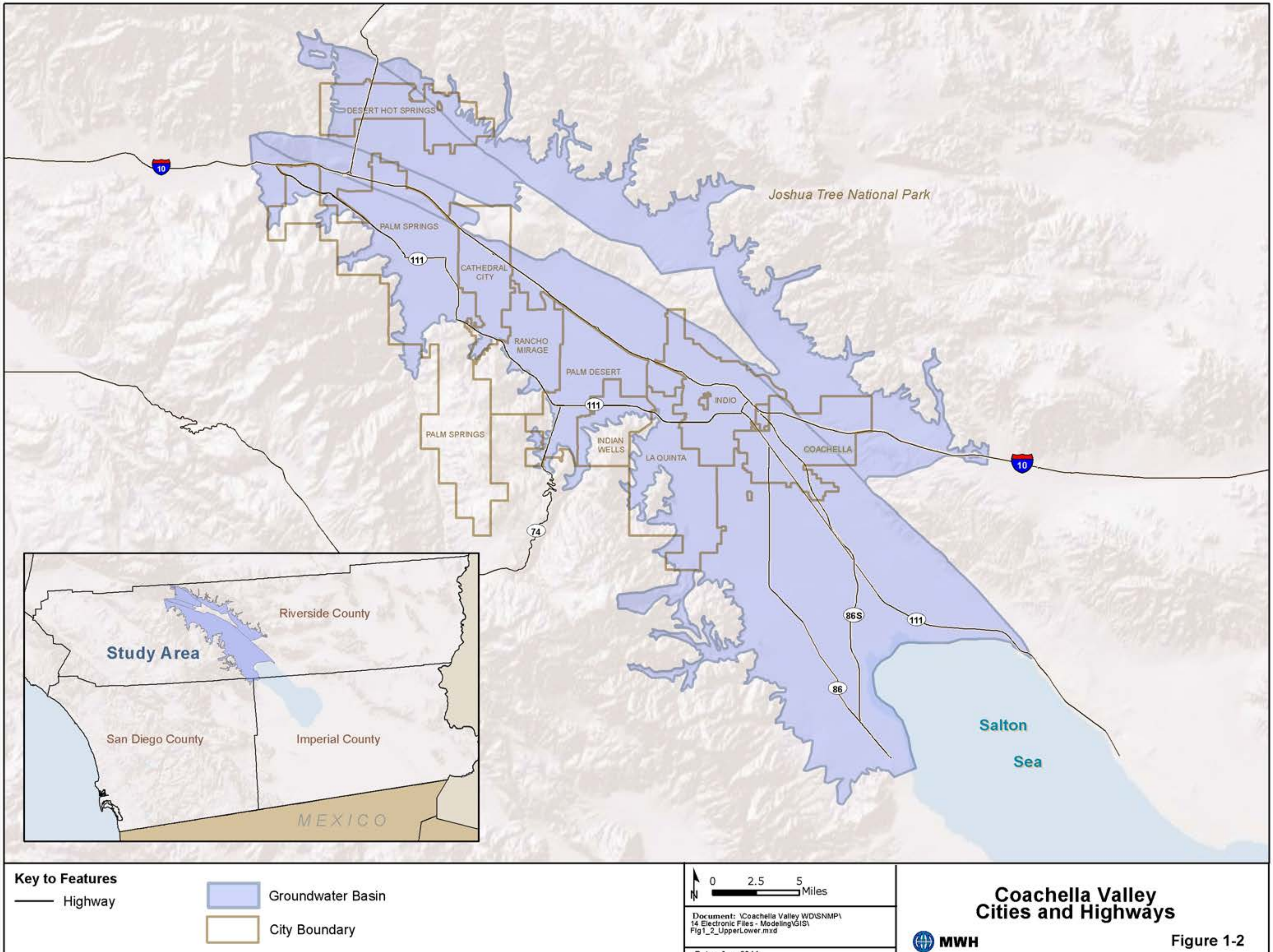
Figure 1-1



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Coachella Valley Cities and Highways

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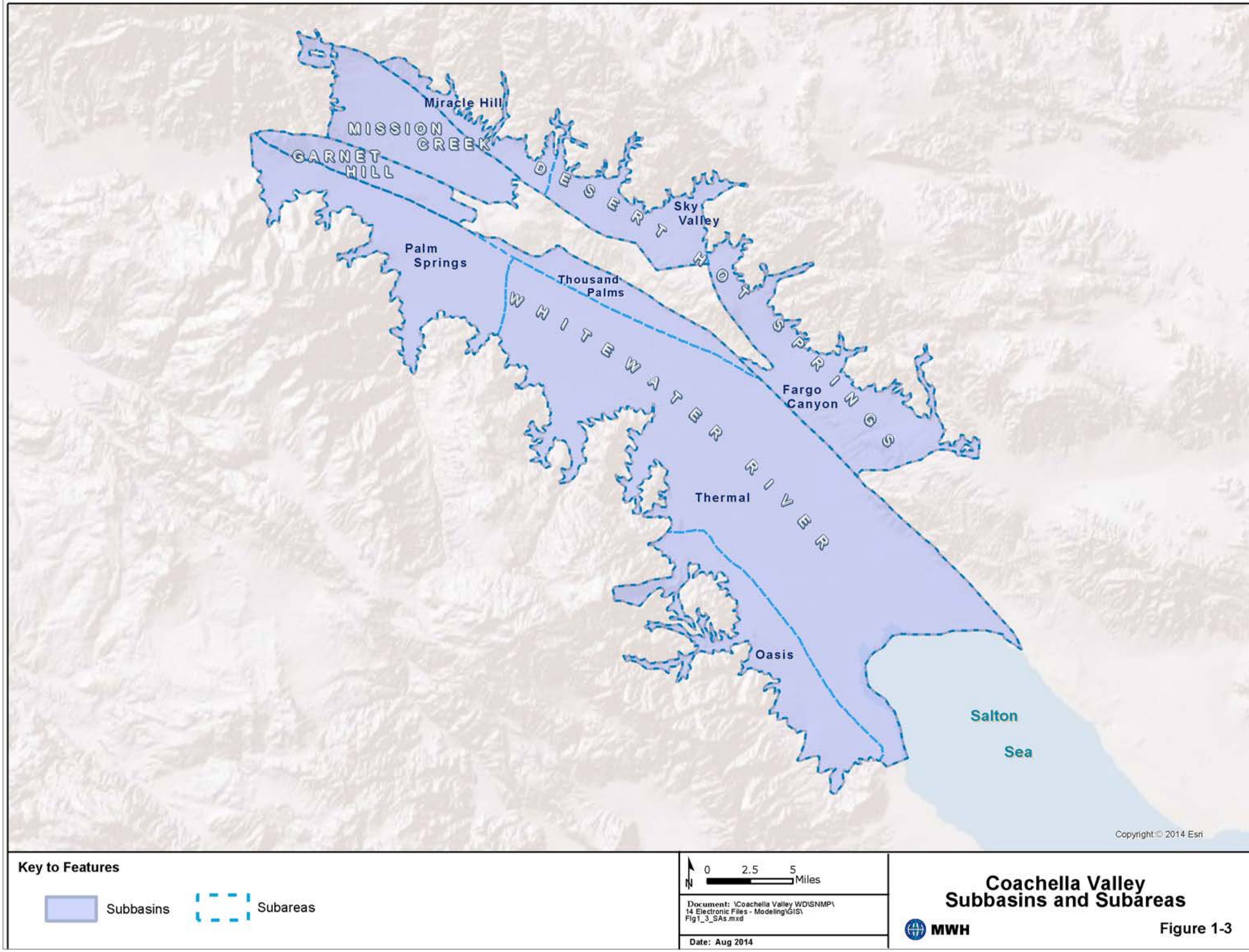
Figure 1-2



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Coachella Valley Subbasins and Subareas

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Figure 1-3

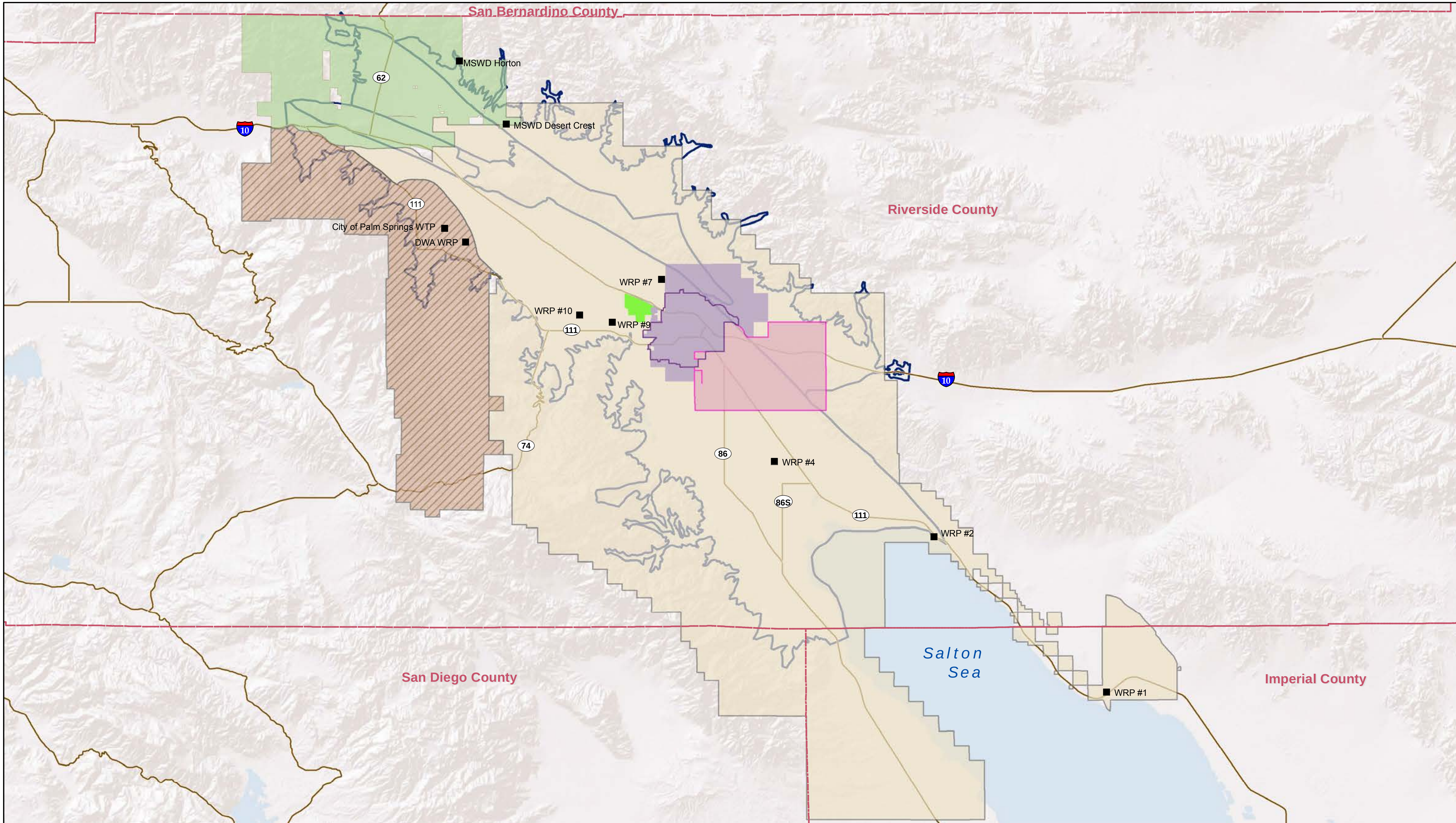
1.4 STAKEHOLDER COLLABORATION

Stakeholder participation is fundamental to ensure that this SNMP reflects the local requirements of the region and is required by the Policy. The Policy states that "local water and wastewater entities, together with local salt/nutrient contributing stakeholders, will fund locally driven and controlled, collaborative processes open to all stakeholders that will prepare salt and nutrient management plans…"

Key stakeholders include agencies associated with groundwater management, owners and operators of recharge facilities, water purveyors, water districts, and salt and nutrient contributing dischargers. These agencies have access to basin-specific data and information that is essential to the development of successful SNMPs. Private well owners may also have essential water quality information. Other parties from regulatory agencies, environmental groups, industry, and interested persons may also provide important support.

Most water users in the Valley receive water service from one of six primary purveyors: CVWD, DWA, IWA, CWA, MSWD, and Myoma Dunes Mutual Water Company. Several isolated communities and commercial developments are supplied by smaller private water companies or by tribal water distribution systems. In addition, private wells supply groundwater to many golf courses, farms, and private water users. Wastewater collection and treatment service is provided by MSWD, CVWD, the City of Palm Springs, Coachella Sanitary District, and Valley Sanitary District (portions of Indio). Areas that are not served by one of these agencies rely on individual on-site waste disposal systems for wastewater treatment and disposal. City boundaries, service area boundaries of Valley water purveyors, wastewater service area boundaries, and locations of wastewater treatment plants (WWTPs) and wastewater reclamation plants (WRPs) are presented in **Figure 1-4**. The results of this plan may have regulatory impacts related to permitting of new projects and renewal of existing projects. If there is no assimilative capacity, this could potentially translate to costs for stakeholders to meet regulatory requirements.

While CVWD, DWA, IWA, and CWA have partnered to complete the plan, no single entity is wholly responsible for SNMP preparation. Lead agencies are required to initiate and coordinate the process, but the desired result of a collaborative process is to leverage collective knowledge of many participating stakeholders. The role of a stakeholder includes attendance at stakeholder meetings, providing data as needed, reviewing of materials distributed during the process, providing information and plans related to salt and nutrient management, and providing comments and feedback.



Key to Features

- Highway
- County Boundary
- Groundwater Subbasin
- Coachella Valley Water District
- Desert Water Agency
- Mission Springs Water District
- Myoma Dunes Mutual Water Company
- Coachella Water Authority
- Indio Water Authority
- Valley Sanitary District
- Water Treatment / Reclamation Plant

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Service Area Boundaries

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Figure 1-4

1.5 SALT AND NUTRIENT MANAGEMENT PLAN DEVELOPMENT

A coordinated group of agencies has organized to evaluate regional water management issues in the Coachella Valley. The Coachella Valley Regional Water Management Group (CVRWMG), whose purpose is to coordinate water resource management efforts, consists of CVWD, CWA, DWA, IWA, and MSWD.

The CVRWMG initially held a series of three public workshops educating stakeholders on the SNMP process. As part of the development of the SNMP-related work that has been completed to date, the current CVRWMG and Stakeholders explored several of the issues that are likely to be addressed as part of the SNMP process. One of the challenges identified for this SNMP was the number of issues and size/scale of the SNMP, especially given the current Basin Plan's lack of subbasin distinction. Therefore, the SNMP process is being developed using a phased approach that will allow it to be completed over time in an incremental manner.

1. Phase I: Initial SNMP Scoping and Work Plan Development
2. Phase II: SNMP Development
3. Phase III: SNMP Monitoring and Other Follow-Up Work such as additional monitoring and data collection (if necessary and dependent on outcomes of Phase II)

Phase I of the SNMP development was completed by the CVRWMG; the result was a work plan for Phase II of the SNMP development. Phases II and III are being completed by CVWD, CWA, DWA and IWA outside the framework of the CVRWMG. Phases II of the SNMP development is the preparation of the plan, including the monitoring plan, and is currently being conducted. Phase III of the process is the implementation of the monitoring plan.

Within Phase II, the process has been divided into three stages, preliminary data review and determination of quantitative methods, determination of ambient water quality and documentation of salt and nutrient sources and sinks, and identification of water management goals and salt and nutrient management strategies. Each of the first two stages will have a technical memorandum documenting the work completed. This technical memorandum, TM-1, represents the documentation of the first stage of the plan development. The second stage will be the calculation of the ambient water quality and will culminate in the deliverable TM-2. The final stage will culminate in the preparation of the SNMP. TM-1 is organized as follows:

Section 1 – Introduction: This section provides an introduction to this technical memorandum, defines the role it plays in the development of the SNMP, specifies the requirements of the SNMP, and defines the SNMP study area.

Section 2 – Regulatory Framework: A regulatory framework exists that drives how the SNMP must be completed. This section provides background for the components of the framework which includes the Recycled Water Policy, Porter Cologne Act, State Antidegradation Policy, and the Basin Plan.

Section 3 – Preliminary Basin Characterization: This section defines the geologic and hydrologic properties of the basin that pertain to salt and nutrient management.

Section 4 – Preliminary Data Review: This section provides a summary of data collected to date relevant to the determination of existing water quality within the Basin. Ambient water quality is needed to determine assimilative capacity as defined in the Policy.

Section 5 – Proposed Methods: Methods are described to calculate the ambient water quality within management zones given the available data.

2 Regulatory Framework

The SWRCB adopted Resolution No. 2009-011 in February 2009 (later updated in January 2013) that established the Recycled Water Policy. It requires the SWRCB and the nine Regional Water Quality Control Boards (RWQCBs) to exercise the authority granted to them by the Legislature to encourage the use of recycled water, consistent with state and federal water quality laws. To achieve this goal, the Policy provides direction to California's nine RWQCBs on appropriate criteria to be used in regulating recycled water projects (SWRCB, 2013). The purpose of the policy is to increase the use of recycled water, augmenting existing supplies, while meeting applicable state and federal water quality laws. This section summarizes the Recycled Water Policy and the most applicable laws.

2.1 RECYCLED WATER POLICY

In California, declining imported water availability has led to the need to increase local water supplies and has encouraged water purveyors to develop water resources, technology, and policy. California water agencies are on the leading edge of the water resource management, supply portfolio diversification, and development of supplemental sources such as stormwater and recycled water. California agencies need to develop sustainable water supplies that meet economic and policy requirements. Based on file data from CVWD and DWA, recycled water usage in the Valley is approximately 12,400 acre-feet per year (AFY) (8,200 AFY CVWD usage, 4,200 AFY DWA usage). Recycled water usage in the East Valley is approximately 700 AFY and is mainly for agricultural irrigation, duck clubs and fish farms. The amount of municipal wastewater available for reuse is expected to increase 150 percent by 2045 (MWH, 2013; IWA, 2011).

In an effort to encourage the diversification of water supply portfolios and encourage the beneficial uses of water, the SWRCB developed a Recycled Water Policy in 2009, and later updated it in 2013. The purpose of the Recycled Water Policy is to increase the use of recycled water while meeting state and federal water quality requirements. The policy provides direction to the RWQCBs and recycled water advocates regarding the appropriate criteria to be used by the SWRCB and the RWQCBs in issuing permits for recycled water projects. The objective of this requirement is to "facilitate basin-wide management of salts and nutrients from all sources in a manner that optimizes recycled water use while ensuring protection of groundwater supply and beneficial uses, agricultural beneficial uses, and human health." The Policy compels stakeholders to develop implementation plans to meet objectives for salts and nutrients. These plans will then be adopted by a RWQCB as amendments to the region's Water Quality Control Plan (Basin Plan). The Policy also requires that SNMPs be completed by May 2014; although an extension can be granted (and has been) by the RWQCB if that the stakeholders have made substantial progress towards completion of an SNMP. On May 28, 2014, the Colorado River RWQCB granted a time extension for completion of the Coachella Valley SNMP until March 31, 2015.

2.2 PORTER-COLOGNE ACT

The Porter-Cologne Water Quality Control Act is the California law designed to protect water quality and beneficial uses of the state's water. Under the law, the SWRCB has the ultimate authority over State water rights and water quality policy. It requires the adoption of water quality control plans (the Basin Plans) and water quality objectives by the nine RWQCBs their regions. California Water Code §13050(f) describes the beneficial uses of surface and ground waters that may be designated by the State or RWQCB for protection as follows:

> "Beneficial uses of the waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves."

Also under the law, the SWRCB and nine RWQCBs, under the auspices of the U. S. Environmental Protection Agency, have the responsibility of granting Clean Water Act National Pollutant Discharge Elimination System (NPDES) permits for certain point-source discharges to surface waters. The RWQCBs are also responsible for issuing and enforcing waste discharge requirements for discharges affecting water quality. The nine RWQCBs differ somewhat in the extent they choose to apply waste discharge requirements and other regulatory actions based on the unique hydrologic conditions of each region.

2.3 BASIN PLAN

The Water Quality Control Plan (Basin Plan) for the Colorado River Basin – Region 7 establishes beneficial uses and water quality objectives for the Colorado River Basin Region.

The Basin Plan is designed to preserve and enhance water quality and protect the beneficial uses of all waters within the region (RWQCB, 2014). Specifically, the Basin Plan:

- Designates existing and potential future beneficial uses for surface and ground waters;
- Sets water quality objectives that must be maintained to reasonably protect the designated beneficial uses and conform to the state's anti-degradation policy;
- Describes implementation programs to protect the beneficial uses of all waters in the Region;
- Describes monitoring activities to evaluate the effectiveness of the Basin Plan (Water Code §13240 through 13244, and 13050); and
- Incorporates all applicable State and RWQCB plans and policies.

The Colorado River Region, the region encompassing the planning area, incorporates all of Imperial County and portions of San Bernardino, Riverside, and San Diego Counties. For planning and reporting purposes, the Basin Plan area of coverage can be divided into seven major planning areas on the basis of different economic and hydrologic characteristics: Lucerne Valley, Hayfield, Coachella Valley, Anza-Borrego, Imperial Valley, Salton Sea, and East Colorado River Basin. This SNMP covers the Coachella Valley.

The designation of beneficial uses for the waters of the State by the RWQCB is mandated under California Water Code §13240. The federal Clean Water Act Section 303 requires that the State adopt designated beneficial uses for surface waters. The requirements of both Acts relative to the designation of beneficial uses are summarized below (RWQCB, 2014).

The state must maintain the highest water quality which is reasonable while considering all demands being made and to be made on the water source and the total values involved. These values may be beneficial and detrimental, economic and social, tangible and intangible. In order to maintain a balance between water quality and total value, RWQCBs are required to consider the following issues when determining water quality objectives (California Water Code §13241):

- Past present and probable beneficial uses;
- Environmental characteristics of the hydrographic unit under consideration, including water available thereto;
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors that affect water quality in the area;
- Economic considerations;
- The need for developing housing in the region; and
- The need to develop and use recycled water.

The implementation portion of a Basin Plan must contain a description and nature of specific actions that are needed to achieve the water quality objectives, a time schedule, and a plan for monitoring compliance (California Water Code §13242).

2.3.1 Beneficial Uses

Beneficial uses are established in the Basin Plan for surface waters, groundwaters, and springs. Beneficial use categories, as defined in the Basin Plan, are summarized in **Table 2-1**.

The intent of beneficial use establishment as defined in California Water Code §13241, Division 7 is as follows:

> *"Beneficial uses of the waters of the State that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves."*

The Basin Plan designates three beneficial uses for groundwater in the Coachella Valley Planning Area: municipal, agricultural, and industrial supply. Beneficial use designations for individual aquifers have not been defined at this time. The presumption in the Basin Plan is all groundwaters in Coachella Valley either are or could potentially be used for these purposes. The Regional Board identified "Beneficial Use Designations of Aquifers" as a potential water quality issue for investigation and review in the 2007 Triennial Review of the Basin Plan. The Regional Board envisioned "recommending changes to the beneficial use designations of groundwater to correspond to individual groundwater aquifers within hydrologic units." This SNMP will document the existing beneficial uses of groundwater within the Coachella Valley. To the extent of available data, beneficial uses will be identified by aquifer within the Plan area.

Beneficial uses of surface waters for this region are designated by the California Regional Water Quality Control Board, Colorado River Basin Region. **Table 2-2** summarizes the designated beneficial uses of surface waters within the study area as identified in the Basin Plan for the region (RWQCB, 2014).

Table 2-1
Definitions of Beneficial Use Categories

Category		Definition
MUN	Municipal and Domestic Supply	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
AGR	Agriculture Supply	Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
AQUA	Aquaculture	Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.
IND	Industrial Service Supply	Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
GWR	Groundwater Recharge	Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting salt water intrusion into fresh water aquifers.
REC I	Water Contact Recreation	Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs.
REC II	Non-Contact Water Recreation	Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
WARM	Warm Freshwater Habitat	Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
COLD	Cold Freshwater Habitats	Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
WILD	Wildlife Habitat	Uses of water that support terrestrial ecosystems including, but not limited to, the preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
POW	Hydropower Generation	Uses of water for hydropower generation.
FRSH	Freshwater Replenishment	Uses of water for natural or artificial maintenance of surface water quantity or quality.
RARE	Preservation of Rare, Threatened, or Endangered Species	Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.

Source: RWQCB, 2014; Table 2-1

Table 2-2
Beneficial Uses for Study Area Surface Waters and Ground Waters
Designated by the RWQCB Region 7

Beneficial Use	Use Code	Surface Water							Groundwater
		Salton Sea	Coachella Valley Stormwater Channel[1]	Coachella Valley Drains	Coachella Canal	Whitewater River[2]	Colorado River Aqueduct[4]	Unlisted Perennial and Intermittent Streams	Coachella Hydrologic Subunit
Municipal and Domestic Supply	MUN				P	X	X	P	X[6]
Agricultural Supply	AGR				X	X			X
Aquaculture	AQUA	X							
Freshwater Replenishment	FRSH		X	X					
Industrial Service Supply	IND	P							X
Groundwater Recharge	GWR				X	X	X	I X	
Water Contact Recreation	REC I	X	X[3]	X[3]	X[3]	X	P[3]	I P X	
Non-Contact Water Recreation	REC II	X	X[3]	X[3]	X[3]	X		I X	
Warm Freshwater Habitat	WARM	X	X	X	X	I	X	I X	
Cold Freshwater Habitats	COLD					X			
Wildlife Habitat	WILD	X	X	X	X	X	X	I X	
Hydropower Generation	POW					X	P		
Preservation of Rare, Threatened, or Endangered Species	RARE	X	X[5]	X[5]	X[5]			[5]	

Source: RWQCB, 2014.
Notes: X – Existing Use
P – Potential Use
I – Intermittent Use
1 – Section of perennial flow from approximately Indio to the Salton Sea
2 – Includes the section of flow from the headwaters in the San Gorgonio Mountains to (and including) the Whitewater Spreading Facility recharge basins near Indian Avenue crossing in Palm Springs
3 – Unauthorized Use
4 – Metropolitan's Colorado River Aqueduct
5 – Rare, endangered, or threatened wildlife exists in or utilizes some of these waterway(s). If the RARE beneficial use may be affected by a water quality control decision, responsibility for substantiation of the existence of rare, endangered, or threatened species on a case-by-case basis is upon the California Department of Fish and Game on its own initiative and/or at the request of the RWQCB; and such substantiation must be provided within a reasonable time frame as approved by the RWQCB.
6 - At such time as the need arises to know whether a particular aquifer which has no known existing MUN use should be considered as a source of drinking water, the RWQCB will make such a determination based on the criteria listed in the "Sources of Drinking Water Policy" in Chapter 2 of this Basin Plan. An "X" placed under the MUN in this Table for a particular hydrologic unit indicates only that at least one of the aquifers in that unit currently supports a MUN beneficial use. For example, the actual MUN usage of the Imperial hydrologic unit is limited only to a small portion of that ground water unit.

Several inconsistencies are apparent in the Basin Plan regarding the existing and potential beneficial uses. For example, several "existing" uses for the Coachella Canal such as contact and non-contact recreation are listed; however, these uses are prohibited by CVWD. A similar situation exists regarding potential contact recreation in the Colorado River Aqueduct where contact recreation is both dangerous and illegal. It may be appropriate to designate these uses as "prohibited." Power generation is an existing beneficial use for Colorado River Aqueduct water released at the Whitewater turnout. Future Basin Plan updates should reflect these changes.

2.3.2 Region Water Quality Objectives

Water quality objectives (WQO) are established by the Basin Plan to protect and maintain the integrity of each type of Beneficial Use. Objectives may be narrative or numeric, and vary by location, Beneficial Use category, and surface water body/groundwater basin.

General objectives that apply to the entire planning region include the antidegradation provision of the Basin Plan, which states:

> *"Wherever the existing quality of water is better than the quality established herein as objectives, such existing quality shall be maintained unless otherwise provided for 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."*

The Basin Plan recognizes the lack of available data to develop specific numeric groundwater objectives for each Subbasin in the Region. Therefore, groundwater objectives are typically referenced at the applicable numeric objectives related to their Beneficial Use. A summary of referenced codes and narrative objectives for groundwater is summarized in **Table 2-3**.

Table 2-3
Basin Plan Groundwater Objectives

Constituent	Water Quality Objective
Taste and Odors	Ground waters for use as domestic or municipal supply shall not contain taste or odor-producing substances in concentrations that adversely affect beneficial uses as a result of human activity.
Bacteriological Quality	Section 64426.1 of California Code of Regulations, Title 22.
Chemical and Physical Quality	Sections 64431 (Inorganic Chemicals), 64444 (Organic Chemicals), and 64678 (Lead and Copper) of California Code of Regulations, Title 22.
Brines	Discharges of water softener regeneration brines, other mineralized wastes, and toxic wastes to disposal facilities which ultimately discharge in areas where such wastes can percolate to ground waters usable for domestic and municipal purposes are prohibited.
Radioactivity	Sections 64442 and 64443 of California Code of Regulations, Title 22.

For the purpose of estimating assimilative capacity, numeric objectives may be required for individual constituents of concern. The Title 22 primary maximum contaminant level (MCL) of 45 mg/L nitrate (as NO_3) will be used as the water quality objective for nitrate. As TDS is a taste and odor constituent, the basin plan lists no specific numeric objective. It is recommended that a range of water quality objectives be considered for TDS. A major source of water currently being used to augment groundwater supplies is the Colorado River. A protective water quality objective of 879 mg/L TDS is currently being used for this surface water at Imperial Dam and will be considered for the groundwater numeric objective. Additionally, the Title 22 upper consumer acceptance contaminant level for TDS of 1,000 mg/L will be considered.

2.4 RESOLUTION NO. 68-16 - STATE ANTI-DEGRADATION POLICY

SWRCB Resolution No. 68-16 is a state policy that establishes the requirement that discharges to waters of the state shall be regulated to achieve the "highest water quality consistent with maximum benefit to the people of the State". Under SWRCB Resolution No. 68-16, the RWQCB and the SWRCB must have sufficient grounds to adopt findings which demonstrate that any water quality degradation will:

- Be consistent with the maximum benefit to the people of the State;
- Not unreasonably affect existing and potential beneficial uses of such water; and
- Not result in water quality less than described in the Basin Plan (RWQCB, 2014).

In addition, any activity that results in discharges to existing high quality waters are required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that a) a pollution or nuisance will not occur, and b) the highest water quality consistent with the maximum benefit to the people of the State will be maintained.

Resolution No. 68-16 establishes a general principle of non-degradation. The policy does allow for flexibility as water quality pertains to the best interests of the people of the State. Changes in water quality are allowed only where it is in the public interest and beneficial uses are not unreasonably affected. The SWRCB has interpreted Resolution No. 68-16 as incorporating the three part principles set forth in the federal anti-degradation policy. These three principles include: 1) Existing in-stream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected; 2) where the quality of the waters exceed levels necessary to support propagation of wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds after full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process that allowing lower water quality is necessary to accommodate important economic or social development in the area. By allowing such degradation, the State shall assure water quality adequate to protect existing uses fully; and 3) where high quality waters constitute an outstanding National resource, such as waters of national and state parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected (40 C.F.R.§131.12a). The terms and conditions of Resolution No. 68-16 serve as a general narrative water quality objective in all state water quality control plans (RWQCB, 2014).

The Resolution does not require that existing high quality water always be maintained. It states that any change must be consistent with maximum benefit to the people of the State; it cannot unreasonably affect beneficial uses, and must comply with applicable water quality control policies (SWRCB, 1994). To be consistent with the resolution, discharges may range between ambient or background and the water quality objectives in the Basin Plan. The resolution assumes the discharger must use best practicable treatment and control technology (BPTC). If a treatment or control method results in a discharge that maintains the existing water quality, then a less stringent level of treatment or control would not be in compliance with the Resolution. If the discharge, even after treatment, unreasonably affects beneficial uses or does not comply with the Basin Plan, the discharge is prohibited. The discharge is not required to be treated to levels that are better than ambient background water quality (SWRCB, 1994).

In November 2012, the California Third District Court of Appeal ruled in the case *Asociacion de Gente Unida Por El Agua v. Central Valley Regional Water Quality Control Board* (210 Cal.App.4th 1255) that the anti-degradation policy applies whenever there is "an existing high quality water" and "an activity which produces or may produce waste … that will discharge into such high quality water." The appeals court interpreted an existing high quality water to exist where the baseline water quality (that existed in 1968) is better than the water quality objective.

While this case related to waste discharges from dairies in the Central Valley, the SWRCB Chief Counsel issued a memorandum on the case in February 2013. That memorandum stated "The Court … based its analysis on existing State Water Board guidance, so the case does not establish new rules or legal principles. [The case] is nevertheless significant because it gives precedential effect to some of this guidance. The decision also underscores the importance of documenting the steps to support an antidegradation analysis or to support a finding that an antidegradation analysis is unnecessary."

The Court relied extensively on existing State Water Board guidance, including Administrative Procedures Update (APU) 90-004 and the 1995 Question and Answer document on Resolution 68-16. While APU 90-004 technically only applies to NPDES permitting, the Court found it instructive in applying Resolution 68-16 in other contexts stating:

> APU-90-004 sets forth a procedure for determining whether the existing water quality is to be protected: "The baseline quality of the receiving water determines the level of water quality protection. Baseline quality is defined as the best quality of the receiving water that has existed since 1968 when considering Resolution No. 68-16, … unless subsequent lowering was due to regulatory action consistent with State and federal antidegradation policies."
>
> When undertaking an antidegradation analysis, the RWQCB must compare the baseline water quality (the best quality that has existed since 1968) to the water quality objectives. If the baseline water quality is equal to or less than the objectives, the objectives set forth the water quality that must be maintained or achieved. In that case the antidegradation policy is not triggered. However, if the baseline water quality is better than the water quality objectives, the baseline water quality must be maintained in the absence of findings required by the antidegradation policy.

The SWRCB Chief Counsel offered several additional observations regarding the effect of this decision:

- Time schedules or phased implementation of anti-degradation requirements are appropriate. As with other requirements, time schedules must be justified by facts in the record and supported by findings.
- The case confirms that what constitutes BPTC can vary in different situations involving the same type of discharge only if the board finds that any lesser treatment or control requirements were necessary to accommodate important economic or social development in the area, would avoid pollution or nuisance (i.e., would not cause water quality objectives to be exceeded) and would maintain the highest water quality consistent with the maximum benefit to the people of the state.
- "Maximum benefit" findings must consider the costs to the affected public, such as costs to treat water supplies affected by a discharge. When cost savings to the discharger are part of the justification for allowing degradation, a Water Board must also demonstrate how the cost savings are necessary to accommodate important social and economic development.
- The decision does not require regulated facilities in other programs to conduct groundwater quality monitoring in addition to or instead of other types of monitoring. Specific monitoring requirements must be based on the facts of each case. Orders authorizing discharges of waste should include findings demonstrating that the order as a whole provides adequate assurance that only the authorized amount of degradation, if any, will occur, and that monitoring and reporting requirements are adequate to detect degradation or to prevent any additional degradation if it were to occur.
- BPTC determinations may consider relative benefits of proposed treatment or control methods to proven technologies; performance data; alternative methods of treatment or control; methods used by similarly situated dischargers; and/or promulgated BAT or other technology-based standards. Costs of treatment or control should also be considered.

The effect of this decision on development of the SNMP has not been determined.

2.5 ASSIMILATIVE CAPACITY

The assimilative capacity of a surface water or groundwater is the ability of the water body to receive and accommodate natural and anthropogenic sources of pollutants, while maintaining water quality standards that are protective of the beneficial uses of the water resource. The SNMP coverage of assimilative capacity is focused exclusively on groundwater. Factors that affect the assimilative capacity of a basin depend on the contaminant, the soil type, and the groundwater chemistry and hydraulic parameters.

The available assimilative capacity of a water body or management zone is also defined as the difference between the applicable water quality objective for a pollutant parameter and the ambient water quality for that pollutant parameter (where it is lower than the objective). This is illustrated on **Figure 2-1**. Ambient water quality is the representative concentration of a water quality constituent within a water body or management zone. If the ambient water quality exceeds, the water quality objective, the presumption is that assimilative capacity does not exist.

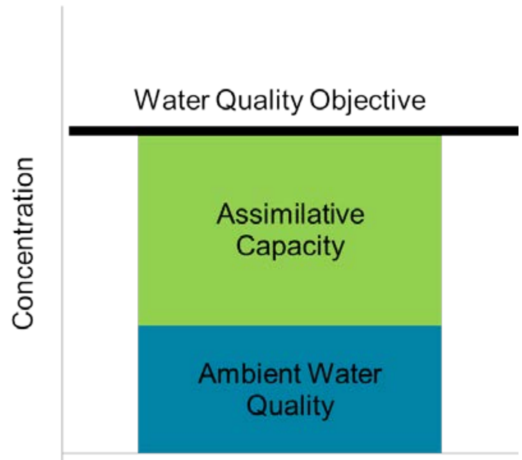


Figure 2-1
Assimilative Capacity Relationship to Ambient Water Quality

Resolution No. 68-16 satisfies the federal requirement that each state establish its own anti-degradation policy consistent with the federal Anti-Degradation Policy. While the federal Anti-Degradation Policy addresses water quality of surface waters, Resolution No. 68-16 applies to both surface waters and groundwater. The basic policy directions of Resolution 68-16 are that whenever the ambient water quality is a lower concentration than the water quality objectives established in the Basin Plan, the existing high quality shall be maintained, or it can be "demonstrated to the state that any change will be consistent with maximum benefit to the people of the state, will not unreasonably affect present and anticipated beneficial use of such water ... ." This is often referred to as maximum benefit. The resolution also states that "... any activity ... which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained."

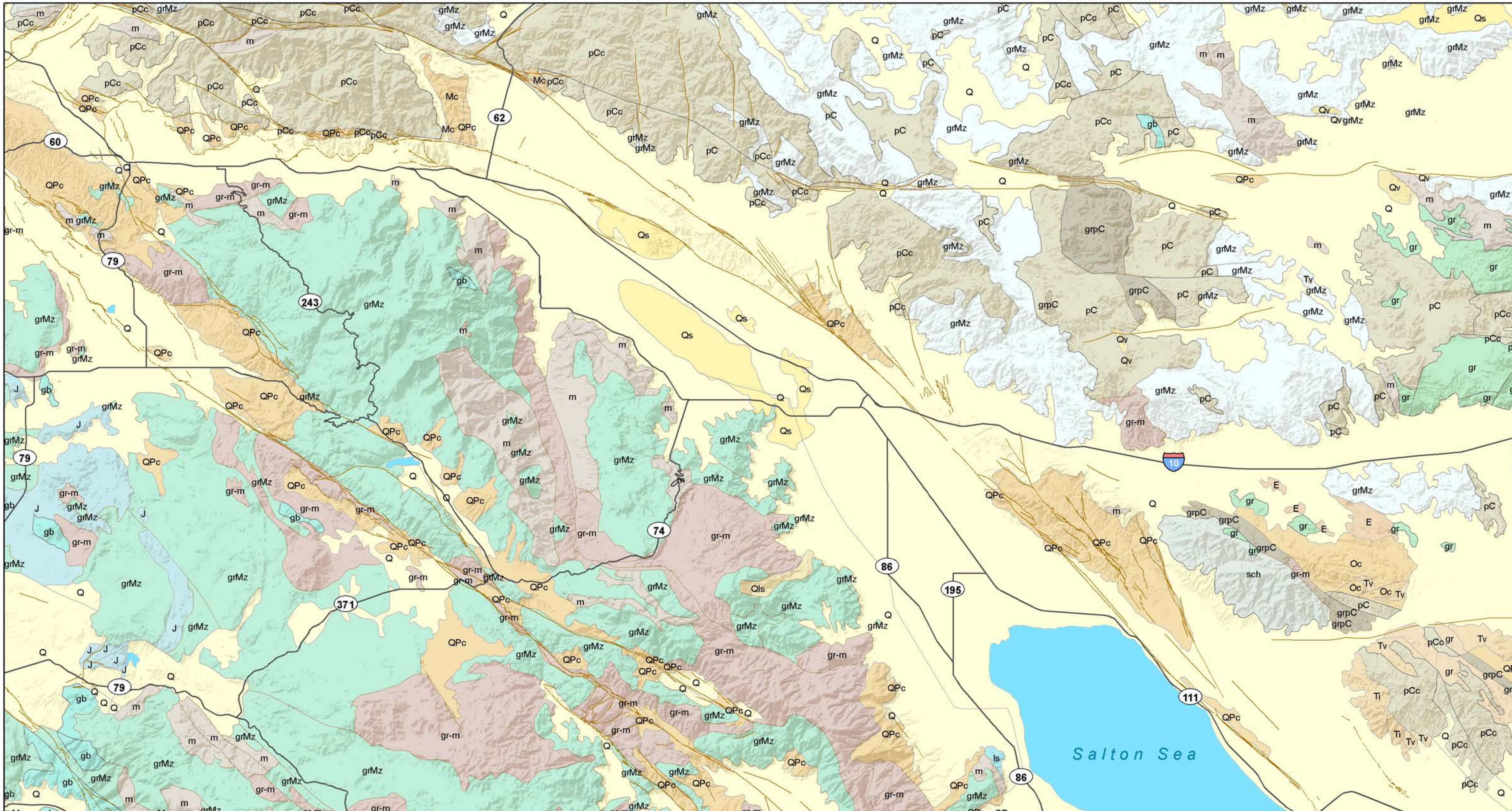
3 Initial Basin Characterization

This section summarizes the geologic and hydrologic properties of the Basin that pertain to salt and nutrient management. This includes a description of the Coachella Valley, groundwater basins within the Valley, and groundwater quality. This discussion is primarily based on Bulletin 108 (DWR, 1964), Bulletin 118 (DWR, 2003), the Coachella Valley Water Management Plan and Plan Update (Water Consult and MWH, 2002; MWH, 2012), the Mission Creek and Garnet Hill Subbasins Water Management Plan (MWH, 2013), and Engineers Reports on Water Supply and Replenishment Assessment (CVWD 2010; CVWD 2014). Water quality data gathered for SNMP development, discussed in Section 4, is included to summarize the historical and current groundwater quality within Coachella Valley.

3.1 DESCRIPTION OF THE COACHELLA GROUNDWATER BASIN

Coachella Valley lies in the northwestern portion of the Salton Trough, which extends from the Gulf of California in Mexico northwesterly to the Cabazon area. The Basin is bounded on the north and east by crystalline bedrock of the San Bernardino and Little San Bernardino Mountains and on the south and west by the crystalline rocks of the Santa Rosa and San Jacinto Mountains. The Basin is bounded on the west end of the San Gorgonio Pass groundwater divide. The southern boundary is the Salton Sea. Geologic faults and structures generally divide the Basin into four subbasins (Tyley, 1974); these faults limit groundwater flow between the subbasins. The four subbasins include: the Whitewater (Indio), Garnet Hill, Mission Creek, and Desert Hot Springs.

The primary aquifer system in the Valley is unconsolidated Pleistocene-Holocene valley fill. **Figure 3-1** illustrates the Valley geology. Groundwater recharge is primarily runoff from the surrounding mountains, local precipitation, irrigation return, stream flow from the Whitewater River and other rivers and creeks, and from imported Colorado River water supplied to spreading grounds throughout the Valley. Groundwater discharge is to evapotranspiration, to underflow to the Salton Sea and Imperial Valley areas, and to pumping wells.



Key to Features

- Quaternary Fault
- Major Roadways
- Water

Geology (USGS OFR 2005-1305, Updated 2007)

Quaternary
- Qv — Basalt
- Qs — Dune Sand
- Qls — Landslide

Tertiary
- Q — Alluvium
- Ti — Basalt
- E — Mudstone
- Tv — Rhyolite

- QPc/Oc/Qc/Mc — Sandstone

Cretaceous
- sch — Schist

Jurassic
- gr — Plutonic rock
- grMz — Tonalite

Triassic
- gb — Gabbro

Permian
- grMz — Diorite

Paleozoic
- J — Argillite
- ls — Limestone

PreCambrian
- pC/pCc — Gneiss
- grpC — Granite
- gr-m — Plutonic rock
- m — Schist

N 0 5 10 Miles

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Date: 8/13/2014

Coachella Valley Geology

MWH.

Figure 3-1

3.2 WHITEWATER RIVER (INDIO) SUBBASIN

The Whitewater River Subbasin, designated the Indio Subbasin (Basin No. 7-21.01) in DWR Bulletin No. 118 (DWR, 2003), underlies the major portion of the Valley floor and encompasses approximately 400 square miles. Beginning approximately one mile west of the junction of State Highway 111 and Interstate Highway 10, the Whitewater River Subbasin extends southeast approximately 70 miles to the Salton Sea. The subbasin underlies the cities of Palm Springs, Cathedral City, Rancho Mirage, Palm Desert, Indian Wells, La Quinta, Indio, and Coachella, and the unincorporated communities of Thousand Palms, Thermal, Bermuda Dunes, Oasis, and Mecca.

The Whitewater River Subbasin is divided into four subareas: Palm Springs, Thermal, Thousand Palms, and Oasis. The Palm Springs Subarea is the forebay or main area of recharge to the subbasin and the Thermal Subarea comprises the pressure or confined area within the basin. The other two subareas are peripheral areas having unconfined groundwater conditions (CVWD, 2010).

3.2.1 Geologic Structure and Water Levels

The geology of the subbasin varies with coarse-grained sediments located in the vicinity of Whitewater and Palm Springs, gradually transitioning to fine-grained sediments near the Salton Sea. From about Indio southeasterly to the Salton Sea, the subbasin contains increasingly thick layers of silt and clay, especially in the shallower portions of the subbasin. These silt and clay layers, which are remnants of ancient lake beds, impede the percolation of water applied for irrigation and limit groundwater recharge opportunities to the westerly fringe of the subbasin.

The subbasin is bordered on the southwest by the Santa Rosa and San Jacinto Mountains and is separated from Garnet Hill, Mission Creek, and Desert Hot Springs Subbasins to the north and east by the Garnet Hill and San Andreas Faults (CVWD, 2010; DWR, 1964). The Garnet Hill Fault, which extends southeastward from the north side of San Gorgonio Pass to the Indio Hills, is a relatively effective barrier to groundwater movement from the Garnet Hill Subbasin into the Whitewater River Subbasin, with some portions in the shallower zones more permeable. The San Andreas Fault, extending southeastward from the junction of the Mission Creek and Banning Faults in the Indio Hills and continuing out of the basin on the east flank of the Salton Sea, is also an effective barrier to groundwater movement from the northeast. Water placed on the ground surface in the West Valley will percolate through the sands and gravels directly into the groundwater aquifer. However, in the East Valley, several impervious clay layers lie between the ground surface and the main groundwater aquifer. Water applied to the surface in the East Valley does not easily reach the East groundwater aquifers due to these impervious clay layers. The only outlet for groundwater in the Whitewater River Subbasin is through natural subsurface outflow to the Salton Sea or through agricultural drains and transport to the Salton Sea directly or via the Coachella Valley Stormwater Channel (CVSC).

In 1964, the DWR estimated that the five subbasins that make up the Coachella Valley groundwater basin contained a total of approximately 39.2 million acre-feet (AF) of water in the first 1,000 feet below the ground surface; much of this water originated as runoff from the adjacent mountains. Of this amount, approximately 28.8 million AF of water was stored in the

Whitewater River Subbasin. However, the amount of water in the Whitewater River Subbasin has decreased over the years due to pumping to serve urban, rural and agricultural development in the Coachella Valley has withdrawn water at a rate faster than its rate of recharge.

The Whitewater River Subbasin is not adjudicated. From a management perspective, the subbasin is divided into two management areas referred to in this document as the West Valley and the East Valley. The division between these two areas is an irregular line trending northeast to southwest between the Indio Hills north of the City of Indio and Point Happy in La Quinta. The West Valley is jointly managed by CVWD and DWA under the terms of the 2014 Water Management Agreement. The East Valley is managed by CVWD. DWA and CVWD jointly operate a groundwater replenishment program whereby groundwater pumpers (other than minimal pumpers[1]) within designated management areas pay a per acre-foot charge that is used to pay the cost of importing water and recharging the aquifer.

The conceptual hydrostratigraphic section for the Valley consists of four zones (DWR, 1964):

- Semi-perched aquifer and intervening retarding layers (correlated with Recent lake deposits and alluvium)
- Upper aquifer (correlated with Upper Pleistocene alluvium)
- Aquitard
- Lower aquifer (correlated with the Pleistocene Ocotillo Conglomerate)

Each of the four water-bearing zones, from shallowest to deepest, are described briefly below. **Figure 3-2** illustrates the approximate area of semi-perched and confined aquifers and **Figure 3-3** illustrates the generalized hydrogeologic section of the Whitewater River Subbasin. The following sections provide a brief description of each stratigraphic zone based upon the work of DWR (1964 and 1979), United States Geological Survey (1974), and more recent data collected as part of the 2010 CVWD Water Management Plan Update (MWH, 2012).

3.2.1.1 Semi-perched Aquifer

The semi-perched aquifer is characterized by fine-grained Holocene and Recent lake deposits and alluvium that form an effective barrier to the deep percolation of surface runoff and applied water within the central portion of the East Valley where present. This zone is not present in the West Valley. In the East Valley, the semi-perched aquifer extends across the central portion of the basin but is absent from the basin margins. The general extent of the semi-perched aquifer is shown in **Figure 3-2**; **Figure 3-3** shows a generalized hydrogeologic profile of the Valley. Groundwater flow is generally from the northwest to the southeast. More detailed cross-sections are presented in **Appendix B** and **Appendix C** (MWH, 2010). The thickness of this aquifer unit is as much as 100 feet in the center of the basin. The semi-perched aquifer consists of interbedded layers of fine sand and clay and is separated from the underlying upper aquifer by a laterally discontinuous clay zone (DWR, 1964). Where the clay zone is absent in portions of the East Valley, the semi-perched aquifer merges with the underlying upper aquifer.

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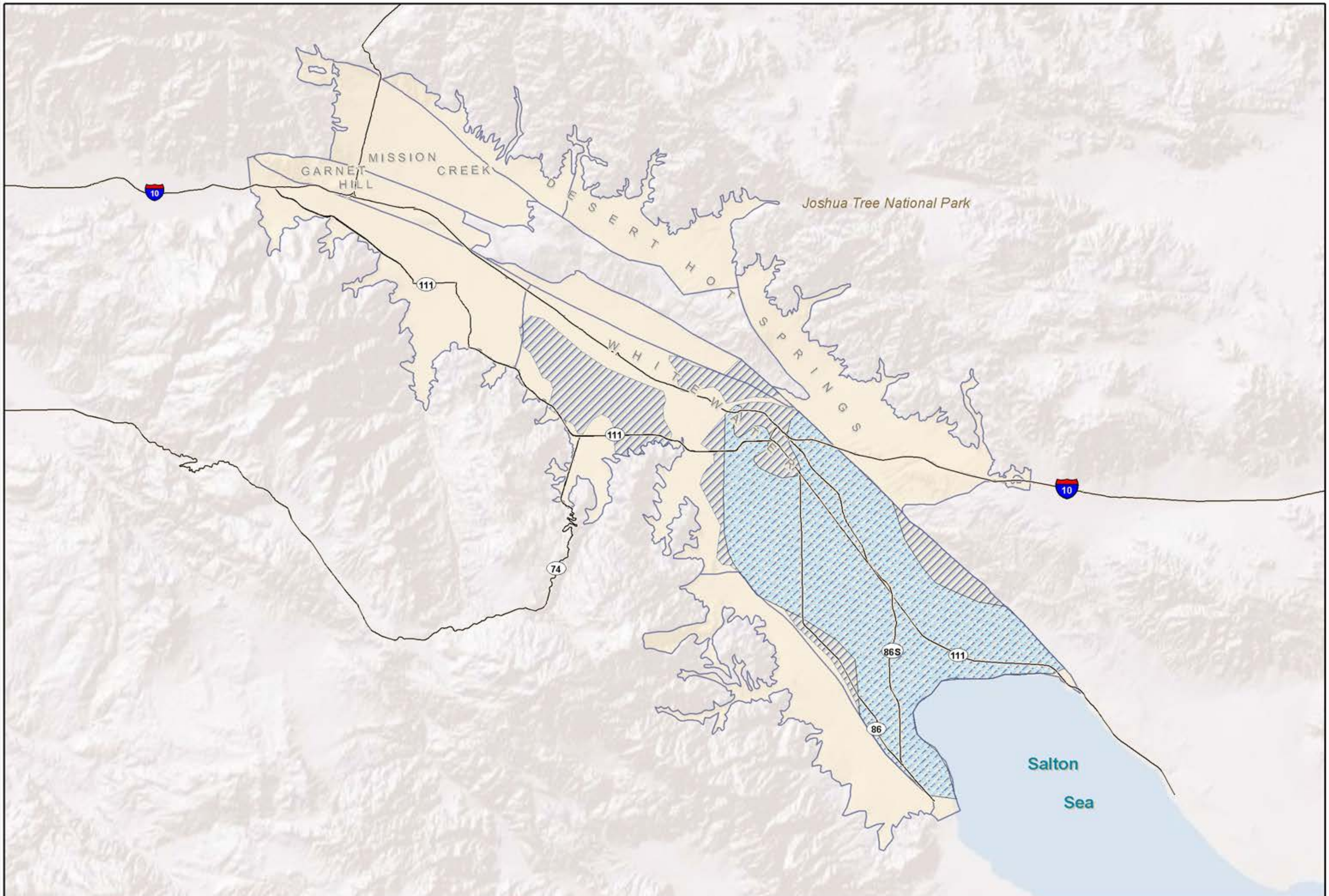
[1] CVWD's enabling legislation defines a minimal pumper as any producer who produces 25 or fewer AF in any year. DWA's legislation defines a minimal pumper as any producer who produces 10 or fewer AF in any year.



Key to Features

- Highway
- Subbasin
- Groundwater Basin
- Confining Layer
- Semi-Perched

0 2.5 5 Miles

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Date: July 2014

Confining Layer

MWH

Figure 3-2

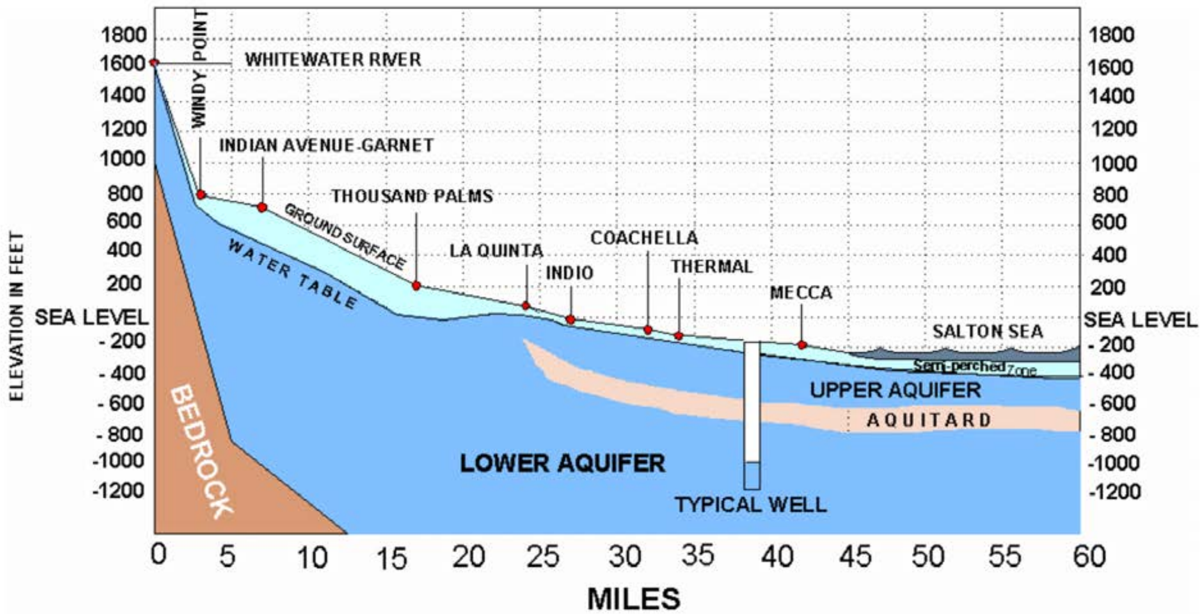


Figure 3-3
Coachella Valley Groundwater Basin Generalized Profile

Recharge of the semi-perched aquifer is largely from percolation of surface runoff and return flows of applied water. Groundwater leaves the semi-perched aquifer as surface flow into agricultural drains, evapotranspiration and vertical leakage to the upper aquifer.

3.2.1.2 Upper Aquifer

Based on DWR (1964), the upper aquifer, which is formed of Upper Pleistocene alluvium, underlies the semi-perched aquifer. The upper aquifer typically consists of coarse sand and gravel with discontinuous clay lenses in the West Valley and the northern part of the East Valley. Finer sand and sandy clay dominate in the southern part of the East Valley. The upper aquifer is believed to be unconfined or semi-confined in most of the West Valley, and is confined in most of the East Valley by the semi-perched aquifer and a discontinuous clay layer (referred to as the aquitard).

The upper aquifer is approximately 150 to 300 feet thick (DWR. 1964). It is relatively flat in the central part of the Coachella Valley and is upturned and thin along the basin margins, sub-parallel to the ground surface. In the northern portion of the East Valley, the top of the upper aquifer is located at elevations ranging from 100 feet above mean sea level (MSL) along the basin margins to 200 feet below MSL in the central portion of the basin. In the southern portion of the basin, the top of the upper aquifer is encountered at elevations ranging from approximately 100 feet above MSL along the basin margins to 500 feet below MSL in the center of the basin. Recharge to the upper aquifer is by:

- Percolation of streamflow runoff, particularly near the margins of the Valley
- Percolation of agricultural irrigation water from the semi-perched aquifer

- Subsurface inflow from outside the study area, both beneath the San Gorgonio Pass and, to a lesser extent, across the Banning Fault.

Groundwater leaves the upper aquifer primarily by percolation into the underlying lower aquifer, particularly where the aquifers merge in the West Valley and at the margins of the East Valley. Additional groundwater discharge occurs by water supply wells throughout the Coachella Valley.

3.2.1.3 Aquitard

A discontinuous aquitard separates the upper and lower aquifers in the East Valley. The aquitard typically consists of clay and sandy clay with discontinuous sand lenses having low permeability. Sand is more common in the northern portion of the aquitard, which thins in the West Valley but is identifiable as far north as Cathedral City. The aquitard cannot be found in all well construction logs, it is absent at the basin margins and reaches a maximum thickness of approximately 200 feet in the portions of the East Valley; in small areas adjacent to the Salton Sea, it is as much as 500 feet thick (DWR, 1964). It is underlain by the lower aquifer. The fine-grained materials making up the aquitard are not tight enough or persistent enough to completely restrict the vertical flow of water between the upper and the lower aquifers (DWR, 1964). The lateral extent of the aquitard is presented in **Figure 3-2.**

3.2.1.4 Lower Aquifer

The lower aquifer is formed of the Ocotillo conglomerate and is the deepest and principal water-bearing zone of the East Valley. Rocks of the semiwater-bearing group and nonwater-bearing group underlie it. In the area generally described as the West Valley, the northern portion of the East Valley and the basin margins, the lower aquifer typically consists of coarse sand and gravel. In most of the East Valley, the lower aquifer is composed of sandy clay. One or two lower-permeability layers subdivide the lower aquifer through most of its extent.

Like the overlying units, the edges of the lower aquifer are upturned along the basin margins. The top of the lower aquifer is encountered at elevations ranging from 100 to 300 feet below MSL in the northern portion of the basin and at elevations ranging from 400 to 600 feet below MSL in the southern portion of the basin. The aquifer dips in the direction of the Salton Sea. It is typically 100 to over 1,000 feet thick.

The lower aquifer is recharged by percolation from the upper aquifer, particularly in areas where the two aquifers merge. Near the margins of the East Valley, where the semi-perched aquifer and the aquitard are absent, runoff from mountain streams percolates into the alluvial fans at the base of the mountains and provides an additional source of recharge to the merged upper and lower aquifers. Through most of the West Valley, the two aquifers are not clearly distinguishable and groundwater levels are approximately equal. The water levels in the aquifers begin to diverge where they become separated by the aquitard. With increased groundwater pumping to supply increasing urbanization and agricultural use, groundwater levels have declined in the area in which the aquifers are merged.

Outflow from the lower aquifer is primarily through water supply wells. Historically, some groundwater migrated out of the lower aquifer flowing into the area beneath the Salton Sea. Basin pumping, however, may have reversed the direction of this subsurface flow in some portions of the basin, as indicated by increased TDS measurements and modeling studies. The increased TDS concentration may be a result of ancient saline water left by previous saline lakes (CVWD, 2011).

3.2.2 Palm Springs Subarea

The triangular area between the Garnet Hill Fault and the east slope of the San Jacinto Mountains southeast to Cathedral City is designated the Palm Springs Subarea, and is an area in which groundwater is unconfined. The Valley fill materials within the Palm Springs Subarea are essentially heterogeneous alluvial fan deposits with little sorting and little fine grained material content. The thickness of these water bearing materials is not known; however, it exceeds 1,000 feet (CVWD, 2010). The probable thickness of recent deposits suggests that Ocotillo conglomerate underlies recent fanglomerate in the Subarea at depths ranging from 300 to 400 feet (DWR, 1964).

Natural recharge to the aquifers in the Whitewater River Subbasin occurs primarily in the Palm Springs Subarea. The major natural sources include infiltration of stream runoff from the San Jacinto Mountains and the Whitewater River, and subsurface inflow from the San Gorgonio Pass and Garnet Hill Subbasins. Deep percolation of direct precipitation on the Palm Springs Subarea, and the entire Valley, is considered negligible as it is consumed by evapotranspiration.

3.2.3 Thermal Subarea

Groundwater of the Palm Springs Subarea moves southeastward through the interbedded sands, silts, and clays underlying the central portion of the Valley. The division between the Palm Springs Subarea and the Thermal Subarea is near Cathedral City. The permeabilities parallel to the bedding of the deposits in the Thermal Subarea are several times the permeabilities normal to the bedding and, therefore, movement of groundwater parallel to the bedding predominates. Confined or semi-confined groundwater conditions are present in the major portion of the Thermal Subarea. Movement of groundwater under these conditions is present in the major portion of the Thermal Subarea and is caused by differences in piezometric (pressure) level or head. Unconfined or free water conditions are present in the alluvial fans at the base of the Santa Rosa Mountains, as in the fans at the mouth of Deep Canyon and in the La Quinta area.

Sand and gravel lenses underlying this Subarea are discontinuous and clay beds are not extensive. However, two aquifer zones separated by a zone of finer-grained materials were identified from well logs (DWR, 1964). The fine-grained materials within the intervening horizontal plane are not tight enough or persistent enough to restrict completely the vertical interflow of water, or to assign the term “aquiclude” to it. Therefore, the term “aquitard” is used for this zone of less permeable material that separates the upper and lower aquifer zones in the southeastern part of the Valley. Capping the upper aquifer at the surface are tight clays and silts with minor amounts of sands. Semi-perched groundwater occurs in this capping zone, which is up to 100 feet thick.

The lower aquifer zone, composed in part of the Ocotillo conglomerate, consists of silty sands and gravels with interbeds of silt and clay. It is the most important source of groundwater in the Whitewater River Subbasin. The top of the lower aquifer zone is present at depths ranging from 300 to 600 feet below the surface. The thickness of the zone is undetermined, as the deepest wells present in the Valley have not penetrated it in its entirety. The available data indicate that the zone is at least 500 feet thick and may be in excess of 1,800 feet thick; depth information for Well 06S08E36M01S indicate a screened depth to 1,880 feet below ground surface. DWR (1964) inferred the depth to bedrock was in excess of 12,000 feet below ground surface based on gravity survey data.

The aquitard overlying the lower aquifer zone is generally 100 to 200 feet thick, although in small areas on the periphery of the Salton Sea it is in excess of 500 feet in thickness. North and west of Indio, in a curving zone approximately one mile wide, the aquitard is apparently lacking and no distinction is made between the upper and lower aquifer zones. This may be the result of erosion and deposition from Whitewater River flood flows. The aquitard is also responsible for artesian groundwater conditions in the central portion of the Thermal Subarea. Wells perforating the lower aquifer in this area experience artesian flowing conditions.

Capping the upper aquifer zone in the Thermal Subarea is a shallow fine-grained zone in which semi-perched groundwater is present. This zone consists of Recent silts, clays, and fine sands and is relatively persistent southeast of Indio. It ranges from zero to 100 feet thick and is generally an effective barrier to deep percolation. However, north and west of Indio, the zone is composed mainly of clayey sands and silts and its effect in retarding deep percolation is believed to be limited. The low permeability of the materials southeast of Indio has contributed to the irrigation drainage problems of the area. Semi-perched groundwater has been maintained by irrigation water applied to agricultural lands south of Point Happy. This condition causes waterlogged soils and the accumulation of salts in the root zone in agricultural areas. Surface drains were constructed in the 1930s to alleviate this condition. Subsurface tile drainage systems were installed in the 1950s to control the high water table conditions, allow reclamation of saline soils, and intercept poor quality return flows. CVWD operates and maintains a collector system of 166 miles of pipe, ranging in diameter from 18 inches to 72 inches, along with 21 miles of open ditches, to serve as a drainage network for irrigated lands. All agricultural drains empty into the CVSC except those at the southern end of the Valley, which flow directly to the Salton Sea. This system serves nearly 38,000 acres and receives water from more than 2,293 miles of on-farm drain lines (Water Consult and MWH, 2002).

3.2.4 Thousand Palms Subarea

The small area along the southwest flank of the Indio Hills is designated the Thousand Palms Subarea. The southwest boundary of the Subarea was determined by tracing the limit of distinctive groundwater chemical characteristics (DWR, 1964). Whereas calcium bicarbonate water is characteristic of the major aquifers of the Whitewater River Subbasin, water in the Thousand Palms Subarea is sodium sulfate in character.

These quality differences suggest that recharge to the Thousand Palms Subarea comes primarily from the Indio Hills and is limited in supply. The relatively sharp boundary between chemical characteristics of water derived from the Indio Hills and groundwater in the Thermal Subarea suggests there is little intermixing of the two waters.

The configuration of the water table north of the community of Thousand Palms is such that the generally uniform, southeast gradient in the Palm Springs Subarea diverges and steepens to the east along the base of Edom Hill. This historical steepened gradient suggests a barrier to the movement of groundwater, or a reduction in permeability of the water bearing materials. A southeast extension of the Garnet Hill Fault could also coincide with this anomaly. However, there is no surface expression of such a fault, and the gravity measurements taken during the 1964 DWR investigation do not suggest a subsurface fault. The residual gravity profile across this area supports these observations. The sharp increase in gradient is therefore attributed to lower permeability of the materials to the east. Most of the Thousand Palms Subarea is located within the upper portion of the Whitewater River Subbasin. Groundwater levels in this area show similar patterns to those of the adjacent Thermal Subarea, this suggests a hydraulic connectivity.

3.2.5 Oasis Subarea

Another peripheral zone of unconfined groundwater that differs in chemical characteristics from water in the major aquifers of the Whitewater River Subbasin is found underlying the Oasis Piedmont slope. This zone, named the Oasis Subarea, extends along the base of the Santa Rosa Mountains. Water bearing materials underlying the Subarea consist of highly permeable alluvial fan deposits. Although groundwater elevation data suggest that the boundary between the Oasis and Thermal Subareas may be a buried fault extending from Travertine Rock to the community of Oasis, the remainder of the boundary is a change from the coarse fan deposits of the Oasis Subarea to the interbedded sands, gravel, and silts of the Thermal Subarea. Little information is available as to the thickness of water bearing materials, but it is estimated to be in excess of 1,000 feet.

3.2.6 Surface Water Hydrology

Over geologic time, the Whitewater River and other local watercourses (including San Gorgonio, Snow, Falls, Chino, Tahquitz, and Andreas, Palm Canyon, Deep Canyon, Martinez Canyon, and smaller creeks) sent floodwaters into the Coachella Valley, discharging onto the floor of the desert. Early records indicate that the mouth of the Whitewater River was at what is now known as Point Happy in the City of La Quinta. Historically, floodwaters reaching Point Happy fanned out across the desert floor in this area, flooding areas downstream. DWR (1964) estimated the average seasonal mountain-front runoff to the Whitewater River (Indio) Subbasin totals 38,100 AFY. Subsequent hydrologic studies performed for the Coachella Valley Water Management Plan (Water Consult and MWH, 2002; MWH 2013) indicated the local surface and subsurface inflow from the mountain-front to the Whitewater River Subbasin has averaged 46,000 AFY, ranging from about 8,000 to more than 200,000 AFY.

The CVSC, a constructed extension of the Whitewater River that is managed and operated by CVWD, is the main drainage channel for the East Valley. This unlined earthen channel extends approximately 17 miles southeast from the City of Indio, through the agricultural communities of Coachella, Thermal and Mecca, to the north end of the Salton Sea. The construction of the CVSC was begun in the early 1920s to convey Whitewater River storm flows safely past

Coachella Valley communities and to provide adequate drainage for agricultural return waters in the area of semi-perched groundwater (see **Section 5.6**). Its design capacity is 82,000 cfs (Dan Farris, CVWD, pers. comm. 2000). In addition to agricultural drainage, the CVSC also receives treated effluent from three municipal wastewater treatment plants (CVWD's Water Reclamation Plant 4, Valley Sanitary District, and Coachella Sanitary District).

Throughout the East Valley, agricultural drains have been installed to drain shallow groundwater perched on fine-grained, ancient lakebed soils. Most of the drains empty into the CVSC; however, 25 smaller open channel drains at the southern end of the Coachella Valley discharge directly to the Salton Sea. The quantity of flow in the drains, and therefore in the CVSC, depends upon water levels in the underlying aquifers and the quantities of applied irrigation water.

3.2.6.1 The Coachella Canal and Distribution System

As agriculture in the Imperial and Coachella valleys developed during the early 1900s, alternative sources of water including the Colorado River were considered to meet growing demand. The Imperial Valley began receiving Colorado River water in 1901 via the Imperial Canal that was partially located in Mexico. In the Coachella Valley, the rapid rate of groundwater extraction led to a substantial decline in groundwater levels, limiting the groundwater supply. Local supplies were not adequate to meet future demands. These problems generated interest in construction of a storage reservoir on the river and a canal that would be located entirely in the United States.

Under the *Seven Party Agreement* dated August 18, 1931, executed by the California agencies already using or seeking to use Colorado River water, a system of priorities was established that defined certain amounts and places of use for the water. Water delivered to the Coachella Valley via the Coachella Canal is diverted from the Imperial Dam 18 miles upstream from Yuma, Arizona into the All-American Canal. Coachella's supply is then diverted into the 122-mile-long Coachella branch, which extends from near the Mexican border northwestward to Lake Cahuilla near La Quinta. This man-made lake, located at the terminus of the Coachella Canal, serves as a storage reservoir to regulate irrigation water demands and provides opportunity for recreation. The capacity of the Coachella Canal is approximately 1,300 cfs.

Colorado River water delivered to the Coachella Valley is diverted from the Imperial Dam 18 miles upstream from Yuma, Arizona, into the All-American Canal. The CVWD supply is then diverted into the 122-mile-long Coachella Canal, which extends from near the Mexican border northwestward to Lake Cahuilla near La Quinta. The Canal is concrete-lined. The capacity of the Coachella Canal is approximately 1,300 cubic feet per second (cfs) to 1,550 cfs. For a more detailed description of the Coachella Canal, the reader is referred to the Final EIS/EIR for the Coachella Canal Lining Project (USBR and CVWD, 2001).

3.2.6.2 Metropolitan's Colorado River Aqueduct

The Colorado River Aqueduct conveys river water from Lake Havasu to Lake Mathews in western Riverside County. Metropolitan Water District of Southern California completed construction of the aqueduct in 1941. The facility consists of 242 miles of canals, pipelines and tunnels along with five pumping stations that lift Colorado River water over 1,600 feet. The aqueduct has a capacity of 1,800 cfs or 1.3 million AFY. This aqueduct passes along the easterly side of CVWD and crosses the Whitewater River channel north of Palm Springs. The proximity of the aqueduct to the Coachella Valley made it a logical choice for delivering imported water to the valley. Consequently, beginning in 1973, CVWD and DWA commenced a program with Metropolitan to exchange the Valley's SWP water for Colorado River water delivered at Whitewater to avoid the cost of constructing an extension to the California Aqueduct. This exchange program was expanded to the Mission Creek Subbasin in 2002.

3.2.6.3 Salton Sea

The Salton Sea is a terminal body of saline water that occupies the bottom of the Salton Sink, a topographic low located between the Coachella and Imperial Valleys. The Salton Sink is a structural trough formed by the San Andreas fault zone, which filled with sediments from the surrounding mountains and marine deposits from the Gulf of California that inundated the Valley as far north as San Gorgonio Pass. Near the close of the Tertiary period, the Colorado River formed a delta that stopped the marine water invasion. Periodically, the Colorado River would change course over its delta and flow northward into the Coachella Valley, creating a large shallow lake that would exist until the river again changed course. This lake, known originally as Lake LeConte or later as Lake Cahuilla, would occur and disappear periodically flooding as far north as Indio as evidenced by a so-called "bath-tub ring" of travertine deposits on the mountains near La Quinta (DWR, 1964).

The current Salton Sea was formed when flood flows from the Colorado River broke through a temporary canal heading that had been designed to bypass a silted section of the Imperial Canal. The Imperial Canal, which was routed from the Colorado River to the Imperial Valley through Mexico, was completed in 1901, but by 1904, it had become blocked by sediment. A series of high flows from February through April 1905 destroyed the temporary heading resulting in uncontrolled flows into the Salton Basin for the next 18 months. It flooded the railroad line, railroad stations, and the salt works on the basin floor (DeBuys and Myers, 1999). When the breach was finally repaired in 1907, the elevation of the Salton Sea had reached 195 feet below mean sea level (MSL), and had a surface area of 520 square miles. Today, the Salton Sea has a surface elevation of 235 feet below MSL and occupies a surface area of about 365 square miles (233,000 acres) out of the total 8,360 square miles within the watershed (Salton Sea Authority, 2014).

Executive Order of Withdrawal (Public Water Reserve No. 114, California No. 26), signed by the President of the United States on February 26, 1928, withdrew from all forms of entry all public lands of the United States in the Salton Sea area lying below the elevation of 220 feet below sea level for the purpose of creating a reservoir in the Salton Sea for storage of wastes and seepage water from irrigated land in the Coachella and Imperial Valleys (RWQCB, 2014).

3.2.7 Groundwater Quality

Water quality is evaluated in terms of the historical quality of groundwater pumped from wells. Basin-wide groundwater quality is difficult to characterize because groundwater quality varies with such factors as depth (or the screened interval of a water supply well), proximity to faults, presence of surface contaminants, proximity to recharge basins, variable sedimentary characteristics, and other hydrogeologic or cultural features.

Total dissolved solids (TDS) and nitrate water quality data for the Whitewater River Subbasin to be used in SNMP development are summarized in **Table 3-1** and **Table 3-2**, respectively. Note that these tables present all water quality data points without filtering and may not be representative of conditions in the basin. For example, very high TDS appears in the lower aquifer in Well 07S09E30R01S; this well is located next to the Salton Sea, is screened at a depth of 1,430 to 1,470 feet and is likely reading high salinity due to ancient salt water deposits. TDS and nitrate trends for the Whitewater River Subbasin are shown for select wells in **Appendix A**.

Table 3-1
Summary of Total Dissolved Solids in Whitewater River Subbasin

		Total Dissolved Solids (mg/L)						
Aquifer	**Value**	**< 1961**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-present**
Upper Aquifer	**Count**	16	168	101	99	275	494	50
	Range	180 - 3,298	130 - 1,571	148 - 3,200	104 - 1,410	1 - 1,898	135 - 2,320	170 - 1,500
	Average	857	361	513	429	440	645	952
	Median	266	256	360	320	373	681	795
Lower Aquifer	**Count**	12	194	393	637	1,053	1,077	161
	Range	188 - 427	121 - 1,996	100 - 2,420	108 - 1,130	104 - 19,500	19 - 12,100	140 - 7,100
	Average	313	280	254	238	1,200	845	301
	Median	308	191	183	194	211	228	210

Table 3-2
Summary of Nitrate in Whitewater River Subbasin

		Nitrate (as NO_3) (mg/L)						
Aquifer	**Value**	**< 1961**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-present**
Upper Aquifer	**Count**	36	200	112	99	290	498	46
	Range	ND - 142	ND - 110	ND - 97	ND - 143	ND - 145	ND - 190	0.1 - 260
	Average	5.4	10.9	16.3	10.2	4.8	11.6	25.9
	Median	0.6	4.0	10.1	3.8	0.9	2.6	3.0
Lower Aquifer	**Count**	19	190	406	824	1,865	2,911	592
	Range	ND - 19	ND - 68	ND - 69	ND - 127	ND - 152	ND - 221	ND - 61
	Average	3.7	3.8	6.8	19.3	7.8	12.3	14.9
	Median	1.8	2	3.3	3.5	3.1	3.9	5.8

ND = non-detect

3.2.7.1 Total Dissolved Solids

During the 1930s, total dissolved solids (TDS) concentrations throughout the Coachella Valley were typically less than 250 mg/L except in localized areas (DWR, 1979). In the 1970s, the groundwater typically contained 300 mg/L TDS in the upper aquifer and 150 to 200 mg/L TDS in the lower aquifer (DWR, 1979). Higher TDS concentrations in the upper aquifer are typically detected along the Valley margins, particularly in the vicinity of the San Andreas Fault system and in an area southeast of Oasis. Groundwater in areas south of Indio and east of Mecca also contain higher TDS concentrations. The water quality of the upper aquifer has decreased since the 1930s.

In general, the lower aquifer has lower TDS concentrations than the upper aquifer. TDS concentrations in some areas of the lower aquifer may be more representative of upper aquifer quality in areas where the upper and lower aquifers are merged (e.g., along the western margin of the Valley). Similarly, in other areas adjacent to major faults, the TDS content of the lower aquifer is greater than 1,000 mg/L TDS. One of these areas is along the fault zone separating the Thousand Palms and Fargo Canyon Subareas from the Thermal Subarea. Along this northern fringe of the basin, near the San Andreas Fault and the presumed extension of the Garnet Hill Fault, the TDS concentrations exceed 1,000 mg/L. Isolated wells near Indio and Coachella exhibit similar TDS concentrations. In portions of the Oasis Subarea, groundwater also ranges from 500 to 1,000 mg/L TDS. Unlike the shallower zones, the TDS concentrations in much of the lower aquifer have remained relatively constant since the 1930s.

3.2.7.2 Nitrate

Elevated nitrate concentrations have been a relatively localized problem in the Coachella Valley. Nitrate concentrations during the 1930s were typically less than 4 mg/L (as nitrate) throughout the Valley (DWR, 1979). A notable exception was the high nitrate content of some wells in the Palm Desert-Indian Wells area (Huberty *et al.*, 1948). Huberty *et al.* evaluated the source of nitrate and concluded that the area was at one time covered by extensive mesquite forests. Mesquite is known to fix atmospheric nitrogen in its roots and accumulate nitrogen in its leaves and stems. Huberty *et al.* discovered high amounts of nitrate in the soils under similar mesquite forests. Under natural conditions, there was insufficient moisture for the leaf and twig litter to decompose. However, when these lands were leveled and irrigated, the organic matter decomposed and nitrates appear to have leached into the shallow groundwater (Huberty *et al.*, 1948). By the late 1970s, a greater number of wells adjacent to the Whitewater River in this area exhibited elevated nitrate concentrations of more than 45 mg/L (DWR 1979). The area of high nitrate shallow groundwater follows the approximate trace of the Whitewater River from Cathedral City to east of La Quinta. Municipal wells generally avoid this high nitrate groundwater by using deep perforations.

In addition, a cluster of high nitrate concentrations is present northwest of the community of Oasis. These elevated concentrations may be a result of fertilizer use in the unconfined area. Municipal wells belonging to DWA in Palm Springs have experienced nitrate concentrations above the MCL. Discharges of wastes from individual domestic septic tank/leachfield systems, water recycling, widespread application of fertilizers, and discharges of domestic wastes to evaporation/percolation ponds may be the source of the elevated nitrate.

However, it is noted that studies conducted by the University of California, Riverside concluded most nitrogen applied to turfgrass usually stays within the “turfgrass system”. Fertilizer nitrogen applied to a dense, mature and well-maintained turf is normally rapidly used by the turfgrass plant and by soil microorganisms. There appears to be little chance of downward movement of nitrogen, other than on pure sand (Gibeault *et al*., 1998). An additional University of California, Riverside study suggests that “if turfgrass is properly managed, it may provide an opportunity to mitigate nitrate loading to surface and ground waters, even when [nitrogen] application rate is high” (Wu *et al*., 2007). Uptake of nitrogen by managed turf should be addressed in this SNMP and future Basin Plan updates.

3.2.8 Other Potential Constituents of Concern

Key constituents, TDS and nitrate, were discussed in the groundwater quality section above. Listed below are other potential constituents of concern, all of which are naturally occurring.

3.2.8.1 Hexavalent Chromium

Chromium is a heavy metal that occurs throughout the environment. Ultramafic sediments commonly found along the margins of fault systems throughout California contain elevated levels of chromium that are released through natural erosion. In July of 2014, the California Department of Public Health (CDPH) limit of 10 µg/L MCL for hexavalent chromium became effective; hexavalent chromium occurs naturally in the Coachella Valley Groundwater Basin at background levels above the MCL. The extent of hexavalent chromium occurrence in the Coachella Valley Groundwater Basin is well known and is currently a large focus area for water managers and purveyors within the Valley. About half of the public water wells in the Coachella Valley produce water with naturally-occurring hexavalent chromium above the new MCL. As a result of this new regulation, more than half of the groundwater in the Coachella Valley is no longer potable without costly treatment; the cost impact from hexavalent chromium to maintain municipal beneficial use may exceed the combined impact from all the remaining contaminants that occur in the Coachella Valley Groundwater Basin.

3.2.8.2 Fluoride

Fluoride is a naturally-occurring constituent in groundwaters within the Coachella Valley. Wells possessing fluoride levels above the MCL of 2 mg/L are generally limited to two groups of wells in the East Valley and along the fault in the Thousand Palms Subarea. The first group of wells is located to the east of the communities of Indio and Coachella. These concentrations may reflect the influence of the San Andreas Fault Zone, located immediately to the east. The second cluster of wells with elevated fluoride concentrations is located between the communities of Oasis and Mecca.

3.2.8.3 Arsenic

Arsenic is a naturally occurring element found in the earth’s crust. The primary MCL for arsenic is 10 µg/L. Throughout much of the East Valley, from Coachella to Oasis, concentrations of arsenic in the groundwater exceed the MCL. Many of these wells are used for agricultural irrigation. Most of the elevated arsenic concentrations occur in wells perforated solely in the lower aquifer.

3.2.8.4 Radionuclides

Uranium found in the Whitewater River Subbasin is naturally-occurring. It is detected in several groundwater wells. Although not above the MCL, uranium levels in groundwater are elevated compared to the Public Health Goal.

3.3 MISSION CREEK SUBBASIN

The Mission Creek Subbasin is located in the northwestern Coachella Valley in the north-central portion of Riverside County, California. DWR has designated this basin as No. 7-21.02 in Bulletin 118 (DWR, 2003). Groundwater is naturally replenished by subsurface flow from the Desert Hot Springs Subbasin to the north, as well as by mountain front recharge by subsurface flow. The Mission Creek Fault and the Banning Fault form the northern and southern boundaries of the subbasin, respectively. Both act to limit groundwater movement as these faults have folded sedimentary deposits, displaced water-bearing deposits, and caused once permeable sediments to become impermeable (DWR, 1964). The main water bearing units of the Mission Creek Subbasin are relatively undisturbed and unconsolidated Holocene and late Pleistocene alluvial deposits. These detritus deposits are eroded from the surrounding San Bernardino and Little San Bernardino Mountains, first as filled topographic depressions and then as deposits on the piedmont alluvial fans. The individual beds are lens shaped and not extensive, but coalesce with other beds to form larger water bearing areas. Hydrogeologic units included in these water-bearing deposits are: Ocotillo conglomerate, Cabazon fanglomerate and Holocene alluvial and sand dune deposits.

The Mission Creek Subbasin is considered an unconfined aquifer with a saturated thickness of 1,200 feet or more and an estimated total storage capacity of approximately 2.6 million AF (DWR, 1964). The volume of groundwater estimated to be in storage for the subbasin is 1.4 million AF (MSWD, 2006). The subbasin is naturally recharged by surface and subsurface flow from the Mission Creek, Dry, and Big Morongo Washes, the Painted Hills, and surrounding mountain drainages. Subsurface flow also occurs across the Mission Creek Fault from the adjacent Desert Hot Springs Subbasin. Return flow from applied water and discharges from municipal and individual subsurface wastewater disposal systems also contribute to recharge.

The principal outflows from the subbasin are groundwater production for municipal and private uses, evapotranspiration and subsurface outflow across the Banning Fault into the Garnet Hill Subbasin. Groundwater generally flows from the northwest to the southeast until about mid-basin where the contour lines curve indicating a southerly flow on the eastern side of the subbasin.

CVWD, DWA, and MSWD jointly manage this subbasin under the terms of the Mission Creek Settlement Agreement (CVWD-DWA-MSWD, 2004). This agreement and the 2014 Mission Creek Groundwater Replenishment Agreement between CVWD and DWA specify that the available SWP will be allocated between the Mission Creek and Whitewater River Subbasins in proportion to the amount of water produced or diverted from each subbasin during the preceding year (CVWD-DWA, 2003). In 2009, production from the Mission Creek Subbasin was about 7 percent of the combined production from these two subbasins. A water management plan was prepared for the Mission Creek and Garnet Hill Subbasins in 2013 (MWH, 2013).

3.3.1 Surface Water Hydrology

Surface water flow in the Study area consists of ephemeral or intermittent streams that originate in the San Bernardino and Little San Bernardino mountains. Mission Creek is the only stream that flows to the valley floor on a consistent basis, but the stream usually disappears underground a short distance from its entrance into the Study area. The only stream gauge currently operated by the USGS in the Study area is on Mission Creek. Based on 44 years of record (1967-2011), this creek has an average annual streamflow of 2,160 AFY. Streams flowing through Morongo Valley, Big Morongo, Little Morongo, and Long Canyon periodically reach the valley floor for short periods when there are localized, intense storms in the mountains (Mayer and Mays, 1998). Investigations conducted for the Mission Creek-Garnet Hill Water Management Plan concluded the natural inflow to the Mission Creek Subbasin averages about 7,500 AFY (Psomas, 2013). None of the surface flow from the local watercourses is used directly for municipal, industrial, or agricultural uses in the Study area.

3.3.2 Groundwater Level

DWR Bulletin 118 identifies the Mission Creek Subbasin to be in an overdraft condition. However, since the commencement of the groundwater recharge program at the Mission Creek Spreading Facility, groundwater levels have generally increased in the Mission Creek Subbasin. Groundwater level increases in the Mission Creek Subbasin are observed in areas closer to the Mission Creek Recharge Facility as compared to the locations of the groundwater production wells.

The San Andreas Fault system has a dramatic impact on groundwater levels in the subbasin. Previous studies have shown that the various faults that make up the fault system act as partially effective barriers to groundwater flowing from north to south through the area. Groundwater levels and at times groundwater temperatures on either side of the fault trace are significantly different. Groundwater levels are generally higher on the northeast side of the fault because of its barrier effect, to the extent that springs have been recorded on the north. Groundwater levels within the Mission Creek Subbasin are generally higher in the northern and western portion of the subbasin than the southern and eastern portion of the subbasin. Groundwater temperatures in the subbasin are generally higher to the north because of the influence of the Desert Hot Springs Subbasin (GSi/water, 2005; URS, 2006).

In 1936, groundwater pumping in the subbasin was significantly lower than current conditions and groundwater is believed to have flowed under generally natural conditions. Water levels in the Mission Creek Subbasin have been declining since the early 1950s due to scarce annual precipitation and groundwater extractions (DWR, 2003). Valley-wide groundwater level data indicate that since 1952, water levels have declined at a rate of 0.5 to 1.5 feet per year (CVWD, 2000). MSWD monitoring data indicates a rate of decline of about 3 feet per year between 1999 and 2007.

Groundwater levels in the subbasin have increased since 2003 as a result of the artificial recharge activities (including normal and advanced deliveries) coupled with reduced pumping. Wells in the subbasin have shown varying responses to recharge. Water levels in a MSWD well located 0.5 mile south of the recharge facility responds similarly to the DWA monitoring well located at the recharge facility, increasing as much as 250 feet since 2004. However, MSWD wells located 1.2 miles south and 1.1 miles to the southeast show 20- and 50-foot increases, respectively. Prior to recharge, water levels in these two wells were 200 feet lower than levels near the recharge facility. The difference in level is now more than 400 feet. These differences in basin response may be the result of mounding near the recharge facility, a previously unknown geologic structure (fault or change in bedrock depth), insufficient transmissivity near the recharge facility or a combination of these factors (Psomas, 2013). Water levels in a CVWD well located 4.4 miles southeast of the recharge facility shows a 4-foot increase since 2004 (MWH, 2013).

3.3.3 Groundwater Quality

In general, groundwater quality for the Mission Creek Subbasin meets all current drinking water standards except for the newly established limit for hexavalent chromium. A review of historical and recent water quality data indicates that the parameters that have exceeded either primary or secondary drinking water standards within the groundwater basins in the Study area include TDS, nitrate, hexavalent chromium, uranium, and gross alpha.

TDS and nitrate water quality data for the Mission Creek Subbasin to be used in SNMP development are summarized in **Table 3-3** and **Table 3-4**, respectively. Note that these tables present all water quality data points without filtering and may not be representative of conditions in the basin. TDS and nitrate trends for the Mission Creek Subbasin are shown for select wells in **Appendix A**.

Table 3-3
Summary of Total Dissolved Solids in Mission Creek Subbasin

	Total Dissolved Solids (mg/L)						
Value	**< 1961**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-current**
Count	55	289	76	17	45	50	9
Range	300 - 910	173 - 1,087	176 - 880	374 - 478	278 - 1,096	270 - 1,100	300 - 540
Average	597	561	539	423	501	520	412
Median	607	527	455	425	445	458	420

Table 3-4
Summary of Nitrate in Mission Creek Subbasin

	Nitrate (as NO_3) (mg/L)						
Value	**< 1961**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-current**
Count	78	256	73	18	90	254	33
Range	ND - 4.5	ND - 9	ND - 14	1 - 39.4	ND - 67	ND - 86	ND - 8.2
Average	1.2	2.0	2.6	6.6	7.9	31.8	4.1
Median	0.7	1.0	2.0	4.7	4.5	6.2	4.1

ND = non-detect

3.3.3.1 Total Dissolved Solids

In general, TDS concentrations in groundwater improve across the Mission Creek Subbasin towards the Garnet Hill Fault. Wells located closer to the Garnet Hill Subbasin have TDS concentrations ranging between 300 mg/L and 400 mg/L. Wells located closer to the Desert Hot Springs Subbasin have higher TDS concentrations ranging between 400 mg/L and 500 mg/L. Wells in the southeastern portion of the subbasin show TDS concentrations as high as over 1,000 mg/L; this could be due to the flow of mineralized water from Desert Hot Springs Subbasin.

3.3.3.2 Nitrate

Generally, nitrate exists in the unsaturated and shallow aquifer zones above 300 to 400 feet below ground surface, and has not been observed in the deeper aquifer zones below 500 feet. Activities in the basin that could cause nitrate to leach into higher quality groundwater include recharge, pumping, and overdraft reduction. A study conducted by MSWD to assess groundwater quality indicates that the use of septic tanks for waste disposal is a primary contributor of high nitrates to the groundwater (GSi/water, 2011). Nitrate concentrations are below the MCL for all recorded public water supply samples in the Mission Creek Subbasin; however, several private wells have recorded nitrate exceeding the MCL. In general, no trends are observed with regards to nitrate concentrations over time.

3.3.4 Other Potential Constituents of Concern

Key constituents, TDS and nitrate, were discussed in the groundwater quality section above. Listed below are other potential constituents of concern, most of which are naturally occurring.

3.3.4.1 Hexavalent Chromium

Hexavalent chromium is detected in several groundwater wells in the Mission Creek Subbasin. It has been detected in MSWD and CVWD wells above the 10 μg/L MCL. The extent of naturally-occurring hexavalent chromium in the Coachella Valley Groundwater Basin is well known and is currently a large focus area for water managers and purveyors within the Valley. Currently, hexavalent chromium is the contaminant having the greatest impact on beneficial uses in the Valley.

3.3.4.2 Arsenic

Arsenic occurs naturally in the Coachella Valley and is detected in several groundwater wells in the Mission Creek Subbasin. Some CVWD monitoring wells indicate the presence of arsenic with concentrations above the 10 μg/L MCL. These elevated arsenic levels are found toward the southeastern portion of the subbasin close to the faults. Arsenic concentrations for production well samples collected since 1981 have remained below the MCL. Samples collected for MSWD wells in 2008 do not indicate the presence of arsenic.

3.3.4.3 Fluoride

Fluoride is present at elevated levels in the Mission Creek Subbasin in the southeastern portion of the subbasin. Concentrations have ranges from 0.2 to 9.9 mg/L. Fluoride is a naturally-occurring constituent in groundwaters within the Coachella Valley.

3.3.4.4 Radionuclides

Radionuclides are elements that emit radioactivity and may be naturally-occurring or artificially produced. The principal radionuclides of concern for the subbasin are uranium and gross alpha.

Uranium found in the Mission Creek Subbasin is naturally-occurring. The primary MCL for uranium is 20 picocuries/liter (pCi/L) based on a four-quarter average. Uranium is detected in several groundwater wells in the Mission Creek Subbasin. For samples collected in 2008, the presence of uranium was detected in MSWD wells. Uranium concentrations exceeding the MCL occur in two MSWD wells that are not being used. Well-head treatment currently exists for uranium removal at select MSWD wells. Uranium was also detected in CVWD wells with concentrations below the MCL.

Gross alpha occurs naturally in drinking water sources, since it is present in the geologic formations of the groundwater basin. The primary MCL for gross alpha is 15 pCi/L based on a four-quarter average. For groundwater samples obtained in 2008, two MSWD wells exceeded the MCL for gross alpha with recorded samples having a concentration of 16 pCi/L, but none of the wells exceeded the four-quarter average MCL of 15 pCi/L at this time.

3.4 GARNET HILL SUBBASIN

The area between the Garnet Hill Fault and the Banning Fault, named the Garnet Hill Subarea by DWR (DWR, 1964), was considered a distinct subbasin by the USGS (Tyley, 1974) because of the effectiveness of the Banning and Garnet Hill Faults as barriers to groundwater movement. The Garnet Hill Fault is a branch of the San Andreas Fault system consisting of a series of northwest-trending right-lateral faults with active folds at each *en echelon* step. These folds are exhibited in a series of small hills (West Whitewater Hill, East Whitewater Hill, Garnet Hill, Edom Hill, and several small unnamed hills) between each fault segment (Yule and Sieh, 2003). This is illustrated by a difference of 170 feet in groundwater level elevation in a horizontal distance of 3,200 feet across the Garnet Hill Fault, as measured in the spring of 1961. This subbasin is considered part of the Whitewater River (Indio) Subbasin in DWR Bulletin 118 (2003); however, CVWD and DWA consider it a separate subbasin based on the USGS findings and water level observations. In 1964 when the initial DWR evaluation was conducted, it was observed that limited data existed to characterize the hydrogeology of this subbasin (DWR, 1964).

The Garnet Hill Subbasin is considered an unconfined aquifer with a saturated thickness of 1,000 feet or more based on well depths and has an estimated total storage capacity on the order of 1.0 million AF. The subbasin is naturally recharged by subsurface flow from the Mission Creek Subbasin and runoff from the Whitewater River watershed on the west. Irrigation return flow and discharges from municipal and individual subsurface wastewater disposal systems also contribute to recharge but is considered very small.

Although some recharge to this subbasin may come from Mission Creek and other streams that pass through during periods of high flood flows, the main sources of recharge to the subbasin are channel infiltration and subsurface flow in the Whitewater River, subsurface flow through the semi-permeable deposits which underlie Whitewater Hill and from subsurface flow across the Banning Fault from the Mission Creek Subbasin. In general, there is subsurface flow from the Garnet Hill Subbasin across the Garnet Hill Fault to the Whitewater River Subbasin westerly of the Garnet Hill outcrop. Based on groundwater level measurements, this area is partially influenced by artificial recharge activities at the Whitewater Spreading Facilities at Windy Point.

3.4.1 Surface Water Hydrology

The lower reaches of Mission Creek and Morongo Wash flow across the Garnet Hill Subbasin and are believed to contribute to recharge primarily through subsurface flows. The Whitewater River appears to contribute significant recharge to of the Garnet Hill Subbasin through subsurface flow in the alluvial channel across the Banning Fault and through the semi-permeable deposits that underlie the Whitewater Hill (GSi/water, 2005). Much of this water flows across the Garnet Hill Fault into the Whitewater River Subbasin.

3.4.2 Groundwater Levels

The Garnet Hill Subbasin has groundwater elevations approximately 200 to 250 feet lower than the Mission Creek Subbasin along the Banning Fault indicating that the groundwater flow is partially restricted by the Banning Fault (DWR, 1964). Groundwater in the Garnet Hill Subbasin flows to the east-southeast until the southeastern end of the subbasin where groundwater flow direction turns south and presumably discharges into the Upper Whitewater River Subbasin across the Garnet Hill Fault. The outcropping Garnet Hill appears to create a partial flow restriction that affects movement of groundwater to the southeastern portion of the subbasin.

The upper portion of the Whitewater River Subbasin has groundwater elevations approximately 150 feet to 200 feet lower than what is observed in the Garnet Hill Subbasin, indicating that groundwater flow is partially restricted by the Garnet Hill Fault. Groundwater in the Whitewater River Subbasin flows in an east to southeast direction towards the Salton Sea.

Measured groundwater levels in portions of the Garnet Hill Subbasin have shown a response to recharge activities in the Whitewater River Subbasin (MWH, 2013) Water levels in Whitewater River Subbasin wells near the recharge basins (03S04E20K01S and 03S04E29R01S) show rapid response to increased recharge (gray line). Wells in the western portion the Garnet Hill Subbasin ((03S04E17K01S and 03S04E22A01S) also show response to larger recharge events as in 1984-86, 1996-2001, 2005-06 and 2010-12). Water levels in the central portion of the subbasin (03S04E13N01S/N02S and 03S04E14J01S) show a more muted and delayed response to the largest recharge events; while the well in the eastern portion of the subbasin (03S04E30G01S) shows minimal response. These data show a 250-foot gradient between the northwest and southeast portions of the subbasin. Monitoring of additional wells would provide a better picture of basin response and long-term water level trends.

3.4.3 Groundwater Quality

Information available on groundwater quality for the Garnet Hill Subbasin is limited. In several cases, for a given year data is available only at a single well. The available data are not sufficient to make any meaningful conclusions about temporal or spatial distribution of water quality constituents in the subbasin. This is a significant data gap for the Garnet Hill Subbasin.

TDS and nitrate water quality data for the Garnet Hill Subbasin to be used in SNMP development are summarized in **Table 3-5** and **Table 3-6**, respectively. Note that these tables present all water quality data points without filtering and may not be representative of conditions in the basin. TDS and nitrate trends for the Garnet Hill Subbasin are shown for select wells in **Appendix A**.

Table 3-5
Summary of Total Dissolved Solids in Garnet Hill Subbasin

	Total Dissolved Solids (mg/L)						
Value	**< 1961**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-current**
Count	9	51	8	0	5	15	0
Range	164 - 219	157 - 933	190 - 217	-	156 - 390	186 - 376	-
Average	184	246	209	-	261	276	-
Median	181	211	211	-	255	278	-

Table 3-6
Summary of Nitrate in Garnet Hill Subbasin

	Nitrate (as NO_3) (mg/L)						
Value	**< 1961**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-current**
Count	10	55	8	1	4	15	0
Range	0.1 - 5.0	0.2 - 5.0	0.2 - 3.0	7.0 - 7.0	1.25 - 5.2	ND - 14.3	-
Average	1.3	1.7	1.3	7.0	2.6	3.7	-
Median	0.6	1.1	0.8	7.0	1.9	2.5	-

ND = non-detect

3.4.3.1 Total Dissolved Solids

Historically, recorded TDS concentrations at different groundwater wells in the Garnet Hill Subbasin have ranged from a low of 156 mg/L to a high of 933 mg/L. TDS is generally low with averages below 300 mg/L. No significant trends are observed with regard to TDS concentrations over time.

3.4.3.2 Nitrate

In general, nitrate concentrations are relatively low with no MCL exceedances. Groundwater quality within the Garnet Hill Subbasin is suitable for domestic water use and meets current drinking water standards. No trend is observed for nitrate concentrations over time.

3.4.4 Other Potential Constituents of Concern

Key constituents, TDS and nitrate, were discussed in the groundwater quality section above. Listed below are other potential constituents of concern, most of which are naturally occurring.

3.4.4.1 Arsenic

Arsenic was detected in 1993 and 1999 at or above the MCL of 10 µg/L. Arsenic was not detected in samples collected in 2008.

3.4.4.2 Radionuclides

Samples collected in 2008 indicate the presence of uranium; however, the concentrations are below the primary MCL of 20 pCi/L.

3.5 DESERT HOT SPRINGS SUBBASIN

The Desert Hot Springs Subbasin is located adjacent to the Mission Creek and Whitewater River Subbasins and trends northwest-southeast along the foothills of Joshua Tree National Park. DWR Bulletin 118 (2003) has designated this subbasin as No. 7-21.03. The Desert Hot Springs Subbasin is bounded on the north by the Little San Bernardino Mountains and to the southeast by the Mission Creek and San Andreas Fault. The San Andreas Fault separates the Desert Hot Springs Subbasin from the Whitewater River Subbasin and serves as an effective barrier to groundwater flow. The subbasin has been divided into three subareas: Miracle Hill, Sky Valley, and Fargo Canyon. The subbasin is bounded on the southwest by the Banning and Mission Creek Faults and the semipermeable rocks of the Indio Hills. These faults act as groundwater barriers and direct the groundwater in a southeast direction. Hot thermal springs occur on the Mission Creek Fault and have been actively pumped for over 50 years. The subbasin is comprised of late Pleistocene and Holocene alluvium, coarse sand and gravel (DWR, 2003). Thermal mineral waters occur near active faults such as the Mission Creek Fault in the Miracle Hill subarea where the groundwater is used to supply local resorts.

The Desert Hot Springs Subbasin has little residential, industrial, or agricultural development with exception to the community of Desert Hot Springs; residential communities exist within the Sky Valley Subarea, and Indio Hills. The Miracle Hill subarea underlies portions of the City of Desert Hot Springs and is characterized by hot mineralized groundwater, which supplies a number of spas in that area. The Sky Valley Subarea underlies the central portion of the subbasin and is separated from the Fargo Canyon Subarea by the Indio Hills Fault. There is sparse data on this subarea. The Fargo Canyon Subarea underlies a portion of the study area along Dillon Road north of Interstate 10. This area is characterized by coarse alluvial fans and stream channels flowing out of Joshua Tree National Park. Based on limited groundwater data for this area, flow is generally to the southeast. Sand and gravel mining operations currently exist and urban development has been proposed within the Fargo Canyon Subarea.

3.5.1 Surface Water Hydrology

Long Canyon Creek and the Little Morongo Creek provide recharge in the Desert Hot Springs Subbasin. Other tributaries including those from the Painted Hills, White House Canyon, Midway Canyon, Blind Canyon, Long Canyon, and North Short Canyon appear to contribute much smaller amounts of water. DWR (1964) estimates that amount of seasonal tributary runoff into the Desert Hot Springs Subbasin to be roughly 2,900 AFY, while GSi/water (2005) estimated that these canyons may provide up to 2,200 AFY in groundwater recharge. Previous investigations indicated the amount of recharge contributed through these canyons is negligible compared to the recharge from the major canyons within the Valley (Tyley, 1974). Subsurface outflow from the Miracle Hill Subarea to the Mission Creek Subbasin is estimated to be about 1,800 AFY (Psomas, 2013).

3.5.2 Groundwater Levels

A lack of historic data together and the scarcity of wells outside the Miracle Hill Subarea prevent rigorous analyses of fluctuations and trends of the water table within Desert Hot Springs. However, the available data suggest that water levels remain relatively unchanged except for a decline in water levels in the Miracle Hill Subarea (DWR, 1964).

3.5.3 Groundwater Quality

Limited water quality data is available, but from the few records reviewed the water quality is typically poor. This water quality has limited the use of this subbasin for groundwater supply (CVWD, 2014). Hot water wells, by the city of Desert Hot Springs, in the subbasin along the Mission Creek Fault, have groundwater temperatures averaging 118°F (DWR, 1964).

TDS and nitrate water quality data for the Desert Hot Springs Subbasin to be used in SNMP development are summarized in **Table 3-7** and **Table 3-8**, respectively. Note that these tables present all water quality data points without filtering and may not be representative of conditions in the basin. TDS and nitrate trends for the Desert Hot Springs Subbasin are shown for select wells in **Appendix A**.

Table 3-7
Summary of Total Dissolved Solids in Desert Hot Springs Subbasin

Value	Total Dissolved Solids (mg/L)						
	< 1961	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-current
Count	36	161	40	3	7	168	82
Range	774 - 1,340	378 - 1,410	368 - 1,150	161 - 1,160	394 - 845	240 - 2,200	390 - 2,100
Average	1,008	916	834	827	521	1,384	1,377
Median	982	955	873	1,160	440	1,500	1,400

Table 3-8
Summary of Nitrate in Desert Hot Springs Subbasin

Value	Nitrate (as NO_3) (mg/L)						
	< 1961	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-current
Count	42	143	32	3	11	193	103
Range	ND - 5.0	ND - 65.0	ND - 30.0	0.1 - 1.9	0.3 - 6.0	ND - 101.0	2.2 - 85.5
Average	0.7	3.0	3.5	0.7	3.4	19.2	18.1
Median	0.1	1.4	1.0	0.1	3.6	10.8	14.0

ND = non-detect

3.5.3.1 Total Dissolved Solids

TDS within the Desert Hot Springs Subbasin is among the highest in the Coachella Valley. Naturally-occurring high TDS groundwater exists upwards of 2,000 mg/L. This hot mineral water is pumped for use in spas or domestic use. High concentrations of TDS in the groundwater throughout the subbasin limits agricultural or domestic water resources (CVWD, 2000). No trend is observed with regard to TDS concentration over time.

3.5.3.2 Nitrate

In general, nitrate is not a large concern in the Desert Hot Springs Subbasin. Monitoring wells in Fargo Canyon Subarea have shown some high levels of nitrate exceeding the MCL after 2001. No trend is observed with regard to nitrate concentration over time.

3.5.4 Other Potential Constituents of Concern

Key constituents, TDS and nitrate, were discussed in the groundwater quality section above. Sulfate is another potential constituent of concern that is naturally occurring.

3.5.4.1 Fluoride

Fluoride is present at elevated levels in the Desert Hot Springs Subbasin. These concentrations may reflect the influence of the San Andreas Fault Zone. Fluoride is a naturally-occurring constituent in groundwaters within the Coachella Valley.

3.5.4.2 Arsenic

Naturally-occurring arsenic is found at elevated levels within the Desert Hot Springs Subbasin. The primary MCL for arsenic is 10 µg/L.

4 Preliminary Data Review

This section reviews and summarizes the data gathered to date. This includes an initial review of data pertaining to AWQ calculation as well as a brief discussion on salt and nutrient loading data requirements.

4.1 DATA REQUIREMENTS

SNMP development requires several datasets to determine current water quality within the basin as well as current and projected salt and nutrient loading. The Policy states that basin or subbasin assimilative capacity must be provided as a component of the SNMP. The SNMP will describe a process to evaluate new recycled water projects and a large consideration will be the ability for the Basin to absorb the salt and nutrient impacts these projects will have, the assimilative capacity. The assimilative capacity of a particular area of the groundwater basin or subbasin is determined as the difference between the water quality objective and the current water quality conditions, i.e., the AWQ.

For the methods described in Section 5, in addition to historical water quality data, basin hydrogeology is taken into consideration. Effective porosity, aquifer geometry, and groundwater levels are helpful together with groundwater quality to better approximate AWQ.

To develop salt and nutrient loading trends, the following data and reports are useful: water supply plans, groundwater production, waste discharge water quality, groundwater flow and drain flows, imported water and recharge operation, and water user waste increments.

4.2 DATA SOURCES

Groundwater quality, groundwater level, annual production, water supply plan, and disposal plan data were requested directly from CVWD, DWA, IWA, and CWA; groundwater quality and groundwater level data were received from MSWD. GeoTracker Groundwater Ambient Monitoring and Assessment (GAMA) data were retrieved to augment groundwater quality data with careful attention to removing duplicate records; GeoTracker GAMA provides access to digitized records of groundwater quality from multiple sources of well sample records across California. Additional groundwater production records were gathered from SWRCB and Psomas. General well information was collected from the agencies (e.g., well locations, status, screened interval, and owner), as well as drain flows and quality, Coachella Valley Stormwater Channel flows and quality, and Coachella Canal water quality for varying periods of record from CVWD. Additional data to fill gaps is being collected from water and wastewater agencies in the Valley.

4.2.1 Groundwater Models

Two groundwater models were obtained for quantifying the vertical and horizontal extent of the groundwater systems. These models cover the Whitewater, Garnet Hill, and Mission Springs subbasins. CVWD (Fogg *et al.*, 2002) developed a groundwater model of the Whitewater and Garnet Hill Subbasins as part the 2002 Water Management Plan (MWH, 2002). The geometry (cell size, layering, and orientation) for this model was used as the base for the recently completed Mission Creek and Garnet Hill Subbasins groundwater model. These models can be used as the basis for AWQ. A summary of model characteristics is listed by subbasin in **Table 4-1**. Average layer depth and thickness by subbasin is shown on **Table 4-2**. The layering of these groundwater models was based on a best estimate of basin lithologic characteristics. The layering is used to categorize areas of the aquifer, e.g., perched aquifer, deep aquifer. When evaluating groundwater quality, well screen intervals are used to categorize a well into a particular model layer. This allows for a general quantification of measurements and quality with depth.

Table 4-1
Groundwater Model Characteristics for Mission Creek, Garnet Hill, and Whitewater River Subbasins

Model Characteristic	Mission Creek Subbasin[1]	Garnet Hill Subbasin[1]	Whitewater River Subbasin[2,3]
Calibration Period	1936-2009		1936-1996
Model Domain	75 rows x 86 columns		270 rows x 86 columns
Cell Size	1,000 feet x 1,000 feet		1,000 feet x 1,000 feet
Layers	4		4
Active Cells	12,360		48,396
Storage Coefficient	0.08 to 0.18		0.06 to 0.13

1. Psomas, 2013
2. Fogg *et al*., 2002.
3. The CVWD model was developed with the idea that it could be expanded to encompass the Mission Creek and Desert Hot Springs subbasins. However, the cells for those subbasins were left inactive in the original model.

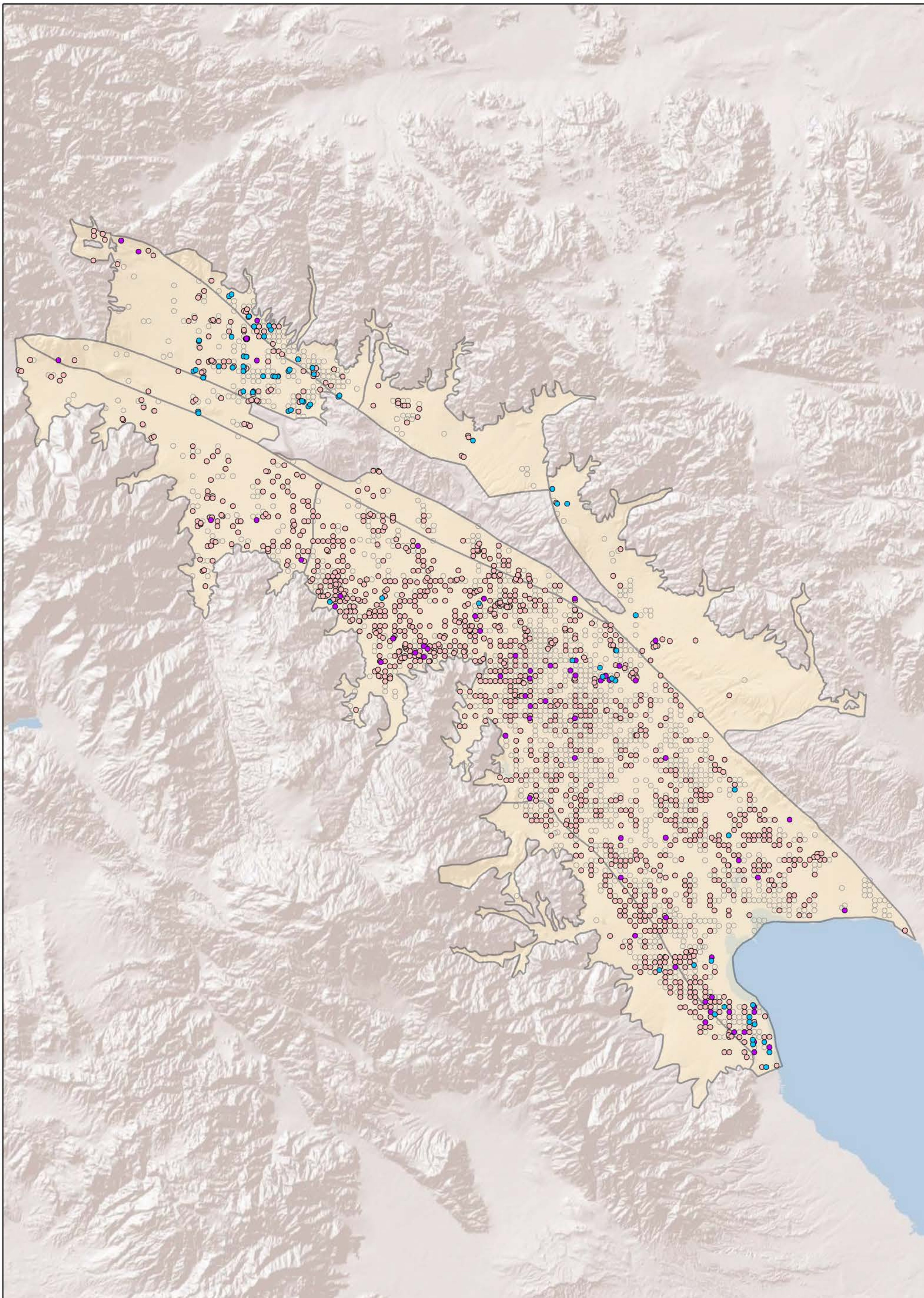
Table 4-2
Groundwater Model Average Layer Depth and Thickness by Subbasin

Subbasin	Layer Depth and Thickness (feet below ground surface)			
	Layer 1	Layer 2	Layer 3	Layer 4
Whitewater River	0 - 190	190 - 300	300 - 410	410 - 1,270
Mission Creek	0 - 810	810 - 880	880 - 960	960 - 1,290
Garnet Hill	0 - 730	730 - 800	800 - 870	870 - 1,340
Desert Hot Springs	-	-	-	-

At the June 4, 2014 stakeholder meeting, stakeholders were encouraged to provide additional data that might contribute to the SNMP development process.

4.2.2 Groundwater Quality Data

Groundwater quality data comes from a total of 1,909 wells in the Coachella Valley. These wells are illustrated on **Figure 4-1**. The overwhelming majority of wells for which there are groundwater quality data are located in the Whitewater River Subbasin. A summary of total wells and those with water quality within the Basin including percentage with depth information is shown on **Table 4-3**.



Key to Features

- TDS Data
- Nitrate Data
- TDS and Nitrate Data
- No TDS or Nitrate Data
- Groundwater Basin

N

0 5 10 Miles

Document: \\USIRV1S01\Projects\Coachella Valley WD\SNMP\GIS_files\wells.mxd

Date: 7/25/2014

Water Quality Data Availability by Well

MWH

Figure 4-1

Table 4-3
Summary of Known Groundwater Wells[1] by Subarea

Subbasin Subarea	Wells		Wells with Water Quality Data	
	Count	Percent of Wells with Screen Interval Records	Count	Percent of Wells with Screen Interval Records
Whitewater River	**4,481**	**58**	**1,701**	**69**
Oasis	298	58	149	70
Palm Springs	301	45	133	59
Thermal	3,755	59	1,369	70
Thousand Palms	127	58	50	66
Mission Creek	**326**	**64**	**115**	**41**
Garnet Hill	**37**	**59**	**17**	**53**
Desert Hot Springs	**412**	**71**	**76**	**38**
Fargo Canyon	60	62	20	**45**
Miracle Hill	313	73	38	29
Sky Valley	39	62	18	50
Total	**5,256**	**59**	**1,909**	**66**

Note: This summary includes all wells known from data received and gathered. This table does not imply that these wells are still active production or monitoring wells. Well screen data allows for water quality evaluation with depth.

1. Wells, in this context, are not necessarily unique; e.g., if two datasets include records from the same well but use different well identifiers that cannot be linked by either recognition of duplicate, overlapping records or some other reference, they are shown as two distinct wells.

Whitewater River Subbasin groundwater quality data include records from 1927 to 2013. In addition, records from the GeoTracker GAMA database, including data from CDPH, USGS, groundwater monitoring from cleanup sites, and the Department of Pesticide Regulation for both monitoring and supply wells, were retrieved and duplicate data points were filtered out. These data consist of 22,264 of groundwater quality records within the Whitewater River Subbasin. Of these, 16,027 records are from wells located within the Thermal Subarea, 4,225 from the Palm Springs Subarea, 1,814 from the Oasis Subarea, and the remaining 198 records from the Thousand Palms Subarea. The majority of the available groundwater quality records in this dataset exist between 1990 and 2010.

Groundwater quality data for Desert Hot Springs Subbasin include records from 1950 to 2013. In addition, records from the GeoTracker GAMA database were retrieved and duplicate data points were filtered out. These data consist of 954 groundwater quality records within the Desert Hot Springs. Of these records, 605 are from wells located within the Fargo Canyon Subarea, 330 from the Miracle Hill Subarea, and the remaining 19 records from the Sky Valley Subarea. The majority of the available groundwater quality records in this dataset exist between 1960 and 2013, with significant gaps between 1980 and 2000. It is expected that more data will be needed to determine ambient water quality within Desert Hot Springs, specifically within the Sky Valley Subarea. **Table 4-4** and **Table 4-5** summarize the number of TDS and nitrate records by period and subarea, respectively.

Table 4-4
TDS Records by Period and Subbasin/Subarea

Subbasin Subarea	< 1960	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-current	Total
Whitewater River	**157**	**968**	**1,257**	**1,384**	**1,971**	**2,420**	**625**	**8,782**
Oasis	0	31	33	90	263	704	179	1,300
Palm Springs	26	273	384	626	660	344	134	2,447
Thermal	120	621	800	647	1,036	1,359	303	4,886
Thousand Palms	11	43	40	21	12	13	9	149
Garnet Hill	**8**	**48**	**12**	**0**	**5**	**15**	**0**	**88**
Mission Creek	**45**	**281**	**97**	**14**	**48**	**50**	**13**	**548**
Desert Hot Springs	**30**	**146**	**61**	**3**	**7**	**147**	**103**	**497**
Fargo Canyon	0	4	7	1	1	143	98	254
Miracle Hill	30	126	53	0	6	3	1	219
Sky Valley	0	16	1	2	0	1	4	24
Total	**240**	**1,443**	**1,427**	**1,401**	**2,031**	**2,632**	**741**	**9,915**

Table 4-5
Nitrate Records by Period and Subbasin/Subarea

Subbasin Subarea	< 1960	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-current	Total
Whitewater River	**253**	**1,030**	**1,175**	**1,208**	**2,867**	**4,831**	**1,484**	**12,848**
Oasis	0	39	33	84	287	723	151	1,317
Palm Springs	65	283	271	259	836	664	232	2,610
Thermal	176	665	835	845	1,731	3,425	1,089	8,766
Thousand Palms	12	43	36	20	13	19	12	155
Garnet Hill	**8**	**53**	**12**	**1**	**4**	**15**	**0**	**93**
Mission Creek	**68**	**249**	**94**	**14**	**79**	**261**	**45**	**810**
Desert Hot Springs	**37**	**129**	**51**	**3**	**10**	**166**	**131**	**527**
Fargo Canyon	0	3	4	1	1	143	99	251
Miracle Hill	37	113	47	0	9	22	28	256
Sky Valley	0	13	0	2	0	1	4	20
Total	**366**	**1,461**	**1,332**	**1,226**	**2,960**	**5,273**	**1,660**	**14,278**

4.2.2.1 Vertical Distribution of Groundwater Quality Data

Groundwater quality can vary by both well location and depth. The extent to which wells and water quality can be classified by depth is a function of available perforated interval data and distinct zone or aquifer sampling. Typically, production wells are perforated in aquifer zones that are expected to provide the best production rates and water quality. Zones of known poor water quality are usually avoided. Wells are not usually perforated within distinct aquifers; instead, they may be perforated across multiple aquifer zones. This results in a pumped water quality that is a blend of the waters from each aquifer zone or perforated interval. In the absence of sampling from distinct aquifer zones, water quality classification by depth is difficult.

Well screen intervals may allow an evaluation of water quality with depth. Based on a review of available well data as summarized in **Table 4-3**, about one-third of all wells with water quality data have no known screened intervals. As discussed above, many of the wells with known screened intervals appear are perforated across multiple zones, making classification by aquifer difficult.

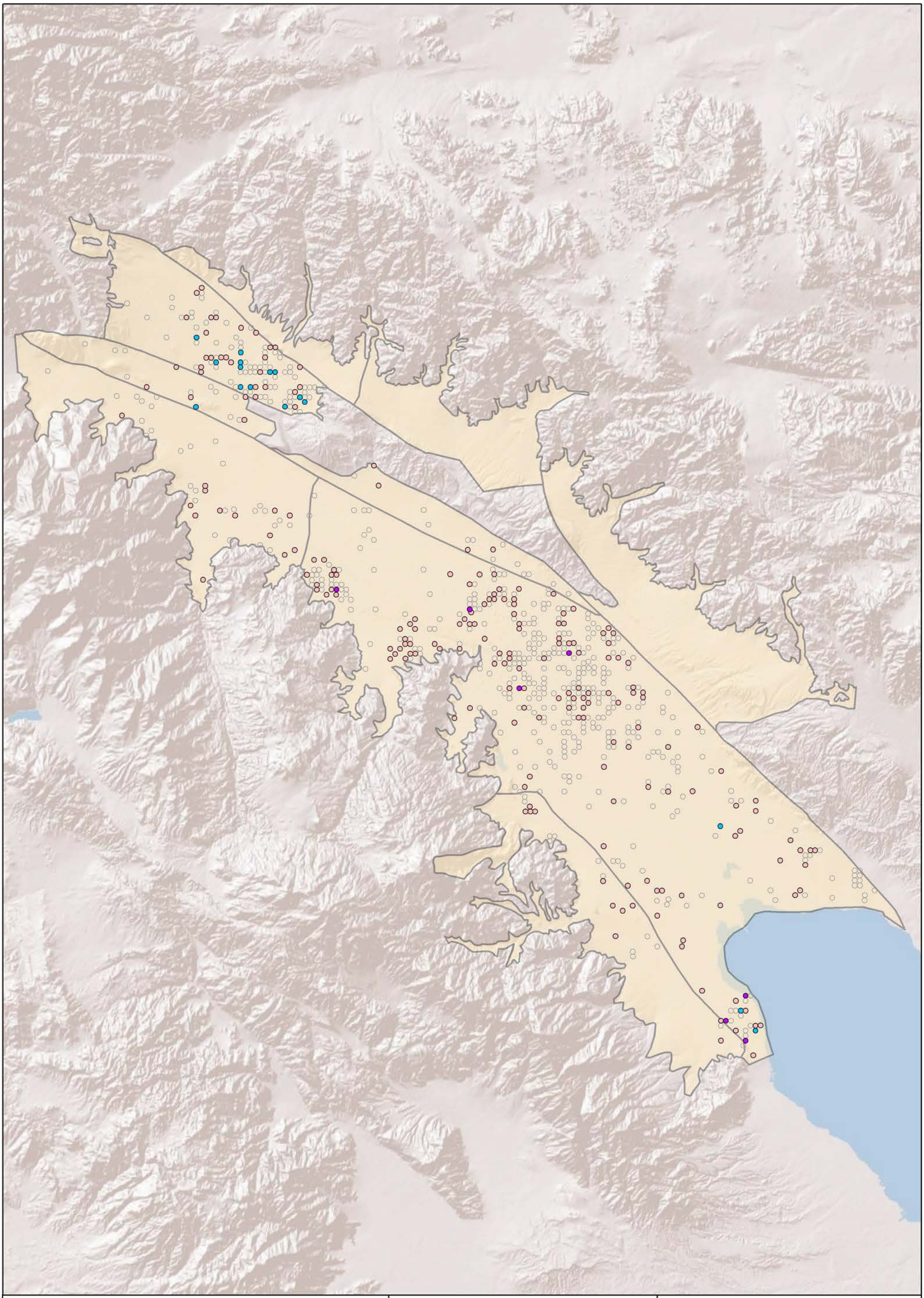
Another potential approach for assessing water quality by depth is to use information from the available groundwater models to classify wells by aquifer zone based on their location. Both groundwater models utilized four vertical layers to separate lithologic zones of differing flow parameters, or hydrostratigraphic units. Within the two models, wireline logs and drillers logs were used to determine the percentage of coarse material and clay to discretize the model layers (Psomas, 2013, Fogg *et al.*, 2002).

Fogg *et al.* (2002) used conceptual hydrogeologic data from earlier reports, notably DWR Bulletin 108 (1964) and USGS (Tyley, 1974; Swain, 1978. and Reichard and Meadows, 1992) that described areas containing multiple aquifers within the Whitewater River Subbasin. In the East Valley, the four layers represent the semi-perched aquifer (Layer 1), the upper aquifer (Layer 2), an aquitard zone (Layer 3), and the lower aquifer (Layer 4). Isolated areas of multiple aquifer systems are also present from Cathedral City to Indian Wells in the West Valley (Fogg *et al.*, 2002). Outside of these multiple aquifer zones, the four model layers have no particular hydrogeologic significance, but the layering allows computation of vertical flow. The majority, if not all, of the groundwater pumping comes from model Layers 2 and 4.

Within the Mission Creek and Garnet Hill Subbasins, distinct hydrostratigraphic zones do not exist. The four layers used in the original CVWD model were maintained to permit potential basin-wide use of the model. For the Mission Creek and Garnet Hill Subbasins, a total aquifer thickness of 1,000 feet was used. Toward the Little San Bernardino Mountains, the 1,000 feet thickness was reduced due to rise in the basement bedrock. The minimum aquifer thickness in the upper reaches of the Mission Creek subbasin was approximately 700 feet (Psomas, 2013).

The model layers may allow grouping of wells by depth to quantify where records are plentiful and where there are data gaps. **Figure 4-2** and **Figure 4-3** show the wells with water quality records in model Layers 1 through 3 and Layer 4, respectively. **Figure 4-4** and **Figure 4-5** show the median concentrations for TDS and nitrate (as nitrate) with depth, i.e., model layers, respectively; note that these figures show median concentrations for each well's entire history of record and only wells screened strictly in model Layers 1 through 3 or Layer 4 are shown (wells with no screened interval data are not shown). Additional evaluation of well construction and water quality data may allow additional classification of wells by either depth or aquifer zone. This will be evaluated in TM-2.

Limited recent monitoring data exist within the semi-perched aquifer (Layer 1 in the groundwater model). DWR and CVWD collected samples from a series of shallow piezometers (less than 100 feet) in 1975 (DWR, 1979). This sampling indicated electrical conductivity ranging from 620 to over 12,000 microsiemens per centimeter. The current status of these piezometers is unknown; no data on these piezometers exist within the current well database. The only water quality data that may represent the semi-perched aquifer is surface quality for CVWD's drain system.



Key to Features

- TDS Data
- Nitrate Data
- TDS and Nitrate Data
- No TDS or Nitrate Data
- Groundwater Basin

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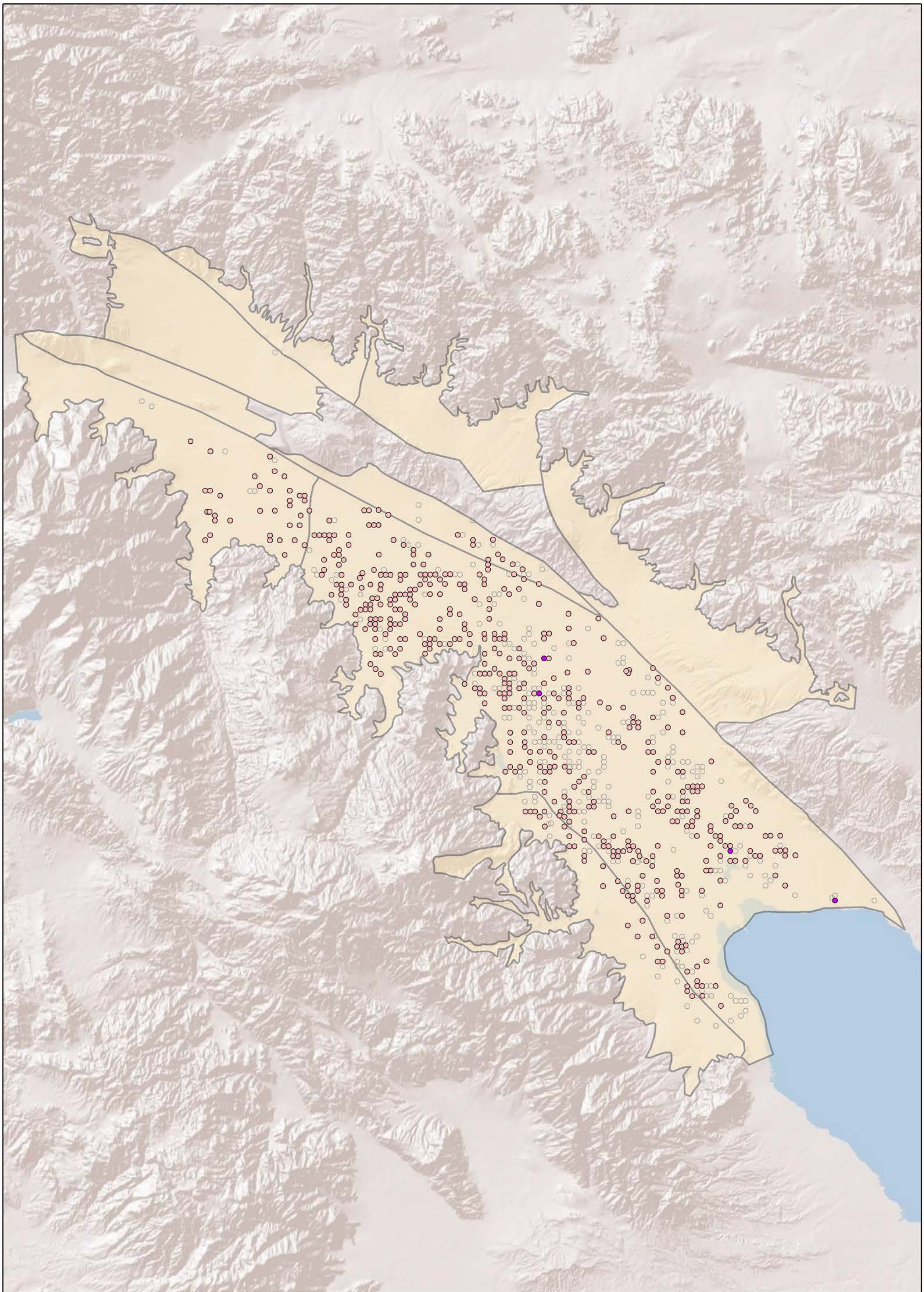
Date: 7/25/2014

Water Quality Data Availability by Well Model Layers 1, 2, & 3

MWH

Figure 4-2



Key to Features

- TDS Data
- Nitrate Data
- TDS and Nitrate Data
- No TDS or Nitrate Data
- Groundwater Basin

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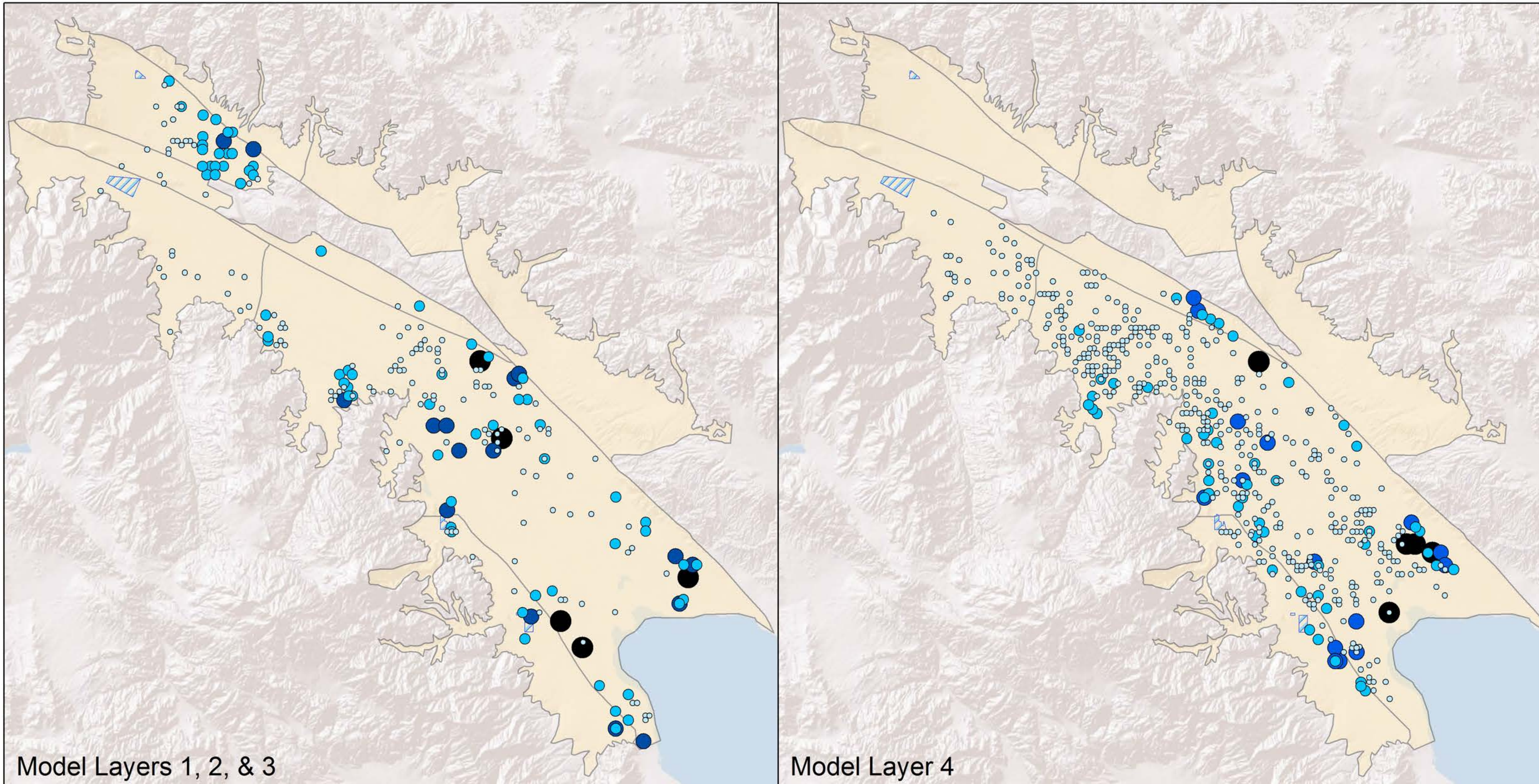
Document: \\USIRV1S01\Projects\Coachella Valley WD\SNMP\GIS_files\wells.mxd

Date: 7/25/2014

Water Quality Data Availability by Well Model Layer 4

MWH

Figure 4-3



Total Dissolved Solids (mg/L)

- < 500
- 500 - 1,000
- 1,000 - 1,500
- > 1,500
- Spreading Facilities
- Groundwater Basin

N

0 5 10 20 Miles

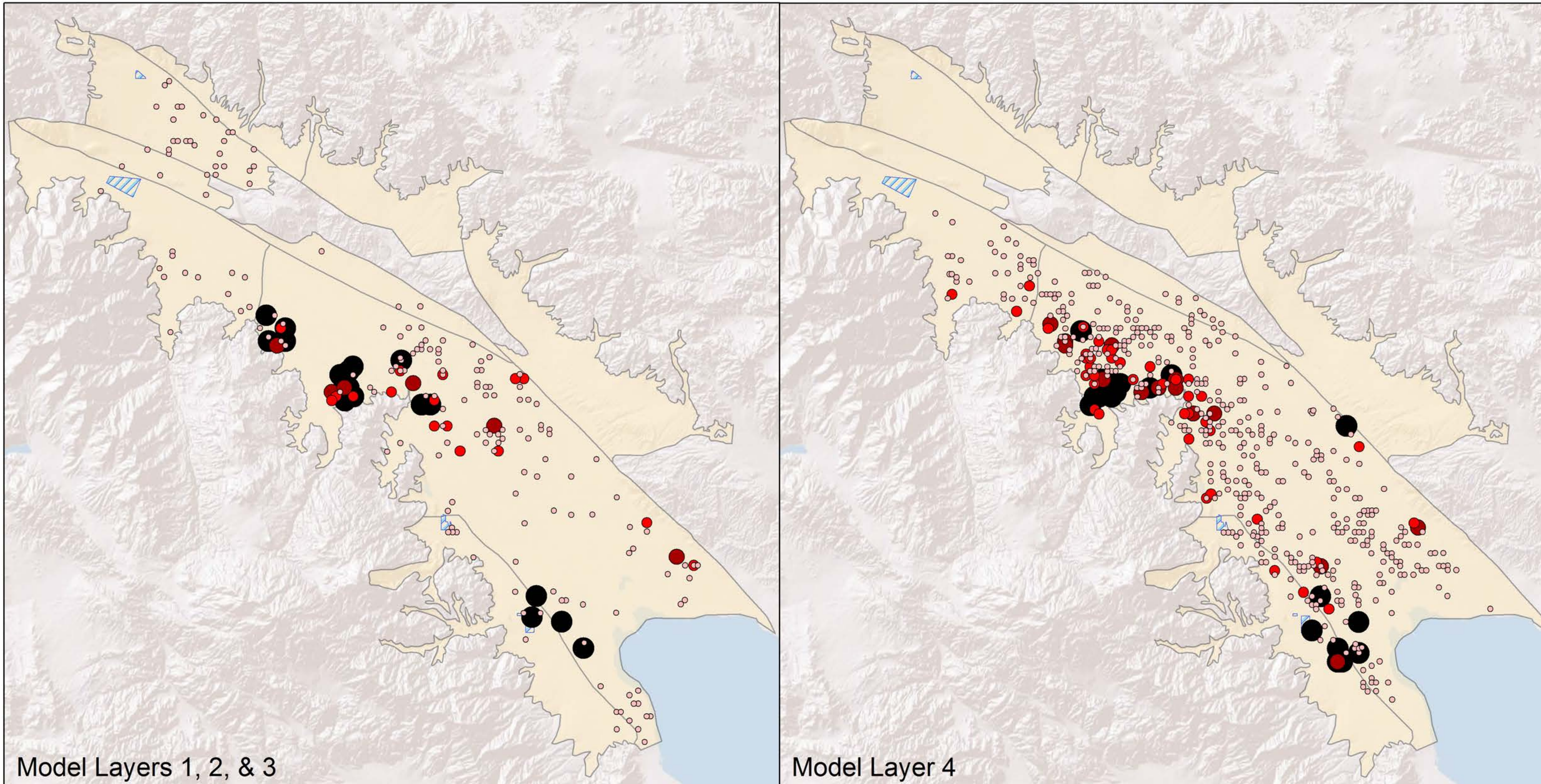
Document: \\USIRV1S01\Projects\Coachella Valley WD\SNMP\GIS_files\WQbyLayer.mxd

Date: 7/28/2014

Water Quality
Median Concentrations
by Model Layer

MWH

Figure 4-4



Nitrate (as Nitrate) (mg/L)

- < 15
- 15 - 30
- 30 - 45
- > 45
- Spreading Facilities
- Groundwater Basin

N

0 5 10 20 Miles

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Date: 7/28/2014

Water Quality Median Concentrations by Model Layer

MWH

Figure 4-5

4.2.3 Groundwater Level Data

A total of 1,077 wells make up the currently available dataset of groundwater levels in the Coachella Valley. The availability of groundwater level data by subbasin and subarea is summarized in **Table 4-6**.

Table 4-6
Groundwater Level Records by Period and Subbasin/Subarea

Subbasin Subarea	**< 1961**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-current**
Whitewater River	**2,951**	**5,719**	**7,708**	**11,938**	**18,759**	**17,407**	**3,625**
Oasis	248	258	289	540	2,483	3,132	800
Palm Springs	386	901	1,624	2,872	2,213	2,205	506
Thermal	2,193	4,325	5,542	7,921	13,440	11,629	2,221
Thousand Palms	124	235	253	605	623	441	98
Mission Creek	**26**	**253**	**316**	**341**	**409**	**1,260**	**306**
Mission Creek	26	253	316	341	409	1,260	306
Garnet Hill	**28**	**117**	**149**	**142**	**161**	**181**	**57**
Garnet Hill	28	117	149	142	161	181	57
Desert Hot Springs	**10**	**192**	**409**	**421**	**375**	**402**	**74**
Fargo Canyon	0	14	33	64	55	60	22
Miracle Hill	1	100	235	225	224	261	34
Sky Valley	9	78	141	132	96	81	18
Total	**3,015**	**6,281**	**8,582**	**12,842**	**19,704**	**19,250**	**4,062**

4.3 DATA GAPS

In general, groundwater quality data is sparse for the Garnet Hill and Desert Hot Springs Subbasins. Most of the groundwater quality in Mission Creek Subbasin comes from wells in the southeast-most portion of the subbasin; when determining AWQ, this lack of spatial resolution will be an important consideration for the method chosen to determine AWQ. Vertical water quality data availability, specifically in Whitewater River Subbasin due to the presence of confining layers and consequent aquifer zones, may be important when considering the boundaries of management zones and AWQ methods.

Groundwater level data availability is generally sufficient to characterize the water table and subsequently the volume of groundwater in storage. Data gaps include southeast Whitewater River Subbasin, close to the Salton Sea, the northwestern portion of the Mission Creek Subbasin, and most of the Desert Hot Springs subbasin. Assumptions will be made if the volume of water in storage is necessary to calculate the AWQ for these areas.

5 Technical Approach

Section 5 outlines the technical approach and tool to assist in the development of the SNMP. As described in Section 1, the SNMP process consists of three phases. Phase I of the SNMP development was completed by the CVRWMG; the result was a work plan for Phase II of the SNMP development. Phases II of the SNMP development is the preparation of the plan, including the monitoring plan, and is currently being conducted. Phase III of the process is the implementation of the monitoring plan.

Within Phase II, the process has been divided into three stages, preliminary data review and determination of quantitative methods, determination of ambient water quality and documentation of salt and nutrient sources and sinks, and identification of water management goals and salt and nutrient management strategies. Each of the first two stages will have a technical memorandum documenting the work completed. This technical memorandum, TM-1, represents the documentation of the first stage of the plan development. The second stage will be the calculation of the ambient water quality and will culminate in the deliverable TM-2. The final stage will culminate in the preparation of the SNMP. These stages are broken into individual components and shown on **Figure 5-1**.

The initial step in the process is data collection and evaluation. The primary data sources for the SNMP are described in Section 4. Additional data sources will likely be discovered and used during the process, but Section 4 provides the documentation for the bulk of data to be used. After pertinent data is gathered, MZs and constituents of concern (COCs) are identified. Delineation of MZs and determination of COCs provides the structure that the remainder of the SNMP is built on, what constituents to evaluate and where to evaluate them. The next step is to establish a baseline period to evaluate the AWQ for each MZ. The salt and nutrient analysis requires an understanding of the conceptual hydrogeologic models for each MZ, as well as an understanding of the connectivity between MZs. Conceptual hydrogeologic models provide the basis for the development of a tool to estimate future groundwater quality and effects of various management strategies and projects. The final step in the SNMP is to develop a comprehensive monitoring plan to assess compliance with water quality objectives as well as the effects of management strategy implementation. This monitoring plan can be updated after the evaluation of individual projects at a later date.

The technical approach to each step of SNMP development is discussed in detail in the following subsections.

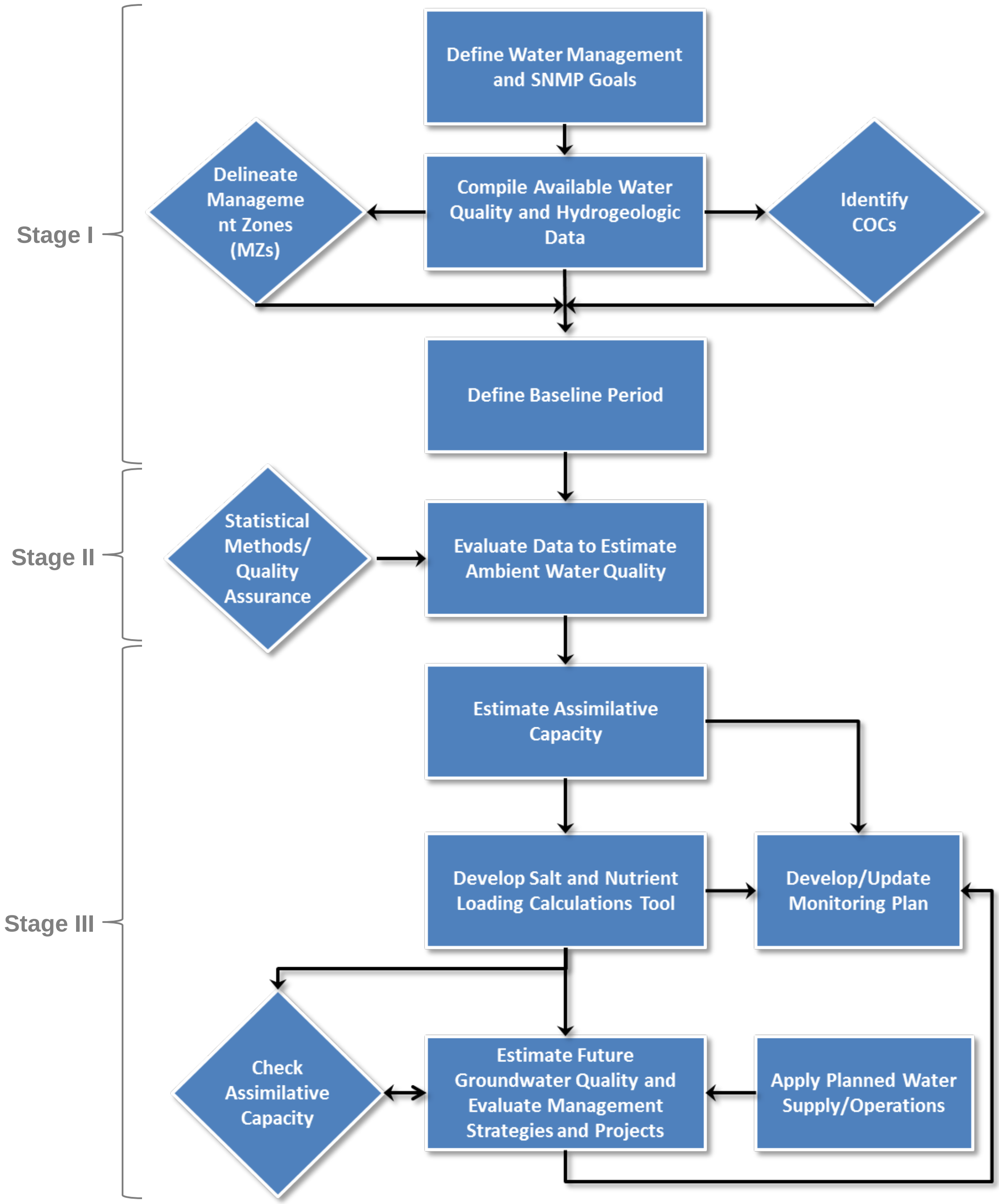


Figure 5-1
SNMP Technical Approach Flow Chart

5.1 APPROACH TO DEFINITION OF MANAGEMENT ZONES

Groundwater basins are typically the smallest unit of management identified within the Basin Plans. Given the size of Coachella Valley groundwater basins, it may be more useful to evaluate and manage groundwater quality on a scale commensurate with the regulatory and resource management decisions that must be made with surface and groundwater sources of salt and nutrient as well as the available data. A large basin could be partitioned into smaller subbasins where the relationship between land use activities, water sources and uses, and constituents of concern concentration levels can be more accurately described and managed. A basin could also be partitioned into shallow or deep zones to allow consideration of management decisions or implementation alternatives that may differ based on groundwater depth. Given the complexity of land uses, water resource management needs, and water quality goals and objectives, it may be appropriate to manage groundwater using a framework that takes into account surface and groundwater management linkages. Each area within the state of California is different, and therefore the development of MZs is not unique; some MZs may be based more on jurisdictional boundaries, such as regional management plans or natural jurisdictional relationships, rather than hydrologic boundaries.

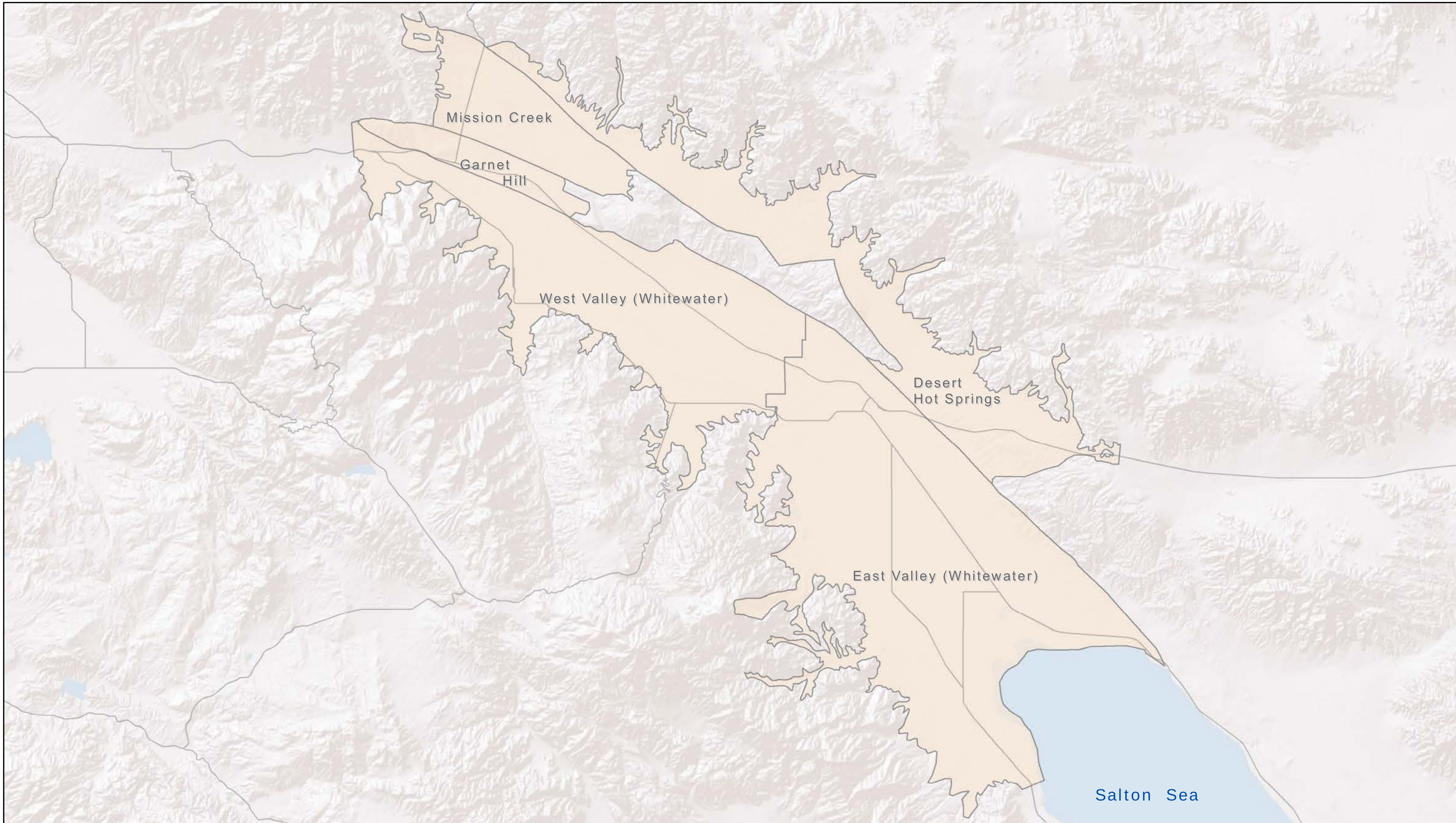
The RWQCB's objective is to protect zones of high-quality groundwater to the extent practical. Delineation of a MZ based on estimated AWQ would allow for higher resolution management strategies to protect the quality of the water. However, several considerations should be made before establishing a MZ. These considerations may include:

- What are the key geographic, jurisdictional, regulatory, or institutional considerations for establishment of a MZ approach to water quality management?
- What are the key considerations for establishment of a groundwater management approach that takes into account varying depths of groundwater?
- Can vertical changes in water quality be clearly documented?
- What types of implementation management strategies may be considered within a MZ if the SNMP provides opportunity to manage water quality from a zonal or depth perspective rather than as individual discharging entities, which is the current practice?
- What are the considerations regarding establishment of a monitoring program to collect the data required to assess water quality in a MZ?

To evaluate MZs, geologic maps, groundwater levels, and hydrogeologic conditions were reviewed and feedback was obtained from the RWQCB. Based on this information, MZs are proposed that are consistent with the groundwater subbasins, with exception to the Whitewater River Subbasin, and the Oasis and Thousand Palms Subareas. The Whitewater River Subbasin will be subdivided into two MZs, West Valley and East Valley. The East Valley MZ will include the Oasis Subarea and a portion of the Thousand Palms Subarea. The West Valley MZ will also contain a portion of the Thousand Palms Subarea. These subareas are included as they have not been shown to be hydrologically distinct groundwater systems. Being hydrologically distinct allows the areas of recharge and discharge to be well defined for each MZ and associated water quality of the recharge and discharge terms can be estimated, evaluated, and managed. The recommended MZs are shown in **Figure 5-2**, and listed below.

- Whitewater River (Indio) Subbasin
    - MZ1: West Valley
    - MZ2: East Valley
- MZ3: Mission Creek Subbasin
- MZ4: Garnet Hill Subbasin
- MZ5: Desert Hot Springs Subbasin

The separation of the East Valley and West Valley MZs is the Whitewater recharge area of benefit line of demarcation. This line extends northeast of Point Happy and is shown on **Figure 5-2**. The West Valley is predominantly a single aquifer system, while the East Valley is a multiple aquifer system. As additional data is collected over time it may be reason for further discretization of subbasins.



Key to Features

Highway

Management Zone

0 2 4 8 Miles

N

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MWH

Management Zones

Figure 5-2

5.2 IDENTIFYING CONSTITUENTS OF CONCERN

Constituents of concern were reviewed with the RWQCB and stakeholders. The following constituents were considered:

- Ammonia-nitrogen
- Arsenic
- Chloride
- Total Chromium and Hexavalent Chromium
- Fluoride
- Iron
- Manganese
- Nitrate
- Nitrite
- Selenium
- Sulfate
- TDS
- Uranium

Of the constituents identified in the initial review list, those of particular interest to salt and nutrient management within the Coachella Valley include:

- Arsenic
- Hexavalent Chromium
- Nitrate
- TDS

Nitrate and TDS were selected as the primary COCs as they are materially affected by recycled water use or other salt/nutrient loads. These parameters are most affected by human-induced activities. These constituents can be used as surrogates for other salt and nutrient constituents and also have a stronger monitoring history, which is a benefit, although not a requirement.

Arsenic and hexavalent chromium will be evaluated to determine how a recycled water project or management policy may impact the constituent concentration within a MZ.

5.3 BASELINE PERIOD

The baseline period is the time frame over which AWQ is evaluated. The period should be sufficiently long to reduce the effects of hydrologic or water supply variation and have sufficient data points to make reasonable statistical inferences. The baseline period serves as the starting point for evaluating the future effects of salt and nutrient loading on groundwater quality. Options available for the Coachella Valley include:

- Historical period –a pre- imported water recharge condition could be selected; however, data availability may be insufficient to properly characterize the water quality throughout the Valley.

- Recent period – a more recent period may have more data but would likely reflect the effects of water management activities implemented to reduce overdraft.

Section 9.c.1 of the SWRCB's Recycled Water Policy states that "available assimilative capacity shall be calculated by comparing the mineral water quality objective with the average concentration of the basin/sub-basin, either over the most recent five years of data available or using a data set approved by the Regional Water Board Executive Officer." However, data availability and validity may require a longer baseline period in order to perform statistically meaningful calculations. Statistically, fewer data points results in greater uncertainty of the mean value (larger confidence interval). Most potable wells in the Coachella Valley are sampled and analyzed for TDS every three years. The baseline period should be at least ten years long to capture, at minimum, three rounds of water quality sampling as this is the minimum number of data points required to evaluate statistical trends.

Based on the requirements above and data availability of each subbasin, as described in Section 4, a baseline period from 1994 to 2013 is proposed. If recent data is not adequate to estimate AWQ for a particular MZ, historical data may be used to estimate AWQ. If availability or validity of data prohibits the estimate of AWQ, it will be stated so in the SNMP.

5.4 APPROACH TO DETERMINE AMBIENT WATER QUALITY

AWQ is an estimate of the representative current water quality within a MZ. One of two methods will be used depending on the availability of data within each MZ. Where sufficient data exists to characterize the spatial distribution of water quality, a volume-weighted approach will be used to determine AWQ for each MZ. If not enough data exists to reasonably use this method, a statistical summary of water quality will be prepared with monitoring recommendations. Regardless of the method, the water quality data is prepared for evaluation and filtered to minimize spatial and temporal bias.

5.4.1 Data Preparation

The raw groundwater quality data must be prepared prior to the analysis of AWQ. Several assumptions will be made to prepare the data into a usable format for AWQ calculation.

As groundwater quality comes from a variety of sources, duplicates will be removed as to not count a particular record more than once (duplicates may be the same measurement from two different databases). This is done by generating unique identifiers for each particular record that includes the well name, record date, and analyte. Those unique identifiers that occur more than once are removed such that only one record remains. In addition, data sources may report non-detect values in several different ways, particularly important for nitrate records. Some examples include:

- non-detect, i.e. "ND", with method detection limit;
- non-detect, i.e. "ND", with no method detection limit;
- zero value, i.e. "0"; and
- less than method detection limit, i.e. "< MDL".

For the AWQ calculation, all non-detects will be represented as true zeroes for three reasons: (1) not all the data may have the method detection limit available for each record; (2) numerical values for all results allow the calculation of summary statistics; and (3) all non-detects are treated in the same way (This is consistent with the use of Aitchison's method as presented in the United States Environmental Protection Agency (EPA) guidelines – Data Quality Assessment: Statistical Methods for Practitioner [EPA, 2006]). This does have the consequence that if the true value is greater than zero but less than the method detection limit, it will be treated as a zero. If the average of an entire dataset is calculated making this substitution, the concentration will be equal to or less than the true average concentration, thus introducing a bias. However, the filtering of data proposed will limit the effect of this bias on the AWQ calculation.

5.4.2 Temporal and Spatial Filter

Groundwater quality data will be filtered temporally and spatially to generate representative groundwater quality throughout the Basin. The reason for this filtering is to eliminate the bias introduced due to the nature of sampling. These biases are (1) frequency bias, (2) age/type bias, and (3) position bias.

5.4.2.1 Frequency Bias

A certain well may become more or less frequently sampled at any time. For example, consider that a production well produces water from 1994-2013 with nitrate below the MCL and so it is sampled once a year. The sample taken in 2010 shows nitrate above the MCL and it is decided that the well will be taken offline and sampled weekly until the nitrate concentration drops below the MCL. The well then continues to stay above the MCL. If all records are considered, AWQ will be skewed in the direction of poorer water quality than a time-weighted average suggests. To address this, the median of all records for a well within a particular year used as the yearly representative water quality. As the baseline period chosen includes 20 years, each well will have at most 20 *yearly medians* for each constituent. If no records exist for a particular year, no annual value is recorded.

5.4.2.2 Age/Type Bias

Over the period of record, old wells may have become inactive and new wells may have been constructed, so their particular records start and stop at different times. Additionally, datasets include multiple types of wells (e.g., production and monitoring) that are sampled at different frequencies for dissimilar purposes. For example, most water purveyors measure the TDS of their production wells every three years for compliance with drinking water regulatory requirements, whereas monitoring wells near the Salton Sea are sampled much more frequently to perhaps assess intrusion or interactions between the Sea and the groundwater basin. Both water qualities are important but weighting water quality in the direction of the monitoring well because of the presence of many more records will not lead to a representative basin water quality. To address this, the yearly medians for a well are aggregated and the median is computed to establish a single value to represent that well's water quality for the entire baseline period for each constituent, referred to as the *baseline well concentration*. For the example above, the monitoring well and the production well would then both contribute equally to the

AWQ. Because median values are used in the temporal filter, using zero values for non-detects as discussed earlier will have less consequence as they tend to fall out.

5.4.2.3 Position Bias

In general, production wells are sited in areas of better water quality and close to the distribution system, i.e., near developed communities. As such, water quality data will cluster around these areas. Using all the wells in the calculation of AWQ will skew results towards the water quality around dense well zones. To address this, a 1,000 foot by 1,000 foot grid is applied to group well data within the same grid cell. The average of the baseline well concentrations of these wells is then calculated to get *cell means* for the baseline period; if sufficient screened interval data exist for wells in a particular MZ, groundwater model layers may be considered such that baseline well concentrations are averaged for a particular grid cell and layer combination to get *cell-layer means*.[2] Discretizing by layer would be the equivalent of determining the AWQ by aquifer.

5.4.2.4 Filter Summary

The following filters are applied for each constituent in each MZ:

- Temporal Filter 1: For each groundwater well, medians are computed for each year of the baseline period to get at most one concentration per year (maximum of 20 values), called a *yearly median*;
- Temporal Filter 2: For each groundwater well, a median of the yearly medians is computed to obtain one concentration for that well for the baseline period, called a *baseline well concentration*;
- Spatial Filter: A grid is applied to the MZ to aggregate temporally filtered data and the mean of the aggregated baseline well concentrations are taken for each cell. The result is a single concentration for each cell in the 1,000 foot grid for the baseline period. If this can be done by model layer/aquifer, it will as well.

5.4.3 Calculation of Ambient Water Quality

As discussed, two methods will be considered for the determination of AWQ. The availability of data within a particular MZ will drive the selection of the AWQ method that will be used for that MZ.

5.4.3.1 Volume-weighted Method

The volume-weighted method for determination of AWQ is used when an adequate amount of data exist for a particular MZ. This method considers the volume of water in storage to assign weights to water quality within the basin. Following the data preparation and filtering, the single cell concentration values are contoured, this will provide inferred concentration values where no well are present. The concentrations are multiplied by the water in storage with the grid cell and the results are totaled to obtain a volume weighted AWQ. If the data is available, this process can be completed at the model layer/aquifer level.

[2] Depending on data availability, model layers may be grouped (e.g., layers 1 and 2 may be treated as one layer).

In addition to water quality, groundwater level data is also filtered and contoured in a similar fashion. The water level contours are then used to generate a water level surface and values from the surface at the cell centers are assigned to each cell within the MZ.

To determine the volume of water in each cell volume between the water level surface and the base of the aquifer), lithologic descriptions will be organized and grouped into categories. The categories would be expected to have similar hydraulic properties. This will be completed for each model layer, or aquifer if no model exists. For the purposes of this plan, the aquifer property that is needed is effective porosity. Once zones and categories have been established, the grid is overlain to delineate cells for calculations. Note the volume being approximated is not to total amount in storage (based on porosity) or the total that can be pumped (based on specific yield), but the amount available for mixing (based on effective porosity).

The volume of each cell combination is calculated as,

$$Vol_{i,j} = (n_e)_{i,j} \times Area_i \times (H_{sat})_{i,j} \, ,$$

where i is the cell, j is the layer, n_e is the effective porosity, and H_{sat} is the saturated thickness. The effective porosity will be corrected for lithostatic loading as a function of depth. **Figure 5-3** shows a conceptual representation of the cell-layers. AWQ is the total mass in all cell-layers divided by the total volume of water in storage in all cell-layers,

$$AWQ_{volume-weighted} = \frac{\sum_i \sum_j \left(C_{i,j} \times Vol_{i,j}\right)}{\sum_i \sum_j Vol_{i,j}} \, ,$$

where C is the concentration. This method requires sufficient water quality data for wells with known depth information; aquifer properties such as layer thickness, effective porosity, and groundwater level; and well-spaced data in both the horizontal and vertical.

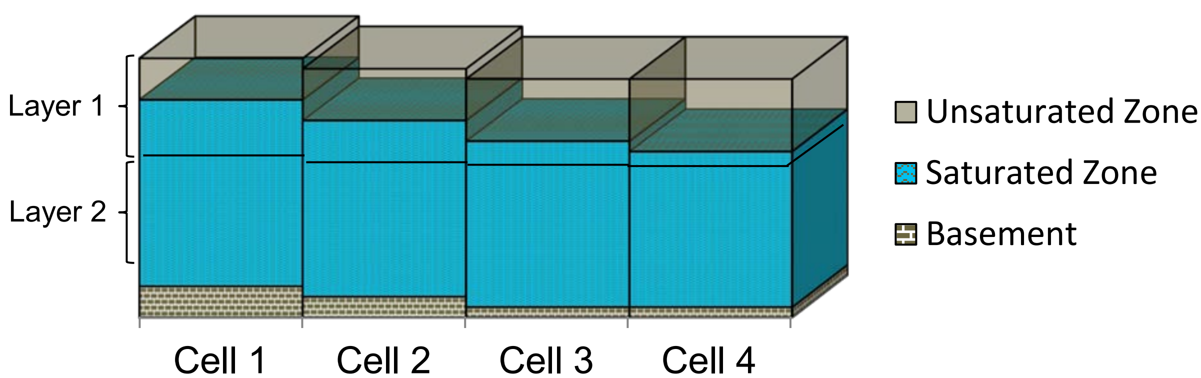

Figure 5-3
Conceptual Representation of Model Cells and Layers

5.4.3.2 Statistical Method

The statistical method for AWQ determination is used when less data is available; this may be due to a lack of well depth information or limited water quality data. Similar to the volume-weighted method, water quality data is filtered temporally and spatially, except aquifer layers are not considered.

All baseline well concentrations are aggregated for each cell, using these data the mean and median is calculated to describe the cell water quality. AWQ is calculated as the average of all cell medians.

5.5 CALCULATING ASSIMILATIVE CAPACITY

Assimilative capacity represents the difference between the MZ numerical water quality objective and the AWQ, as described in Section 2. If the current or projected water quality is better than the defined objective or threshold, then capacity exists for a MZ to assimilate additional salt or nutrients. To determine each MZ assimilative capacity, the AWQ will be subtracted from the water quality objective for the MZ.

5.6 APPROACH FOR SALT AND NUTRIENT LOADING CALCULATIONS

Salt and nutrient loading calculations will be based on spreadsheet-based planning tools that use a constantly stirred reactor model concept within each MZ. Salt and nutrient loading is largely driven by the water balance in the Coachella Valley. **Figure 5-4** shows a conceptual diagram of water interactions in the Coachella Valley. Each element of the water balance will be quantified and a concentration of salt and nutrients applied. Listed below is a description of the steps to prepare the salt and nutrient loading tool:

1. Determine aquifer storage volume from model geometry and storage properties
2. Determine groundwater inflows, including:
    a. Deep percolation of precipitation
    b. Subsurface inflows from adjacent aquifers/MZs
    c. Deep percolation of applied water (i.e., return flows, including potable and recycled)
    d. Deep percolation of wastewater
    e. Deep percolation from surface water bodies
    f. Inflows from recharge facilities
3. Determine groundwater outflows, including:
    a. Groundwater pumping
    b. Evapotranspiration from groundwater dependent vegetation
    c. Subsurface outflow to adjacent aquifers /MZs
    d. Groundwater outflow to surface water bodies
    e. Drain flows to the Salton Sea
4. Establish a water balance, determine net inflow/outflow from the basin, and rate of change of storage of the MZ
5. Assign a concentration to each inflow to the MZ

   a. Monitoring data will be used to the extent available to determine concentrations.
   b. Use-specific waste increments are applied to applicable basin inflows to account for salt and nutrient addition through use
6. Assign a concentration to outflows from the MZ
   a. Monitoring data will be used to the extent available to determine concentrations.
   b. Subsurface outflows from groundwater basins will be based on the volume-weighted average computed with the constantly stirred reactor model
7. Determine baseline salt and nutrient trends for each MZ
8. Perform sensitivity analysis to determine effects of variability in the calculations

To the extent data is available, subsurface flow between adjacent MZs will be estimated using existing groundwater modeling results.

Ideally, the tools will be completed for a 10 year historical period. The end of the period should approximate the current ambient water quality. This allows for a check of reasonableness of the tool. To use the tool into the future, elements of the water balance are estimated for future conditions, assuming long-term average hydrologic conditions.

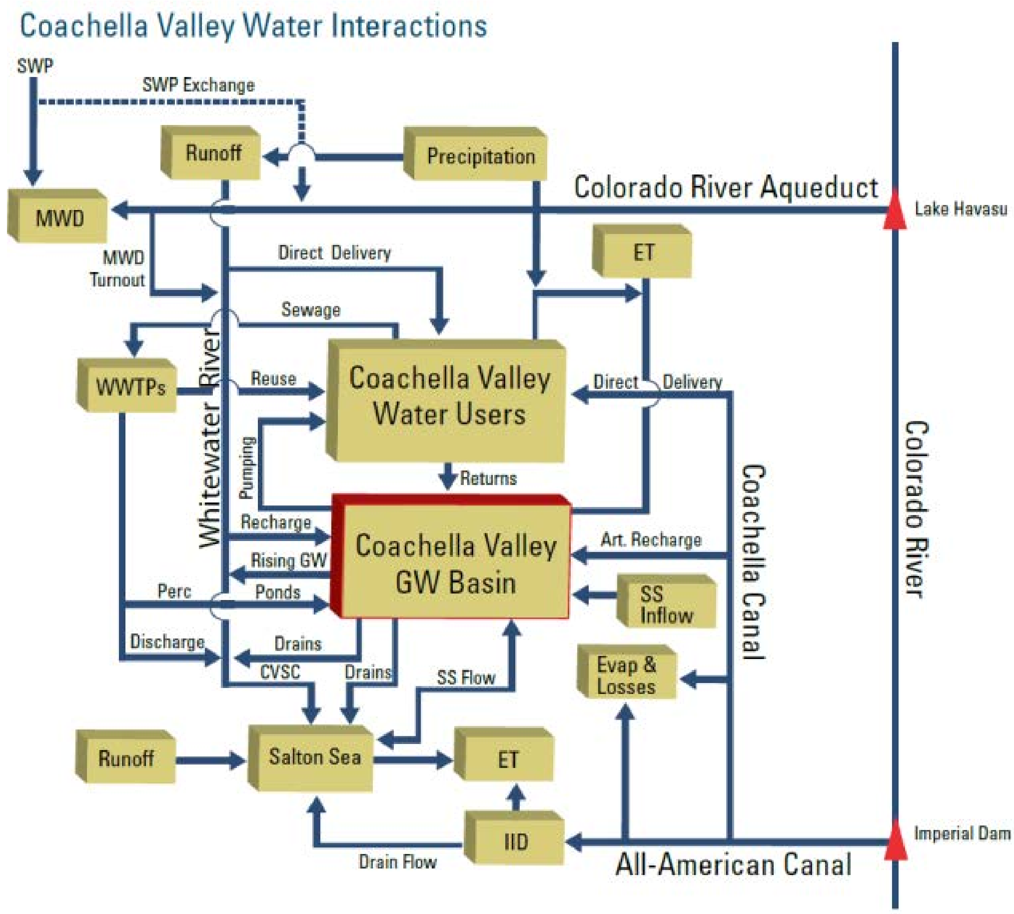

Figure 5-4
Water Interactions in the Coachella Valley

5.7 APPROACH TO ESTIMATING FUTURE GROUNDWATER QUALITY AND ASSIMILATIVE CAPACITY

To evaluate projects into the future, planned water supply conditions will be used along with average hydrologic conditions (i.e. recharge and discharge). The projected water quality conditions of each MZ will be evaluated using the Salt and Nutrient loading calculations tool moving forward with projected conditions. The current AWQ and groundwater storage in each MZ will be used as the starting point for the simulations. The results will be compared to water quality objectives to determine a project's impact on water quality and assimilative capacity. The salt and nutrient loading calculations tool can be used to evaluate various management strategies and scenarios in each MZ. The tool will provide an estimation of the effects of implementing various strategies and projects over future planning time steps. The tool will project average water quality by MZ for a 25-year period.

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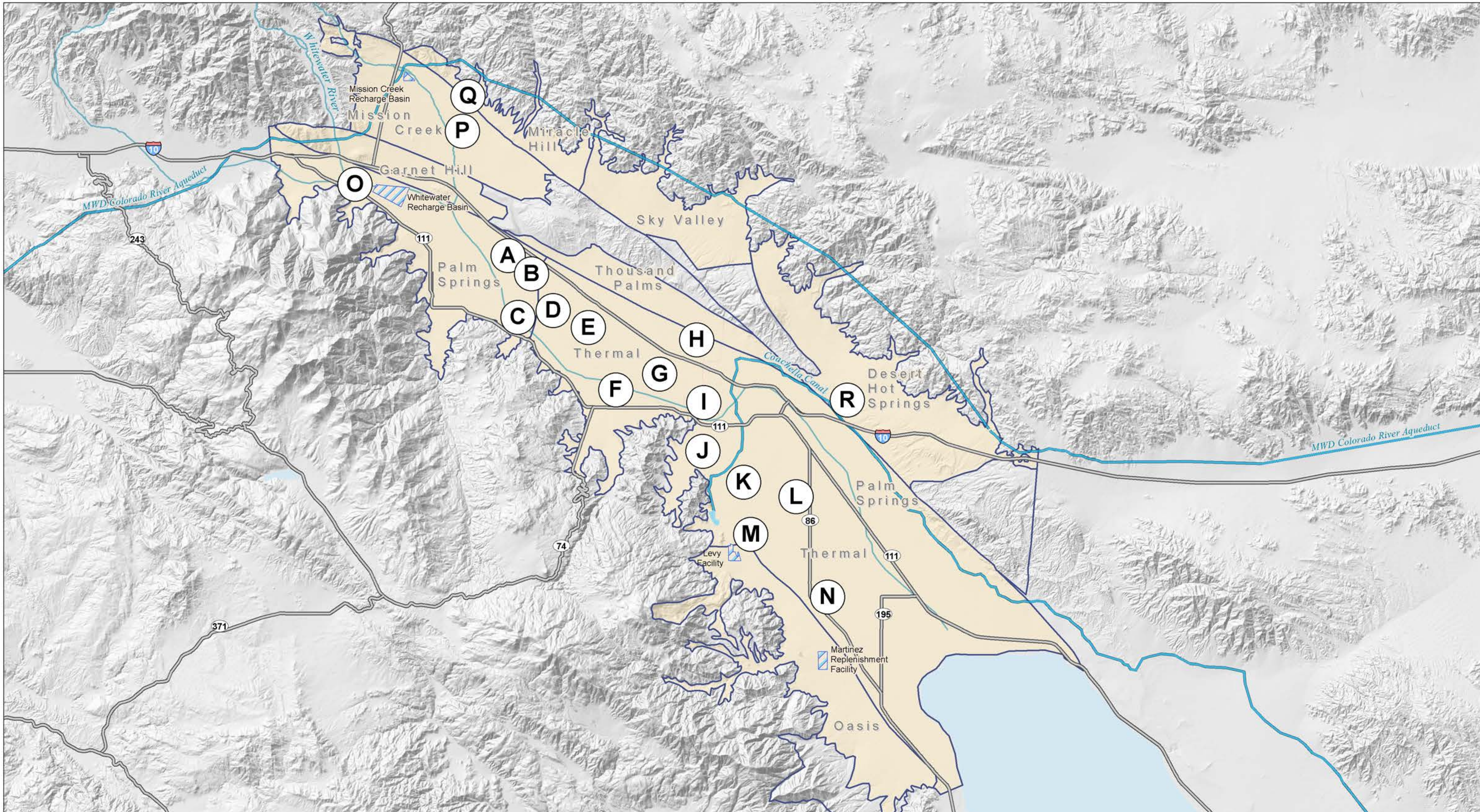

Key to Features

Highway

Group Name

Minor Drainage

Canal / Aqueduct

Spreading Facility

Water Body

Management Zone

N

0 5 10 Miles

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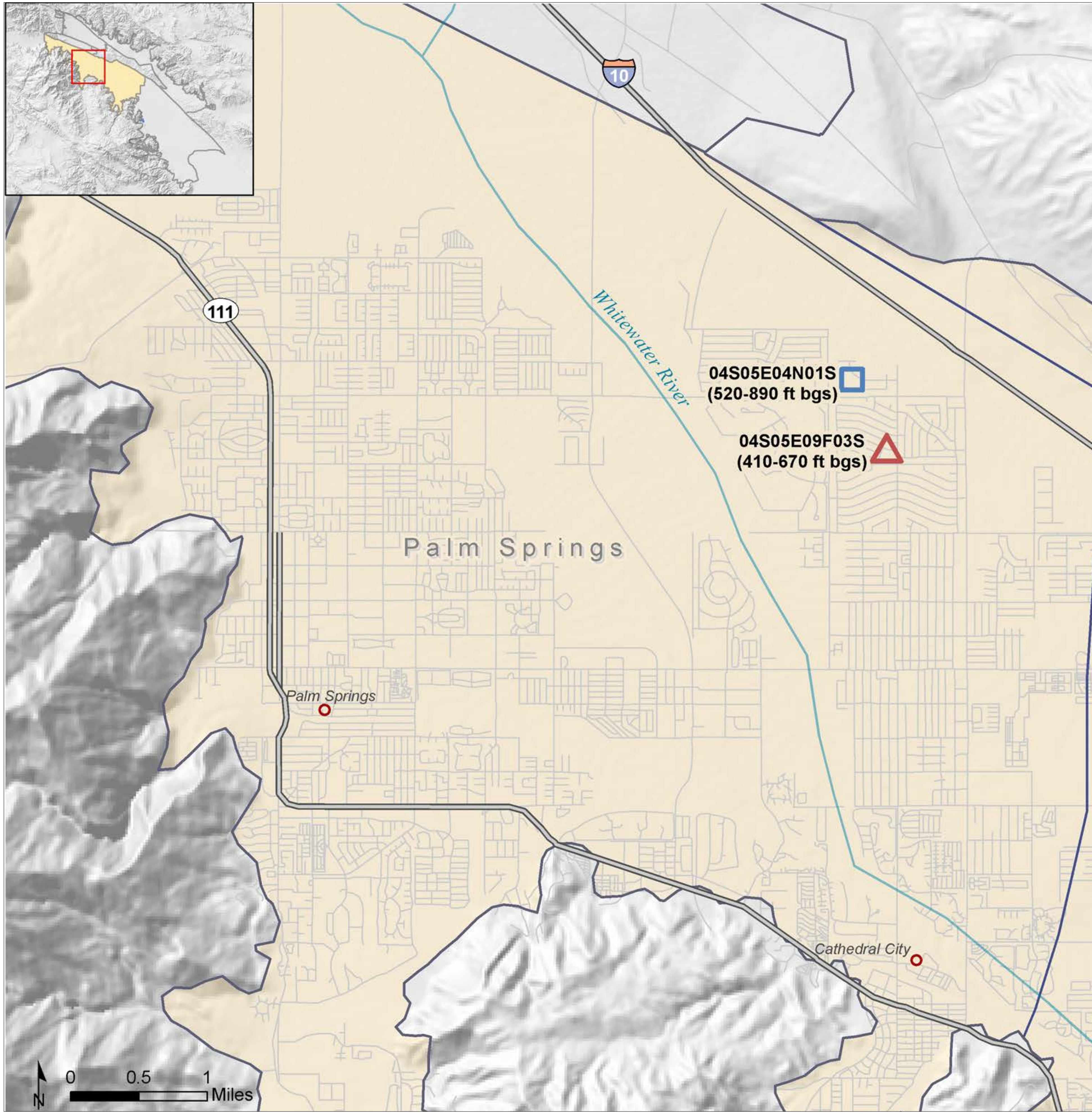
Date: July 24, 2014

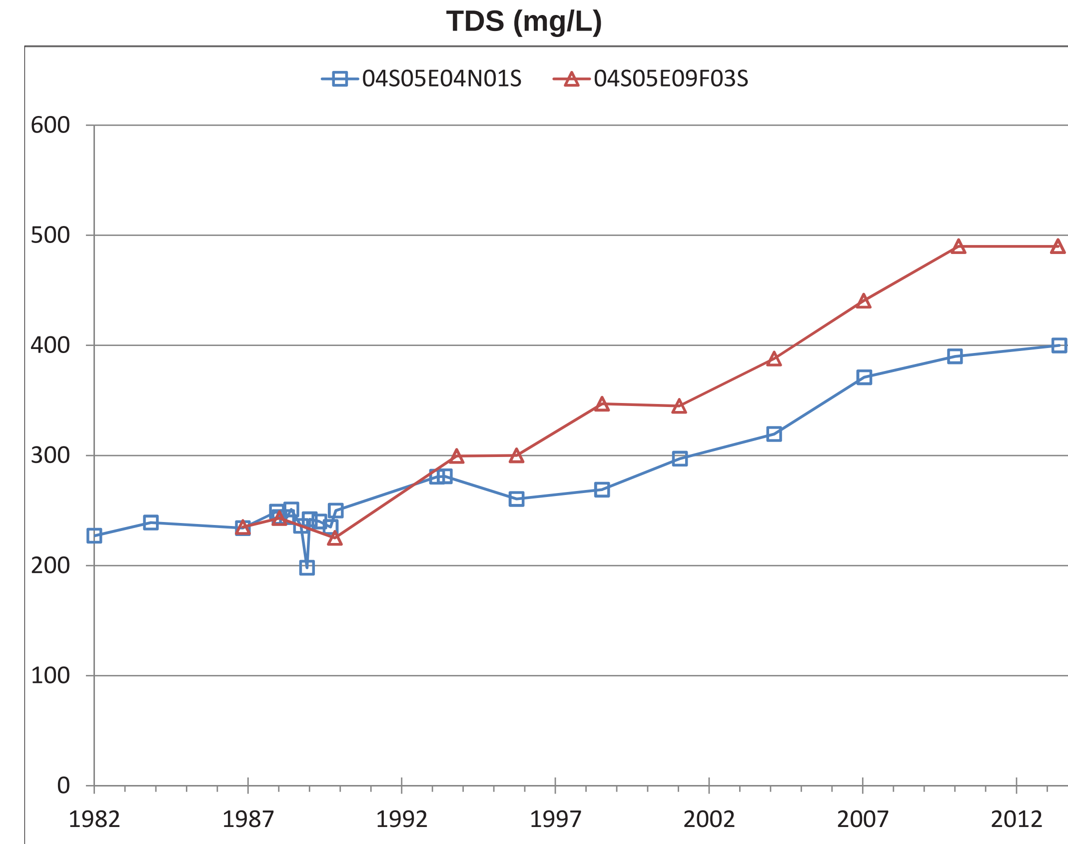
Well Trend Group Name

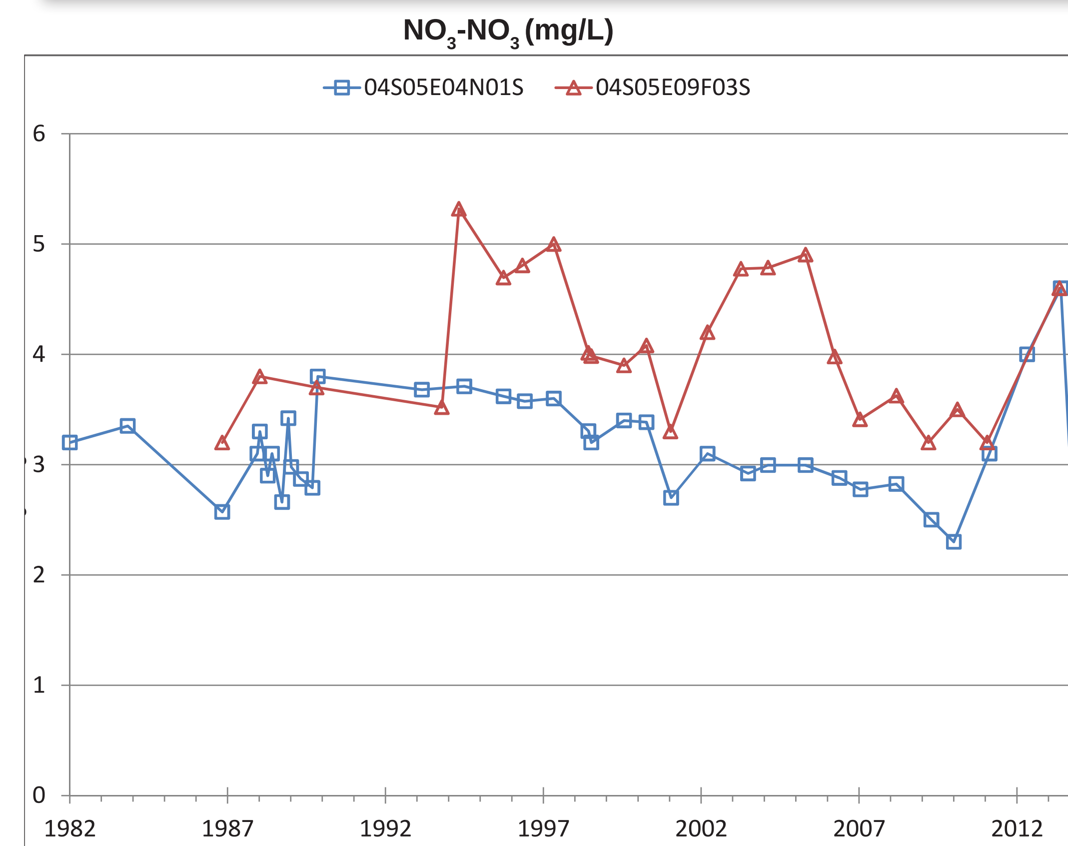
MWH

Appendix A-1

This map has been designed to print size 11'' by 17''.

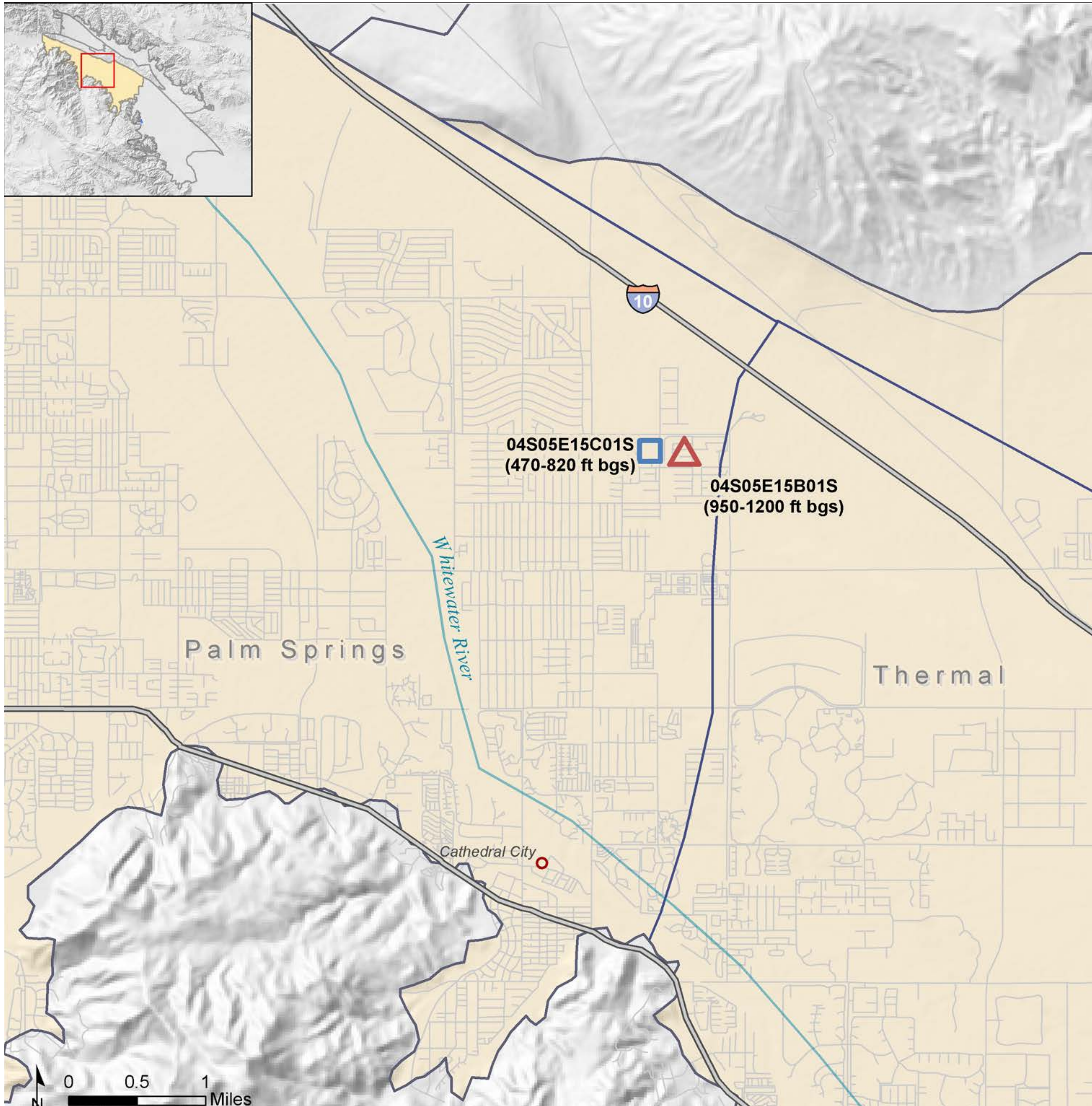


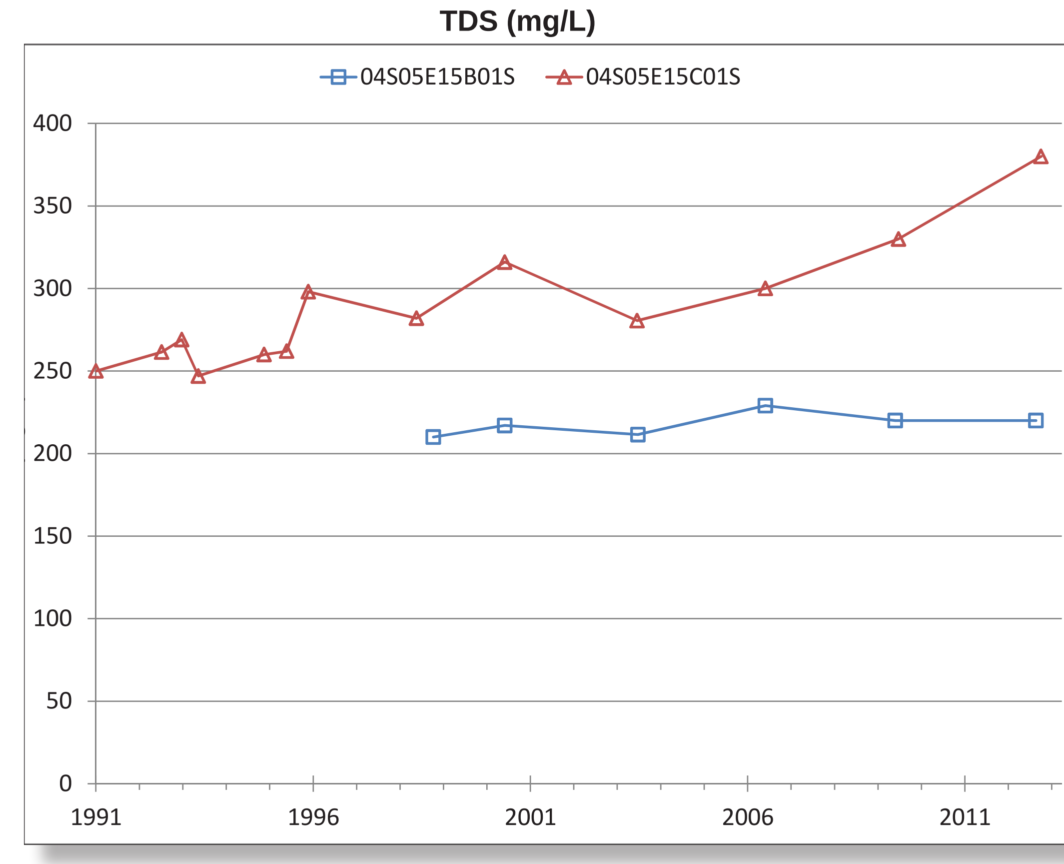


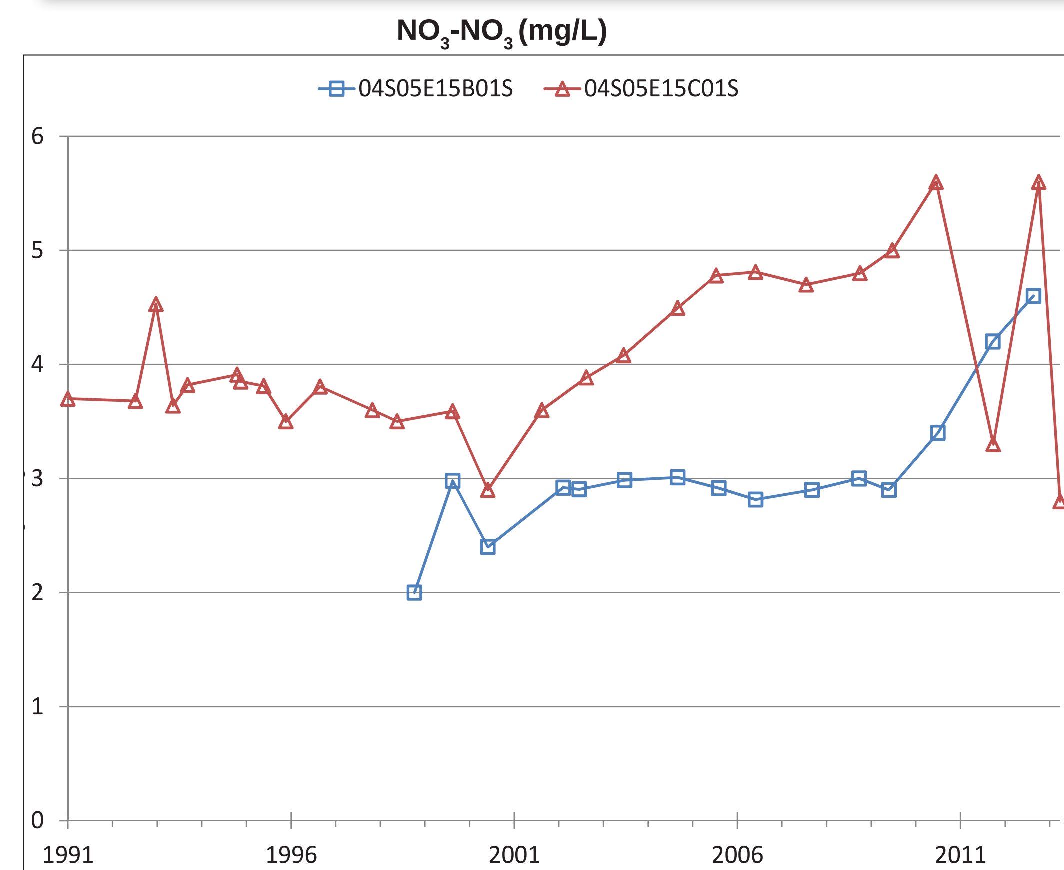


Appendix A-2

Upper Valley Group A

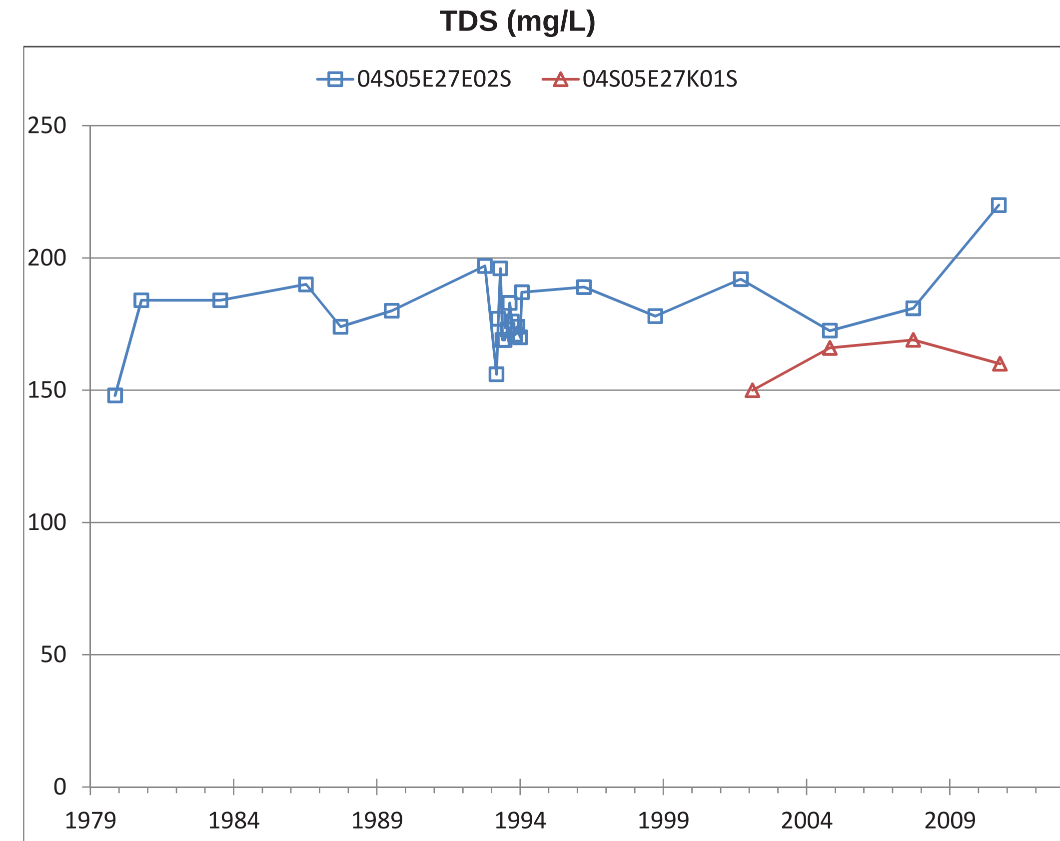


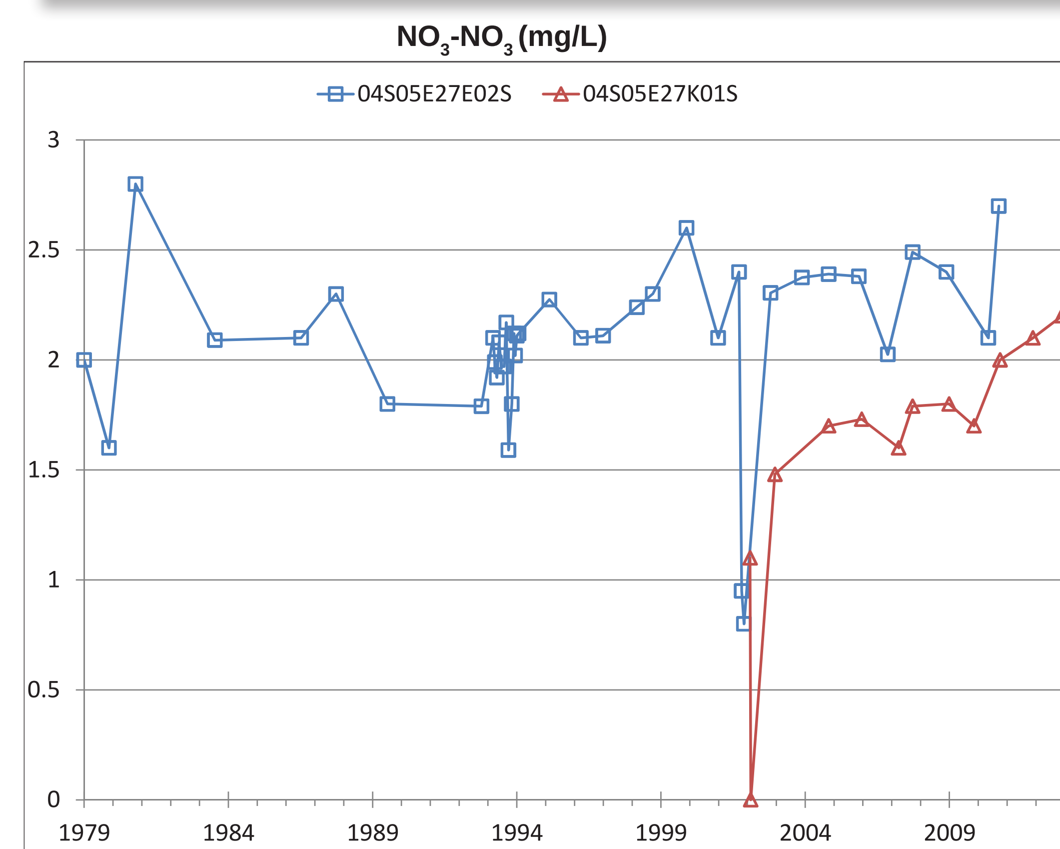




Appendix A-3

Upper Valley Group B

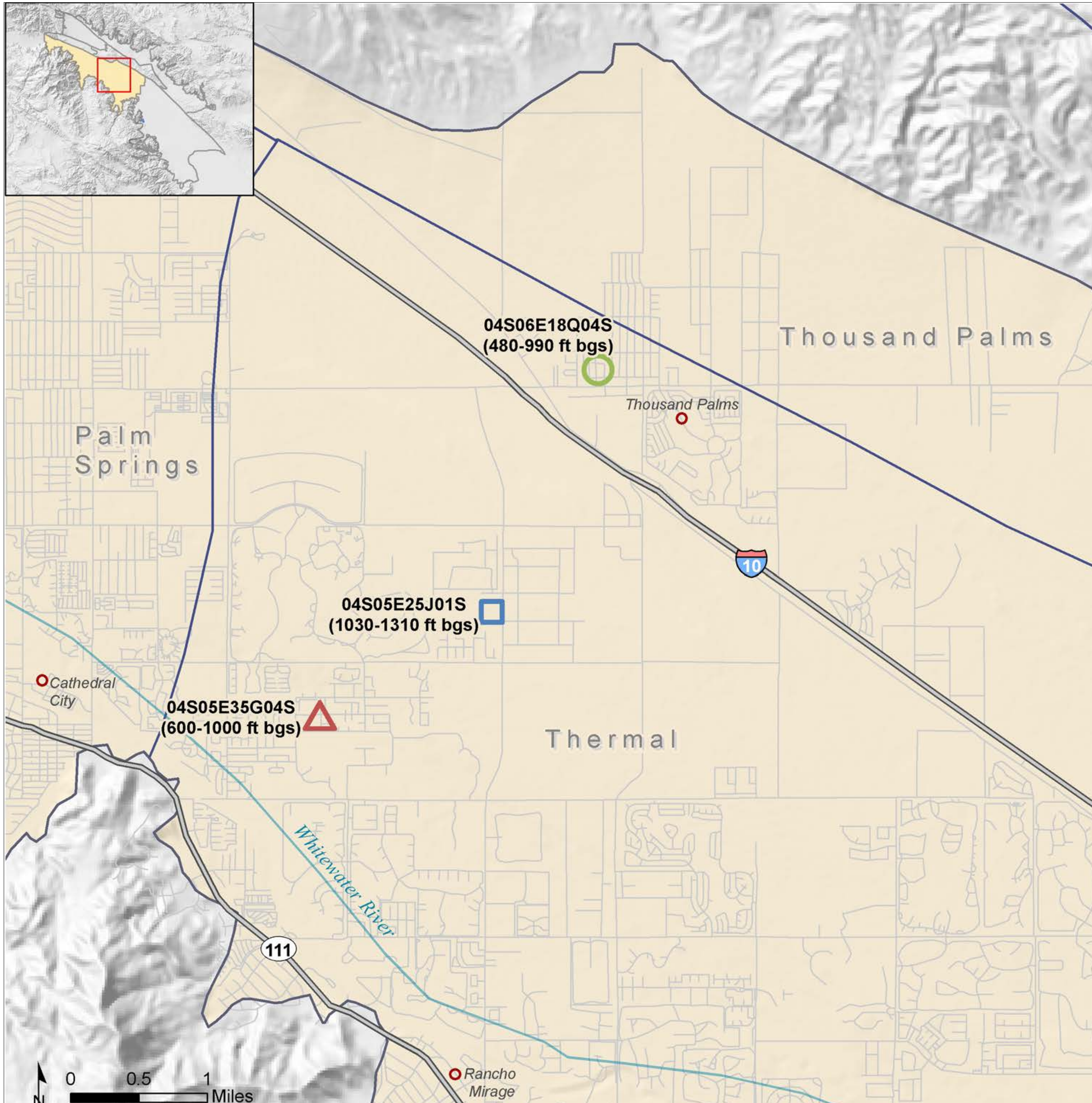


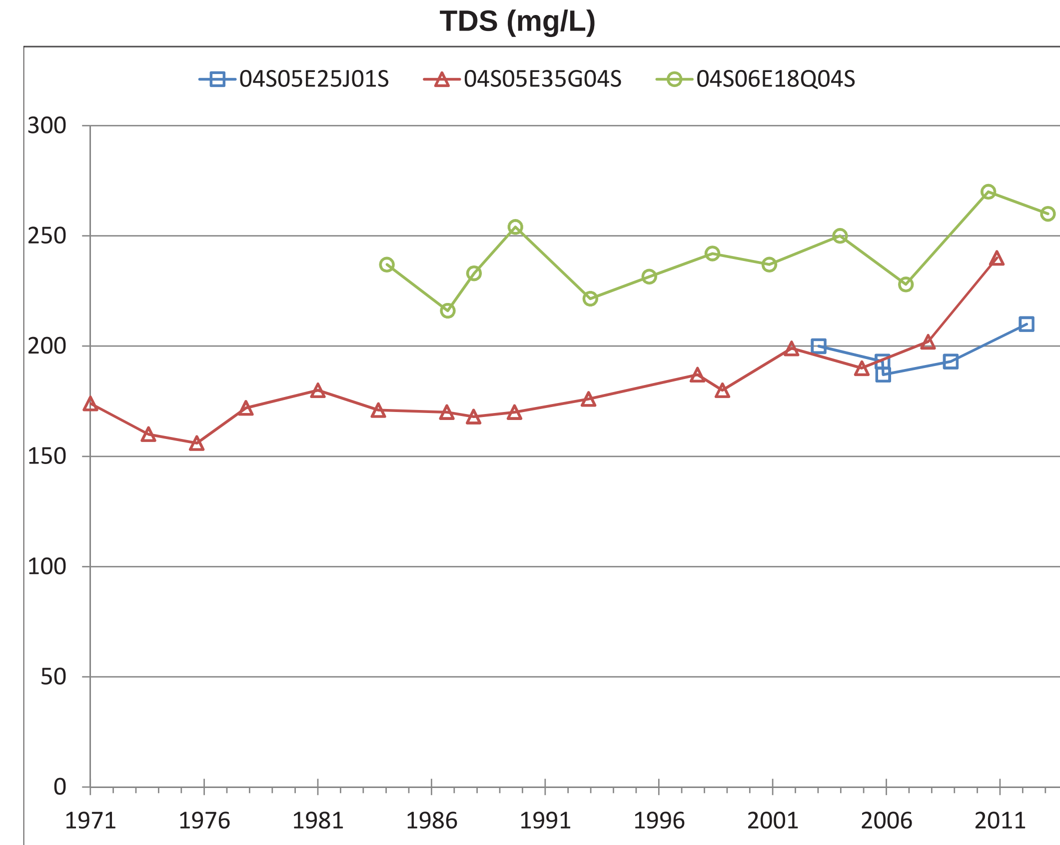


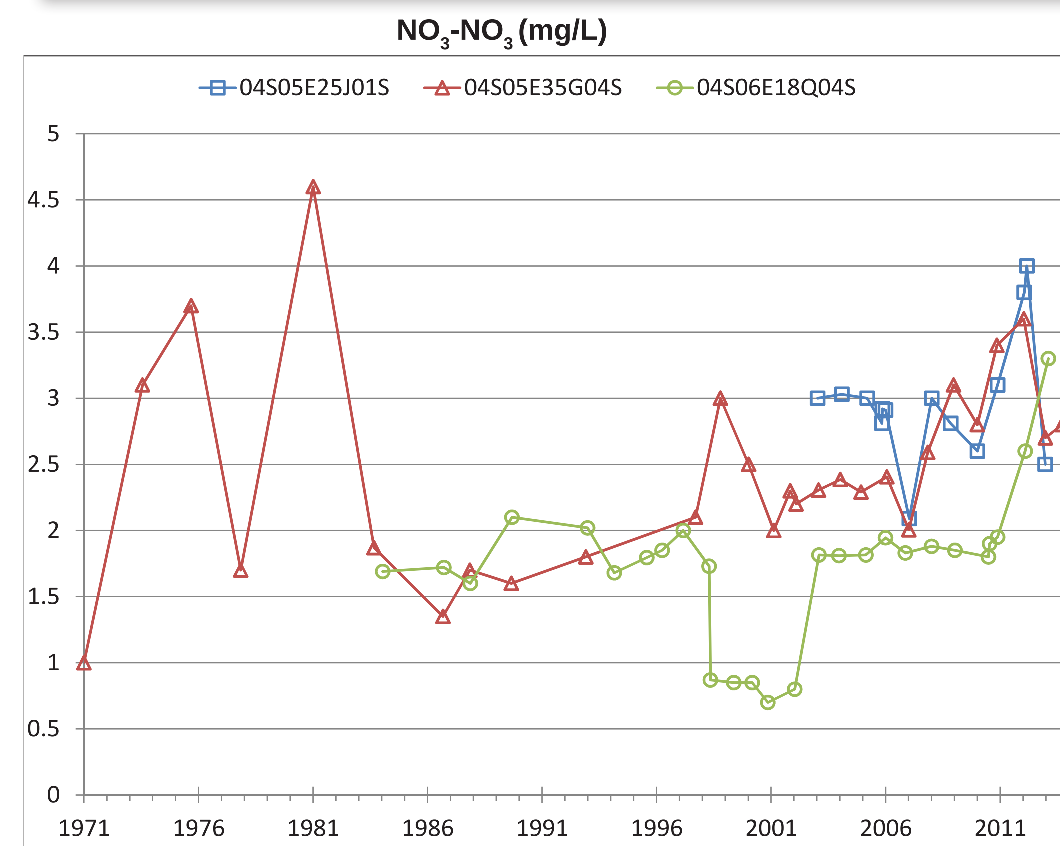
MWH

Appendix A-4

Upper Valley Group C







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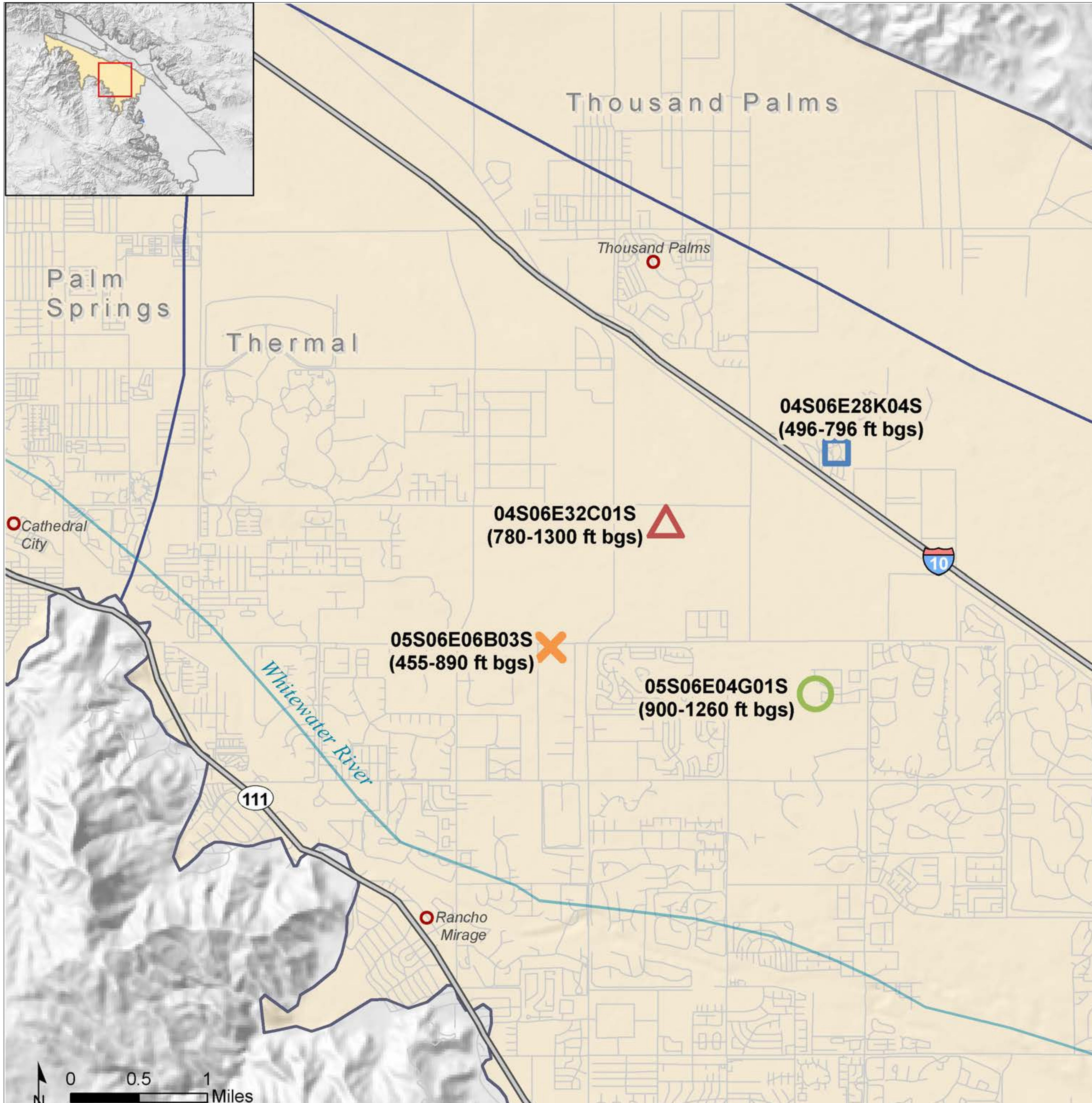
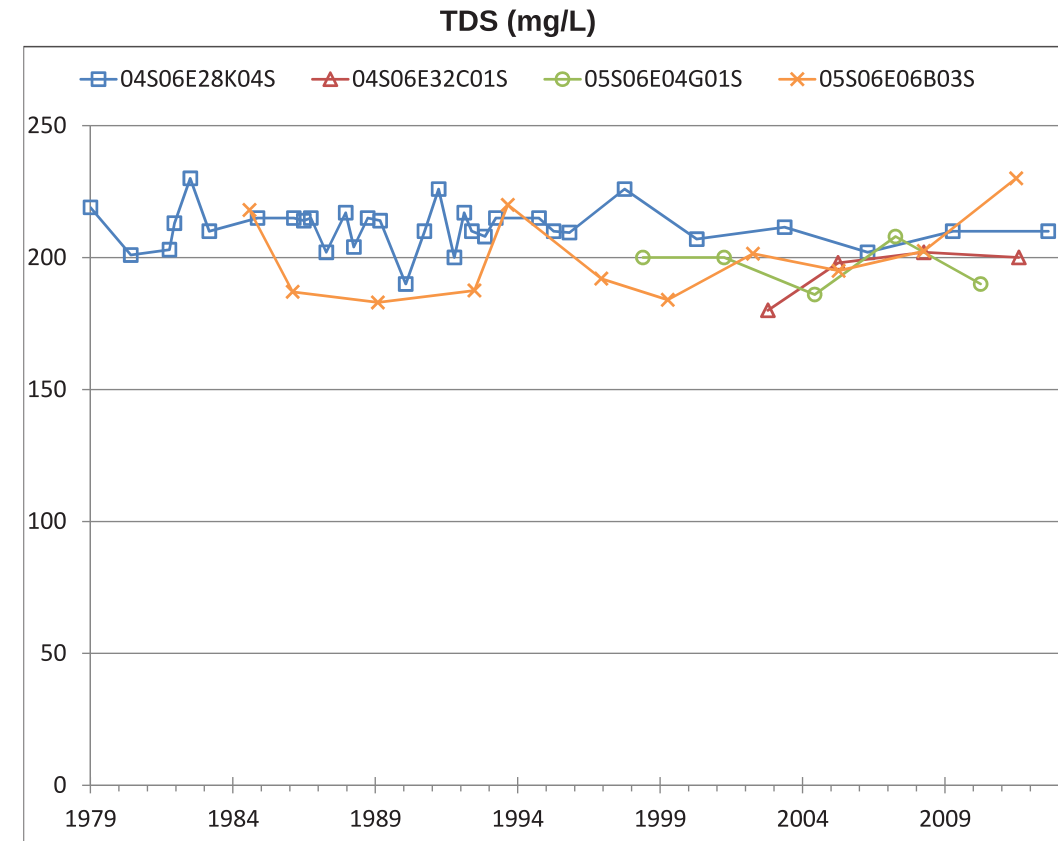
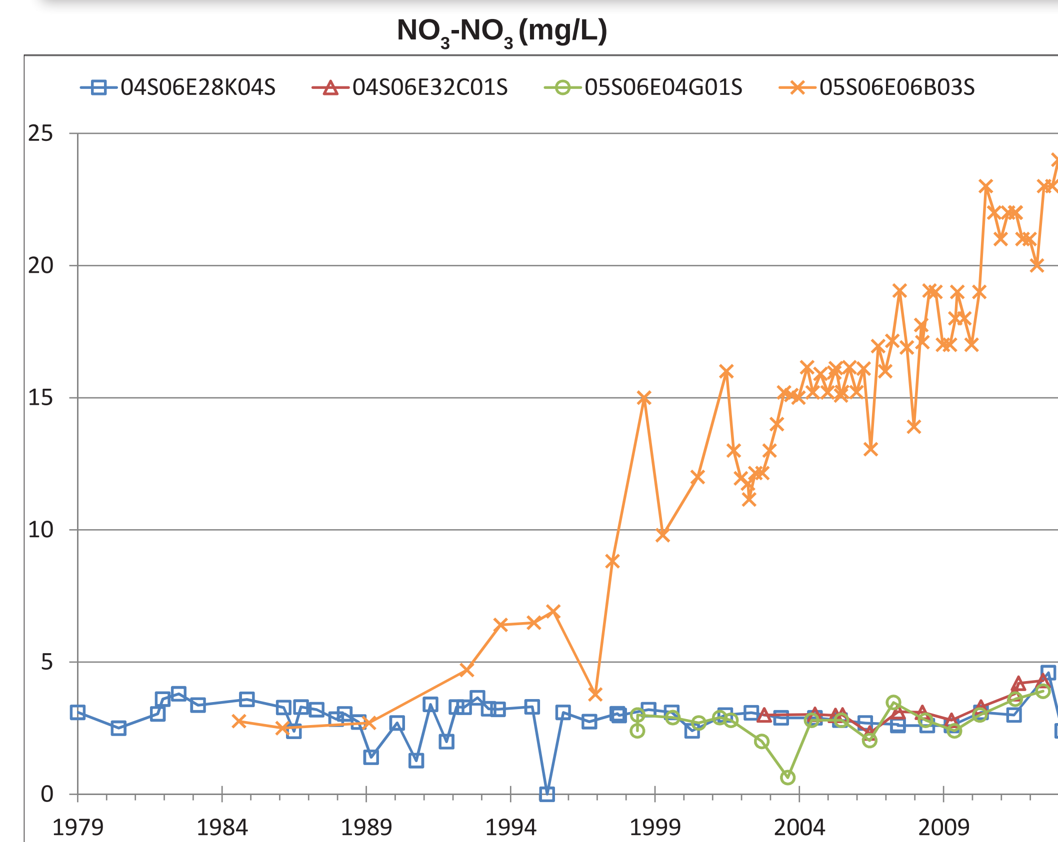
Appendix A-5

Upper Valley Group D

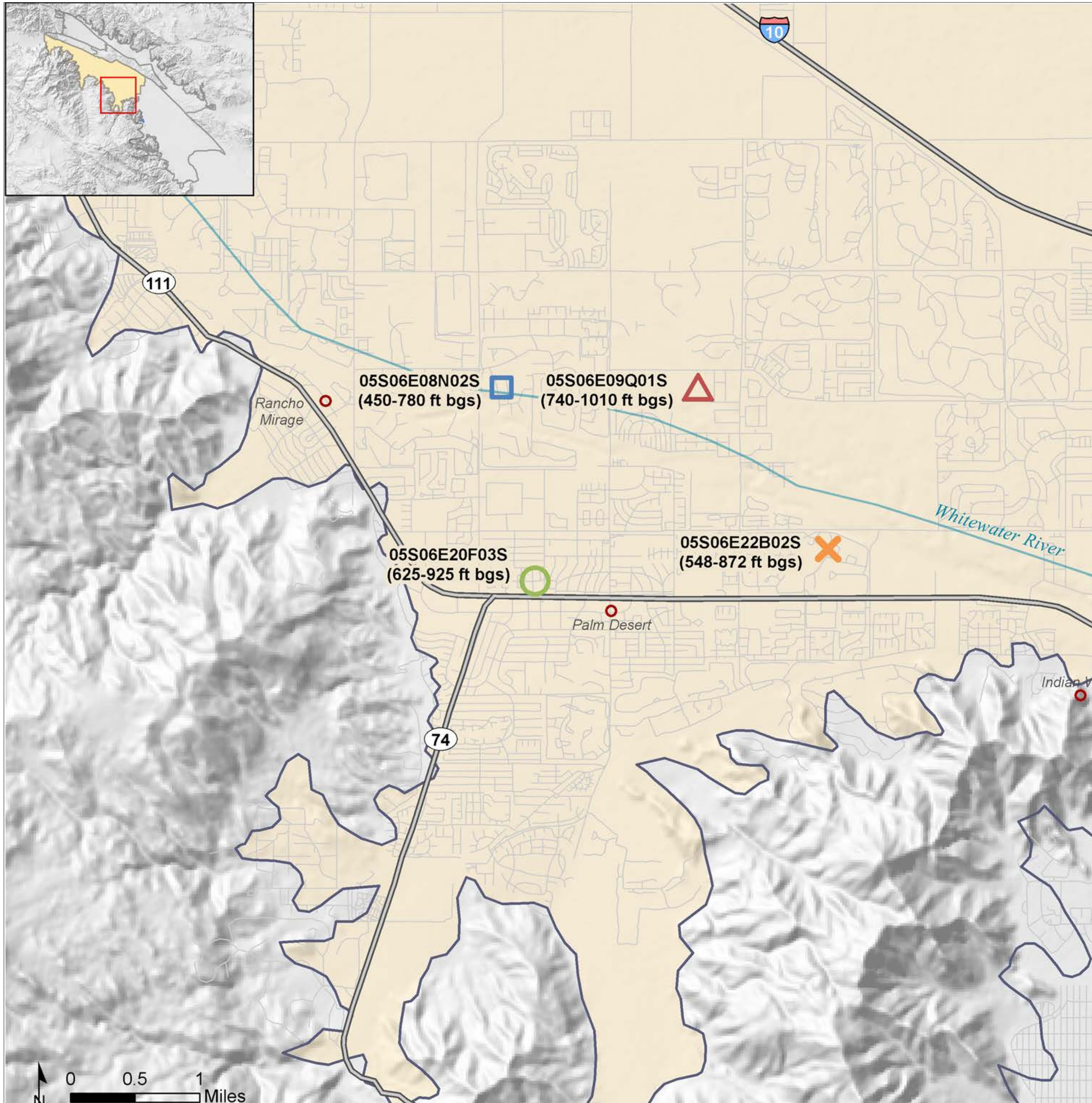


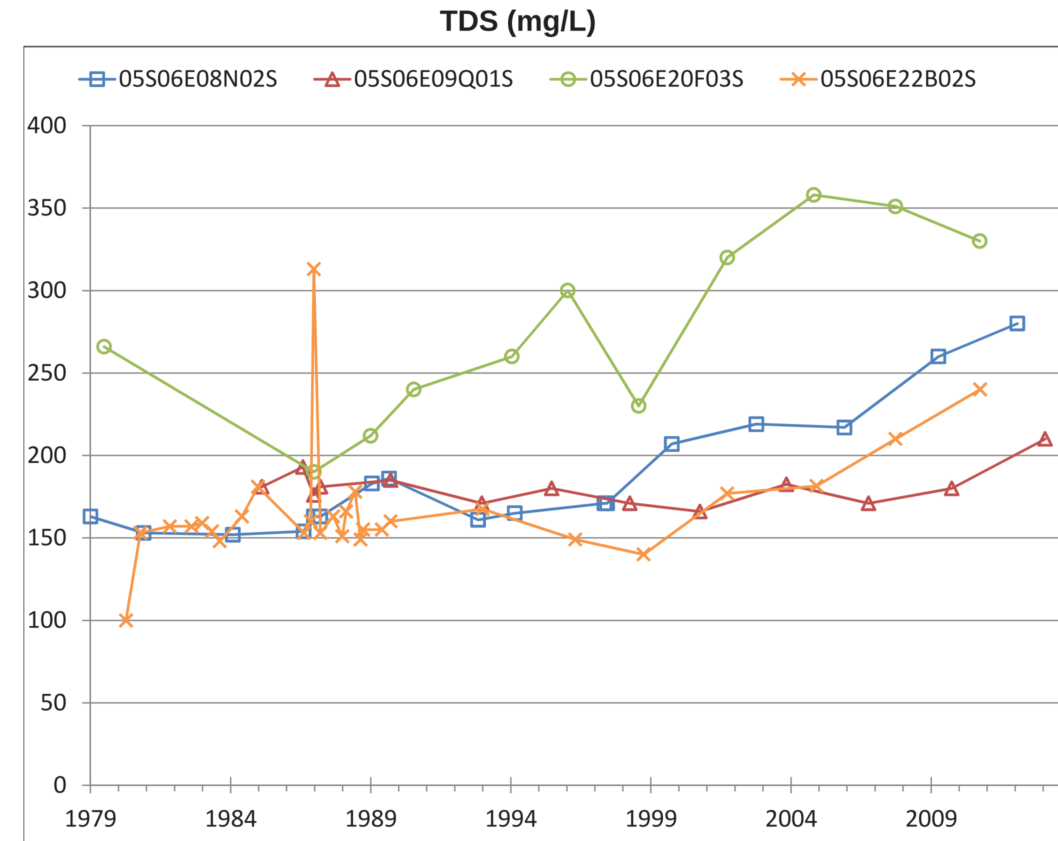


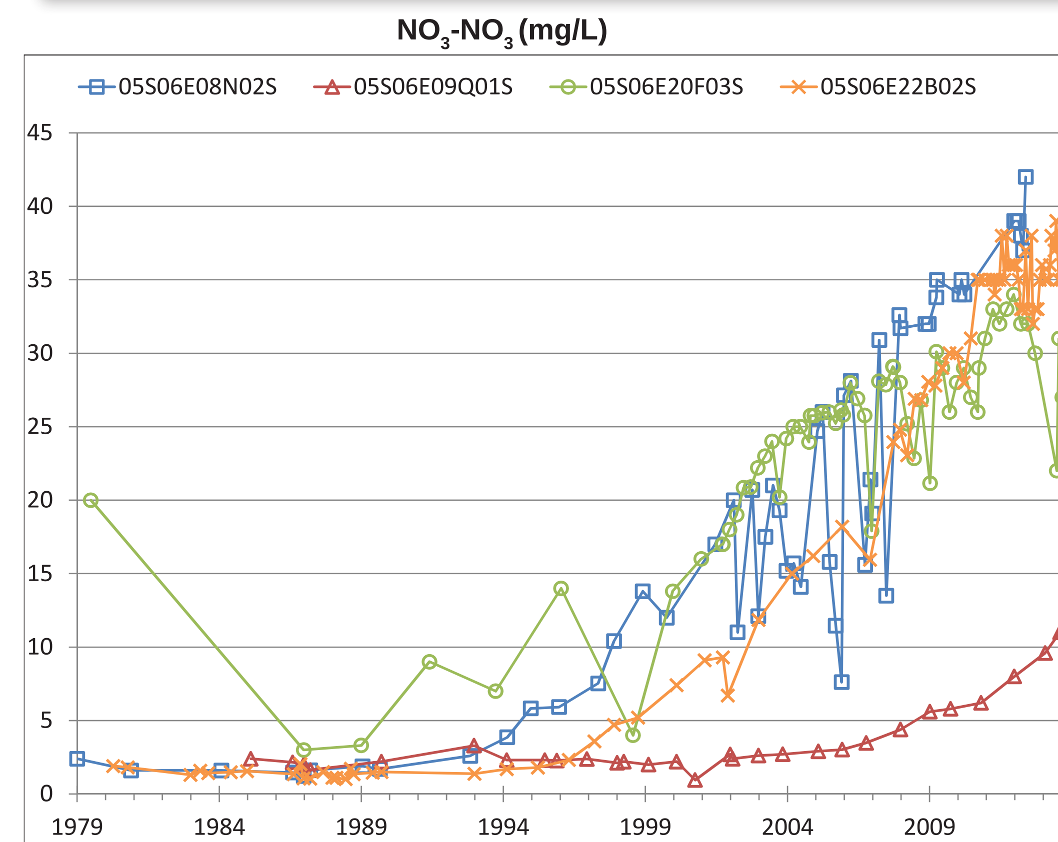


Appendix A-6

Upper Valley Group E

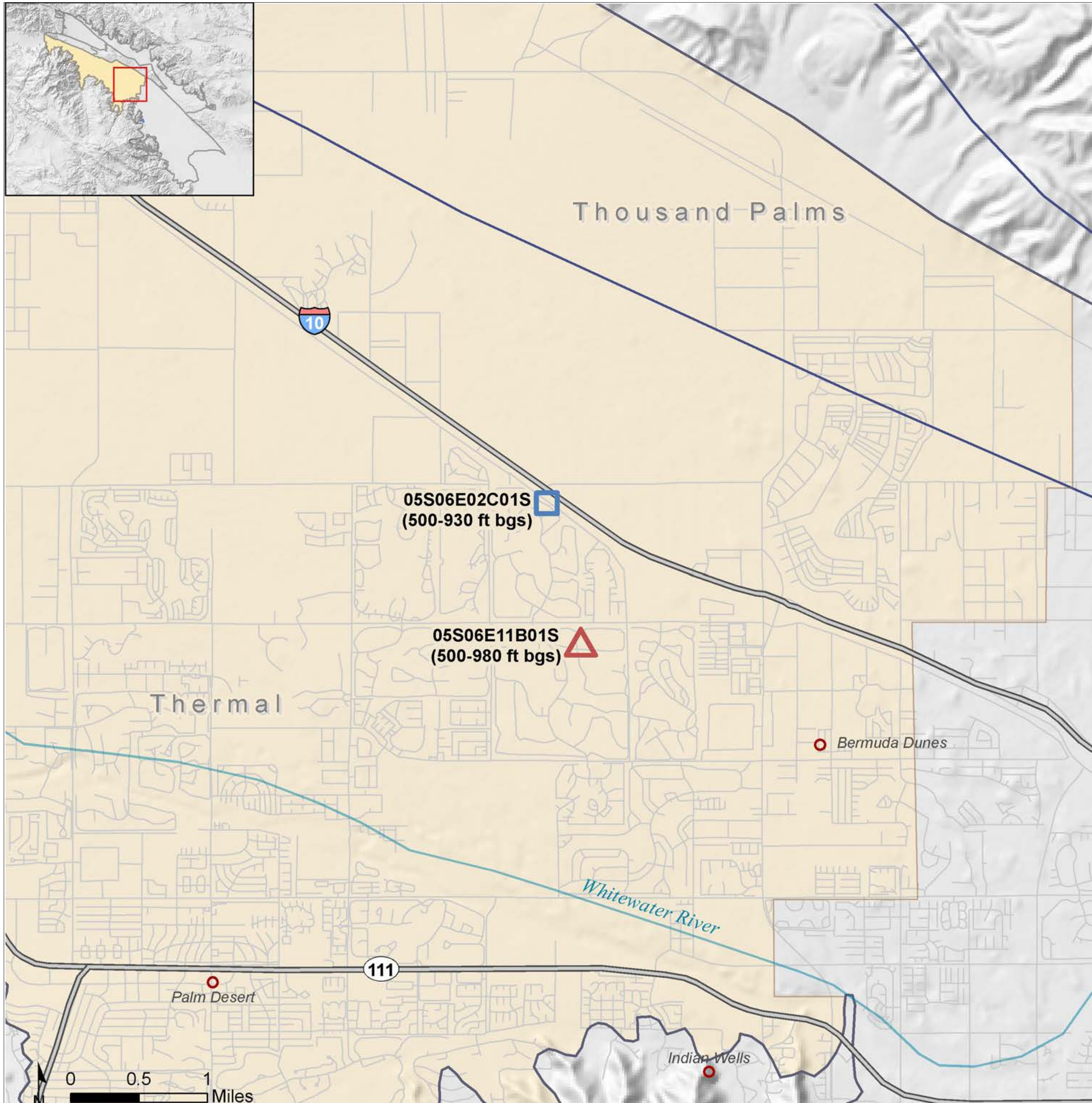


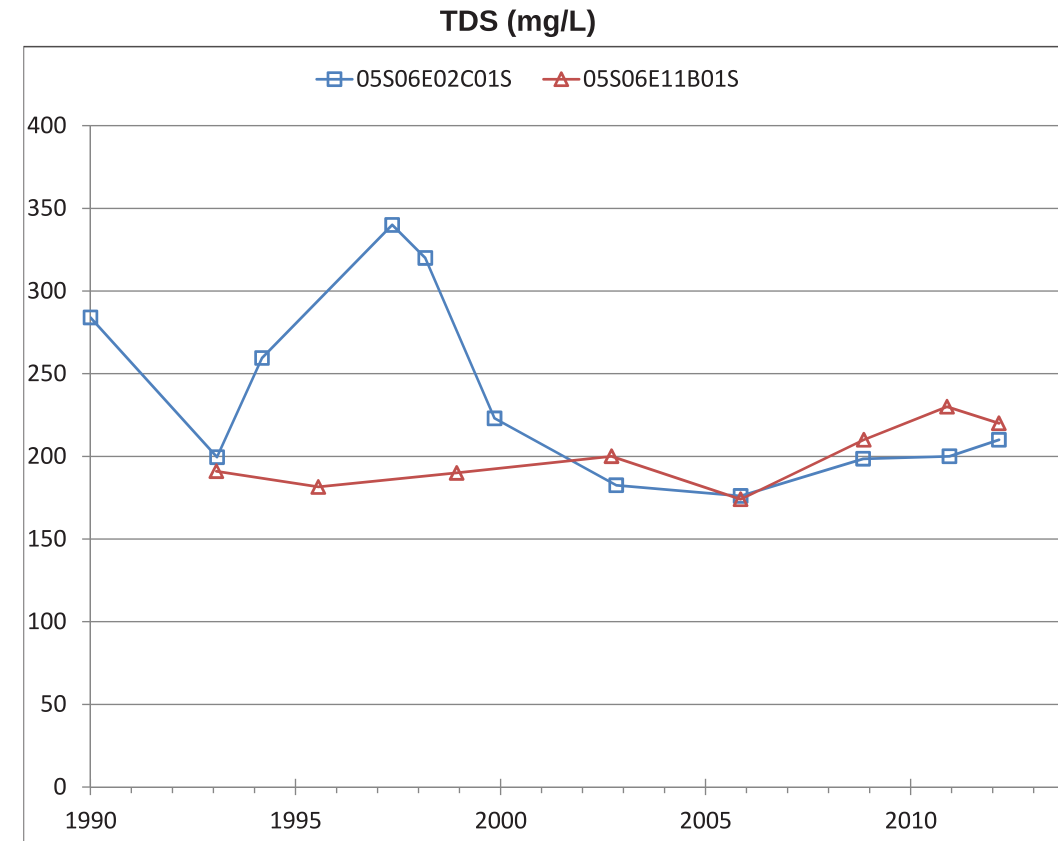


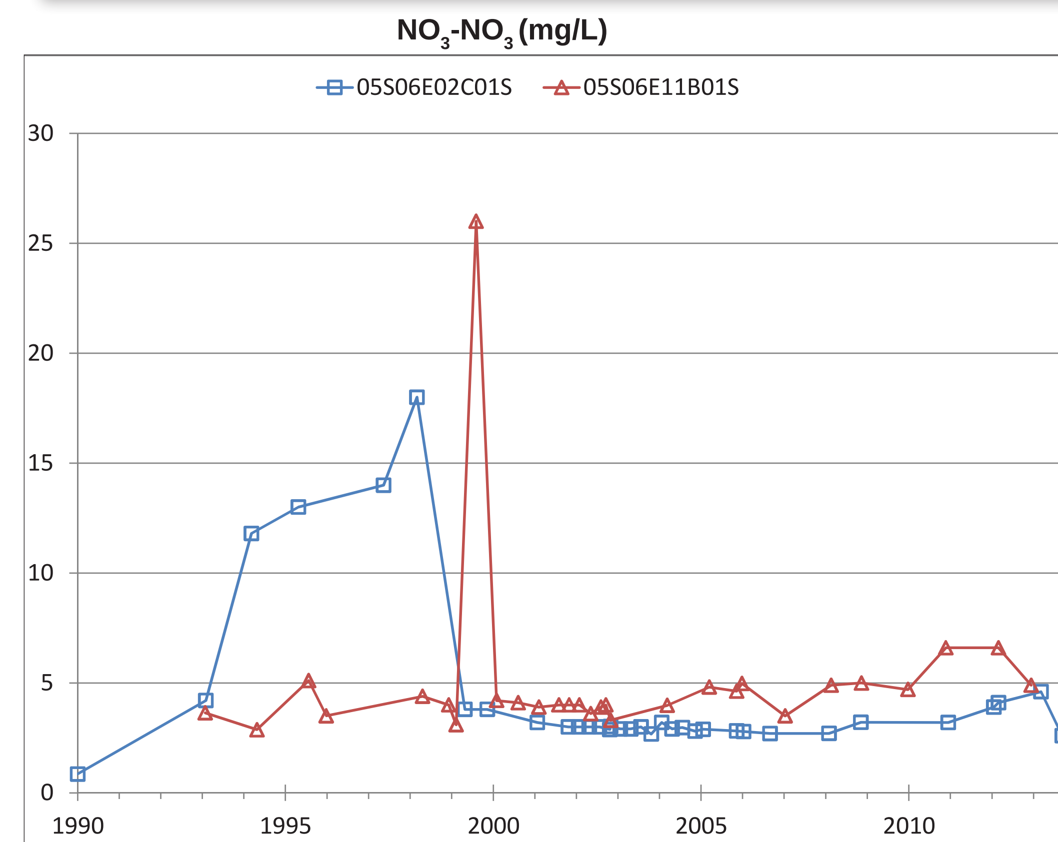


Appendix A-7

Upper Valley Group F

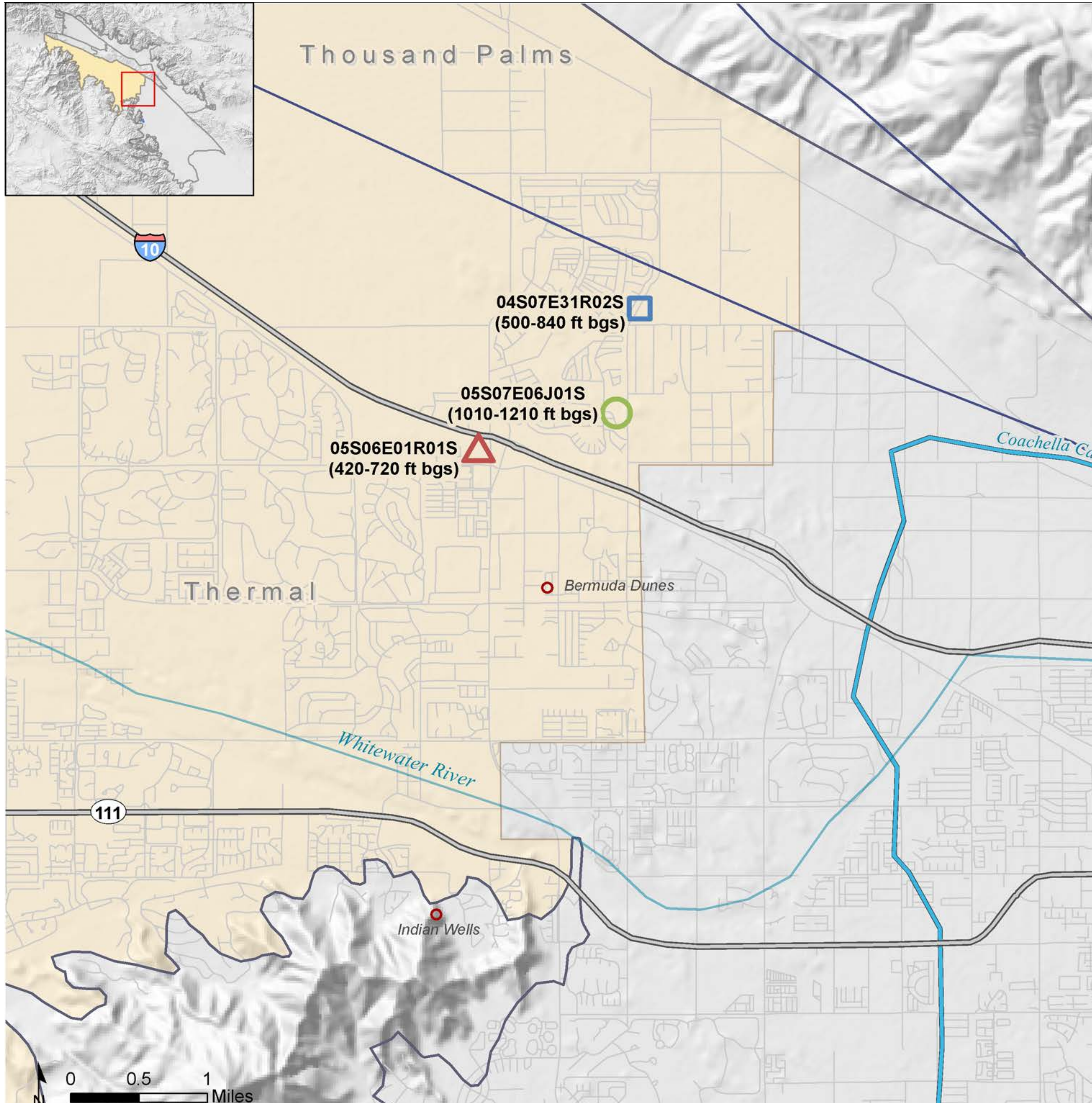


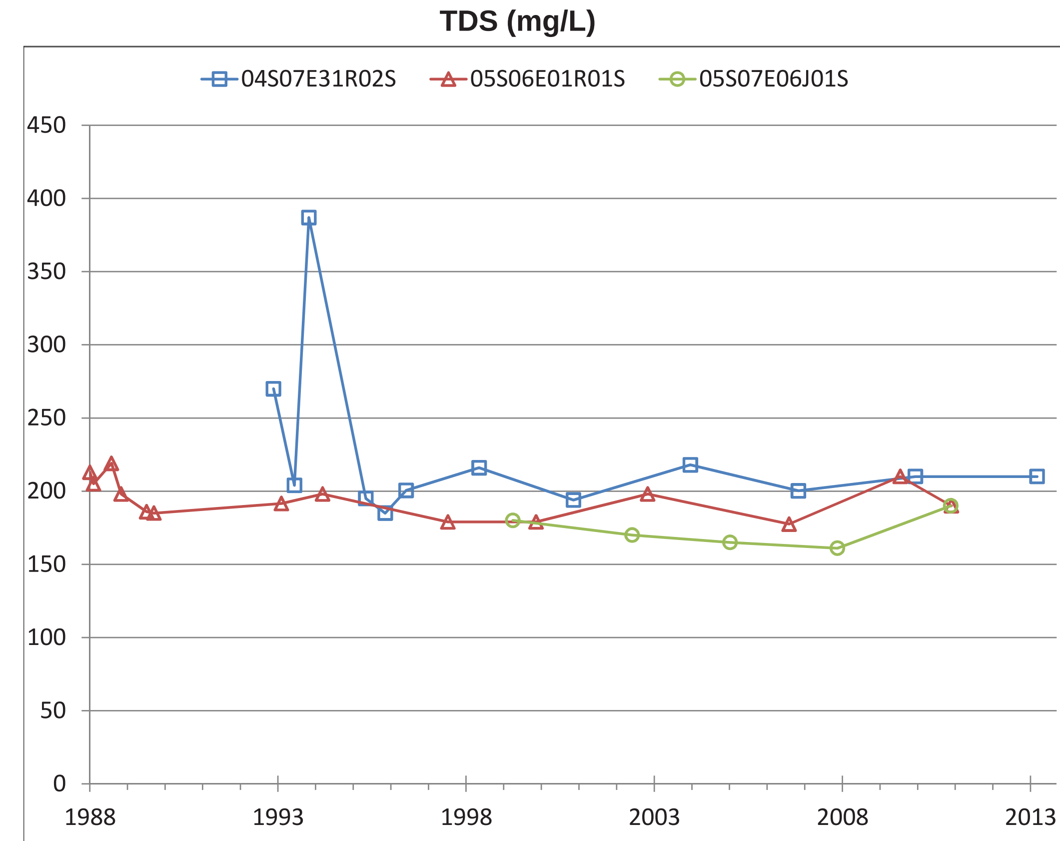


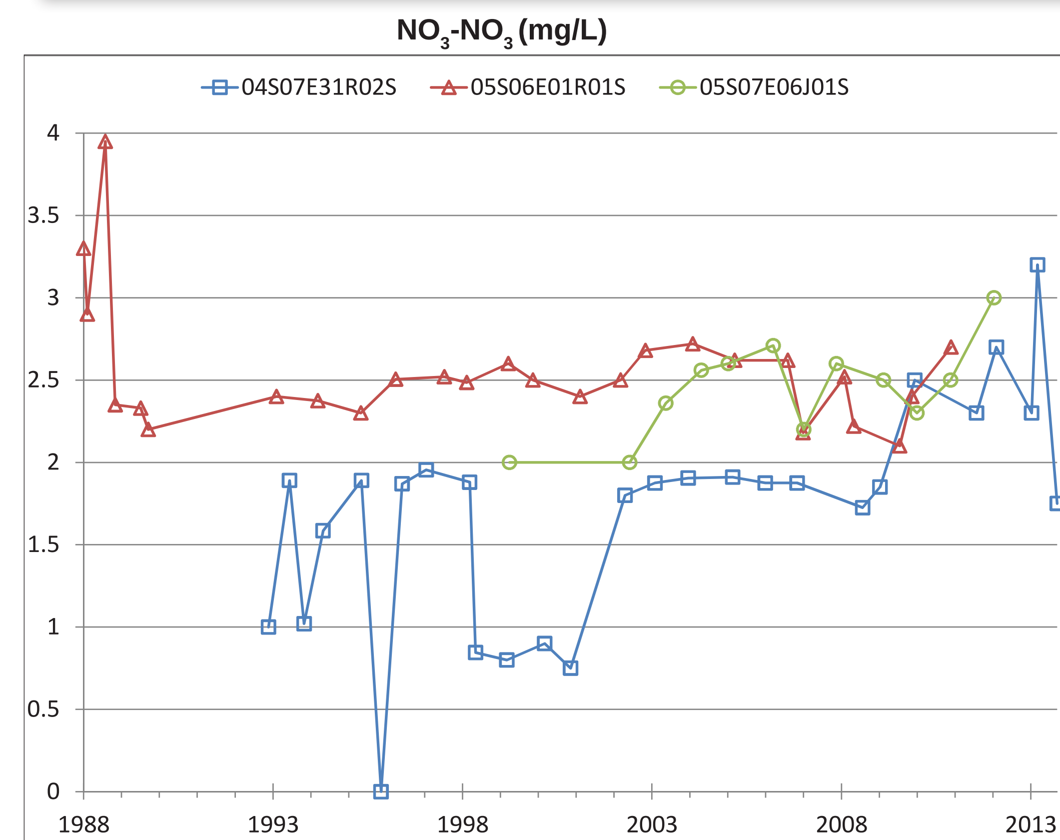


Appendix A-8

Upper Valley Group G







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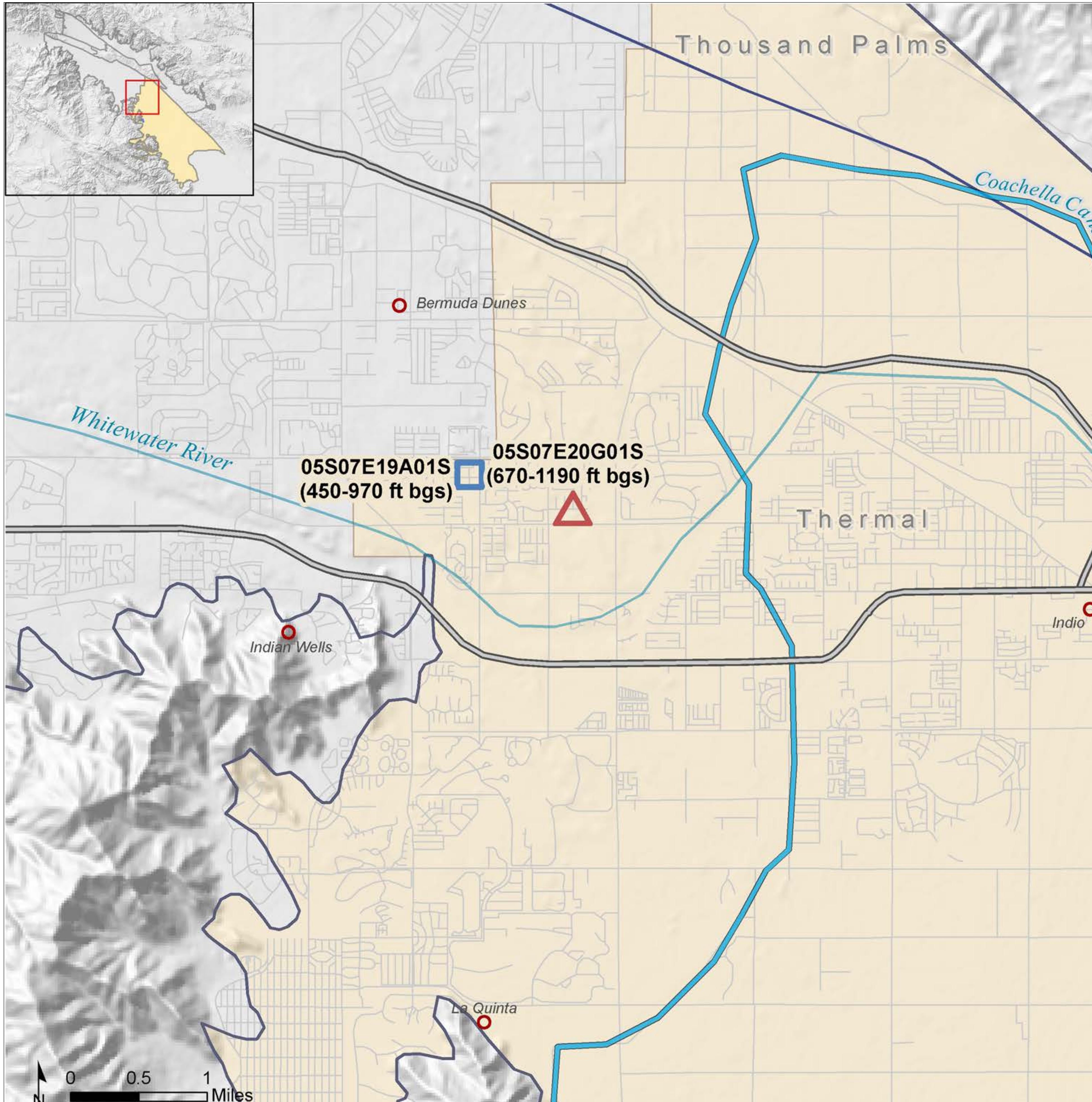
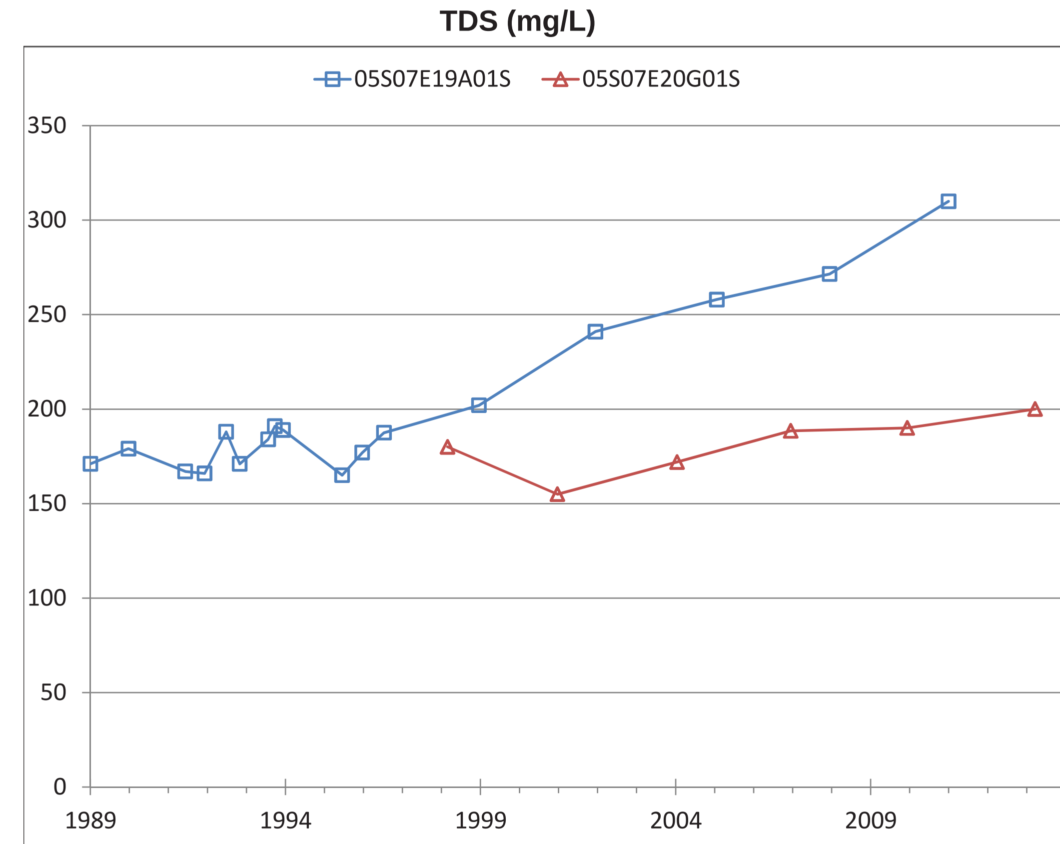
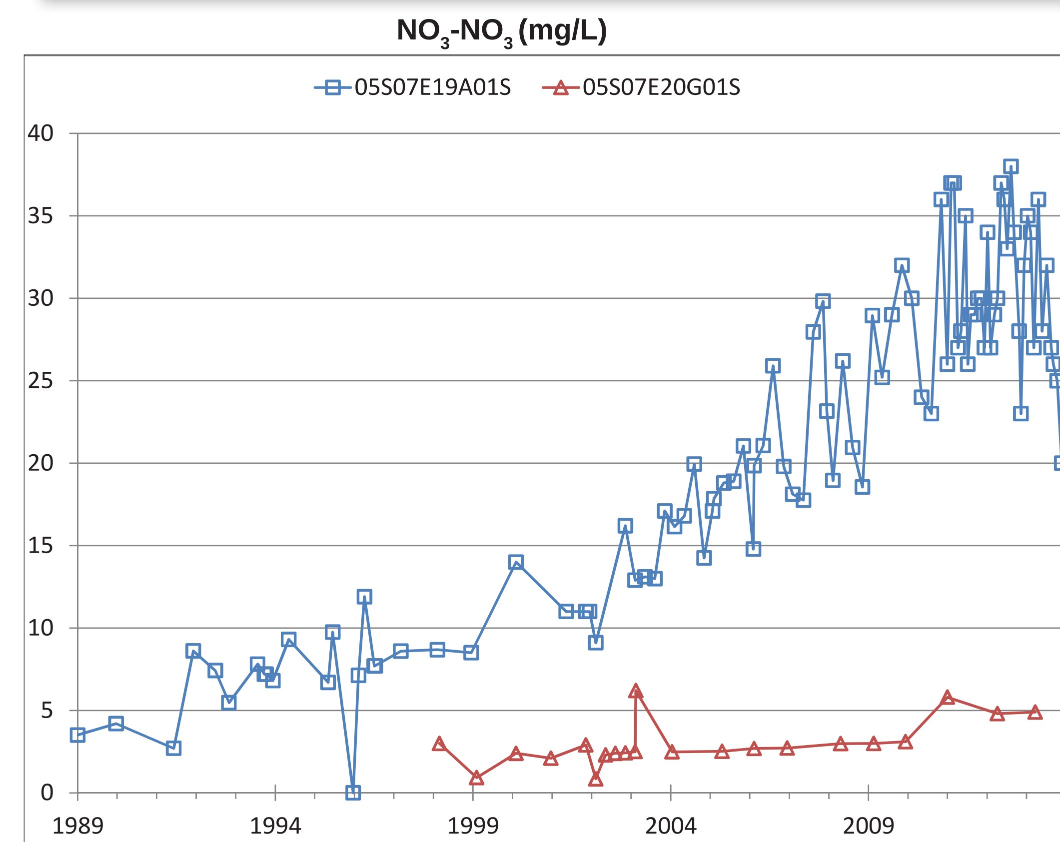
Appendix A-9

Upper Valley Group H

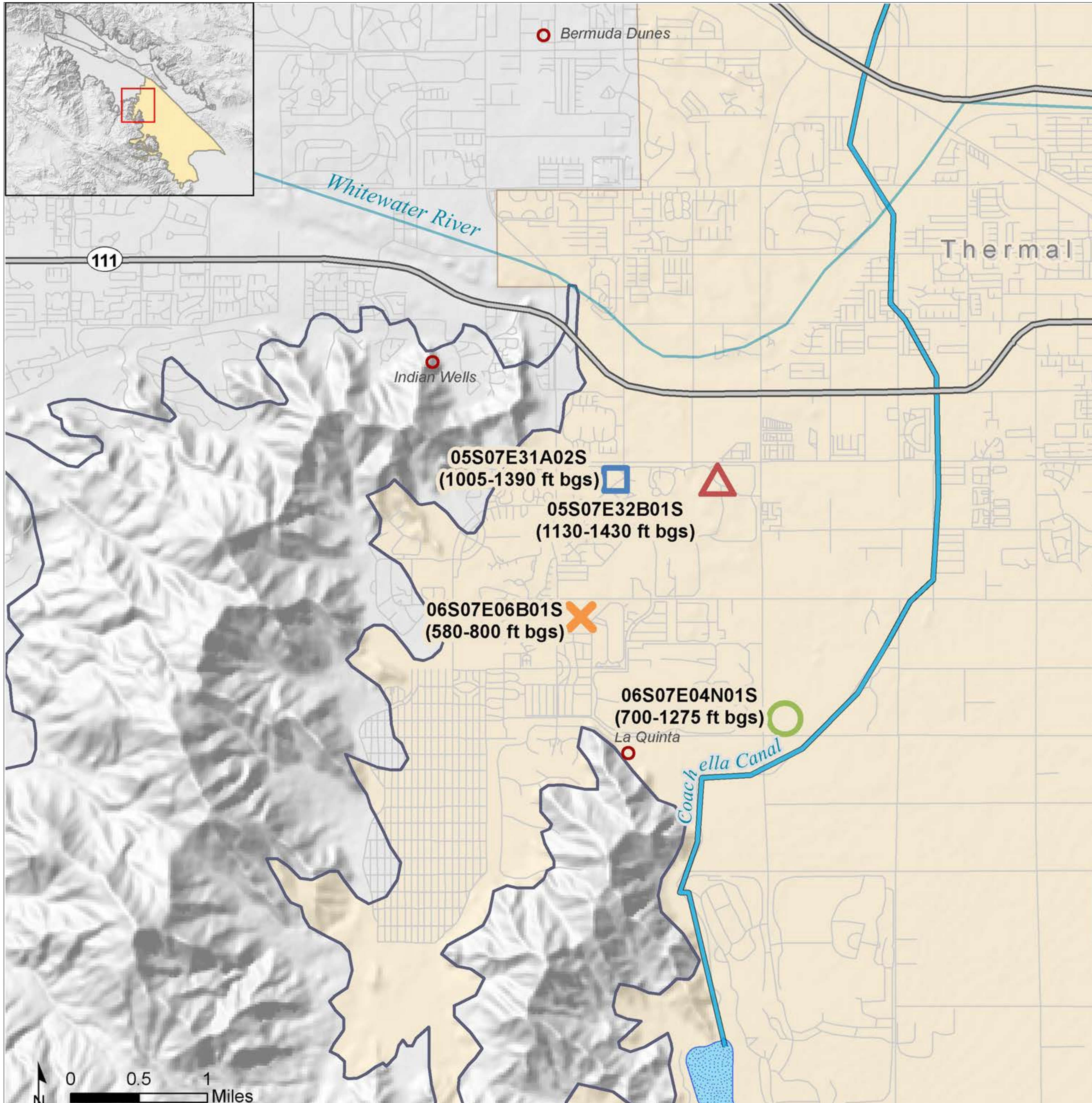


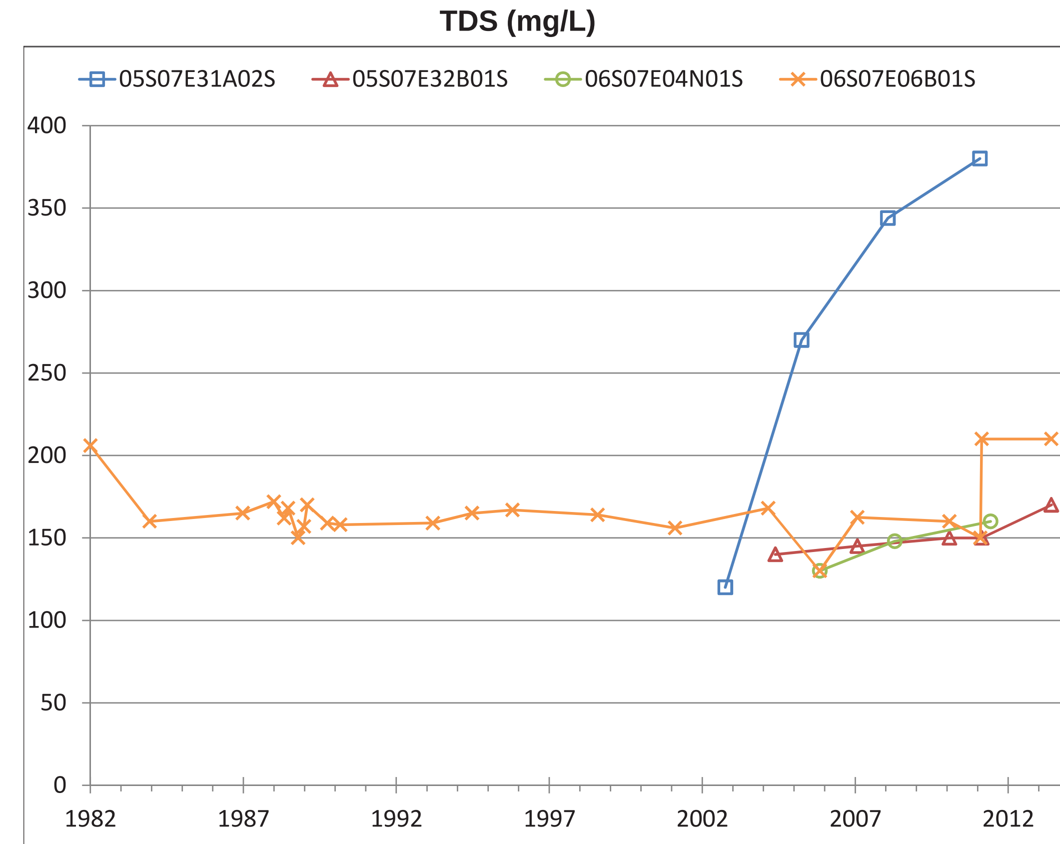


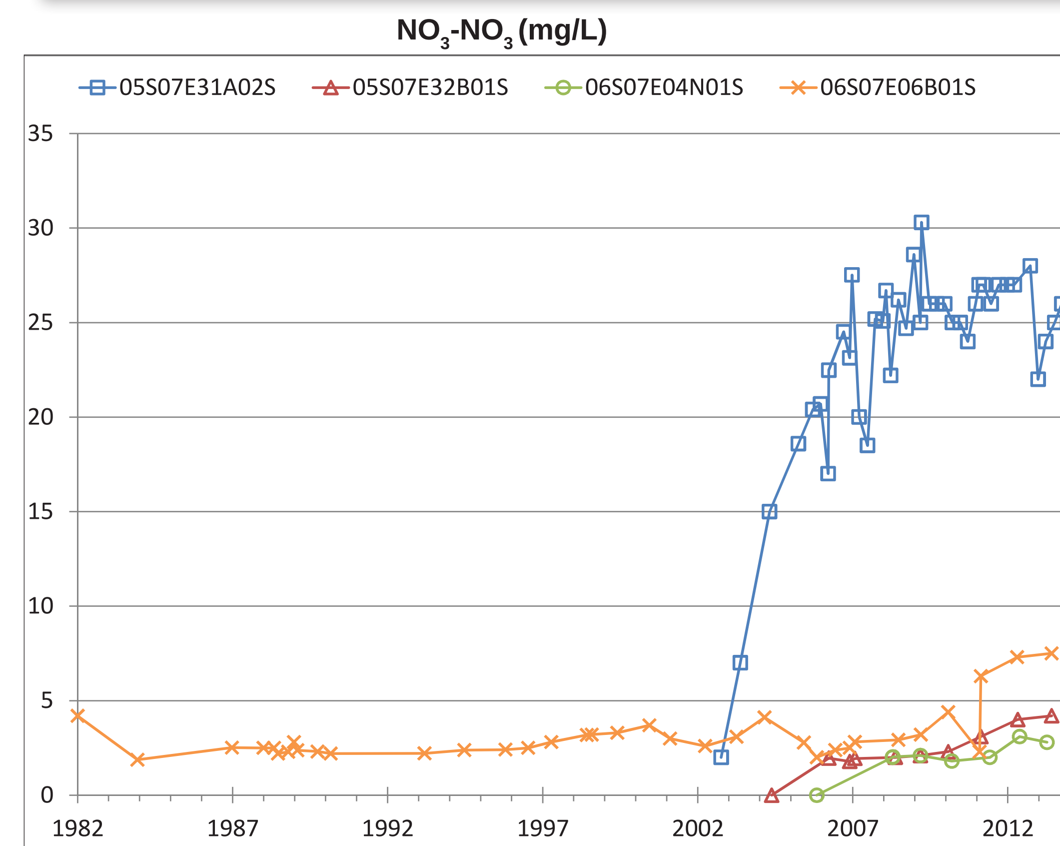


Appendix A-10

Lower Valley Group I







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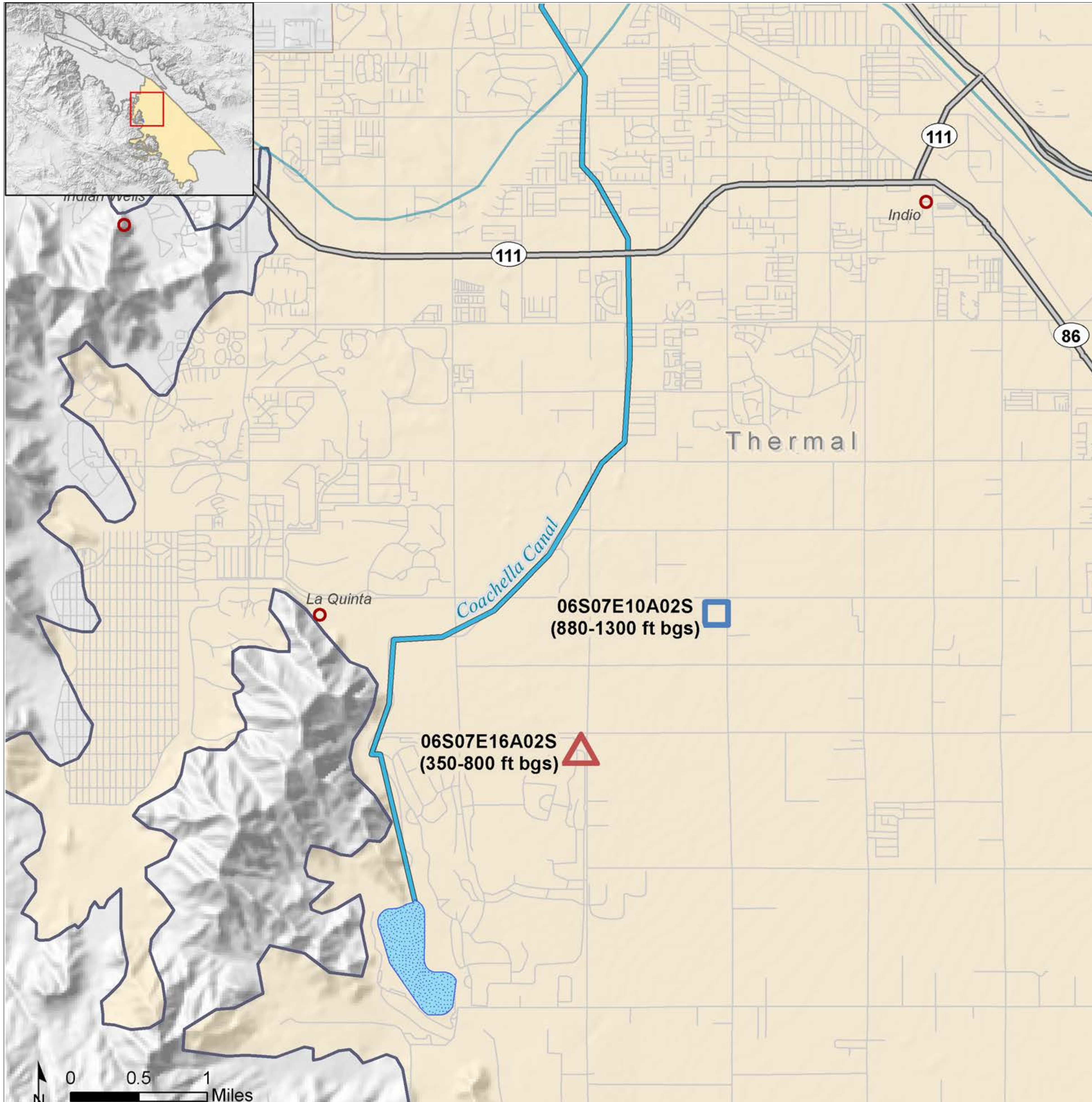
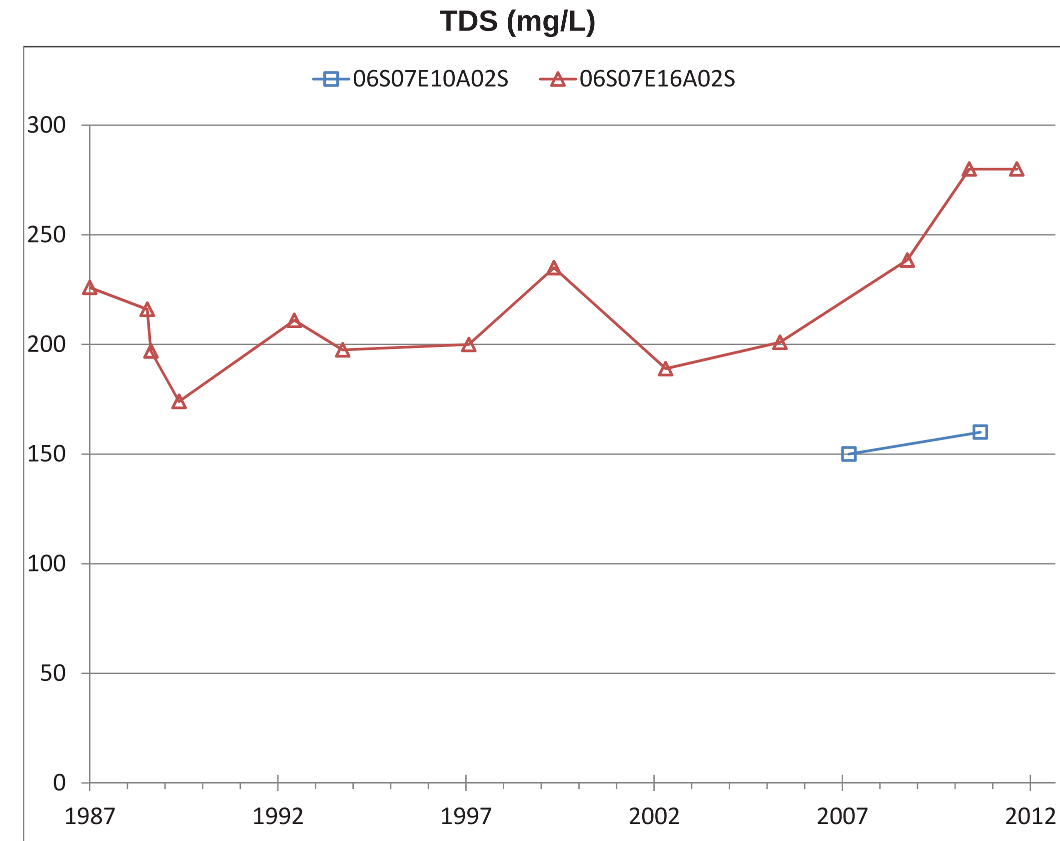
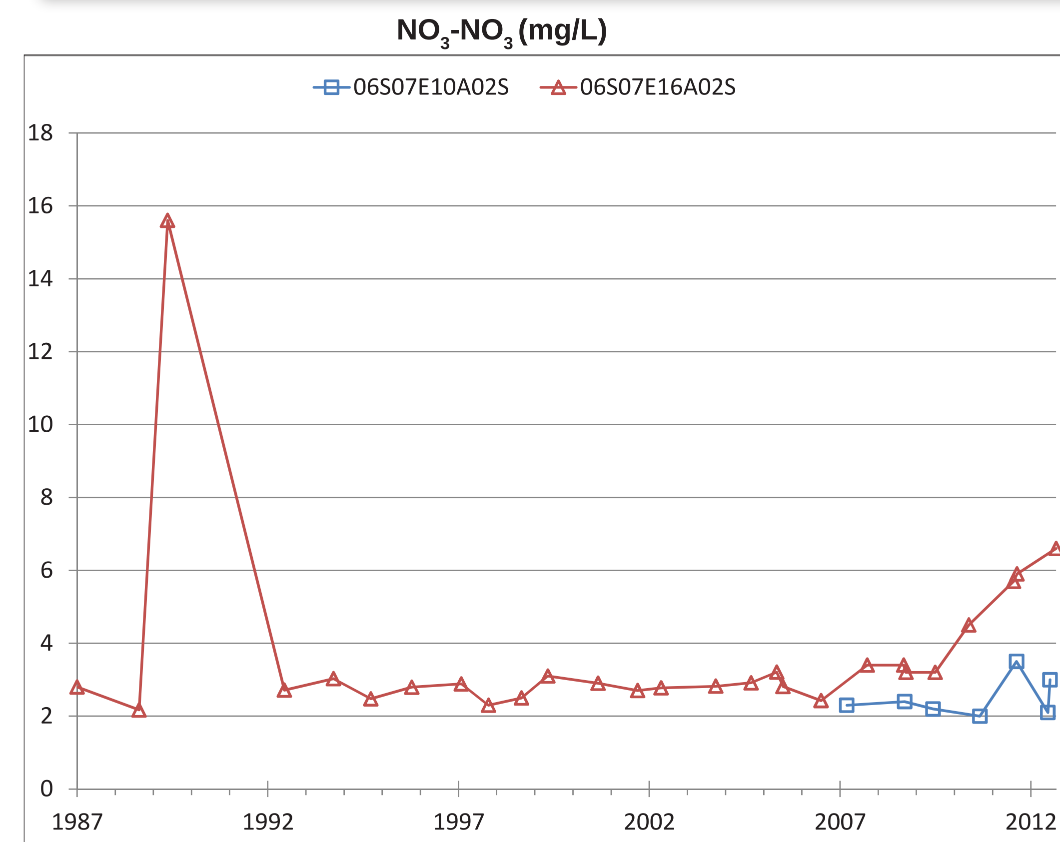
Appendix A-11

Lower Valley Group J

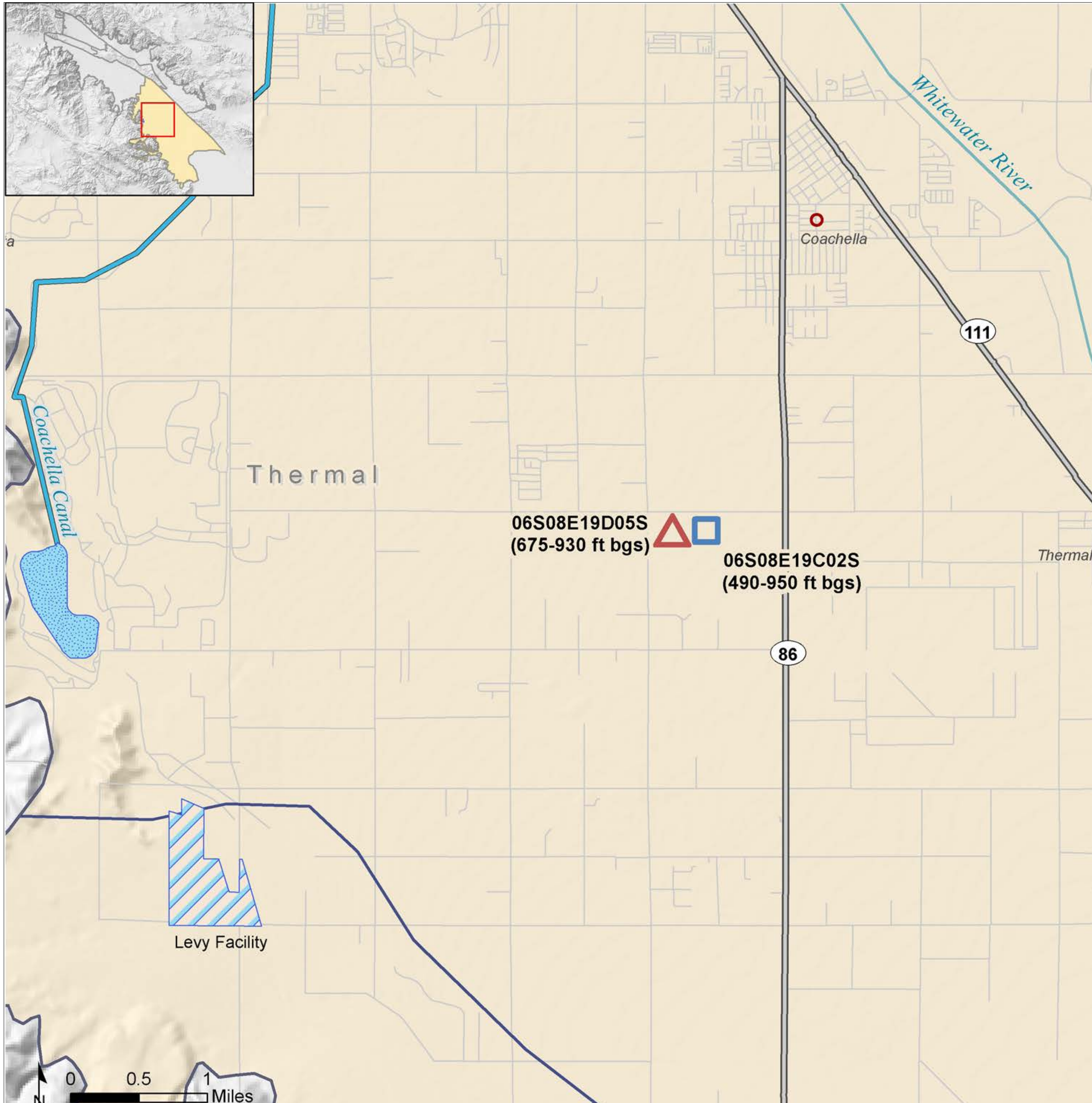


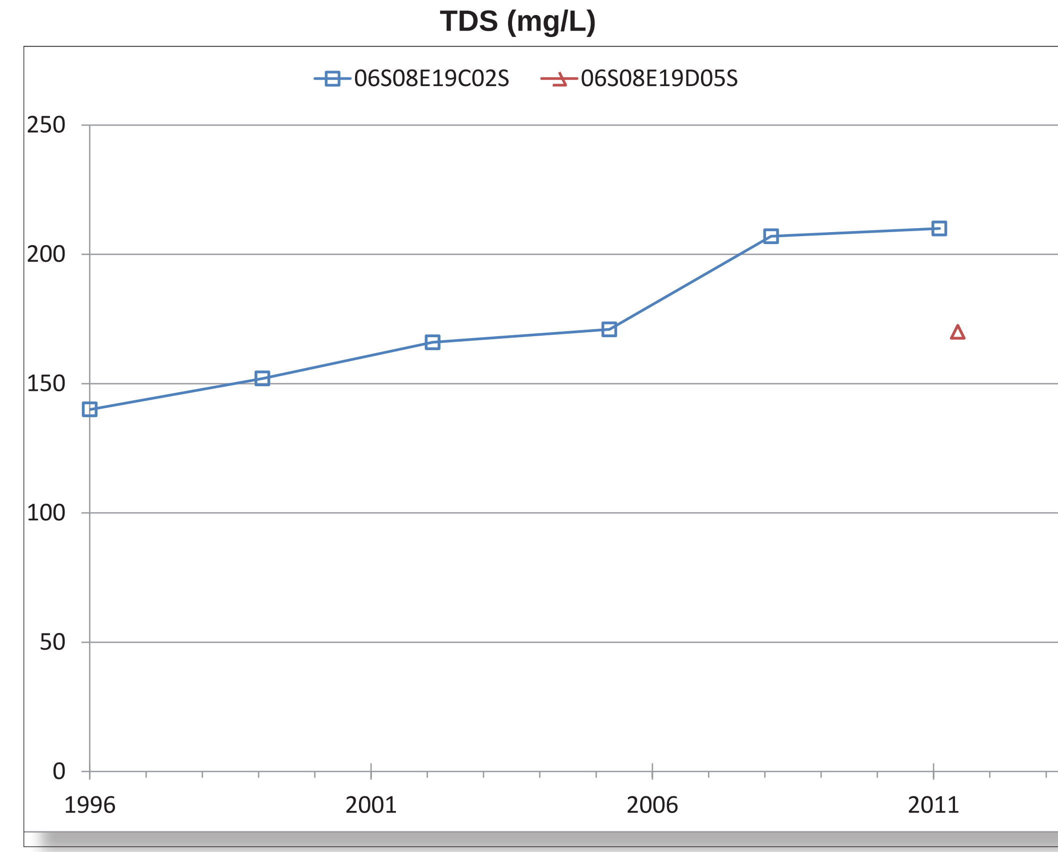


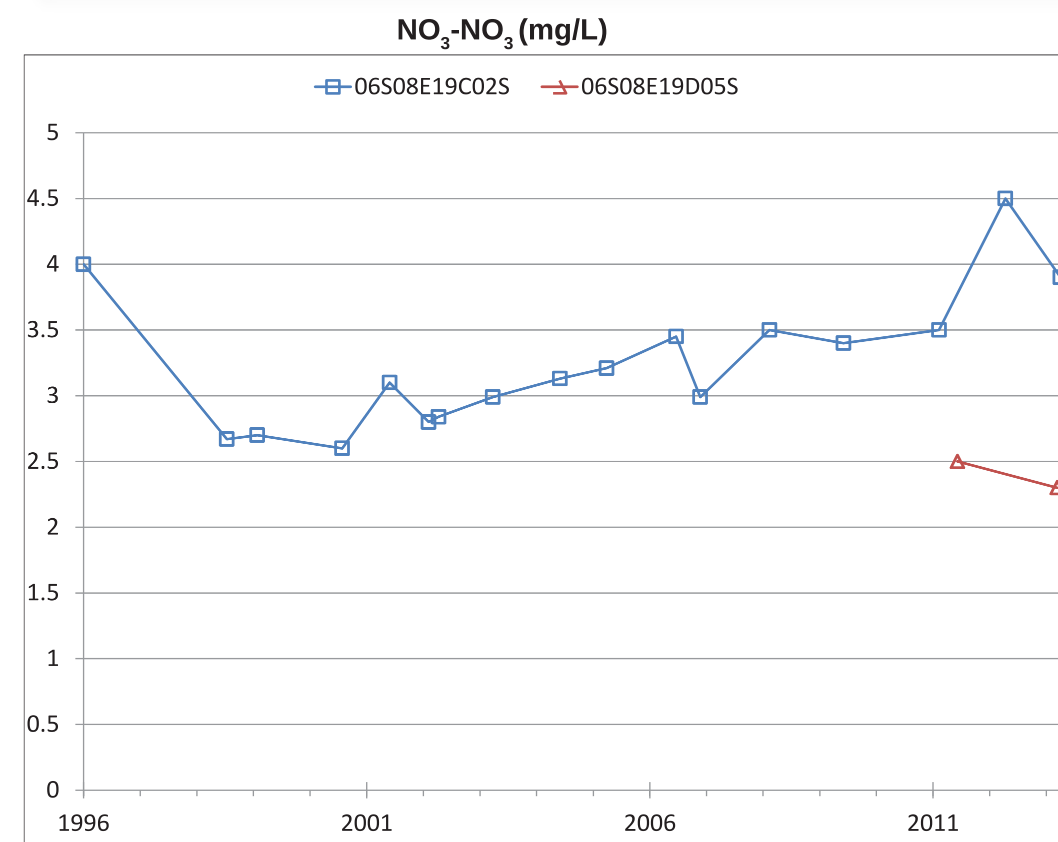


Appendix A-12

Lower Valley Group K

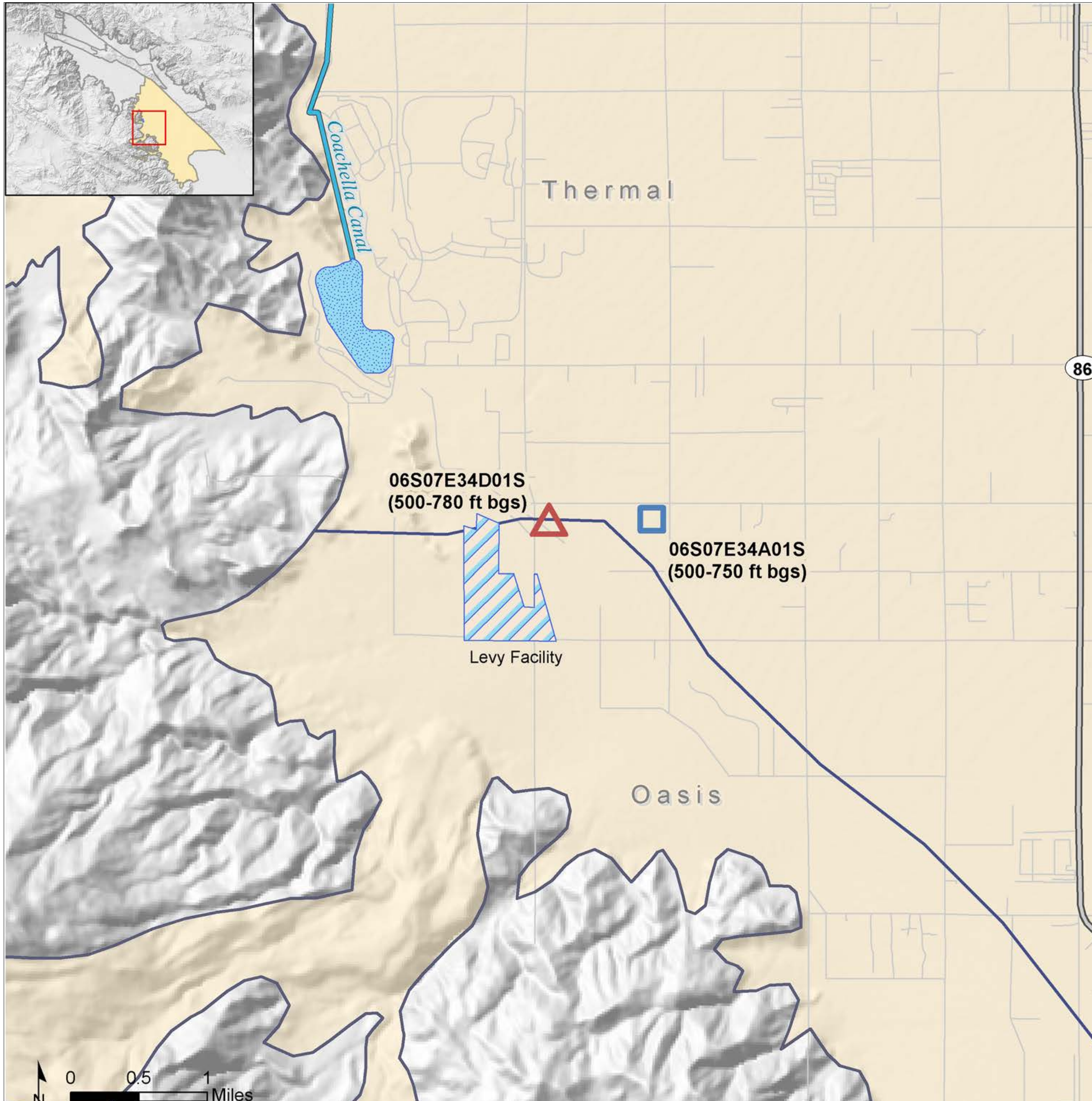


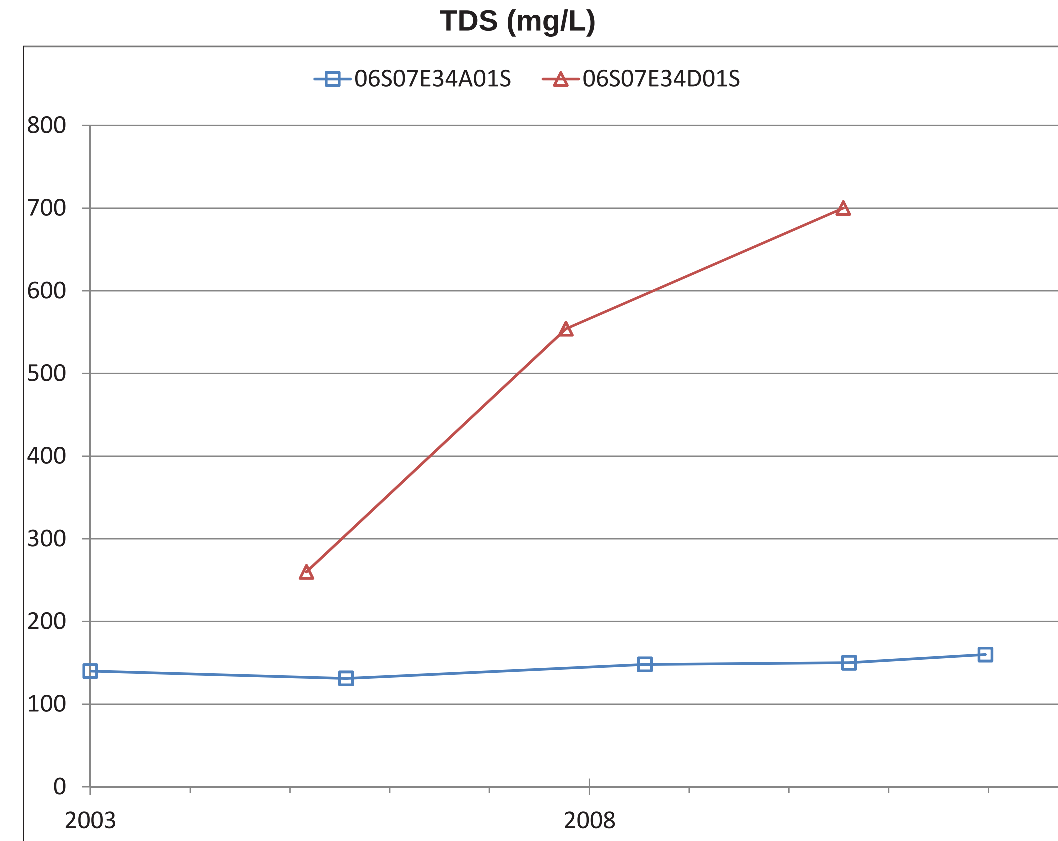


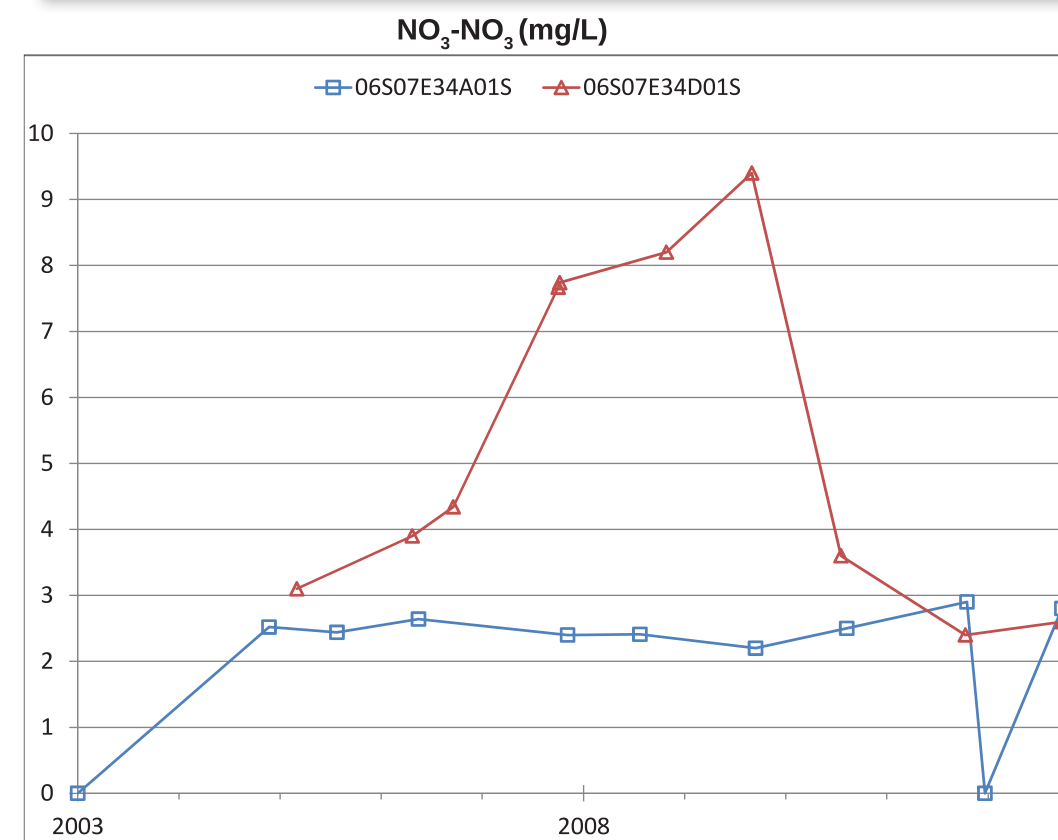


Appendix A-13

Lower Valley Group L



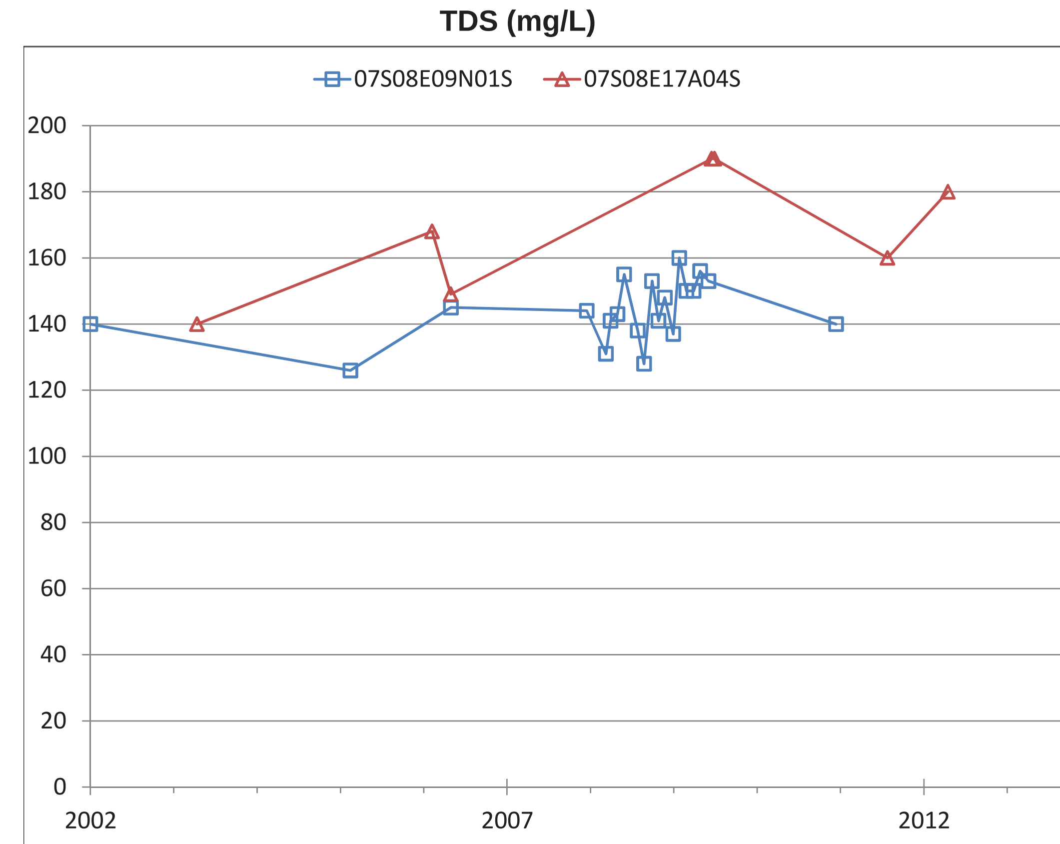


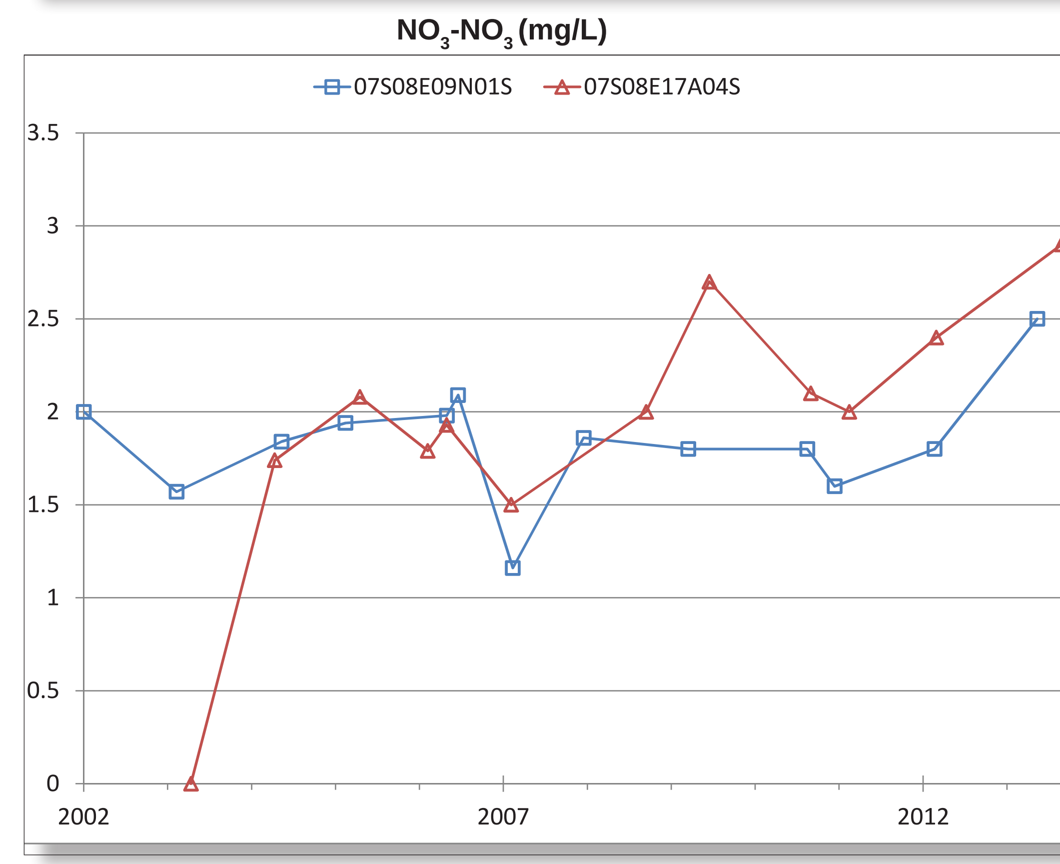


Appendix A-14

MWH

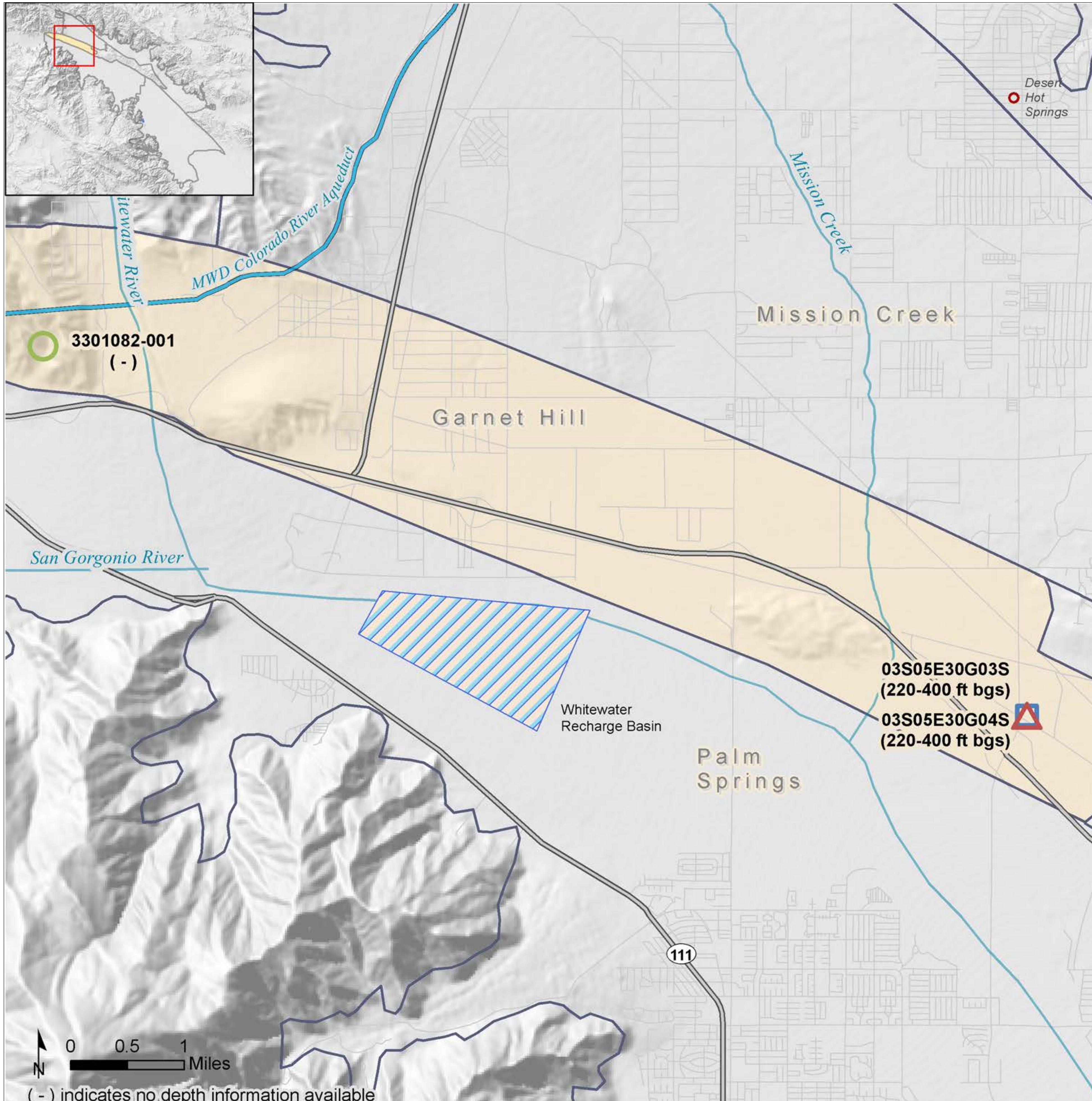
Lower Valley Group M

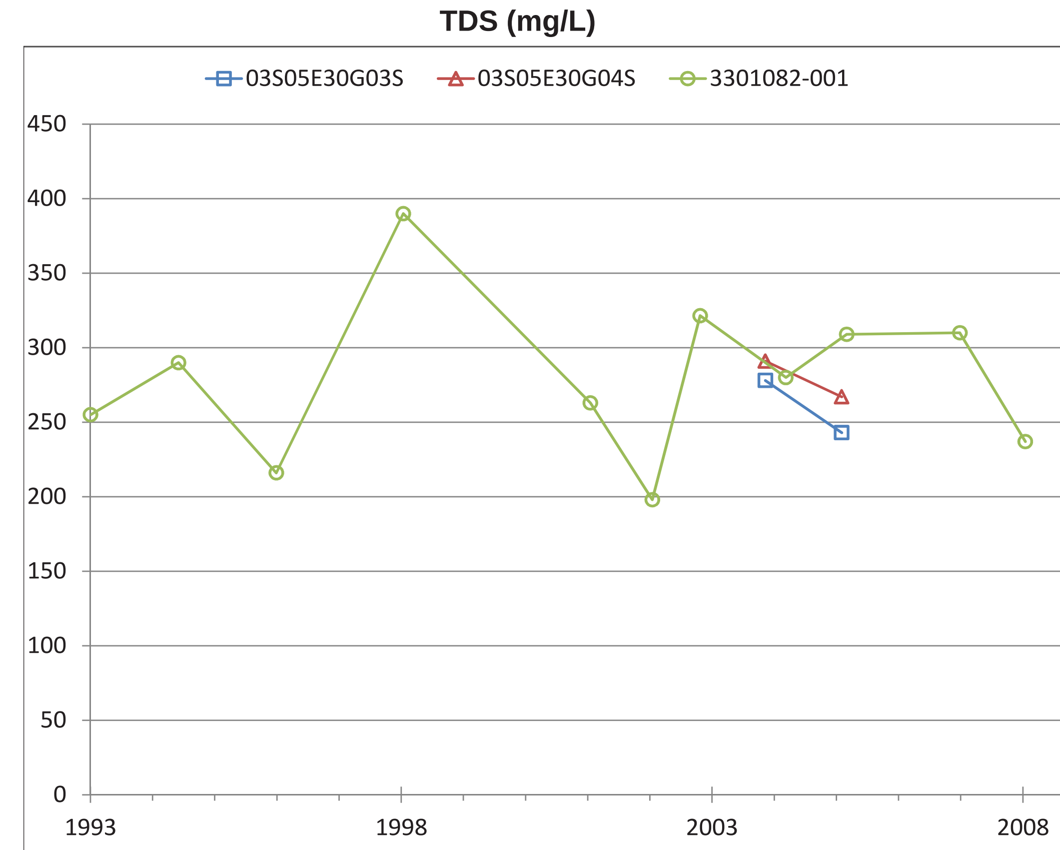


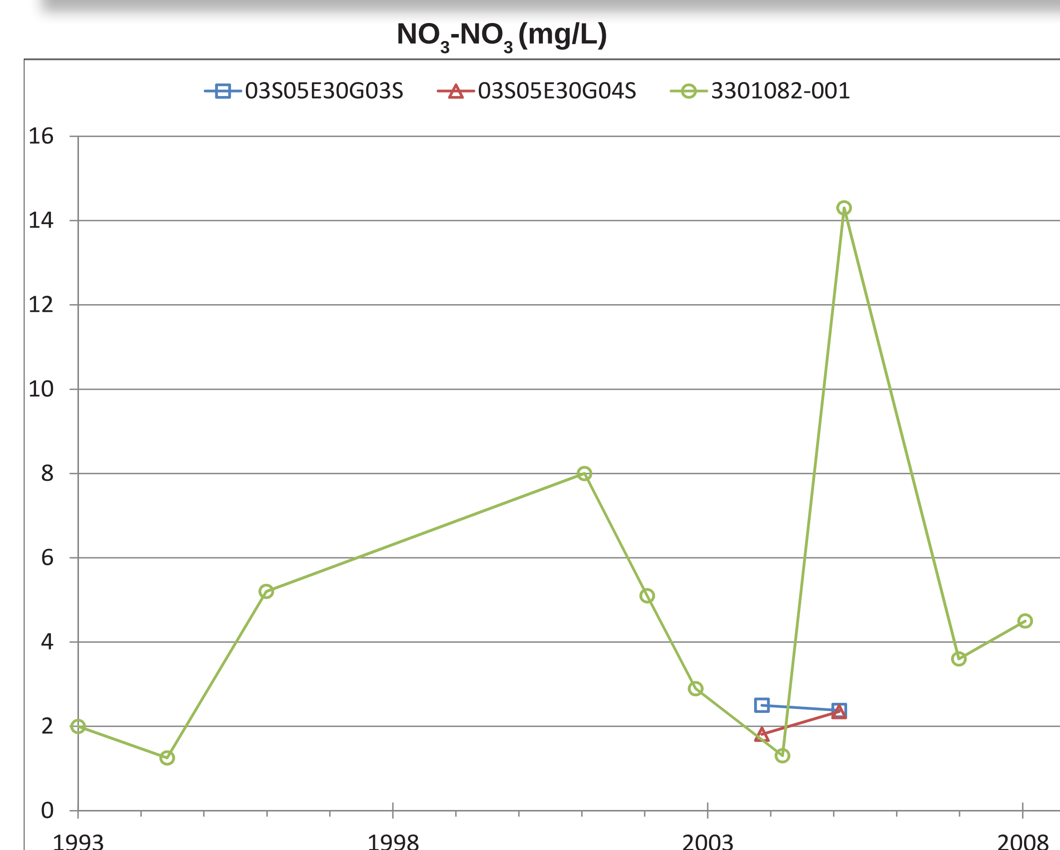


Appendix A-15

Lower Valley Group N





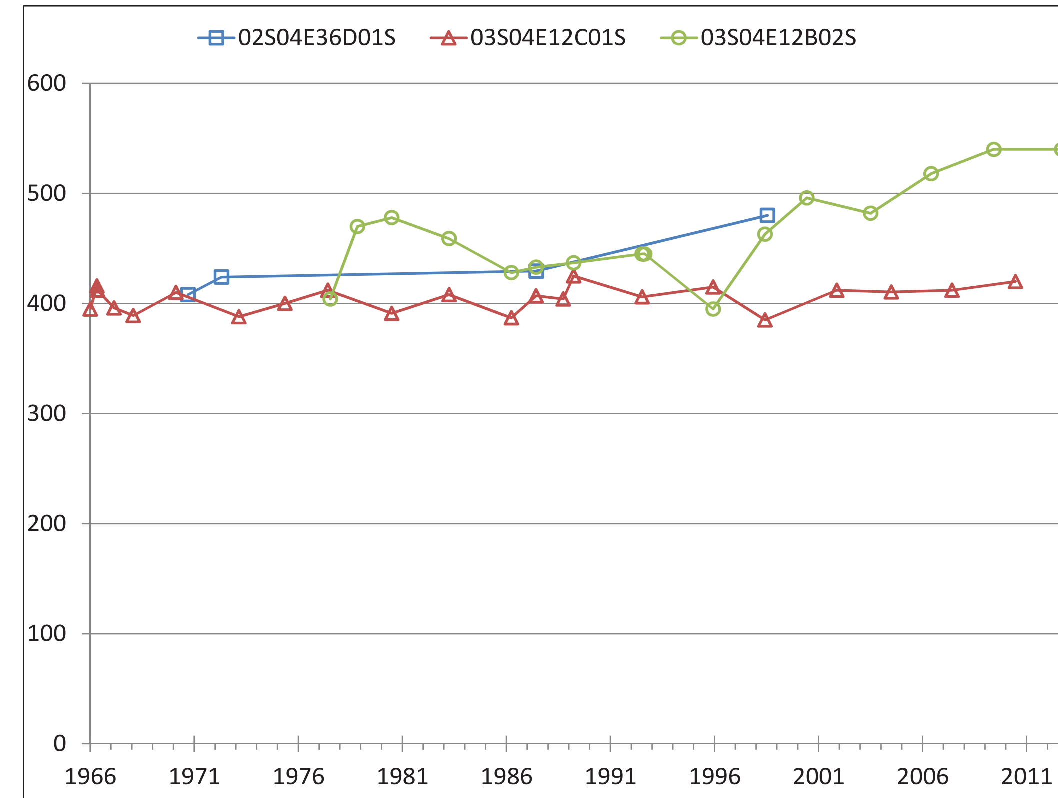


MWH

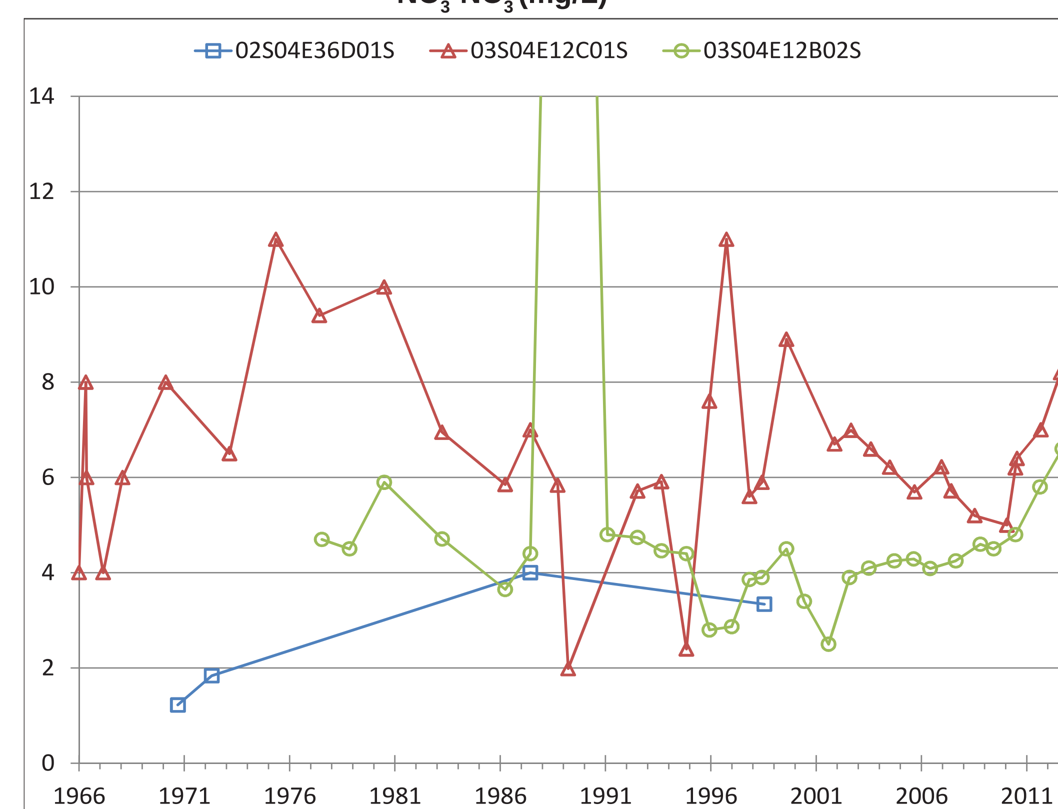
Appendix A-16

Garnet Hill Group O

TDS (mg/L)



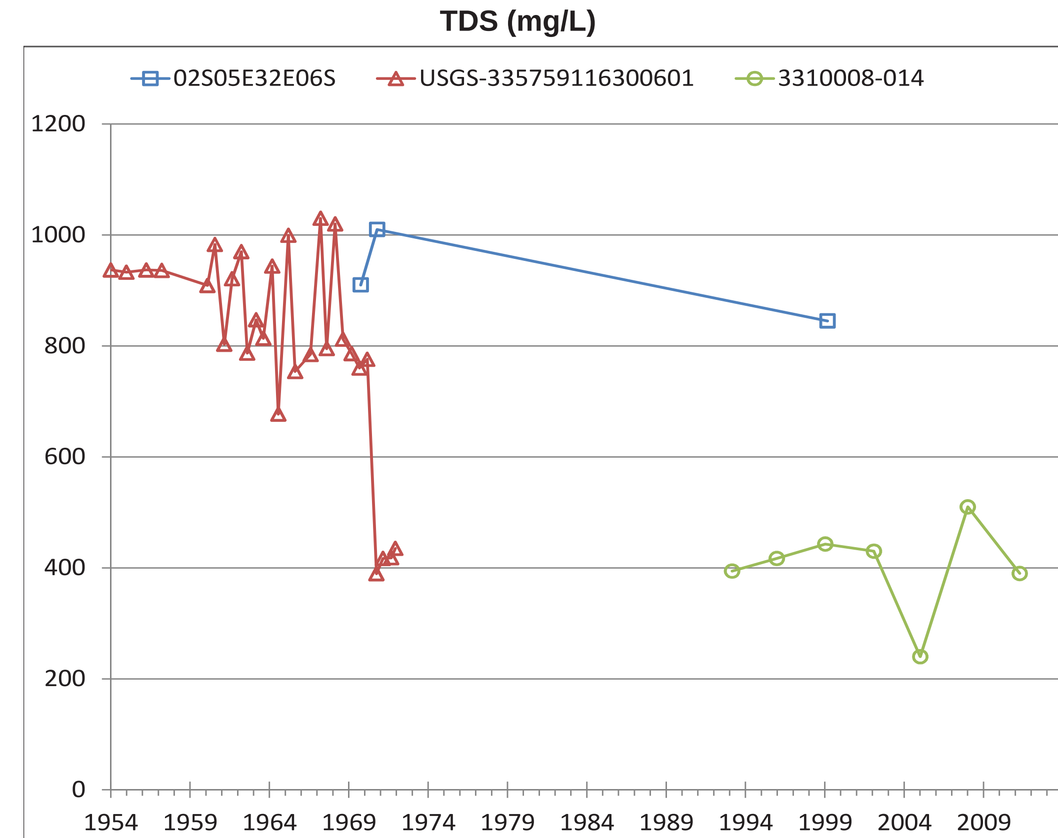
NO_3-NO_3 (mg/L)

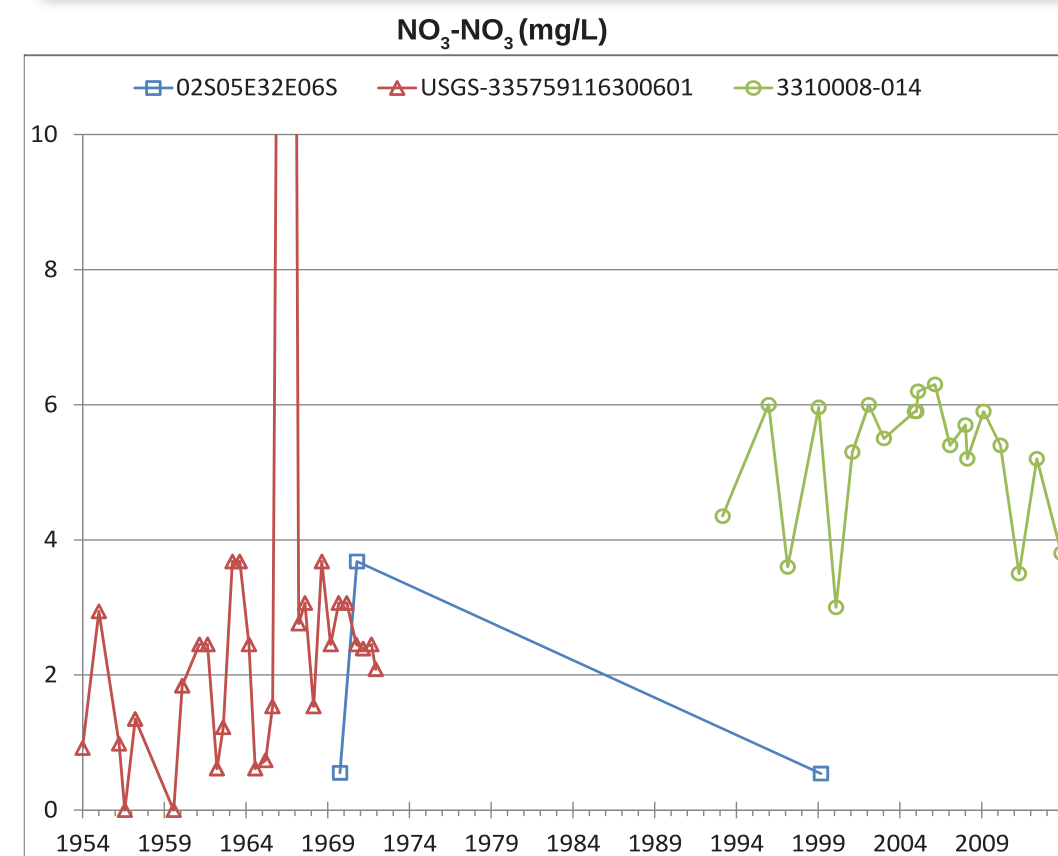


MWH

Appendix A-17

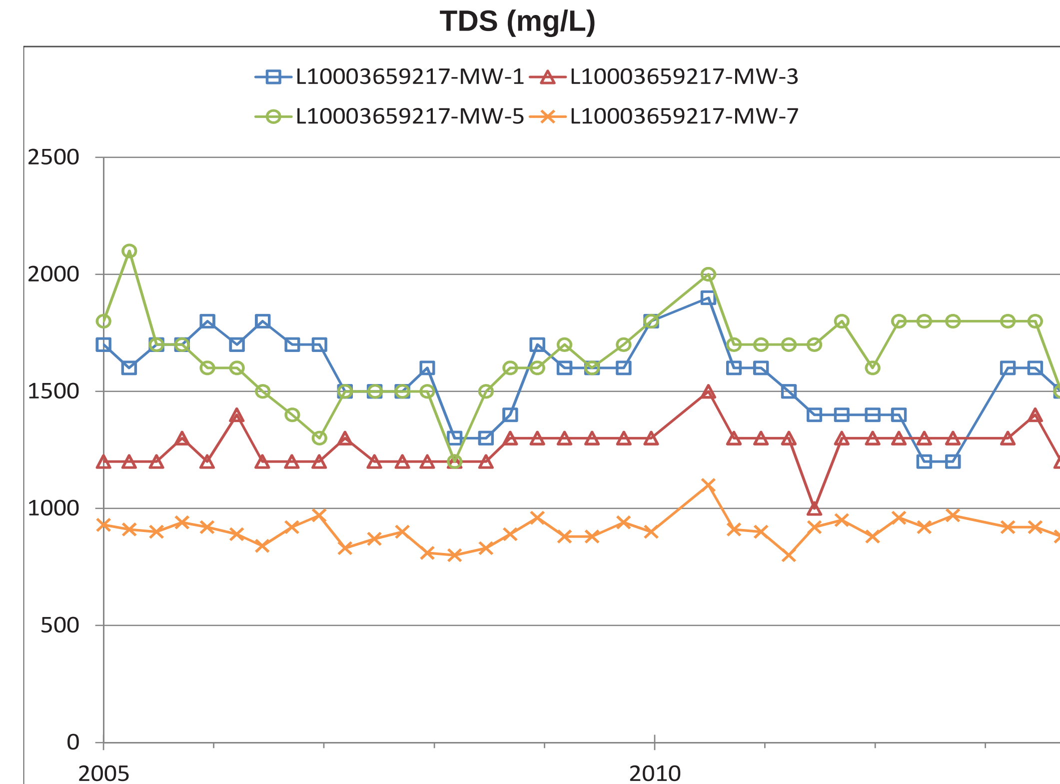
Mission Creek Group P

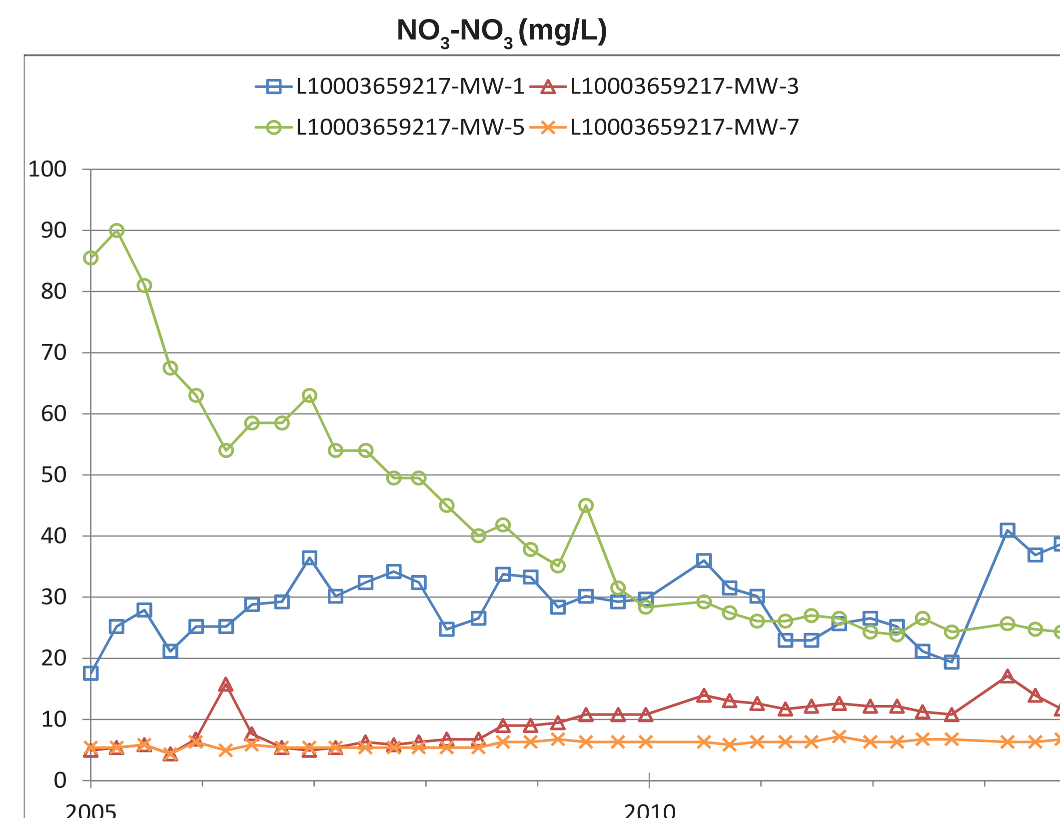




Appendix A-18

Desert Hot Springs Group Q





MWH

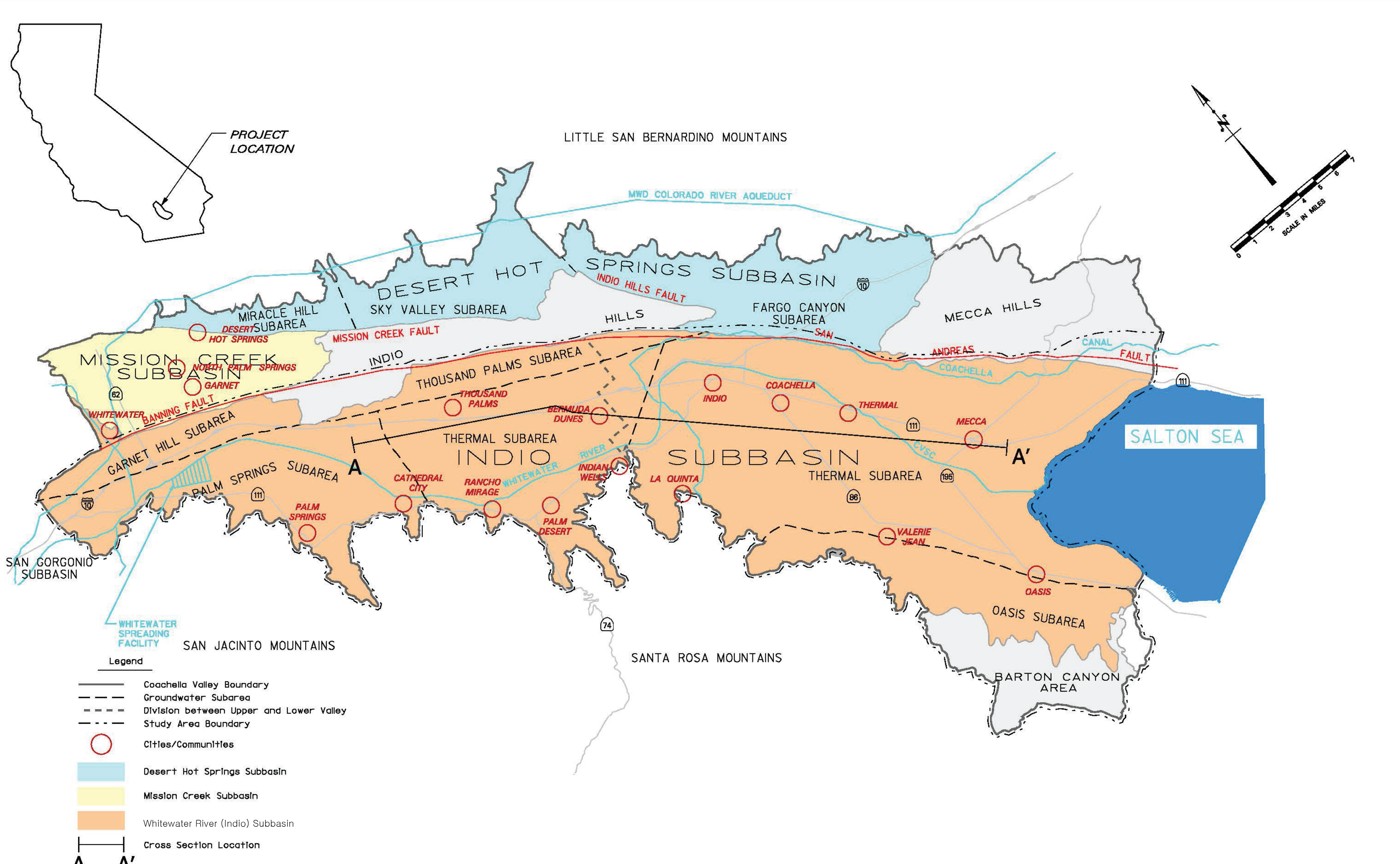
Appendix A-19

Desert Hot Springs Group R

APPENDIX B

Along Valley Cross Section

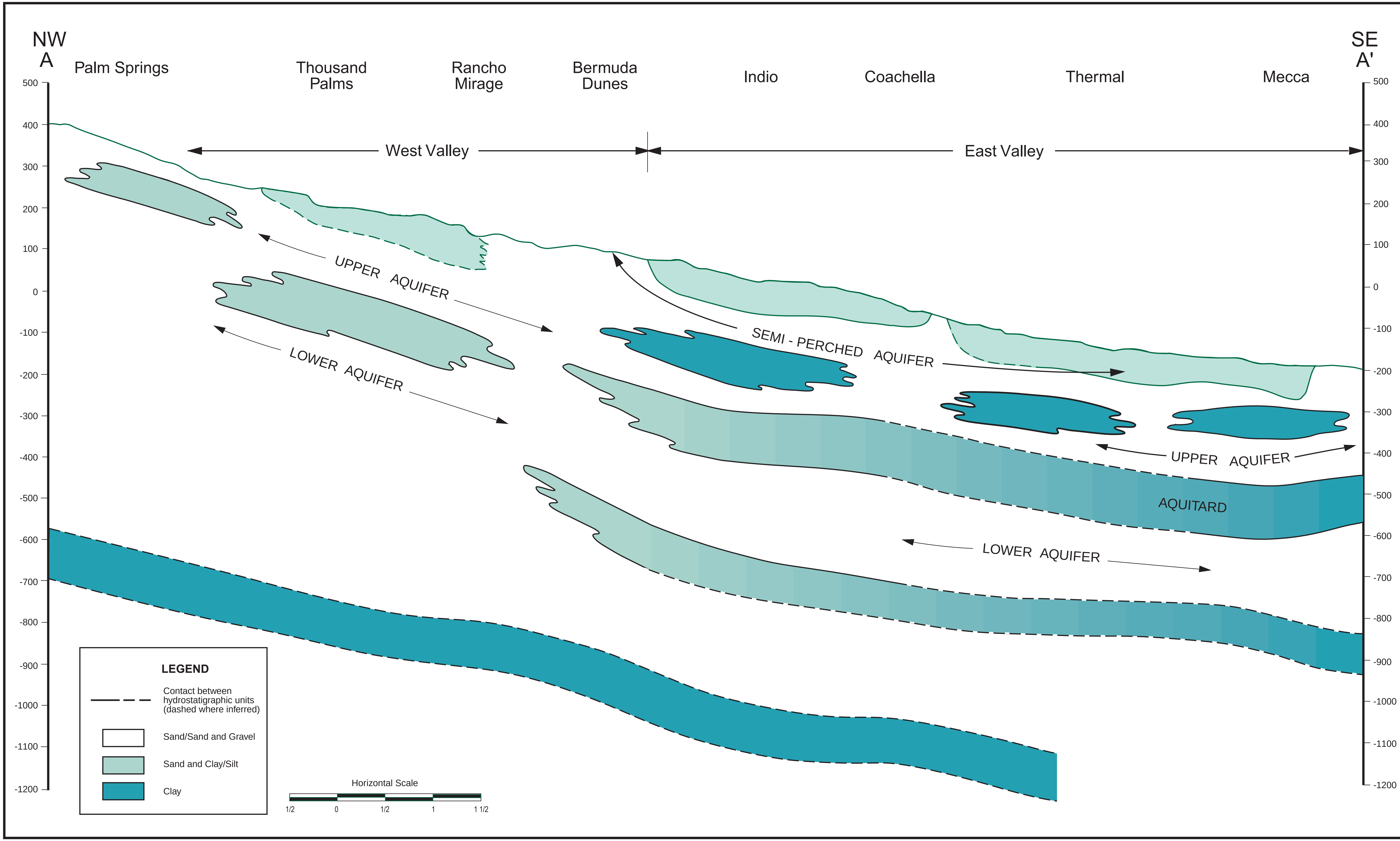
(from MWH, 2010)



JOB No. * FILE No. C:\Drop\CVWD\fig6i.dgn

MWH MONTGOMERY WATSON HARZA

Appendix B-1
Cross Section Along the Coachella Valley

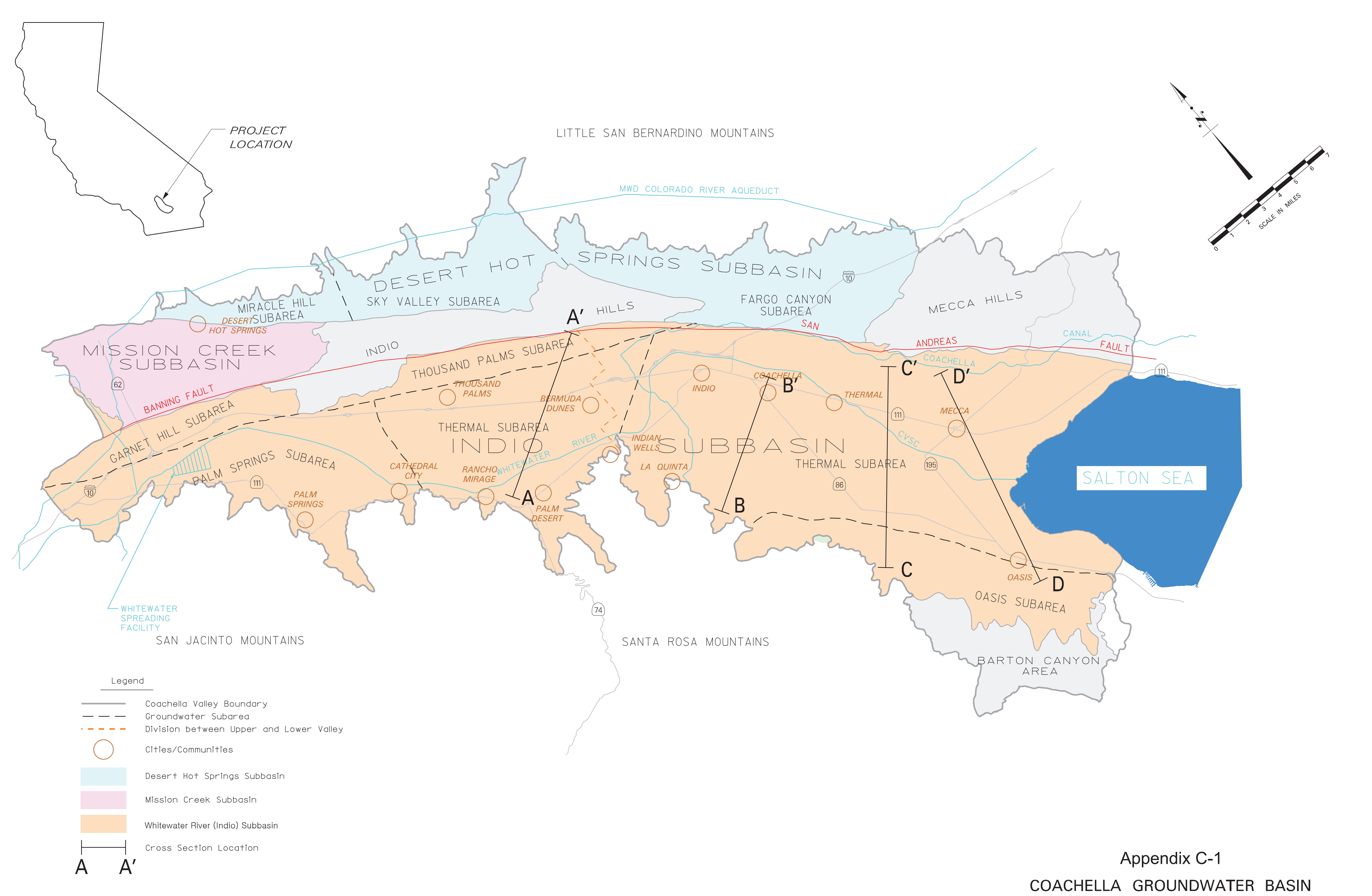


Appendix B-2
Conceptual Hydrogeologic Cross Section of the Coachella Valley

APPENDIX C

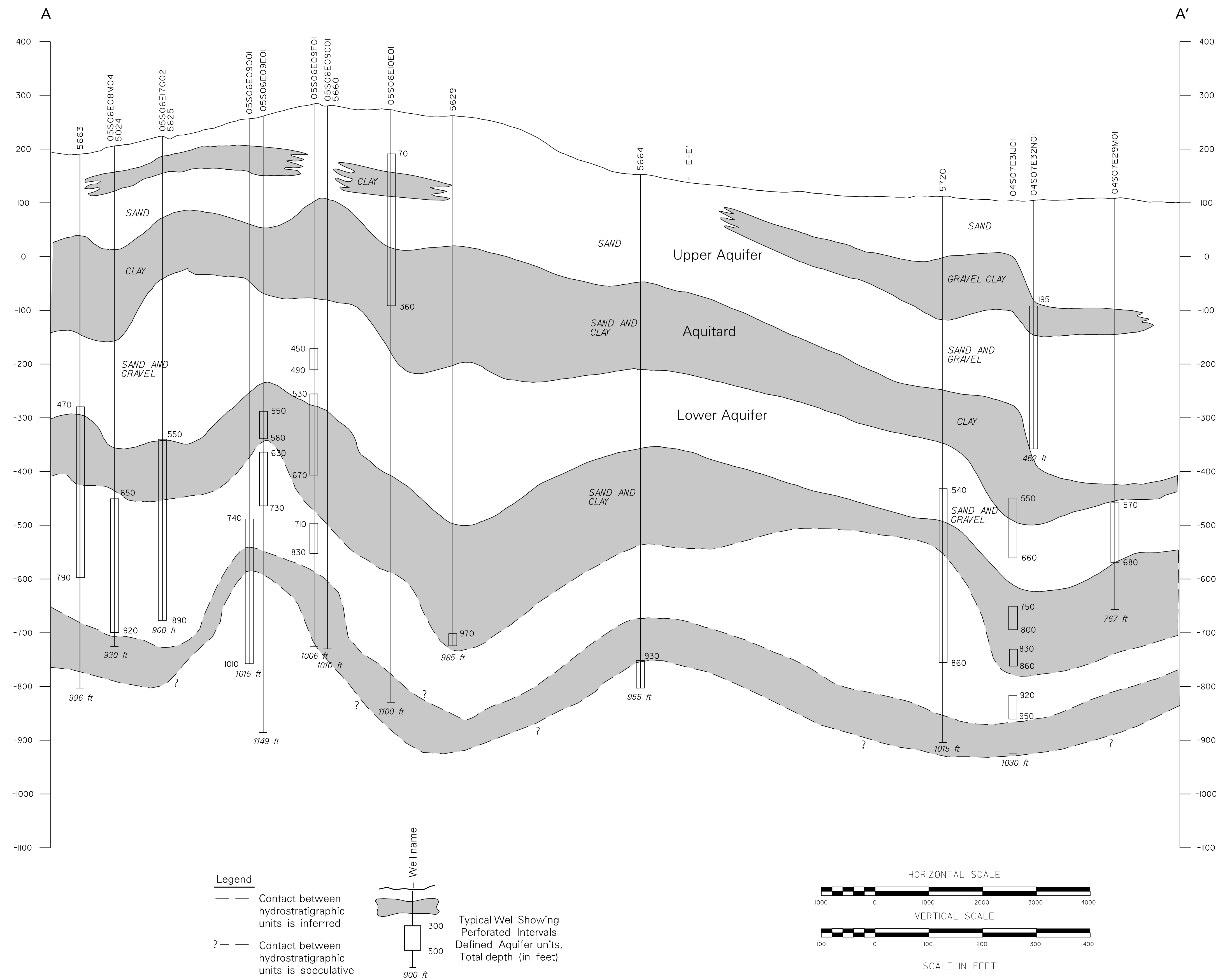
Across Valley Cross Sections

(from MWH, 2010)



Appendix C-1

COACHELLA GROUNDWATER BASIN



MONTGOMERY WATSON

Pasadena, California

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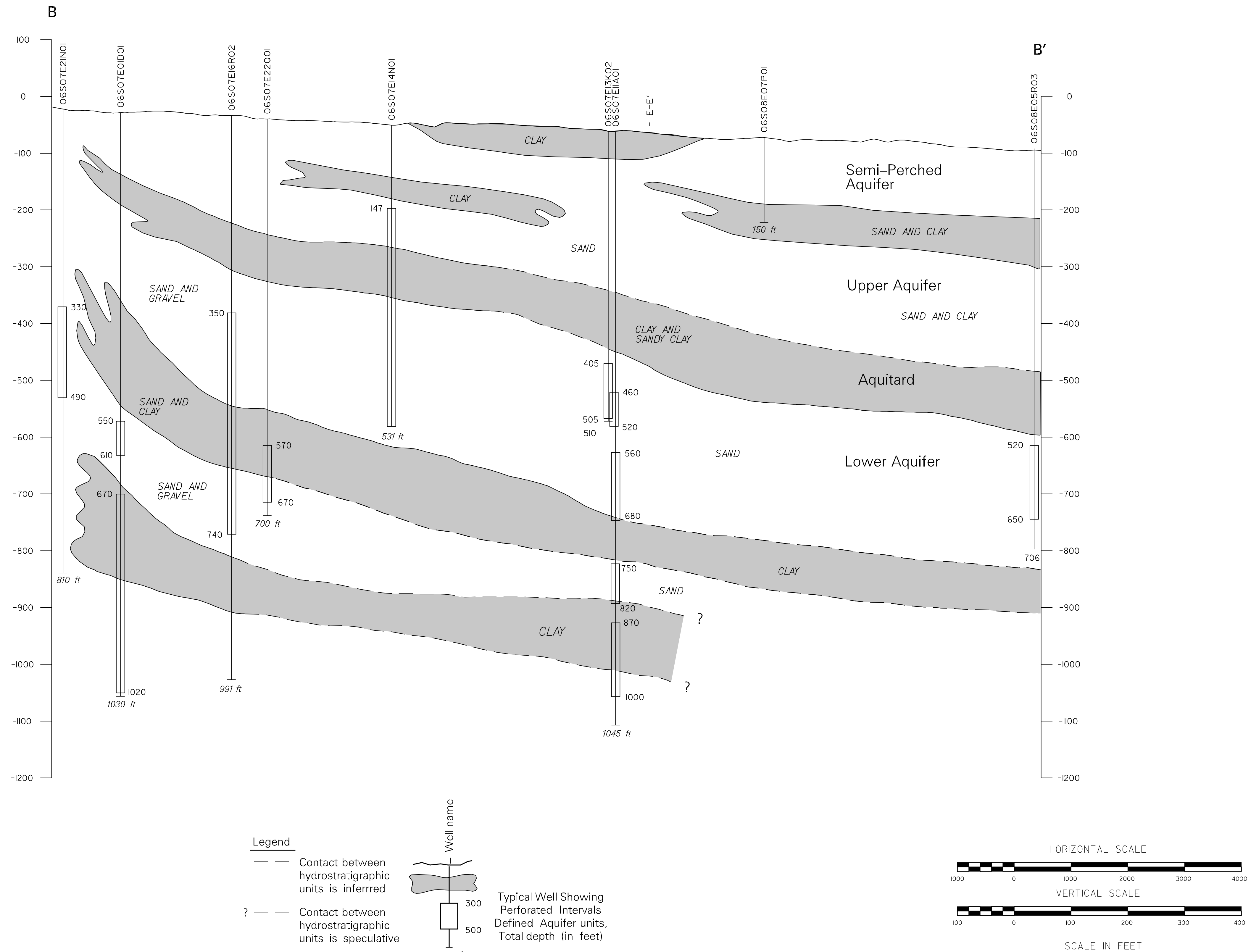
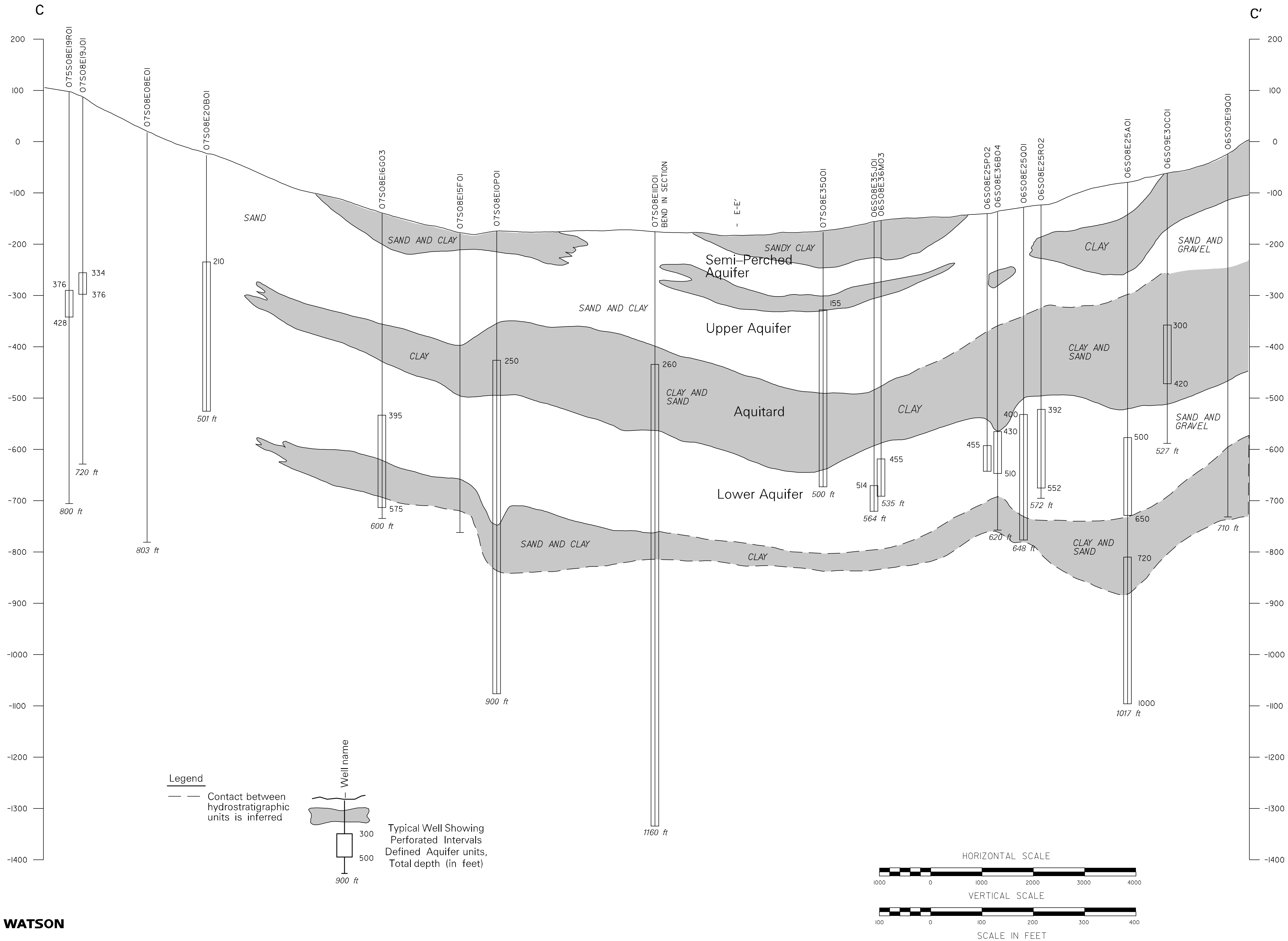
Appendix C-2



MONTGOMERY WATSON

Pasadena, California

Appendix C-3



MONTGOMERY WATSON

Pasadena, California

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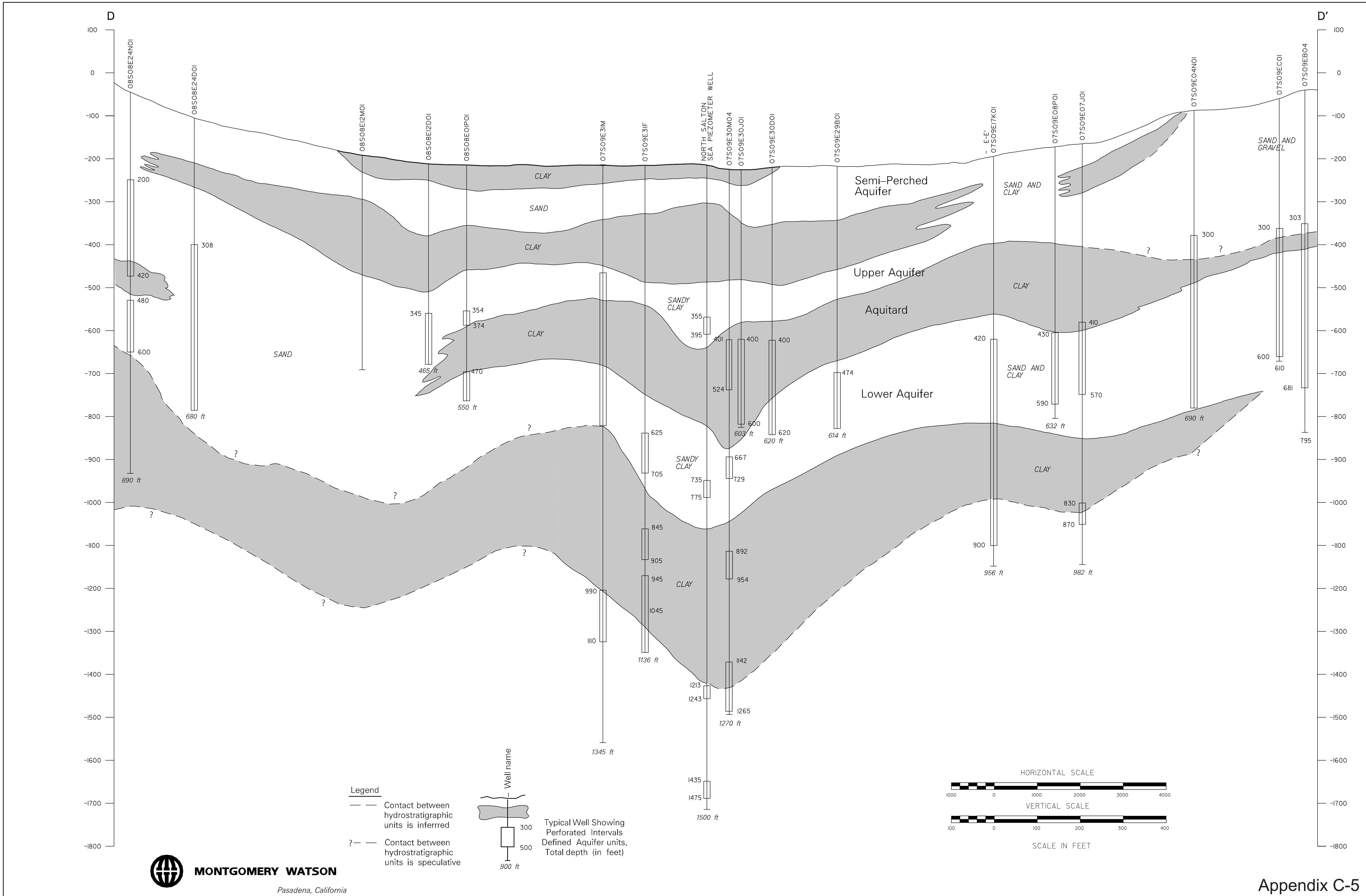
Appendix C-4



Appendix C-5

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ADDENDUM

Stakeholder Comments and Response to Comments

Coachella Valley SNMP - TM-1

Stakeholder	No.	Comment	Response
Agua Caliente Band of Cahuilla Indians Margaret E. Park, AICP Director of Planning & Natural Resources	1	The limitations of the spatial and temporal distribution of concentration data were described, and a 3-step method for filtering data to remove inherent biases was presented. The second filter takes the median of the yearly medians to compute one concentration (i.e. TDS, nitrate) for the AWQ at that well's location. For wells without a clear trend in water quality, selecting the median year is a valid way of dealing with periodic changes in concentration. For wells with clear trends in water quality; such as the Palm Springs area wells (04SOSE04N01 S and 04S05E09N03S) with TDS, or the Palm Desert wells with nitrate; selecting the median year will underestimate the initial water quality, and in turn, overstate the assimilative capacity. For assimilative capacity calculations for these wells with clear trends, the most recent (highest or lowest) concentration or a projected concentration should be used as representative of ambient conditions	The comment makes valid points. The benefit of using a baseline period is to ensure enough data points to accurately characterize a management zone's water quality. The use of medians will determine a representative water quality for the baseline period and remove outliers. Considering trends is important, as such, a Mann-Kendall trend analysis within the final SNMP will examine trends within the baseline period.
	2	MWH proposes to calculate the salt and nutrient loading using a spreadsheet-based planning tool. The limitation of using a spreadsheet versus a numerical groundwater model is that the spreadsheet assumes instant and thorough mixing (constantly stirred reactor model concept) of different qualities of water. A numerical model is usually the better tool to simulate the occurrence and movement of water through a heterogeneous subsurface, and account for the loading (mixing of different concentrations in water) of salts and nutrients. A spreadsheet-based calculation provides an averaged impact of changes within the basin, and may not account for the range of salt and nutrients loading under different conditions.	There are uncertainties with most methods of simulating water quality in a dynamic physical system. Accomplishing objective policy will not require a numerical model. Spreadsheet models do provide an averaged impact of changes within the basin or management zone. Numerical groundwater models also have uncertainty associated with characterizing properties of the physical system. Numerical models also typically have a great cost associated with their development and use. The use of a spreadsheet model is a simple approach that can be further developed and or converted to a numerical model with time. The policy states that the SNMP must be updated in the future. The development of a numerical model may be recommended for future project analysis.
	3	TM-1 discussed why golf course fertilization is not included as a source of nitrate. However, the cited study, by Washington State University (Gibeault et al, 1998), requires an optimal set of conditions for a golf course to not produce nitrate rich runoff or infiltration to groundwater. This indicates a different conclusion, and that less than ideal conditions or improper golf course management could impact water quality.	There are many different conditions that could negatively impact water quality. An additional local reference was added to the technical memorandum, a local leaching study by Wu *et al.* (2007) that suggests nitrate loading may be controlled with well-managed turf grass
	4	Other constituents of concern should include uranium, high levels of which have forced groundwater treatment in the town of Whitewater. While not at the maximum contaminant limit in the Palm Springs area, uranium levels in groundwater are significantly elevated compared to the Public Health Goal (PHG). There is a report in the references on pg. 69, "GSi/water, 2011a. Study and Report on Uranium and the District's Wells, Prepared for Mission Springs Water District," however it is not cited within this document.	Comment noted. Uranium can be considered a constituent of concern in the area. Uranium was added to the constituents of concern list. Nitrate and TDS were selected as the primary COCs as they are materially affected by recycled water use or other salt/nutrient loads. The GSi/water reference was removed
	5	It is stated that the presence of hexavalent chromium and arsenic in groundwater is "naturally occurring." However the potential impacts from pumping distribution or changes to the redox state were not addressed. Arsenic, for example, is highly sensitive to the stability of the iron oxides and sulfides (such as pyrite) it adsorbs to in the surrounding geologic formations.	Comment noted. Hexavalent chromium is a constituent of concern. Aquifer tests in test wells prior to well development and distributed pumping show chromium and arsenic occur in local groundwater almost entirely in oxidized states measured as hexavalent chromium and arsenate, respectively.
	6	This section doesn't discuss the spatial occurrence of hexavalent chromium or with depth. A potential concern is that the "naturally occurring" hexavalent chromium may be more concentrated in geologic formations that the lower aquifer consists of and may be mobilized by overproduction of groundwater.	Comment noted. Hexavalent chromium is a constituent of concern. Aquifer tests in test wells prior to well development show hexavalent chromium is mostly uniformly distributed in relation to depth within local aquifers used for beneficial uses.

Stakeholder	No.	Comment	Response
	7	Some crops incorporate groundwater arsenic into the consumed portion. This section does not discuss if the type of agriculture is appropriate for arsenic-rich water.	Comment noted. Arsenic is a constituent of concern in the area and the discussion of arsenic is related to general water quality. There are numerous studies that evaluate the differences in relative risks between organic arsenic found in plants and inorganic arsenic found in drinking water. The SNMP effort is not intended to evaluate or add to these studies.
Valley Sanitary District Ron Buchwald, P.E. District Engineer	8	The purpose of this TM was to " ... summarizes the purpose o f the SNMP, reviews the areas for which the plan will cover, summarizes a preliminary data review conducted to assess technical methods, and proposes technical methods to develop the SNMP." In general, the TM does a very thorough job of accomplishing these objectives.	Comment noted.
	9	From reading the document, it is not clear what VSD's role is in the development of the SNMP. It appears that the TM was intended for the CVRWMG and its stakeholders. It is recommended that a brief definition be included of the roles different agencies and stakeholders have in this process as the SNMP is a living document that has shared responsibilities amongst us all.	A brief section stating how stakeholders can contribute to the plan was added. A key contribution for stakeholders includes water quality data what projects are planned that may impact salt and nutrients within the region's management zones.
	10	The Phases of the SNMP process (e.g. Phase I, Phase II, etc.) are clearly defined on page eight. However, there are also "stages" of the Phases, which are described, but the delineation of the stages is not quite so clear. Providing a table or figure may be helpful to define the various stages of the phases.	Commented noted, text was added to reflect the comment and clarify stages of Phase II, see section one and section five.
	11	The groundwater modeling description is detailed and in-depth, but it is not clear how the basins and cells interact, and the time step of the modeling. Does one basin drain into another basin and do cells from basins interact with neighboring cells? What is the time step of the modeling and what is the duration of the time series? Overall, our opinion is that the groundwater modeling approach that has been proposed is very ambitious. If the consultant is confident that they can execute what they have proposed, then there are no concerns.	No groundwater modeling is being performed using these models. The groundwater models provide a convenient discretization of the basin for filtering the data and determining volume-weighted ambient water quality. As these models have been peer-reviewed for technical soundness, using them allows the ability to leverage the work already done. The grid enables the grouping of data points from groundwater wells into grid cells and layers while preserving different aquifer properties specific to each grid cell and layer.
	12	There is extensive discussion of the available groundwater data and whether or not it is sufficient. It was not until the end of the document when one gets a sense of how many results and sampling locations were used. The addition of the number of analyses should be presented in the tables where the averages, medians, and ranges are provided (starting with Table 3-1 on page 31).	The text was revised to reflect the comment, including adding the number of analyses ("Count") to the tables referenced.
	13	On page 33, "uptake of nitrogen by managed turf should be addressed in this SNMP..." How is this going to be accomplished? This seems to be an ambitious endeavor.	Agricultural engineers are a part of the project team and will evaluate the uptake of nitrogen by different agricultural practices, including managed turf. This issue will be further addressed in the final SNMP.
	14	In section 5.4.1 Data Preparation: Although there is a decent explanation for using zero for non-detect values, it is not intelleclually honest to treat non-detect values as zero values. This is somewhat of a minor issue and will most likely not have a major impact on the results.	This substitution is consistent with several statistical methods guides such as EPA Data Quality Assessment based on the number of nitrate records in the dataset that are non-detects. Additional text and reference regarding the methods has been added.
	15	On page 7, Figure 1-4, IWA is not referenced in the Key to Features legend.	Commented noted, text is modified to reflect the comment.
	16	On page 9, the last sentence is incomplete.	Commented noted, text is modified to reflect the comment.
	17	On Page 10, Section 2.1, the sentence that reads "In an effort ... " the word "it" appears to be missing between the words "updated" and "in."	Commented noted, text is modified to reflect the comment.
	18	On Page 15, Section 2.3.1, the sentence that reads "For example ... " the word "as" appears to be missing between the words "such" and "contact."	Commented noted, text is modified to reflect the comment.
	19	On page 20, Section 3.1, the sentence that begins "Geologic faults" appears to be missing words in the final phrase or the word "and" should be deleted.	Commented noted, text is modified to reflect the comment.
	20	On page 20, is there no groundwater discharge to rivers or streams?	Within the study area, there is groundwater outflow to phreatophtyes in southern portions of the Mission Creek Management Zone, this may have historically included discharge to streams. Currently there is only outflow to phreatophytes, tile drains, the CVSC, and the Salton Sea.

Stakeholder	No.	Comment	Response
	21	On page 23, in the second paragraph, the sentence that begins "The dividing line .... " Is awkward and appears to be missing words between "irregular" and "trending."	Commented noted, text is modified to reflect the comment.
	22	On Page 23, second and fourth bullet points: replace "correlative" with "correlated" for parallelism.	Commented noted, text is modified to reflect the comment.
	23	On page 23, USGS footnote has too many parentheses.	Commented noted, text is modified to reflect the comment.
	24	In general, starting on page 23, use of word "thick" to describe the aquifer is unclear. At first I understood it to mean "deep" but later the use of "depth" led me to conclude that "thick" meant "wide." I would suggest clarifying this language.	Commented noted, text will be modified to clarify the description. IT is intended to refer to vertical thickness of an aquifer or geologic layer.
	25	If Upper Aquifer and Lower Aquifer are proper names, both words need to be capitalized in all locations.	These descriptions are not proper names. All instances of these descriptions will be checked for consistency.
	26	On page 25, Section 3.1.1.4, last paragraph: more explanation is needed regarding the "reversed the direction of this subsurface flow" and include any references.	Commented noted, text is modified to reflect the comment.
	27	On page 28, end of second paragraph: "waste of groundwater" is an ominous term.	Commented noted, text is modified to reflect the comment.
	28	On Page 28, third paragraph: "Recent" is inappropriately capitalized.	In this context, "Recent" is used as a proper noun describing a particular geologic time period.
	29	On page 33, second paragraph, second sentence: the word "be" is missing between the words "may" and "more."	Commented noted, text is modified to reflect the comment.
	30	On page 34, Section 3.2.8.1: insert words "a limit of" prior to "10 ug/L".	Commented noted, text is modified to reflect the comment.
	31	On page 36, Section 3.3.2, second paragraph: this paragraph is confusing. If the groundwater is generally higher northeast of the fault, then why is the groundwater higher in the southern portion or the sub-basin? I recommend a figure showing the various faults and sub-basins to help explain this.	North and east of the fault system water levels are higher than south and west of the fault system. Within the subbasin, water levels are higher to the west and lower to the east. Text was revised to be more clear.
	32	On page 39, Section 3.4, first paragraph: insert the word "in" between "exhibited" and "a".	Commented noted, text is modified to reflect the comment.
	33	On page 40, Section 3.4.3: delete extra table reference.	Commented noted, text is modified to reflect the comment.
	34	On page 45, Section 4.2: use of i.e. should be replaced with e.g.	Comment noted.
	35	On page 59, Figure 5-2: the legend shows a symbol for highways but none are shown in the figure.	Commented noted, the figure is modified to reflect the comment.
Bureau of Indian Affairs Robert Eben Superintendent	36	The dominant form of groundwater chemistry should be included within the anticipated baseline data. Changing groundwater chemistry, regardless of total salt load can impact the beneficial uses of groundwater. For example a change to more sodium-based waters may cause issues related to sodic soils or worst case saline-sodic soils, if groundwater sources are to be used for irrigation within agriculture or turf grass applications such as golf courses or recreational fields.	Comment noted. Evaluating the differing forms of salts is a rigorous analysis that is out of the scope for the SNMP and not feasible. TDS, however, is a commonly used surrogate for salts and other potential constituents of concern. TDS measurements are also readily available. Use of surrogates is a common practice, for example, drinking water surrogate testing for total coliform bacteria is commonly conducted as it would be infeasible to assess water sources for each individual pathogen.
	37	Data quality assessment and metadata should be included and documented within the available data set, if not already. The EPA has a number of available guides within the EPA's Quality Management Tools - Data Quality Assessment website, http://www.epa.gov/QUALITY/dqa.html. These could be used to address questions brought up within the presentation, such as whether the measurement of nitrate being used was the same in all cases. Without accurate metadata or initial quality assessment, resolving technical issues could be time consuming and under restricted time frames may be overlooked.	The following guides were used to scrutinize the data: - USGS Techniques of Water-Resources Investigations of the United States Geological Survey: Statistical Methods in Water Resources - EPA Data Quality Assessment: Statistical Methods for Practitioners, was used to scrutinize the data Metadata is tracked within the water quality database
	38	TM-1 states that the methodology for handling non-detects would be to set the data to zero. Statistical approaches for handling non-detects like the one listed in the EPA guide, Data Quality Assessment: Statistical Methods for Practitioners, http://www.epa.gov/QUALITY/qs-docs/g9s-final.pdf, should be utilized or similar approaches in order to help eliminate the potential bias from large numbers of non-detects, currently noted to be set to zero.	According to Table 4-4 "Guidelines for Analyzing Data with Non-Detects", simple substitution with zero is an acceptable statistical analysis method for datasets with less than 15% non-detect values. A detection limit substitution was not used because that information is not available for a significant amount of nitrate records. Text was revised to reflect the comment.

Stakeholder	No.	Comment	Response
	39	Within the TM-1 document it was noted that the exceedance of the Total Maximum Daily Load (TMDL) would cause more frequent sampling, and as such some of the averaging within a period of record was used to help eliminate data bias. The frequency of TMDL exceedance should be noted and the exceedance limits during the period of record to reflect changes in modern or historical standards.	There is no reference to Total Maximum Daily Loads (TMDLs) within TM-1; TMDLs are typically developed to restore impaired surface waters, whereas this SNMP is concerned with protecting beneficial uses of groundwater. The frequency bias filtering addresses theoretical increased sampling and how the filter prevents skewing of the data. Existing monitoring and sampling frequency will be discussed in the draft SNMP.
	40	The different techniques for calculation of ambient water quality should be identified and filterable via the tool for the potential bias related to technique differences, or noted if they were averaged together. Uncertainty of the various averaged parameters should also be capable of being tracked.	Statistical summaries of AWQ using pre- and post-filtered data will be presented in TM-2 to track the effects of filtering and provide a transparent review of the data.
	41	The data used to create the SNMP (a public document) should be made publicly available in a documented format for evaluation and use by stakeholders.	The data will be provided to stakeholders/public in the SNMP.
	42	Finally, while not related to the current document, foreseeable questions are centered on the baseline data and how it will be evaluated. Would uncertainty estimation, bootstrapping, monte carlo simulations, or other methodologies be utilized for assessing tool accuracy?+ Since median values are going to be utilized for contouring, will standard deviation contours also be calculated?	At this time no uncertainty evaluation is anticipated. Standard statistics, including standard deviation will be documented for entire management zones and portions of management zones.
Mission Springs Water District Arden Wallum, Mission Springs Water District Michael Thornton, TKE Engineering	43	As indicated in Table 1-1, the SNMP must identify stakeholders responsible for conducting, compiling, and reporting monitoring data. Define the anticipated MSWD role. MSWD's involvement in this process is only fair and necessary to achieve a better analysis. In addition, the SNMP requirements include identifying salt and nutrient sources. For the Mission Creek and Garnet Hill Subbasins, as presented in TM No. 1, key constituents include TDS, nitrates, hexavalent chromium, and uranium. The primary contributors of TDS to groundwater are septage from waste disposal, saline subsurface flow from Desert Hot Springs subbasin, imported water recharged at the Mission Creek Spreading Facility, and percolation of treated wastewater.1 MSWD has and/or will successfully complete $39 million of sewer conversion improvements. MSWD continues to pursue funding opportunities to fully mitigate all onsite disposal systems in its service area effectively managing septage. Wastewater effluent is currently being treated in compliance with MSWD's Waste Discharge Permit (WDR) requirements. Regarding saline subsurface flow from the Desert Hot Springs subbasin and imported Colorado River water, MSWD requests that the SNMP identify these sources of potential groundwater quality degradation and specify measures required to effectively manage them to prevent long term degradation. Note that saline from the Desert Hot Springs subbasin is naturally occurring and yet MSWD has won several awards regarding the taste of water produced from the Mission Creek subbasin. Degradation due to saline increases will be detrimental to the water supply and the region's economic foundation-water. Therefore, imported water and its TDS concentrations are the greatest issues related to water quality degradation in the Mission Creek subbasin. Imported water is the principal source of supplemental water supply for both subbasins and the need for additional imported water is expected to increase in the future. Finally, projects that are identified and evaluated in the SNMP must be implemented to protect groundwater quality. Define the proposed implementation plan.	Comments noted. Please see response to comment No. 9. All stakeholders will be listed in the SNMP along with the public meeting record. To the extent possible, all sources of salt and nutrients will be identified in the SNMP report. Projects related to the management of salts and nutrients will also be documented in the SNMP report. An implementation plan will be provided within the SNMP.
	44	Section 1.4, Salt and Nutrient Management Plan Development - Delete the third full paragraph. Indicate that the SNMP is not being prepared under the direction of the CVRWMG. The last paragraph appears to include an incomplete sentence.	Comment noted. The TM makes note that Phase II and possibly Phase III of this SNMP are being prepared outside of the framework of the CVRWMG.
	45	Section 2.1, Recycled Water Policy - Define quantities of recycled water currently available for reuse together with the expected increases by 2045.	This will be summarized in the draft SNMP. The purpose of this memorandum was to review the areas for which the plan will cover, summarize a preliminary data review, and propose technical methods to develop the SNMP. This information is currently available in the Mission Creek / Garnet Hill 2013 Water management Plan and the Coachela Valley Water Management Plan 2010 Update.

Stakeholder	No.	Comment	Response
	46	Section 2.3, Basin Plan - SNMP shall include an evaluation of a no degradation option and associated costs to confirm that the recommended program will maintain the highest water quality which is reasonable while considering all demands being made. A strict non-degradation option may be more feasible.	Commented noted. It should be noted that typically with any overlying water use there is degradation to local water quality and water quality must be maintained until it has been demonstrated that any change will be consistent with maximum benefit to the people of the State.
	47	Section 2.3.2, Region Water Quality Objectives - The Colorado River Basin Plan does not specify numeric groundwater objectives. It indicates that establishment of numerical objectives for groundwater involves complex considerations since the quality of groundwater varies significantly with depth and of well perforations, existing water levels, geology, hydrology and several other factors. Unavailability of adequate historical data compounds the problem. The Regional Board believes that detailed investigation of groundwater basins should be conducted before establishing specific groundwater quality objectives. This plan should also include a program to continue the acquisition of new data and information into the future. Since adoption of the Basin Plan, MSWD together with CVWD and DWA completed the Mission Creek/Garnet Hill Water Management Plan that contains data that will assist in development of water quality objectives. Using this data and data from the Coachella Valley Water Management Plan, the SNMP should establish water quality objectives prior to estimating assimilative capacities. MSWD rejects the use of the Title 22 MCL for nitrate. As indicated, current TDS levels in the Mission Creek subbasin at MSWD's production facility locations are approximately 400 to 450 mg/L. Suggested objectives of 879 mg/L or the Title 22 MCL is not appropriate. As you may be aware, litigation is pending challenging current water quality management of the Coachella Valley Water Basins. Arbitrary selection of protective water quality objectives may support the tribe's arguments related to mismanagement. For example, the suggested TDS water quality objectives may not be applicable to the Coachella Valley.	As noted on p.2, p.3, p.8, p.54, and p.56, a monitoring plan is a part of the SNMP. It is noted that MSWD rejects the use of the Title 22 MCL for nitrate. It is also noted that MSWD believes the suggested objectives of 879 mg/L or the Title 22 MCL is not appropriate.
	48	Section 2.4, Resolution No. 68-16 – State Anti-Degradation Policy - Revise the sentence "The appeals court interpreted an existing high quality water to exist where the baseline water quality (that existed in 1968) is better than the water quality objective." to "The appeals court defined high quality water as the best water quality achieved since the adoption of the anti-degradation policy by the SWRCB in 1968."	What is currently written is per the appeals court, the recommended change changes the meaning of the sentence and does not represent the appeals court decision.
	49	Section 3.3, Mission Creek Subbasin - In reference to the first paragraph, groundwater replenishment includes mountain front recharge by subsurface flow in addition to the Desert Hot Springs subbasin.	Commented noted, text is modified to reflect the comment.
	50	Section 3.3.2, Groundwater Level - The first and last paragraphs are inaccurate. Groundwater storage in the Mission Creek subbasin has declined continuously from about 1960 until significant recharge activities commenced in 2005. Under existing conditions, groundwater pumping is about 4,000 AFY greater than estimated natural recharge and current artificial recharge activities.Water Quality Control Board, Colorado River Basin – Region 7, Chapter 3 – Water Quality Objectives, Subsection IV, Groundwater Objectives. Paragraph 3, also contradicts the first paragraph. To assist in understanding basin conditions, by separate correspondence, MSWD will provide well static water level data.	Text was modified to be consistent with the Mission Creek/Garnet Hill Water Management Plan Final Report January 2013.
	51	Section 3.3.3, Groundwater Quality - The data presented in the tables does not accurately reflect water quality conditions in the Mission Creek subbasin. MSWD will provide, by separate correspondence, Title 22 water quality data for all MSWD wells. Revise all sections related to water quality based on the provided data. Please note that MSWD has won several awards regarding the taste of water produced from the Mission Creek subbasin.	Commented noted, MWH has been in contact with MSWD staff to obtain additional data. It is likely that all additional data is included in current data sources.
	52	Section 3.3.4.4, Radionuclides - Uranium contamination discussion is not accurately presented. Please review the study prepared by GSI/Water. Currently, uranium concentrations exceeding the MCL only occur in two MSWD wells that are not being used. Verify using the data provided statement regarding gross alpha.	Commented noted, text is modified to reflect the comment.
	53	Section 3.3.4.4, Radionuclides - Uranium contamination discussion is not accurately presented. Please review the study prepared by GSI/Water. Currently, uranium concentrations exceeding the MCL only occur in two MSWD wells that are not being used. Verify using the data provided statement regarding gross alpha.	Commented noted, text is modified to reflect the comment.
	54	Section 4.2, Data Sources - MSWD is providing additional data; revise the first sentence. In addition, include water quality data for the Colorado River Aqueduct.	See response to comment No. 51. Colorado River Aqueduct water quality is not necessary in this memorandum, it will be described in the SNMP report.
	55	Section 4.2.1, Groundwater Models - Further define the use of existing groundwater models for AWQ and potential management strategies. To develop an effective SNMP, modeling will be an essential tool. For example, the model will assist in determining the effects of the imported water recharge at the Mission Creek Recharge Facility on the entire MZ and other MZ's. The CV is comprised of a number of complicated subbasins connected with fault systems. Modeling is a key component to determine water quality impacts of various sources. It will prevent oversight of impacts in critical areas throughout the CV.	Comment noted, please see response to comment No. 2.
	56	Section 4.3, Data Gaps - Revise the first paragraph after review of the Title 22 well data provided by MSWD. Well data is primarily acquired from wells in the northwestern areas of the Mission Creek subbasin. The more diversified water quality data will impact methods chosen to determine AWQ.	Commented noted, MWH has been in contact with MSWD staff to obtain additional data. It is likely that all additional data is included in current data sources.

Stakeholder	No.	Comment	Response
	57	Section 5, Technical Approach - MSWD reserves comments related to this section for further consideration. MSWD will confer with the Regional Board and other experts to assemble comments.	All stakeholder comments are welcomed, this project is an open and transparent process. While we would consider future comments, we respectfully would like to remind you that we are moving forward to adhere to the strict schedule requirements determined by the Regional Water Quality Control Board; therefore, any comments received after the comment deadlines are not guaranteed to be incorporated in the technical memorandum.

AGUA CALIENTE BAND OF CAHUILLA INDIANS

PLANNING & DEVELOPMENT DEPARTMENT
CONSTRUCTION DIVISION • ECONOMIC DEVELOPMENT DIVISION
PLANNING & NATURAL RESOURCES DIVISION • TRIBAL HISTORIC PRESERVATION OFFICE

September 17, 2014

Sent via: U.S. Postal Service
Email: preyes@cvwd.org

Patti Reyes, P.E.
Planning and Special Programs Manager
Coachella Valley Water District
P.O. Box 1058
Coachella, CA 92236

RE: Comments on Technical Memo #1, SNMP Technical Methods for Calculation of Ambient Water Quality

Dear Ms. Reyes:

Thank you for the opportunity to review and comment on Technical Memo #1, SNMP Technical Methods for Calculation of Ambient Water Quality. As you are aware, the Tribe submitted comments on the SNMP Work Plan in December 7, 2012 and continues to participate in the ongoing stakeholder meetings. The Tribe offers the following comments:

1. The limitations of the spatial and temporal distribution of concentration data were described, and a 3-step method for filtering data to remove inherent biases was presented. The second filter takes the *median of the yearly medians* to compute one concentration (i.e. TDS, nitrate) for the AWQ at that well's location. For wells without a clear trend in water quality, selecting the median year is a valid way of dealing with periodic changes in concentration. For wells with clear trends in water quality; such as the Palm Springs area wells (04S05E04N01S and 04S05E09N03S) with TDS, or the Palm Desert wells with nitrate; selecting the median year will underestimate the initial water quality, and in turn, overstate the assimilative capacity. For assimilative capacity calculations for these wells with clear trends, the most recent (highest or lowest) concentration or a projected concentration should be used as representative of ambient conditions.

2. MWH proposes to calculate the salt and nutrient loading using a *spreadsheet-based planning tool*. The limitation of using a spreadsheet versus a numerical groundwater model is that the spreadsheet assumes instant and thorough mixing (*constantly stirred reactor model concept*) of different qualities of water. A numerical model is usually the better tool to simulate the occurrence and movement of water through a heterogeneous subsurface, and account for the loading (mixing of different concentrations in water) of salts and nutrients. A spreadsheet-based calculation provides an averaged impact of changes within the basin, and may not account for the range of salt and nutrients loading under different conditions.

3. TM-1 discussed why golf course fertilization is not included as a source of nitrate. However, the cited study, by Washington State University (Gibeault et al, 1998), requires an optimal set of conditions for a golf course to not produce nitrate rich runoff or infiltration to groundwater. This indicates a different conclusion, and that less than ideal conditions or improper golf course management could impact water quality.

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4. Other constituents of concern should include uranium, high levels of which have forced groundwater treatment in the town of Whitewater. While not at the maximum contaminant limit in the Palm Springs area, uranium levels in groundwater are significantly elevated compared to the Public Health Goal (PHG). There is a report in the references on pg. 69, "GSi/water, 2011a. *Study and Report on Uranium and the District's Wells, Prepared for Mission Springs Water District*," however it is not cited within this document.

5. It is stated that the presence of hexavalent chromium and arsenic in groundwater is "naturally occurring." However the potential impacts from pumping distribution or changes to the redox state were not addressed. Arsenic, for example, is highly sensitive to the stability of the iron oxides and sulfides (such as pyrite) it adsorbs to in the surrounding geologic formations.

6. This section doesn't discuss the spatial occurrence of hexavalent chromium or with depth. A potential concern is that the "naturally occurring" hexavalent chromium may be more concentrated in geologic formations that the lower aquifer consists of and may be mobilized by overproduction of groundwater.

7. Some crops incorporate groundwater arsenic into the consumed portion. This section does not discuss if the type of agriculture is appropriate for arsenic-rich water.

Thank you for the opportunity to review Technical Memo #1. If you have any questions, please feel free to contact me at 760-883-1326.

Very truly yours,

Margaret Park

Margaret E. Park, AICP
Director of Planning & Natural Resources
AGUA CALIENTE BAND
OF CAHUILLA INDIANS

C: Tribal Council
Tom Davis, Chief Planning and Development Officer
John Plata, In-House Counsel

Directors:
Doug A York, *President*
Richard Friestad, *Vice-President*
Merritt W Wiseman, *Secretary/Treasurer*
Mike Duran, *Director*
William R Teague, *Director*
General Manager:
Joseph Glowitz, PE, PMP

September 18, 2014

Ms. Patti Reyes
Planning and Special Programs Manager
Coachella Valley Water District
P.O. Box 1058
Coachella, CA 92236

Re: DRAFT – Technical Memorandum No. 1 Preliminary Data Review and Documentation of Technical Methods

Dear Ms. Reyes:

Valley Sanitary District (VSD) along with their consultant reviewed the following document: DRAFT – Technical Memorandum No. 1 Preliminary Data Review and Documentation of Technical Methods dated August 29, 2014. VSD is providing the following general comments:

1. The purpose of this TM was to "…summarizes the purpose of the SNMP, reviews the areas for which the plan will cover, summarizes a preliminary data review conducted to assess technical methods, and proposes technical methods to develop the SNMP." In general, the TM does a very thorough job of accomplishing these objectives.
2. From reading the document, it is not clear what VSD's role is in the development of the SNMP. It appears that the TM was intended for the CVRWMG and its stakeholders. It is recommended that a brief definition be included of the roles different agencies and stakeholders have in this process as the SNMP is a living document that has shared responsibilities amongst us all.
3. The Phases of the SNMP process (e.g. Phase I, Phase II, etc.) are clearly defined on page eight. However, there are also "stages" of the Phases, which are described, but the delineation of the stages is not quite so clear. Providing a table or figure may be helpful to define the various stages of the phases.
4. The groundwater modeling description is detailed and in-depth, but it is not clear how the basins and cells interact, and the time step of the modeling. Does one basin drain into another basin and do cells from basins interact with neighboring cells? What is the time

step of the modeling and what is the duration of the time series? Overall, our opinion is that the groundwater modeling approach that has been proposed is very ambitious. If the consultant is confident that they can execute what they have proposed, then there are no concerns.

5. There is extensive discussion of the available groundwater data and whether or not it is sufficient. It was not until the end of the document when one gets a sense of how many results and sampling locations were used. The addition of the number of analyses should be presented in the tables where the averages, medians, and ranges are provided (starting with Table 3-1 on page 31).
6. On page 33, "uptake of nitrogen by managed turf should be addressed in this SNMP…" How is this going to be accomplished? This seems to be an ambitious endeavor.
7. In section 5.4.1 Data Preparation: Although there is a decent explanation for using zero for non-detect values, it is not intellectually honest to treat non-detect values as zero values. This is somewhat of a minor issue and will most likely not have a major impact on the results.

In addition, some other minor comments were noted. Those are provided below.

1. On page 7, Figure 1-4, IWA is not referenced in the Key to Features legend.
2. On page 9, the last sentence is incomplete.
3. On Page 10, Section 2.1, the sentence that reads "In an effort…" the word "it" appears to be missing between the words "updated" and "in."
4. On Page 15, Section 2.3.1, the sentence that reads "For example…" the word "as" appears to be missing between the words "such" and "contact."
5. On page 20, Section 3.1, the sentence that begins "Geologic faults" appears to be missing words in the final phrase or the word "and" should be deleted.
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20. On page 45, Section 4.2: use of i.e. should be replaced with e.g.
21. On page 59, Figure 5-2: the legend shows a symbol for highways but none are shown in the figure.

If you have any questions, please do not hesitate to contact me at (760) 238-5408 or at rbuchwald@valley-sanitary.org.

Sincerely,

VALLEY SANITARY DISTRICT

Ron Buchwald, P.E.
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR

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SEP 18 2014

IN REPLY REFER TO:
Natural Resources
Hydrologist

Attn: Patti Reyes
Coachella Valley Salt and Nutrient Management Plan Technical Group
Planning and Special Programs Manager
Coachella Valley Water District
P.O. Box 1058
Coachella, CA 92236

Subject: Comments of the Bureau of Indian Affairs Southern California Agency regarding Coachella Valley Salt and Nutrient Management Plan Technical Group Technical Memorandum No. 1.

This letter is provided by the U.S. Bureau of Indian Affairs Southern California Agency, (BIA), to review and comment on Coachella Valley Salt and Nutrient Management Plan Technical Group, Draft Technical Memorandum No. 1 (TM-1) located at http://www.cvwd.org/snmp/. The BIA understands that this technical memorandum is to be used in preparation for the requirements of the State Water Resources Control Board Resolution No. 2009 011 that establishes the Recycled Water Policy (http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2009/rs2009_0011.pdf).

The BIA is the oldest bureau of the United States Department of the Interior. Established in 1824, the BIA provides services to approximately 1.7 million American Indians and Alaska Natives. Among the many duties of the BIA, as established by the United States Congress, is to serve as an advocate for the sovereignty and rights of tribes in dealing with other governmental entities and, to fulfill and execute the Federal Government's trust responsibility to American Indian Tribes. *All federal agencies share in this trust responsibility.*

Below are specific comments for consideration regarding the TM-1 document, and responses should be addressed to the included parties below.

1. The dominant form of groundwater chemistry should be included within the

anticipated baseline data. Changing groundwater chemistry, regardless of total salt load can impact the beneficial uses of groundwater. For example a change to more sodium-based waters may cause issues related to sodic soils or worst case saline-sodic soils, if groundwater sources are to be used for irrigation within agriculture or turf grass applications such as golf courses or recreational fields.

2. Data quality assessment and metadata should be included and documented within the available data set, if not already. The EPA has a number of available guides within the EPA's Quality Management Tools – Data Quality Assessment website, http://www.epa.gov/QUALITY/dqa.html. These could be used to address questions brought up within the presentation, such as whether the measurement of nitrate being used was the same in all cases. Without accurate metadata or initial quality assessment, resolving technical issues could be time consuming and under restricted time frames may be overlooked.

3. TM-1 states that the methodology for handling non-detects would be to set the data to zero. Statistical approaches for handling non-detects like the one listed in the EPA guide, Data Quality Assessment: Statistical Methods for Practitioners, http://www.epa.gov/QUALITY/qs-docs/g9s-final.pdf, should be utilized or similar approaches in order to help eliminate the potential bias from large numbers of non-detects, currently noted to be set to zero.

4. Within the TM-1 document it was noted that the exceedance of the Total Maximum Daily Load (TMDL) would cause more frequent sampling, and as such some of the averaging within a period of record was used to help eliminate data bias. The frequency of TMDL exceedance should be noted and the exceedance limits during the period of record to reflect changes in modern or historical standards.

5. The different techniques for calculation of ambient water quality should be identified and filterable via the tool for the potential bias related to technique differences, or noted if they were averaged together. Uncertainty of the various averaged parameters should also be capable of being tracked.

6. The data used to create the SNMP (a public document) should be made publicly available in a documented format for evaluation and use by stakeholders.

7. Finally, while not related to the current document, foreseeable questions are centered on the baseline data and how it will be evaluated. Would uncertainty estimation, bootstrapping, monte carlo simulations, or other methodologies be utilized for assessing tool accuracy?+ Since median values are going to be utilized for contouring, will standard deviation contours also be calculated?

If there any clarification is needed, please do not hesitate to call Mr. Patrick Taber, Agency Hydrologist at 951-276-6624 x 256.

Sincerely;

Robert Eben
Superintendent

Cc: Chairperson, Torres Martinez Desert Cahuilla Indians
Chairperson, Agua Caliente Band of Cahuilla Indians
Chairperson, Twenty-Nine Palms Band of Mission Indians
Chairperson, Cabazon Band of Mission Indians
Chairperson, Augustine Band of Cahuilla Indians

MEMORANDUM

Date: September 18, 2014

To: Thomas D. McCarthy, Principal Engineer,MWH
Adnan Anabtawi, Associate Engineer, MWH

From: Arden Wallum,Mission Springs Water District
Michael Thornton, TKE Engineering

Subject: Salt and Nutrient Management Plan (SNMP)
Technical Memorandum No. 1, Preliminary Data Review and Documentation of Technical Methods
MSWD Preliminary Comments

MSWD comments are presented in the following paragraphs:

A. Section 1.2, Purpose of the Plan

As indicated in Table 1-1, the SNMP must identify stakeholders responsible for conducting, compiling, and reporting monitoring data. Define the anticipated MSWD role. MSWD's involvement in this process is only fair and necessary to achieve a better analysis.

In addition, the SNMP requirements include identifying salt and nutrient sources. For the Mission Creek and Garnet Hill Subbasins, as presented in TM No. 1, key constituents include TDS, nitrates, hexavalent chromium, and uranium. Theprimary contributors of TDS to groundwater are septage from waste disposal, saline subsurface flow from Desert Hot Springs subbasin, imported water recharged at the Mission Creek Spreading Facility, and percolation of treated wastewater.[1] MSWD has and/or will successfully complete $39 million of sewer conversion improvements. MSWD continues to pursue funding opportunities to fully mitigate all onsite disposal systems in its service area effectively managing septage. Wastewater effluent is currently being treated in compliance with MSWD's Waste Discharge Permit (WDR) requirements.

Regarding saline subsurface flow from the Desert Hot Springs subbasin and imported Colorado River water, MSWD requests that the SNMP identify these sources of potential groundwater quality degradation and specify measures required to effectively manage them to prevent long term degradation. Note that saline from the Desert Hot Springs subbasin is naturally occurring and yet MSWD has won several awards regarding the taste of water produced from the Mission Creek

[1]Mission Creek/Garnet Hill Water Management Plan, Final Report, January 2013, Section 5, Issues, Strategies and Plan Evaluation, Total Dissolved Solids.

subbasin.[2] Degradation due to saline increases will be detrimental to the water supply and the region's economic foundation-water.

Therefore, imported water and its TDS concentrations are the greatest issues related to water quality degradation in the Mission Creek subbasin. Imported water is the principal source of supplemental water supply for both subbasins and the need for additional imported water is expected to increase in the future.[3]

Finally, projects that are identified and evaluated in the SNMP must be implemented to protect groundwater quality. Define the proposed implementation plan.

B. Section 1.4, Salt and Nutrient Management Plan Development

Delete the third full paragraph. Indicate that the SNMP is not being prepared under the direction of the CVRWMG. The last paragraph appears to include an incomplete sentence.

C. Section 2.1, Recycled Water Policy

Define quantities of recycled water currently available for reuse together with the expected increases by 2045.

D. Section 2.3, Basin Plan

SNMP shall include an evaluation of a no degradation option and associated costs to confirm that the recommended program will maintain the highest water quality which is reasonable while considering all demands being made. A strict non-degradation option may be more feasible.

E. Section 2.3.2, Region Water Quality Objectives

The Colorado River Basin Basin Plan does not specify numeric groundwater objectives. It indicates that establishment of numerical objectives for groundwater involves complex considerations since the quality of groundwater varies significantly with depth and of well perforations, existing water levels, geology, hydrology and several other factors. Unavailability of adequate historical data compounds the problem. The Regional Board believes that detailed investigation of groundwater basins should be conducted before establishing specific groundwater quality

[2] Mission Creek/Garnet Hill Water Management Plan, Final Report, January 2013, Section 5, Issues, Strategies and Plan Evaluation, Water Quality in the Mission Creek Subbasin.

[3] Mission Creek/Garnet Hill Water Management Plan, Final Report, January 2013, Section 5, Issues, Strategies and Plan Evaluation, Amount of Imported Water Supplies.

objectives.[4] This plan should also include a program to continue the acquisition of new data and information into the future.

Since adoption of the Basin Plan, MSWD together with CVWD and DWA completed the Mission Creek/Garnet Hill Water Management Plan that contains data that will assist in development of water quality objectives. Using this data and data from the Coachella Valley Water Management Plan, the SNMP should establish water quality objectives prior to estimating assimilative capacities. MSWD rejects the use of the Title 22 MCL for nitrate. As indicated, current TDS levels in the Mission Creek subbasin at MSWD's production facility locations are approximately 400 to 450 mg/L. Suggested objectives of 879 mg/L or the Title 22 MCL is not appropriate.

As you may be aware, litigation is pending challenging current water quality management of the Coachella Valley Water Basins. Arbitrary selection of protective water quality objectives may support the tribe's arguments related to mismanagement. For example, the suggested TDS water quality objectives may not be applicable to the Coachella Valley.

F. Section 2.4, Resolution No. 68-16 – State Anti-Degradation Policy

Revise the sentence "The appeals court interpreted an existing high quality water to exist where the baseline water quality (that existed in 1968) is better than the water quality objective." to "The appeals court defined high quality water as the best water quality achieved since the adoption of the anti-degradation policy by the SWRCB in 1968."

G. Section 3.3, Mission Creek Subbasin

In reference to the first paragraph, groundwater replenishment includes mountain front recharge by subsurface flow in addition to the Desert Hot Springs subbasin.

H. Section 3.3.2, Groundwater Level

The first and last paragraphs are inaccurate. Groundwater storage in the Mission Creek subbasin has declined continuously from about 1960 until significant recharge activities commenced in 2005. Under existing conditions, groundwater pumping is about 4,000 AFY greater than estimated natural recharge and current artificial recharge activities.[5] Paragraph 3, also contradicts the first paragraph. To assist in understanding basin conditions, by separate correspondence, MSWD will provide well static water level data.

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[4]Water Quality Control Board, Colorado River Basin – Region 7, Chapter 3 – Water Quality Objectives, Subsection IV, Groundwater Objectives.

[5]Mission Creek/Garnet Hill Water Management Plan, Final Report, January 2013, Section 5, Issues, Strategies and Plan Evaluation, Groundwater Overdraft.

I. Section 3.3.3, Groundwater Quality

The data presented in the tables does not accurately reflect water quality conditions in the Mission Creek subbasin. MSWD will provide, by separate correspondence, Title 22 water quality data for all MSWD wells. Revise all sections related to water quality based on the provided data. Please note that MSWD has won several awards regarding the taste of water produced from the Mission Creek subbasin.[6]

J. Section 3.3.4.4, Radionuclides

Uranium contamination discussion is not accurately presented. Please review the study prepared by GSI/Water. Currently, uranium concentrations exceeding the MCL only occur in two MSWD wells that are not being used. Verify using the data provided statement regarding gross alpha.

K. Section 4.2, Data Sources

MSWD is providing additional data; revise the first sentence. In addition, include water quality data for the Colorado River Aqueduct.

L. Section 4.2.1, Groundwater Models

Further define the use of existing groundwater models for AWQ and potential management strategies. To develop an effective SNMP, modeling will be an essential tool. For example, the model will assist in determining the effects of the imported water recharge at the Mission Creek Recharge Facility on the entire MZ and other MZ's. The CV is comprised of a number of complicated subbasins connected with fault systems. Modeling is a key component to determine water quality impacts of various sources. It will prevent oversight of impacts in critical areas throughout the CV.

M. Section 4.3, Data Gaps

Revise the first paragraph after review of the Title 22 well data provided by MSWD. Well data is primarily acquired from wells in the northwestern areas of the Mission Creek subbasin. The more diversified water quality data will impact methods chosen to determine AWQ.

N. Section 5, Technical Approach

MSWD reserves comments related to this section for further consideration. MSWD will confer with the Regional Board and other experts to assemble comments.

---

[6] Mission Creek/Garnet Hill Water Management Plan, Final Report, January 2013, Section 5, Issues, Strategies and Plan Evaluation, Water Quality in the Mission Creek Subbasin.

Comments above are only initial MSWD comments. MSWD will continue to comment as it continues to review the document. MSWD is scheduling a board study session to review the SNMP. Comments raised by MSWD's Board of Directors will be provided. If you need any clarification, please advise.

Appendix B – Technical Memorandum No. 2 - Ambient Water Quality

TECHNICAL MEMORANDUM

MWH

BUILDING A BETTER WORLD

To:	Coachella Valley Salt and Nutrient Management Plan Technical Group	**Date:**	February 27, 2015
From:	MWH	**Reference:**	10505158
Subject:	FINAL - Technical Memorandum No. 2 Ambient Water Quality		

1 Introduction

The Coachella Valley Water District (CVWD), Desert Water Authority (DWA), and Indio Water Authority (IWA) have initiated the preparation of a Salt and Nutrient Management Plan (SNMP) for the Whitewater (Indio), Mission Creek, Garnet Hill, and Desert Hot Springs Groundwater Subbasins. The preparation of the plan is in response to the requirements of the California Recycled Water Policy (Policy). The first technical memorandum (TM-1) described the methodology to be used in the development of the SNMP. This technical memorandum, TM-2, summarizes the results of the ambient water quality (AWQ) analysis, a requirement to determine the assimilative capacity of a basin, based on the methodology described in TM-1.

TM-1 and TM-2 will be used to support the development of the SNMP. The SNMP will include summaries of TM-1 and TM-2; a salt and nutrient source identification; trend summary; assimilative capacity analysis; loading estimates; anti-degradation analysis; water recycling and stormwater recharge/use goals and objectives; and monitoring plans.

Based on feedback from stakeholders, this Final TM-2 includes changes to the method and the baseline period used to calculate the ambient water quality, and hence the ambient water quality value. Descriptions of the final methods and results and presented herein; note these methods also differ from those outlined in TM-1.

1.1 BACKGROUND

In February 2009, the State Water Resources Control Board (SWRCB) adopted Resolution No. 2009-0011 which established the Policy. It requires the SWRCB and the nine Regional Water Quality Control Boards (RWQCBs) to exercise the authority granted to them by the legislation to encourage the use of recycled water, consistent with state and federal water quality laws. To achieve this goal, the Policy provides direction to California's nine RWQCBs on appropriate criteria to be used in regulating recycled water projects (SWRCB, 2009, 2013). One objective of the Policy is that salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis that ensures meeting water quality objectives and protection of beneficial uses. The Policy states that the SWRCB finds the most appropriate way to address salt and nutrient issues through the development of regional salt and nutrient management plans, as opposed to establishing requirements solely on individual recycled water projects.

1.2 SALT AND NUTRIENT MANAGEMENT PLANNING AREA

The planning area for the SNMP includes most of the Coachella Valley subbasins and subareas as shown on **Figure 1-1**. Subbasins are subdivisions, or groundwater basins within the larger Coachella Valley Basin. Subareas are further subdivisions of subbasins based on geology, water quality, areas of confined ground water, and groundwater divides (DWR, 1964). The study area is defined as the Coachella Valley floor and underlying groundwater basins, extending from the Riverside County boundary at the northern end, to the Salton Sea at the southeast end. The planning area is bounded on the west end by the jurisdictional boundary separating Desert Water Agency and Mission Springs Water District (MSWD) from the San Gorgonio Pass Water Agency. This location also corresponds to the boundary between the Whitewater River and the San Gorgonio Pass subbasins. The planning area is bounded to the northeast by the Little San Bernardino Mountains and on the southwest by the San Jacinto and Santa Rosa mountain ranges. This area is coincident with the planning area of the Coachella Valley Integrated Regional Water Management Plan. **Figure 1-2** also shows the management zones that comprise the Coachella Valley Groundwater Basin. Management zones are the areas established in the SNMP to evaluate and manage groundwater quality within the Coachella Valley. The determination of these zones is discussed in further detail in TM-1.

1.3 TECHNICAL MEMORANDUM NO. 2 CONTENTS

TM-2 presents the documentation of the determination of ambient water quality. The resulting analysis will be used in the preparation of the SNMP. TM-2 is organized as follows:

Section 1 – Introduction: This section provides an introduction to TM-2 and defines the role it plays in the development of the SNMP.

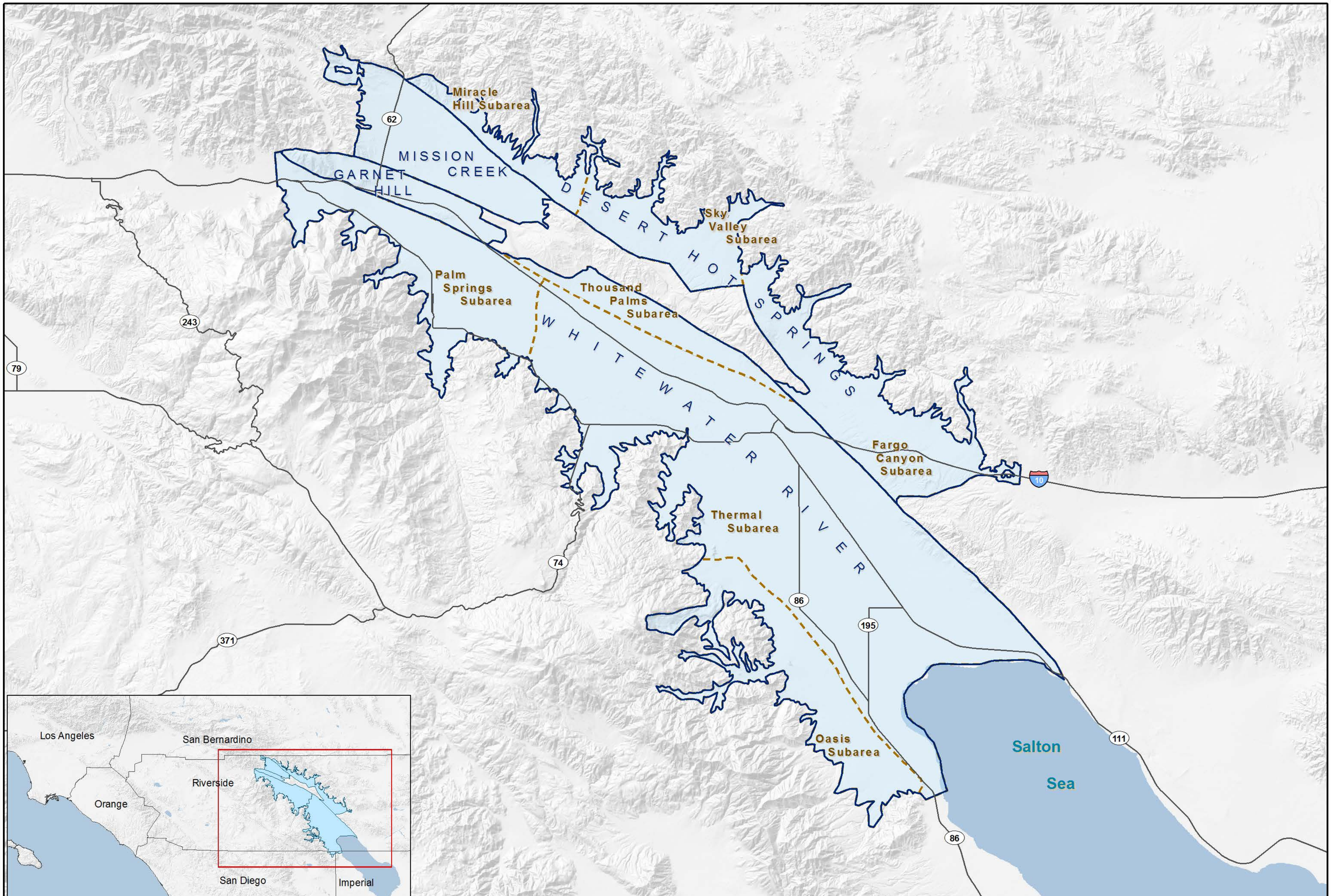
Section 2 – Ambient Water Quality Methods: Methods to calculate the AWQ within management zones are described.

Section 3 – Ambient Water Quality Results: This section summarizes the results of AWQ determination and provides summary statistics of AWQ for each management zone.

Attachment A – Determination of Data Adequacy for Ambient Water Quality Calculation: This section describes the methods applied to determine how management zones and aquifer layers ambient water quality will be represented.

Attachment B - Effective Porosity Approximation for the Volume-Weighted Average Calculation: This section describes the method to approximate effective porosity and ranges of effective porosity for similar lithologic conditions.

Attachment C – Response to Comments on Draft TM-2: Summarizes all comments received for Draft TM-2 and responses to comments.



Key to Features

Subbasins

Subareas

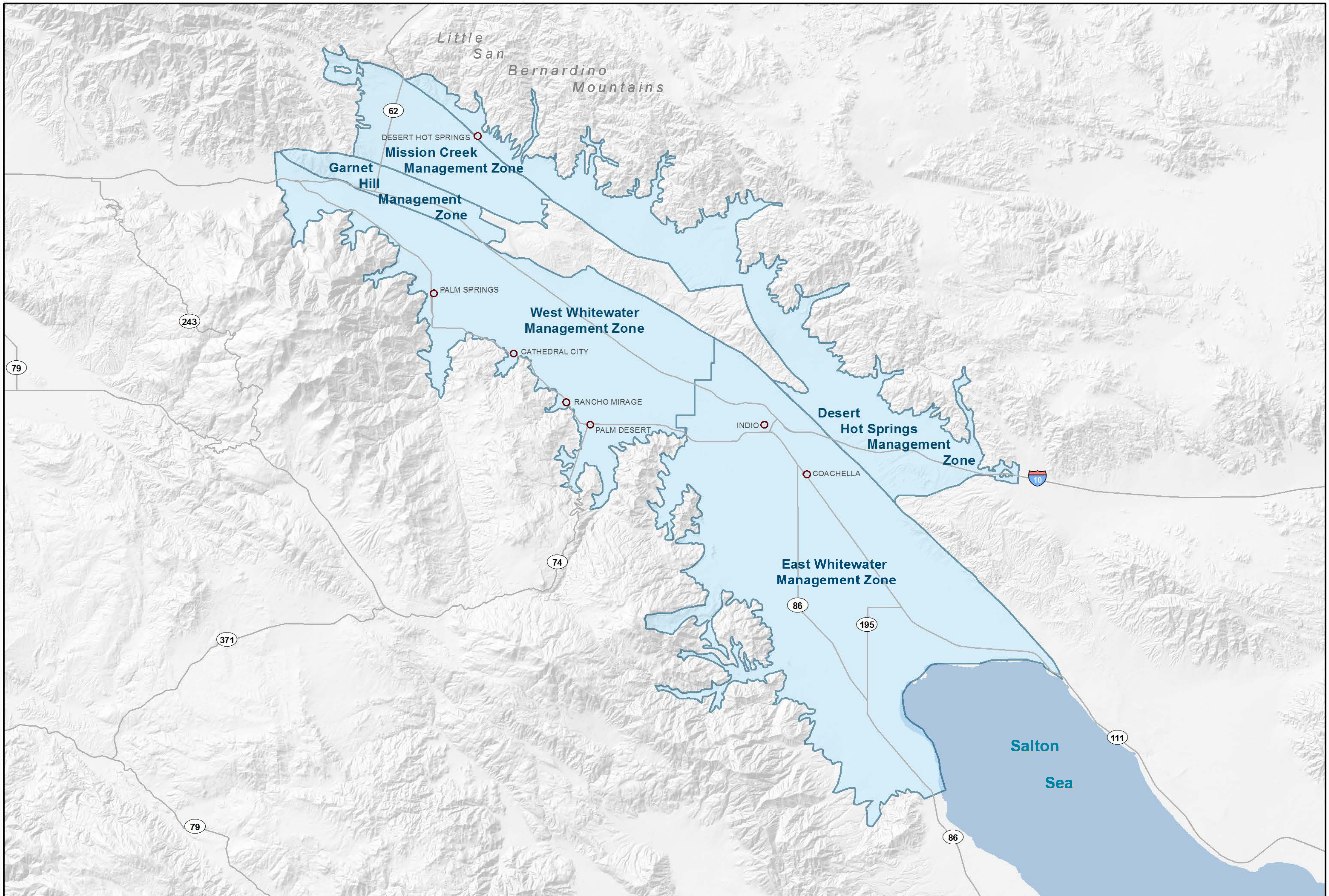
Document: \\usirv1s01\Projects\Coachella Valley WD\SNMP\AWQ\CVWD_AWQ_V3\MXD\TM02_Subareas.mxd

Date: Oct 2014

Coachella Valley Subbasins and Subareas

MWH

Figure 1-1



Key to Features

City

Management Zone

0 2.5 5 Miles

N

Document: \\usirv1s01\Projects\Coachella Valley WD\SNMP\AWQ\CVWD_AWQ_V3\MXD\MZ_Cities.mxd

Date: Feb 2015

Coachella Valley Management Zones

MWH

Figure 1-2

2 Ambient Water Quality Methods

AWQ is a single concentration value that is representative of the water quality within a management zone for a particular constituent and time. The Policy does not address ambient water quality or outline a method to determine ambient water quality, but does state "the available assimilative capacity shall be calculated by comparing the mineral water quality objective with the average concentration of the basin/sub-basin…" As outlined in TM-1, use of a single average value is proposed when data permits, or a statistical summary when data is limited. The approach of using a single value is consistent with the approaches used across the state (Todd Engineers, 2014; Santa Clara Valley Water District, 2014; Wildermuth Environmental, 2000; Los Angeles County Department of Public Works, 2014) and is recommended in *Guidance Document for Salt and Nutrient Management Plans for the San Francisco Bay Region* (Sonoma Valley County Sanitation District, 2013). The AWQ is a prerequisite for determining basin-wide assimilative capacity. Determination of the assimilative capacity is a requirement of the Policy in order to evaluate new projects. Under the Policy, planned recycled water projects are permitted to use no more than 10 percent of the available assimilative capacity for a single project and no more than 20 percent for multiple projects; those planned projects using more assimilative capacity will require additional investigation.

The AWQ is determined for TDS and nitrate (as NO_3) for this SNMP, as these constituents are representative of salts and nutrients in the Coachella Valley within this SNMP. **Figure 2-1** shows the steps leading to AWQ approximation. These data collection was discussed within TM-1, the following steps are described in greater detail in the following subsections.

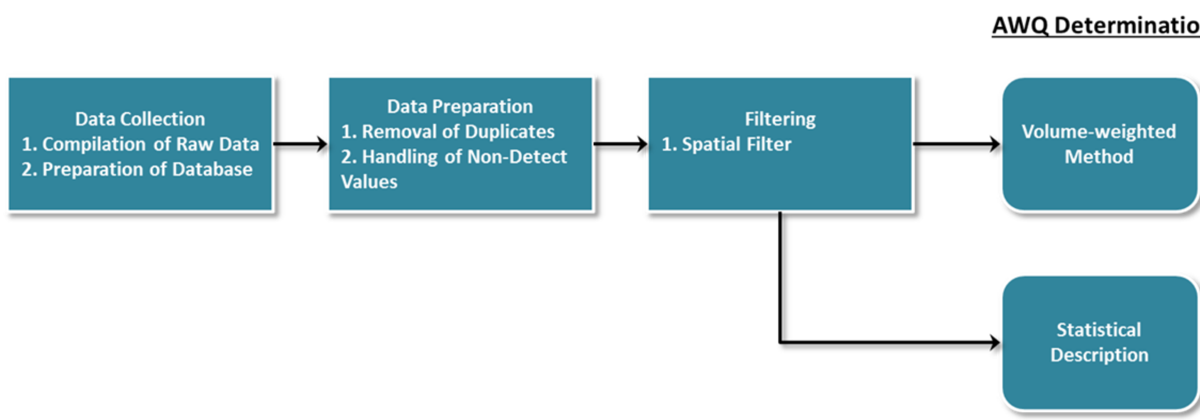


Figure 2-1
Diagram of Generalized AWQ Determination

2.1 DATA PREPARATION

Available groundwater quality data are compiled prior to the analysis of AWQ. The sources of data are presented in Section 4.2.2 – Groundwater Quality Data of TM-1. Since that time, these data have been augmented with hard copy files from the Regional Water Quality Control Board (RWQCB) and electronic data from the County of Riverside Waste Management Department, Cabazon Band of Mission Indians, Valley Sanitary District, CVWD, and DWA. These data are typically shallow wells constructed for specific projects, e.g., landfills.

Because groundwater quality data are obtained from a variety of sources, duplicates can occur and are removed as to not count a particular record more than once (duplicates are the same measurement at the same time from two different databases). Duplicates are determined by generating unique identifiers for each particular record that includes the well name, record date, and analyte concentration. Those unique identifiers that occur more than once are removed such that only one record remains.

In addition, data sources may report non-detect (ND) values in several different ways. Some examples include:

- non-detect, i.e. "ND", with method detection limit;
- non-detect, i.e. "ND", with no method detection limit;
- zero value, i.e. "0"; and
- less than method detection limit, i.e. "< MDL".

For the AWQ calculation, all nitrate non-detects are represented as half the most common minimum detection limit, 0.01 mg/L as NO_3, for three reasons:

1. not all data has a method detection limit available for each record;
2. numerical values for all results allow the calculation of summary statistics; and
3. all non-detects are treated in the same way.

This approach is consistent with the substitution method presented in the United States Environmental Protection Agency (EPA) guidelines – Data Quality Assessment: Statistical Methods for Practitioner (EPA, 2006).

2.2 FILTERING

A temporal filter and spatial filter are applied to the original dataset, hereafter referred to as the unfiltered dataset, to generate a filtered dataset on which AWQ analyses will be conducted. The reason for spatial filtering is to eliminate bias introduced by the nature of sampling. These biases are (1) frequency bias, (2) age/type bias, and (3) location bias. Note that even though a filtered dataset is used for AWQ determination, unfiltered data summaries are provided for transparency and to show the effects of filtering. Each dataset, filtered and unfiltered, has inherent uncertainties, but used together they can provide insight into the variability of groundwater quality. A review of the data and the filtering to create the filtered dataset is provided in the following sections.

When considering the time period for the AWQ calculation, the quantity of data points gained from using older records must be balanced with the desire characterize current water quality (less data). To evaluate the potential impact of older data a trend analysis was completed. Water quality trends were reviewed in TM-1 that considered historical and vertical records throughout the Valley. Trends indicated lower concentrations typically with depth and increasing concentration typically with time. To evaluate trends quantitatively, a Mann-Kendall analysis was completed herein. A Mann-Kendall trend analysis tests for statistically significant trending in water quality records.

A Mann-Kendall test is a widely used method for evaluating trends that compares samples for a particular well and tests for a positive (increasing) or negative (decreasing) trend result for a particular level of statistical significance; see Data Quality Assessment: Statistical Methods for Practitioner (EPA, 2006). Only records with a prescribed number of well records could be considered, hence not all wells in the Valley could be evaluated. The results of the Mann-Kendall trend analyses for TDS and nitrate are shown on **Figure 2-2** and **Figure 2-3**, respectively. Note both analyses indicate an increasing trend in concentration with time. Based on this consistent result, using older records may underestimate the AWQ if the objective is to represent current water quality. Therefore, to obtain the most representative AWQ, the most recent measurements are used for each well.

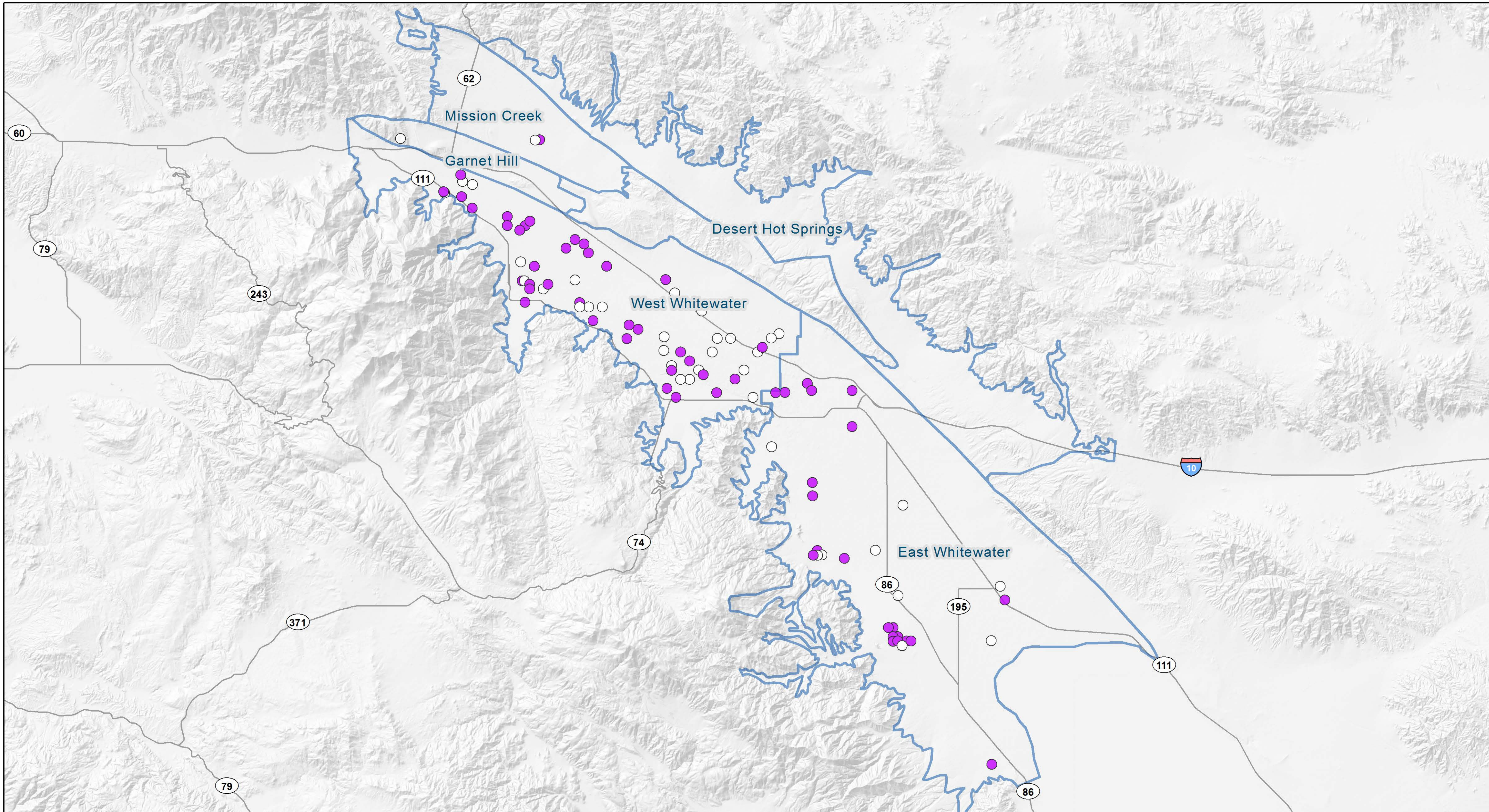
The use of the most recent measurements is a change in approach from the first draft of TM-2 and the method outlined in TM-1. Note that due to the change in approach, the filtered dataset statistical summaries have changed from the draft version of TM-2.

2.2.1 Temporal Filter

The most recent measurement of TDS or nitrate for a well is used to represent the concentration for that well. If there is more than one measurement in the same year of the most recent measurement, the median of those measurements is used; this reduces the chance of selecting a statistical outlier for a particular well. This temporal filter avoids underestimating water quality for wells showing trends and leverages the median for wells with significantly more data to minimize the selection of statistical outliers. Using a representative value for each well minimizes the frequency and age/type biases discussed above as each well contributes equally. This value is referred to as the *baseline well concentration*.

2.2.2 Spatial Filter – Location Bias

A significant portion of the data used is from drinking water supply wells. In general, these production wells are sited in areas close to a water distribution system, i.e., near developed communities and in areas having reasonably good water quality. Similarly, production wells are typically drilled sufficiently deep to produce the desired yield and avoid layers of poor quality. Therefore, water quality data will cluster around these areas. Using all the wells in the calculation of AWQ will skew results towards the water quality around dense well zones. To address this, a 1,000 foot by 1,000 foot grid is applied to group well data within a grid cell. If screen interval data exist for wells in a particular management zone, groundwater model layers or sub-layers are used to subdivide data into aquifer layers such that baseline well concentrations are grouped by cell and layer. For continuity with previous groundwater modeling, the grid cells and layering from the Coachella Valley groundwater model (Fogg *et al.*, 2002) or Mission Creek groundwater model (Psomas, 2013) are used. The mean of baseline well concentrations for each cell are used to obtain the final filtered dataset. A conceptual diagram of the spatial filter is shown on **Figure 2-4**.



Key to Features

Management Zone

Highway

Mann-Kendall test at 5% significance level

Decreasing

No Trend

Increasing

N

0 5 10 Miles

Document: \\Usirv1s01\Projects\Coachella Valley WD\SNMP\AWQ\CVWD_AWQ_V3\MXD\WQ_MannKendall.mxd

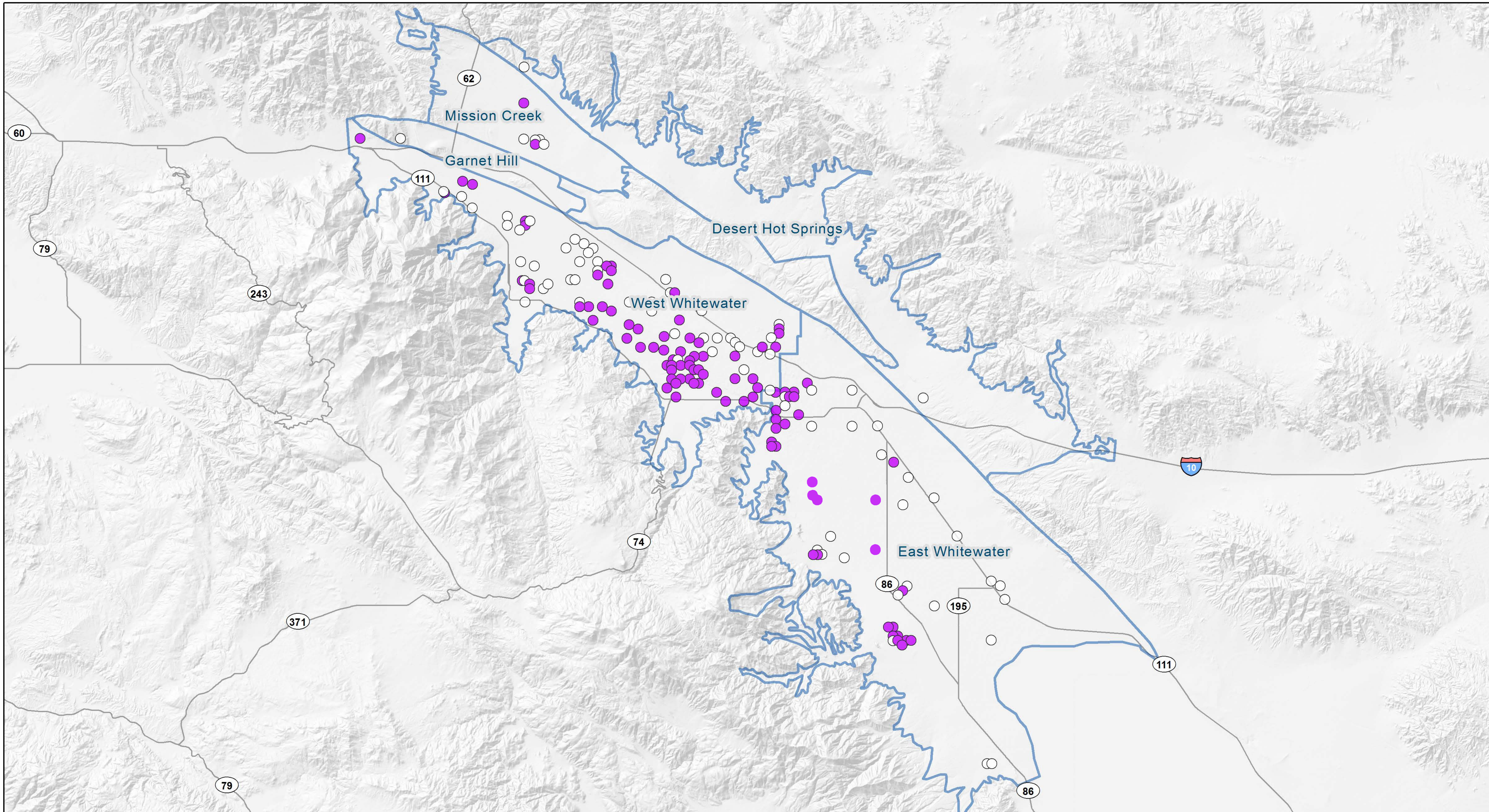
Date: February 10, 2014

Total Dissolved Solids Mann-Kendall Trend Analysis 1980 - 2014

MWH

Figure 2-2

This map has been designed to print size 11'' by 17''.



Key to Features

Management Zone

Highway

Mann-Kendall test at 5% significance level

Decreasing

No Trend

Increasing

N

0 5 10 Miles

Document: \\Usirv1s01\Projects\Coachella Valley WD\SNMP\AWQ\CVWD_AWQ_V3\MXD\WQ_MannKendall.mxd

Date: February 10, 2014

Nitrate
Mann-Kendall Trend Analysis
1980 - 2014

MWH

Figure 2-3

This map has been designed to print size 11'' by 17''.

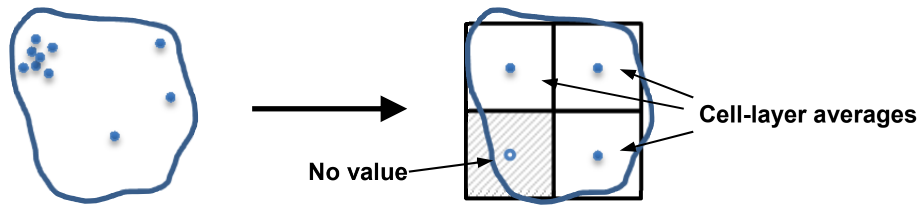


Figure 2-4
Conceptual Diagram of the Spatial Filter that Occurs for Each Management Zone and Layer if Applicable

2.3 METHODS TO DETERMINE AMBIENT WATER QUALITY

Two methods are used for the determination of AWQ. A statistical description of AWQ is presented for each management zone and a volume-weighted AWQ is computed for management zones with adequate data to support the volume-weighted method. Data required for the volume-weighted method includes sufficient water quality data for wells with known depth information, aquifer thickness and effective porosity, and groundwater level.

2.3.1 Data Adequacy for Ambient Water Quality Calculation

During the development of this document, stakeholders made several comments regarding the determination of when contouring should be applied to approximate management zone water quality. The determination of data adequacy for contouring water quality within a management zone to thereby apply the volume-weighted AWQ method, is not a simple question to answer. In fact, this quantification has not has not been made within any other SNMPs within the state; rather, it is typically based on professional judgment. That being said, **Attachment A** describes the methods applied to help determine how management zones and aquifer layers ambient water quality will be represented, specifically, if there is sufficient data to contour water quality. This subject is discussed in detail within the attachment, but the basis of the determination is the following key factors:

- Spatial distribution of data points – The two dimensional arrangement of the data points within a management zone or aquifer layer has a marked effect on the ability to approximate values with certainty. Are data point numerous but grouped in the same location? Are data points evenly distributed across the management zone?
- The assumption of autocorrelation – Autocorrelation assumes that value of a surface are more closely related to nearby points and less related to distant points. If the points are related inferences can be made regarding values between the points.
- Supporting statistics – the underlying summary statistics must support high or low auto correlation and can assist in the decision to develop a contoured surface.

The question of data adequacy is largely dependent on the amount of data available. Therefore, the baseline period chosen has large consequences. **Attachment A** evaluates the key factors above for a 5-, 10-, 15-, and 20-Year baseline period. The goal is to use the shortest baseline period possible that supports the contouring of groundwater quality necessary for the volume-weighted method (see **Section 2.3.3**) to minimize the occurrence of older data; e.g., the most recent data for a certain well may be old if it was destroyed or abandoned.

Based on this evaluation, 5- and 10-Year baseline periods, it was determined that these periods were too short, i.e., too few data points, to support groundwater contouring The 15-Year period was often sufficient. Accordingly, the results presented in **Section 3** use the most recent measurements for any well no older than in the 15 years (1999 to 2013) for filtered data, and all records in the same 15-Year period for unfiltered data. See **Attachment A** for a thorough discussion of all recommendations from the data adequacy evaluation.

2.3.2 Statistical Description

Statistical analyses of water quality data are performed and summarized for each management zone over the period of 1999 to 2013. The statistical descriptions are useful for management zones that lack significant well depth information or have limited water quality data, as there is not sufficient water quality and aquifer information to complete the volume-weighted method.

Descriptive statistics are provided for both unfiltered and filtered datasets. AWQ is evaluated based on the filtered dataset; a 95 percent two-tailed confidence interval on the mean filtered water quality data may be used to determine a range for AWQ in management zones where the volume-weighted method is not appropriate. **Table 2-1** presents definitions of the statistical analyses performed for the management zone statistical description.

Table 2-1
Statistical Descriptors Used to Describe Ambient Water Quality

Statistical Descriptor	Definition in this SNMP	As the Descriptor relates to:	
		Unfiltered Data	Filtered Data
Count	The total number of data points available for a particular constituent and time period within a management zone	Number of individual lab analysis results	Number of filtered data points (as defined in filtering methods)
Mean	The arithmetic mean of all results, or the sum of the results divided by the count	Average of all lab results	Average of filtered data points
Median	The value separating the upper half of all results from the lower half	Middle value of all lab results	Middle value of filtered data points
Mode	The value that appears most often in a set of results	Most common lab result (if one exists)	Most common filtered data point (if one exists)
Standard Deviation	A measure of the amount of variation or dispersion from the average; a lower standard deviation implies that the individual results are closer to the mean of the results	Variation of all lab results	Variation of filtered data points
Range	The lowest and highest result in the dataset	Lowest and highest lab result	Lowest and highest filtered data point; filtered data range will always be less than or equal to the range of unfiltered data
Confidence Interval	An estimated range of values which is likely to include the mean of the population; the width of the confidence interval indicates the possible uncertainty of the mean; e.g., a 95 percent confidence interval has a 95 percent probability of containing the population mean	Measure of how certain the computed mean is compared to the true mean; a wider interval indicates lower certainty	Filtered confidence interval will typically be greater than the confidence interval for unfiltered data due to the reduced size of data points

2.3.3 Volume-weighted Method

The volume-weighted method for determination of AWQ is used when an adequate amount of data exist for a particular management zone. This method weights the average water quality by the amount of mass of a consentient in storage.

2.3.3.1 Approximating Water Quality

If there is enough data to contour water quality constituents, the following steps are taken to prepare contour maps. Upon completion of data preparation and filtering, the filtered dataset is contoured, which provides inferred concentration values in areas where no wells (or water quality data) are present. Water quality is contoured initially by interpolating the filtered dataset with the Kriging method (Matheron, 1978). The Kriging method is a widely-accepted geostatistical interpolation method that attempts to express trends suggested in the underlying data. The contours generated by this method are then refined by hand. The hand contouring considers horizontal and vertical trends, water quality from wells with no available depth information (for management zones contoured by layer) and knowledge of the underlying geology, groundwater flow direction, recharge activity, land use, and professional judgment. The final contours are the result of an iterative process with numerical interpolation and hand contouring.

Resulting cell concentrations are multiplied by the volume of water in storage in each cell, the results are totaled and then divided by the total water volume in the management zone to obtain a volume-weighted AWQ. In management zones where data availability supports layering, this process is completed at the model layer/aquifer level. A conceptual diagram of the steps involved in the volume-weighted method is shown on **Figure 2-5**.

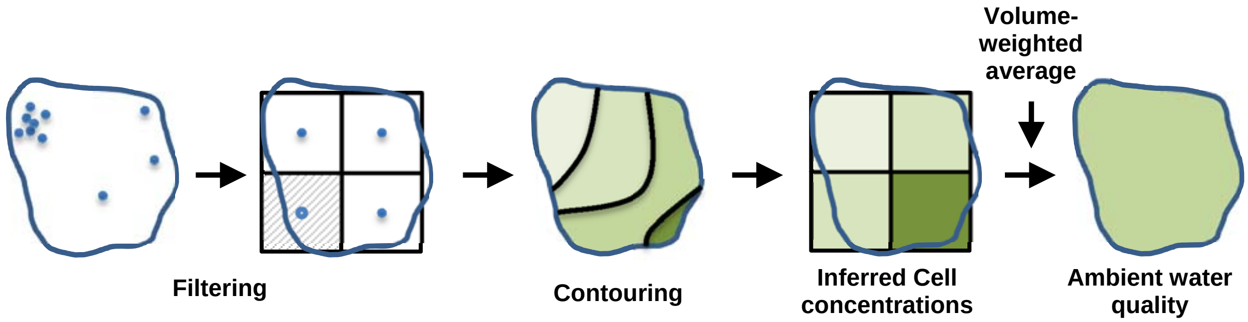


Figure 2-5
Conceptual Diagram of the Volume-weighted Method

In addition to water quality, groundwater level data is also filtered and contoured in a similar fashion. The water level contours are then used to generate a water level surface and values from the surface at the cell centers are assigned to each cell within the management zone.

To determine the volume of water in each cell volume between the water level surface and the base of the aquifer, the effective porosity for each cell and layer is needed. Total porosity is defined as the ratio of void space to the total volume of a geologic formation. The effective porosity is the portion of the void space of a porous material that is capable of transmitting (and thereby mixing) a fluid and excludes clay-bound water (water that is electrochemically attached to clay particles that does not contribute to flow). Effective porosity occurs because a fluid in a saturated porous media will not flow through all voids, but only through the voids which are interconnected. Effective porosity is typically higher than specific yield (the volume of water that can be drained by gravity). The method used to determine the effective porosity of each cell and layer is summarized in **Attachment B**. **Attachment A** discusses the particular layering used for each management zone and all special circumstances associated with data gaps; these are also described in **Section 3**.

The volume of water in each cell is calculated as:

$$Vol_{i,j} = (n_e)_{i,j} \times Area_i \times (H_{sat})_{i,j} ,$$

where i is the cell, j is the layer, n_e is the effective porosity of the cell and layer, and H_{sat} is the saturated thickness of the cell and layer.

The effective porosity is already corrected for lithostatic loading as a function of depth in the model calibration for hydraulic conductivities. **Table 2-2** lists the total area and total water in storage by management zone. **Figure 2-6** shows a conceptual representation of the cells and layers.

The AWQ of a management zone is the total mass in all cells and layers divided by the total volume of water in storage in all cells and layers:

$$AWQ_{volume-weighted} = \frac{\sum_i \sum_j \left(C_{i,j} \times Vol_{i,j}\right)}{\sum_i \sum_j Vol_{i,j}} ,$$

where $C_{i,j}$ is the concentration in cell i and layer j. This method requires sufficient water quality data for wells with known depth information; aquifer properties such as layer thickness, effective porosity, and groundwater level; and well-distributed data in both the horizontal and vertical.

Table 2-2
Summary of Management Zone Area and Total Storage

Management Zone	Total Gridded Area (mi^2)	Volume in Storage (AF)	Grid Cells
West Whitewater River	151	23,626,936	4,212
East Whitewater River	265	54,191,116	7,388
Mission Creek	49	4,618,693	1,365
Garnet Hill	20	N/A	559
Desert Hot Springs	114	N/A	3,189

N/A indicates that aquifer properties are not available and volume-weighted method is not determined for Garnet Hill Management Zone or Desert Hot Springs Management Zone.

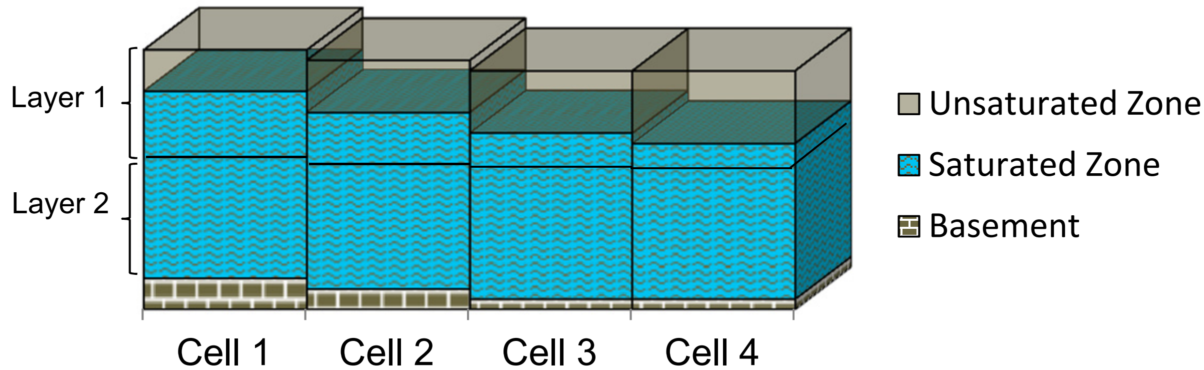


Figure 2-6
Conceptual Representation of Model Cells and Layers

2.3.4 Recommended Methods for Each Management Zone

Attachment A describes the methods applied to help determine how management zones and aquifer layers ambient water quality will be represented, specifically, if there is sufficient data to contour water quality. The analysis also provides recommendations for each management zone base on spatial distribution of data points, autocorrelation, and supporting summary statistics. Listed below are the recommended AWQ methods for each management zone.

West Whitewater MZ: Three layers were evaluated within this management zone. For Layer 2 and Layer 3, use the most current data in any cell, apply temporal filters as needed. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years to fill areas of poor spatial distribution.

Regarding Layer 1, all baseline periods failed to provide enough data for contouring. Given the lack of available data, it is recommended that in place of contouring a range of constant value be assumed for Layer 1 to calculate the volume weighted AWQ. Use of the minimum and maximum for the 15-Year baseline is proposed. Using these single values for Layer 1 will provide a range of AWQ for the aggregated West Whitewater Management Zone AWQ value.

East Whitewater MZ: Three layers were evaluated within this management zone. For Layers 1 through 3, the most current data in each cell should be used, apply temporal filters as needed. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years to fill areas of poor spatial distribution.

Mission Creek MZ: Two layers were evaluated within this management zone. Sufficient data was not present to support two aquifer layers. Therefore, the recommendation is to limit the contouring and AWQ calculation to the eastern portion of the management zone. To limit the area, use half the distance between a boundary and the nearest well with water quality data. For this portion, use the most current data in any cell. Check the most current data point to determine if it is an outlier or constant with older records or continuing a trend. Use older records to 15 years if needed to fill areas of poor spatial distribution.

Garnet Hill MZ: No spatial autocorrelation could be evaluated for any baseline period within Garnet Hill Management Zone due to a lack of data. The recommendation for this management zone is to provide a statistical summary and range for AWQ.

Desert Hot Springs MZ: Spatial autocorrelation could not be evaluated for the Miracle Hill or Sky Valley Subareas within Desert Hot Springs Management Zone due to a lack of data. Similarly, spatial distribution in these areas is limited by data availability. Within Fargo Canyon, a strong positive spatial autocorrelation is observed for TDS in all baseline periods. Nitrate shows strong positive spatial autocorrelation in the 5-Year baseline period. Spatial distribution in these areas is poor due to limited data availability. The recommendation for this management zone is to provide a statistical summary and range of AWQ.

3 Ambient Water Quality Results

This section summarizes the results of the AWQ determination. All analyses used water quality data for wells during the 15-Year period of 1999 to 2013. As discussed in TM-1, this baseline period is selected because it represents the most recent twenty-year period having water quality data. A twenty-year period is used to ensure a statistically significant sample of the historical water quality data because TDS is normally sampled once every three years.

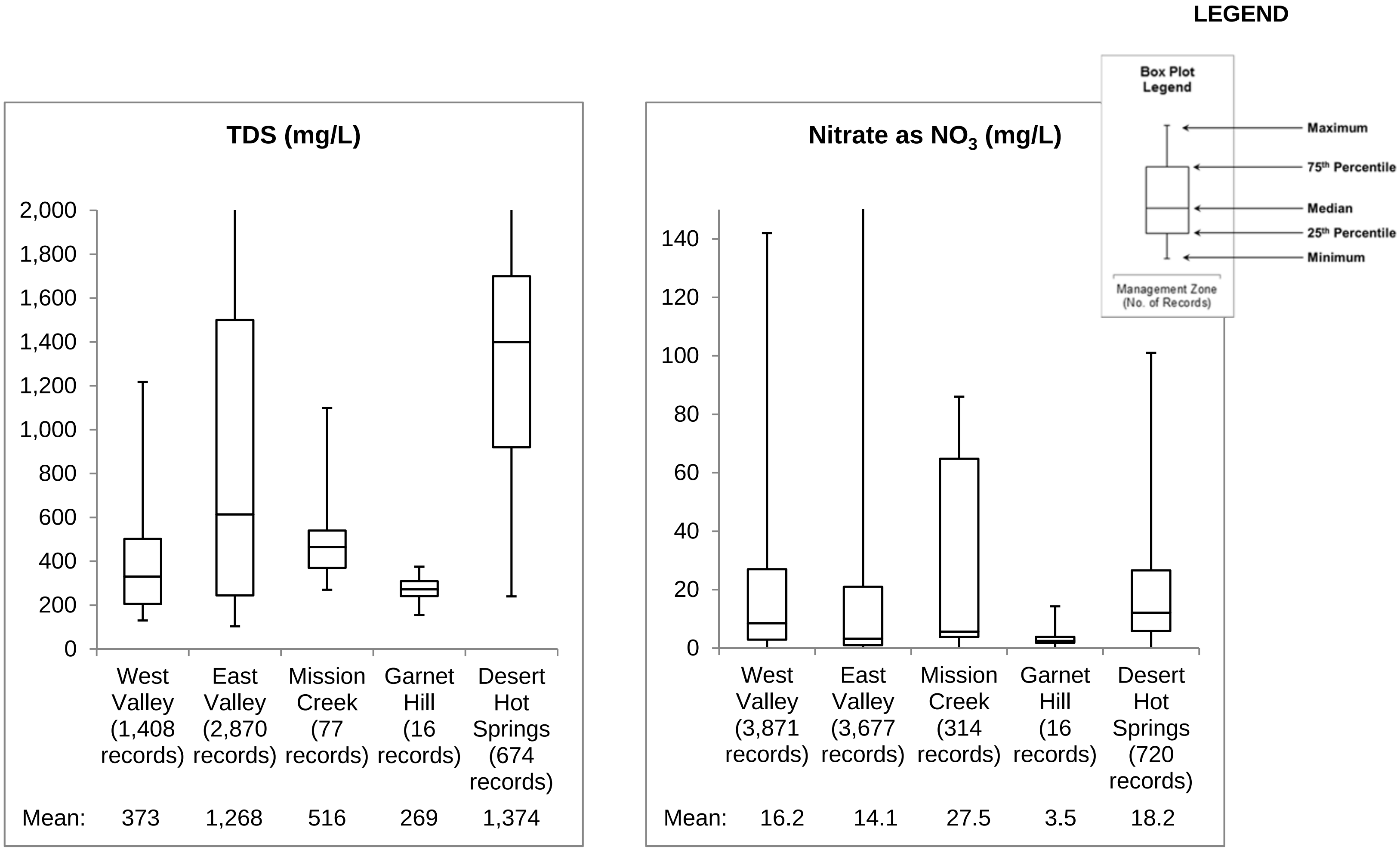
Two sets of statistical descriptions of AWQ are prepared for each management zone: the first set provides statistical descriptions of the unfiltered data within a management zone, and the second set will describe AWQ using the filtered dataset within a management zone. These two sets are presented to demonstrate the effects of the data filtering methods and to provide a deeper understanding of the AWQ. The statistical descriptors presented in this section follow from Section 2.3.1.

Box plots are shown in **Figure 3-1** to illustrate the range of water quality from the unfiltered dataset by management zone. This figure provides convenient visual summaries of the unfiltered data and shows the following:

- The median, or center, of the data (the line contained within the box)
- The range, or variation, of the data (total box height)
- The extreme values in the data (the vertical lines extending from the box)

In addition to the statistical descriptions, a volume-weighted AWQ is calculated for those management zones with adequate horizontal and vertical groundwater quality, aquifer parameter, and water level data. The AWQ for West Whitewater River, East Whitewater River, and Mission Creek management zones include this volume-weighted analysis.

Figure 3-1
Box Plots for of Unfiltered Data for Each Management Zone (1994-2013)



Note:
Maximum recorded TDS concentration for East Valley is 29,000 mg/L;
Maximum recorded TDS concentration for Desert Hot Springs is 2,570 mg/L.

Note:
Maximum recorded nitrate (as NO_3) concentration for East Valley is 260 mg/L.

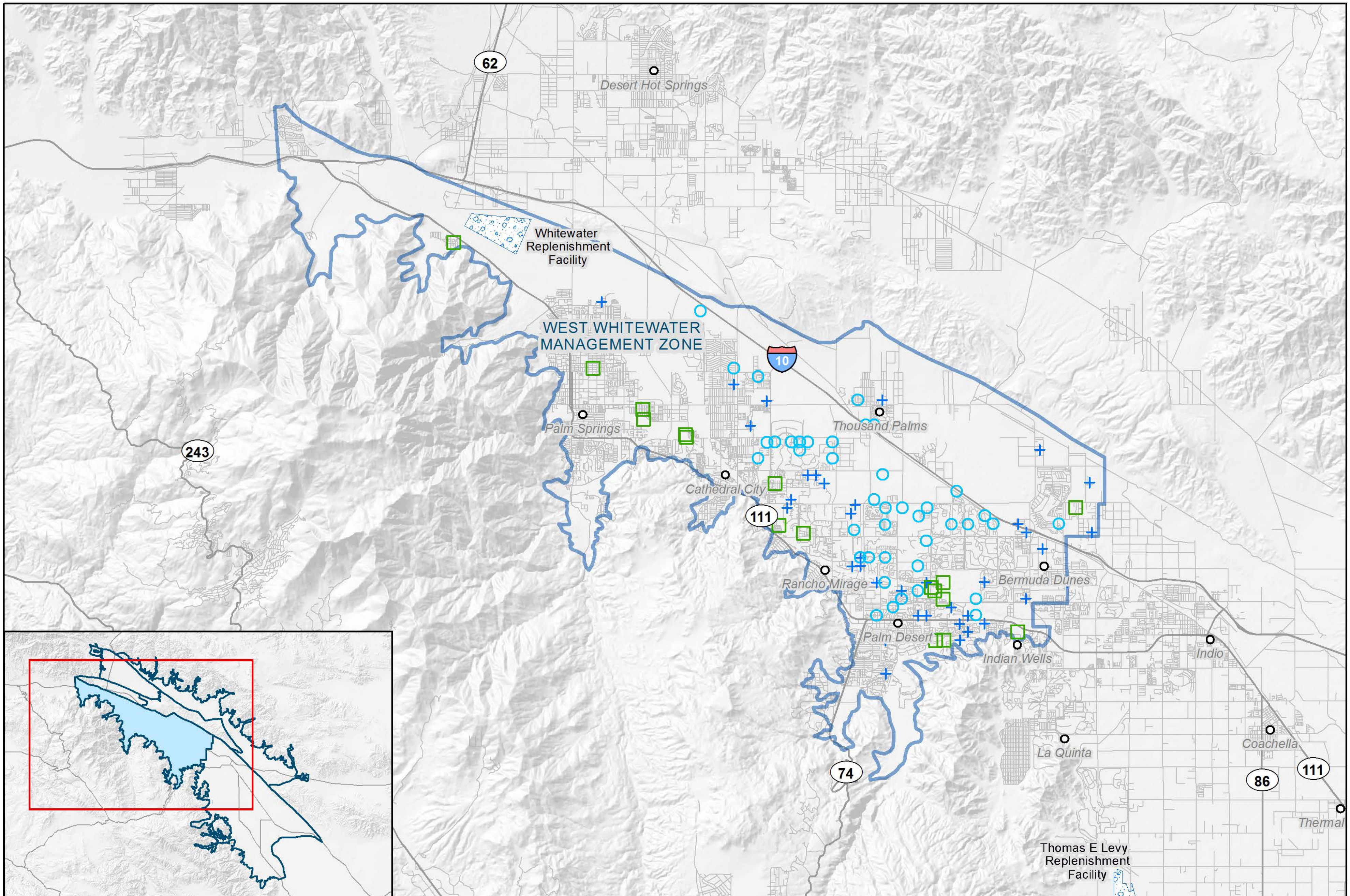
3.1 WEST WHITEWATER RIVER MANAGEMENT ZONE

The West Whitewater River Management Zone is comprised of the Palm Springs Subarea, the Thousand Palms Subarea, and the northern portion of the Thermal Subarea of the Whitewater River Subbasin. It lies south of the Garnet Hill Fault, west of the Indio Hills, east of the San Jacinto Mountains, and extends southeast to approximately Indian Wells. Groundwater is unconfined in this management zone. The fill materials within this area are essentially heterogeneous alluvial fan deposits with little sorting, with some finer clay layers present in the southern portion of the management zone near Palm Desert and Indian Wells. The thickness of these water bearing materials is not known because no wells extend to bedrock; however, it exceeds 1,000 feet (CVWD, 2010). Gravity survey data indicate the basement rock is in excess of 12,000 ft in the Whitewater River subbasin near the San Andreas Fault (DWR, 1964). The Ocotillo conglomerate underlies Holocene (Recent) fanglomerate in the Subarea at depths ranging from 300 to 400 feet (DWR, 1964).

All results are summarized by the layers used in the volume-weighted method. West Whitewater River Management Zone is separated into three layers. The upper portion of the aquifer, approximately less than 450 feet below ground surface, is grouped into Layer 1; the middle of the aquifer, approximately 450 to 750 feet below ground surface, into Layer 2; and the bottom of the aquifer, depths greater than approximately 750 feet below ground surface, is Layer 3.

3.1.1 Summary of Unfiltered Data

The unfiltered dataset for the West Whitewater River Management Zone consists of 1,843 water quality records during the period of 1999 to 2013. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-2**. The unfiltered dataset for West Whitewater River Management Zone contains 584 TDS records and 1,259 nitrate records. Nitrate is more frequently monitored in wells than TDS because groundwater is typically more likely to see short term changes in nitrate levels. The statistical summary of unfiltered data for the West Whitewater River Management Zone is presented on **Table 3-1**.



Key to Features

Management Zone

Highway

City

Local Roads

Groundwater Well Location
Type of Aquifer Penetrated

Layer 1

Layer 2

Layer 3

N

0 2.5 5 Miles

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West Whitewater Wells with Water Quality Records in 1999-2013

MWH

Figure 2-2

Table 3-1
Descriptive Statistics of Unfiltered Data for West Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	364	383	58	323	162	553
Mean (mg/L)	550	24.7	370	28.6	199	9.5
Median (mg/L)	525	12	361	29.7	190	3
Mode (mg/L)	540	11	400	32	200	3
Std. Dev. (mg/L)	161	29	175	19.7	61	13
Range (mg/L)	140 to 1,100	ND to 142	169 to 842	1.6 to 120	140 to 770	ND to 112
95% Confidence Interval (mg/L)	534 to 567	21.7 to 27.6	324 to 416	26.4 to 30.7	189 to 208	8.4 to 10.6

ND = non-detect

3.1.2 Statistical Description of Ambient Water Quality

The filtered dataset (temporal and spatial filter) for West Whitewater River Management Zone consists of 80 TDS values and 81 nitrate values. The statistical summary of filtered data for the West Whitewater River Management Zone is presented on **Table 3-2**.

TDS in West Whitewater River Management Zone typically decreases with depth. Higher TDS appears in the shallower part of the aquifer down gradient of the Whitewater Recharge Facility and in wells from Rancho Mirage to Palm Desert. Some higher TDS also occurs within the Thousand Palms Subarea at the very east of the management zone (cities, subareas, and management zones are shown on Figure 1-1 and Figure 1-2).

Nitrate concentrations within West Whitewater River Management Zone are generally less than the MCL except for high nitrates observed in wells of varying depths between Rancho Mirage and Palm Desert. There is a general decrease in nitrate concentrations with depth.

The true mean TDS of the filtered dataset falls within the interval of 426 to 656 mg/L, 336 to 492 mg/L, and 188 to 220 mg/L for Layer 1, Layer 2, and Layer 3, respectively, with a probability of 95 percent; for nitrate (as NO_3), this interval is from 10.9 to 52.7 mg/L, 22.8 to 51 mg/L, and 3.6 to 12.8 mg/L for Layer 1, Layer 2, and Layer 3, respectively. The higher nitrates that appear from Rancho Mirage to Palm Desert have a large effect on the summary statistics of West Whitewater River Management Zone.

Table 3-2
Descriptive Statistics of Filtered Data for West Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	14	14	28	29	38	38
Mean (mg/L)	544	31.8	414	36.9	204	8.2
Median (mg/L)	520	10.4	375	28.5	195	3.2
Mode (mg/L)	N/A	N/A	302	2.7	210	3
Std. Dev. (mg/L)	194	36.2	201	37	49	14
Range (mg/L)	201 to 1,060	1.2 to 101	169 to 842	1.6 to 120	160 to 420	1.9 to 76
95% Confidence Interval (mg/L)	432 to 656	10.9 to 52.7	336 to 492	22.8 to 51	188 to 220	3.6 to 12.8

ND = non-detect

3.1.3 Volume-weighted Ambient Water Quality

For the determination of volume-weighted ambient water quality, West Whitewater River MZ is separated into three layers. The upper portion of the aquifer, approximately less than 450 feet below ground surface, is grouped into Layer 1; the middle of the aquifer, approximately 450 to 750 feet below ground surface, into Layer 2; and the bottom of the aquifer, depths greater than approximately 750 feet below ground surface, is Layer 3. Water quality is estimated for each layer based on water quality information specific to that layer. Adjacent layer data and wells perforated in multiple aquifers are also used as a reference to approximate water quality concentrations. Note that these depths vary with location according to the model grid described in earlier TM-1 to take advantage of known aquifer geometry.

Shallow groundwater quality data is a known data gap in West Whitewater River Management Zone. For this reason, Layer 1 is not contoured, and instead the 15-year minimum and maximum values for TDS and nitrate found for Layer 1 in **Table 3-2** are used as a low and high range for the average water quality in Layer 1, yielding a low and high total AWQ.

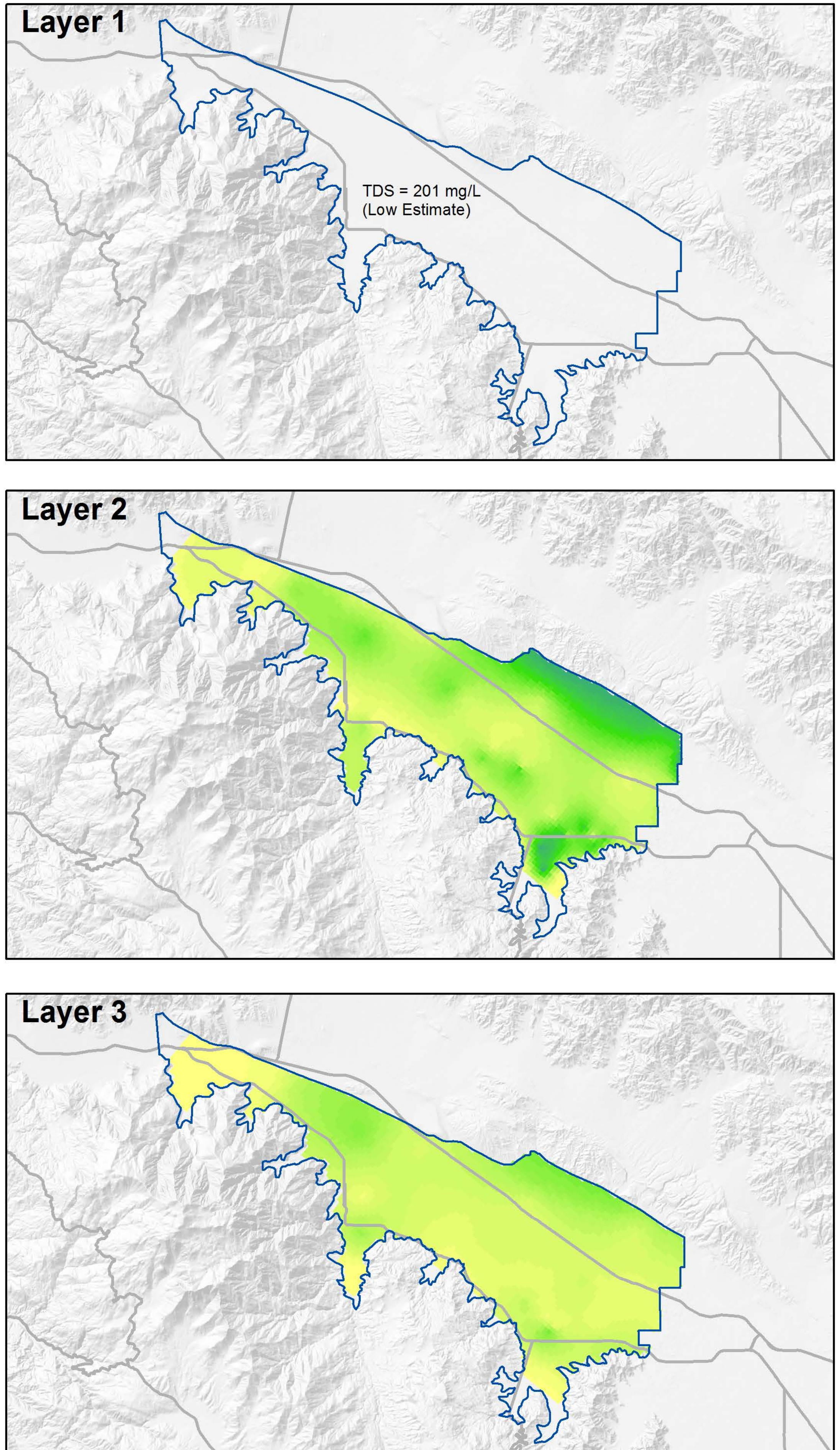
Table 3-3 summarizes the results of the volume-weighted AWQ determination for West Whitewater River Management Zone. Water quality is contoured by layer and TDS/nitrate concentrations are assigned to each cell by layer. Layers are then aggregated using the volume-weighted method to generate the total volume-weighted AWQ. **Figure 3-3** and **Figure** illustrate the relative TDS and nitrate concentrations, respectively, in the West Whitewater River Management Zone by layer and an aggregated total.

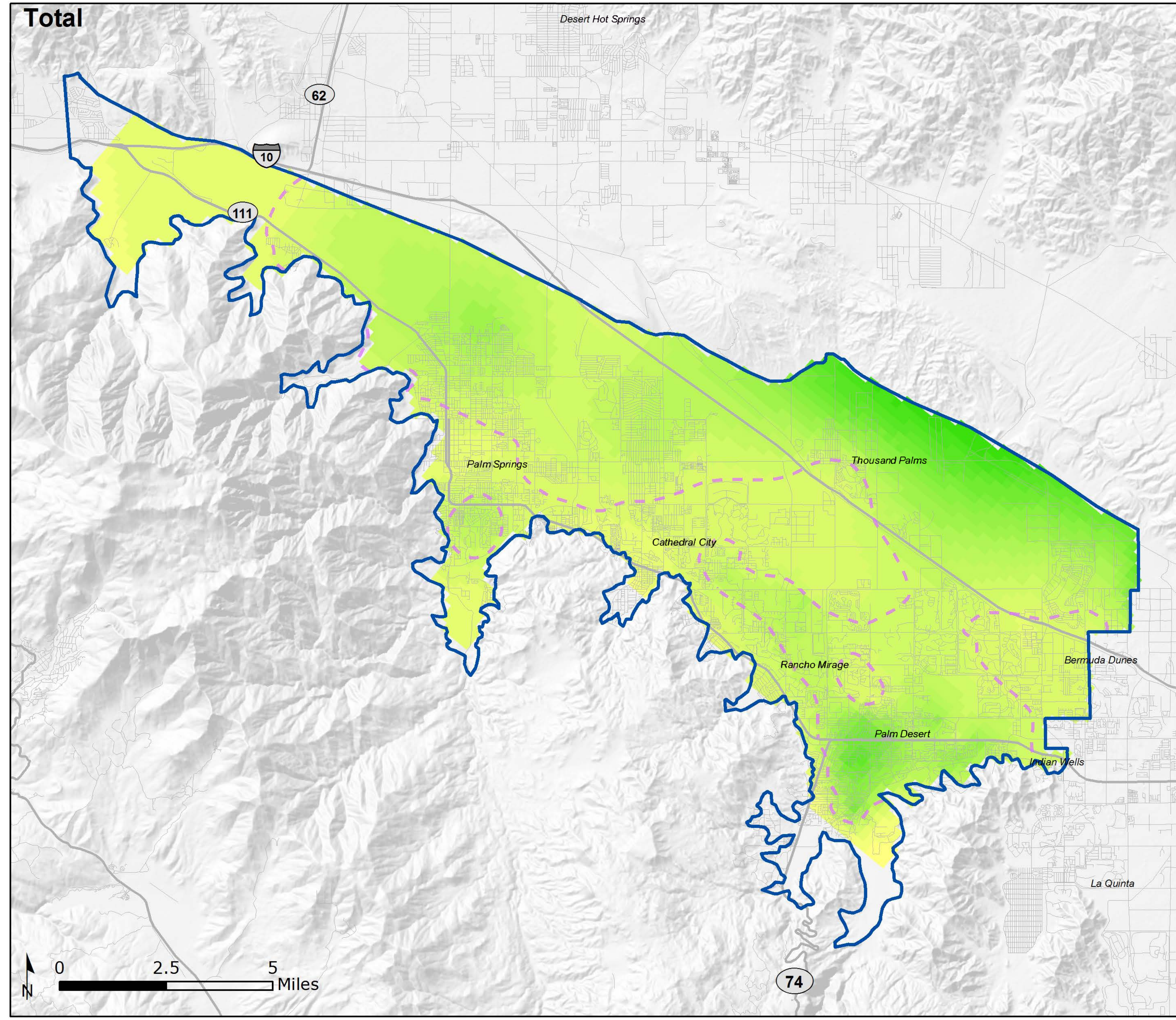
Table 3-3
Volume-weighted Ambient Water Quality for West Whitewater River Management Zone

Aquifer Zone	Total Dissolved Solids (mg/L)	Nitrate as NO_3 (mg/L)
Layer 1	201 to 1,060	1.2 to 101
Layer 2	323	14.3
Layer 3	224	5.0
Total	**252 to 450**	**7 to 30**

The volume-weighted AWQ for TDS in West Whitewater River Management Zone is between 252 and 450 mg/L. TDS concentrations are generally low throughout West Whitewater River. The TDS exceeds the volume-weighted AWQ in three areas: (1) north of Palm Springs to the southeast of the Whitewater Recharge Facility, (2) areas in Thousand Palms Subarea, and (3) in the vicinity of Palm Desert and Indian Wells.

The volume-weighted AWQ for nitrate (as NO_3) in West Whitewater River Management Zone is between 7 and 30 mg/L. Nitrate concentrations are generally below the volume-weighted AWQ from the north end of West Whitewater River to Cathedral City. The Thousand Palms Subarea and surrounding areas are also relatively low in nitrate. The region above the nitrate AWQ is on the southern boundary of West Whitewater River Management Zone just southeast of Palm Springs extending to Palm Desert and the East Whitewater River Management Zone.





Total Dissolved Solids

100 mg/L

1,500 mg/L

1,500 mg/L

19,100 mg/L

Estimated Ambient Water Quality Contour

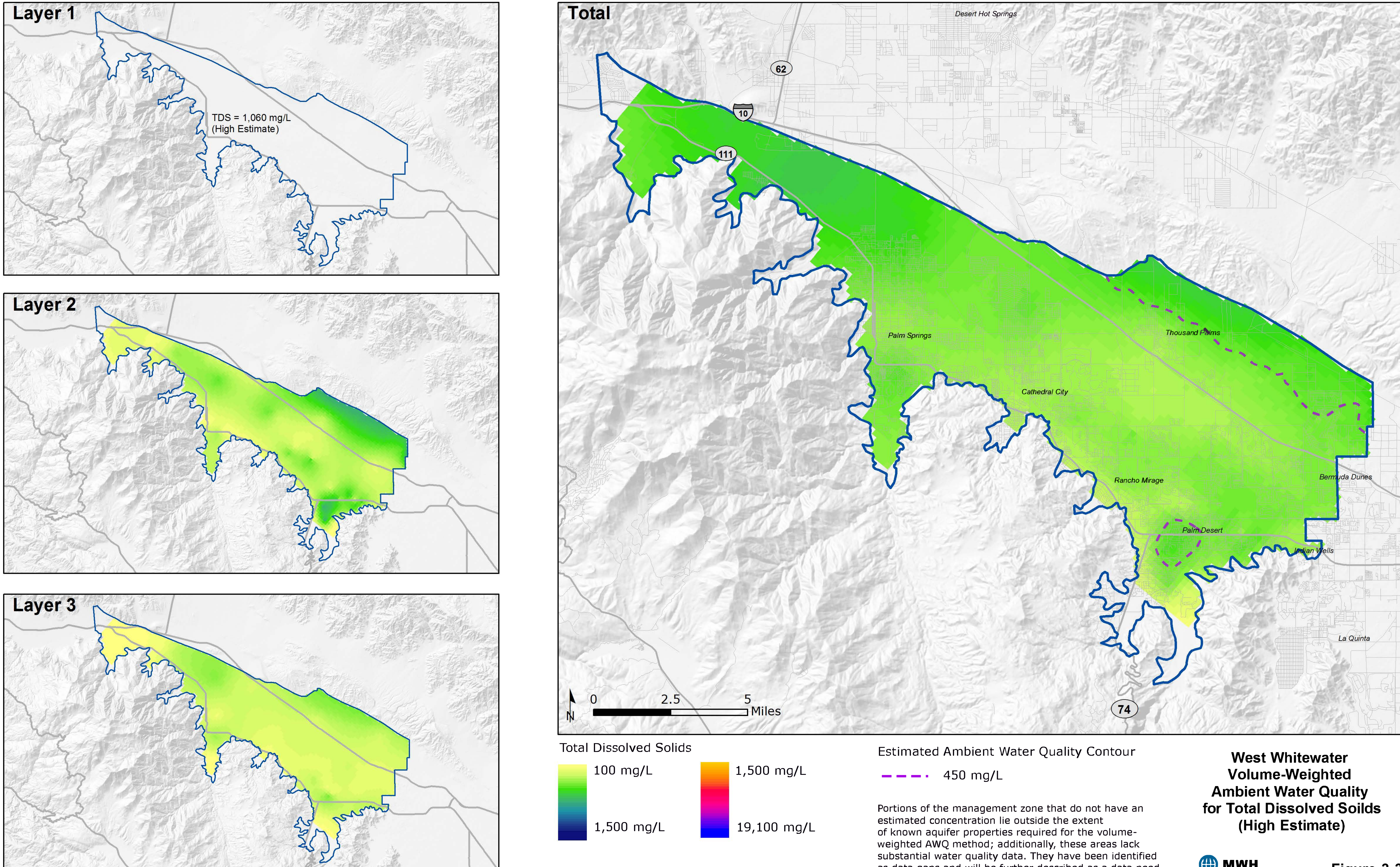
252 mg/L

Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

West Whitewater Volume-Weighted Ambient Water Quality for Total Dissolved Soilds (Low Estimate)

MWH

Figure 3-3a



Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

West Whitewater Volume-Weighted Ambient Water Quality for Total Dissolved Soilds (High Estimate)

MWH

Figure 3-3b

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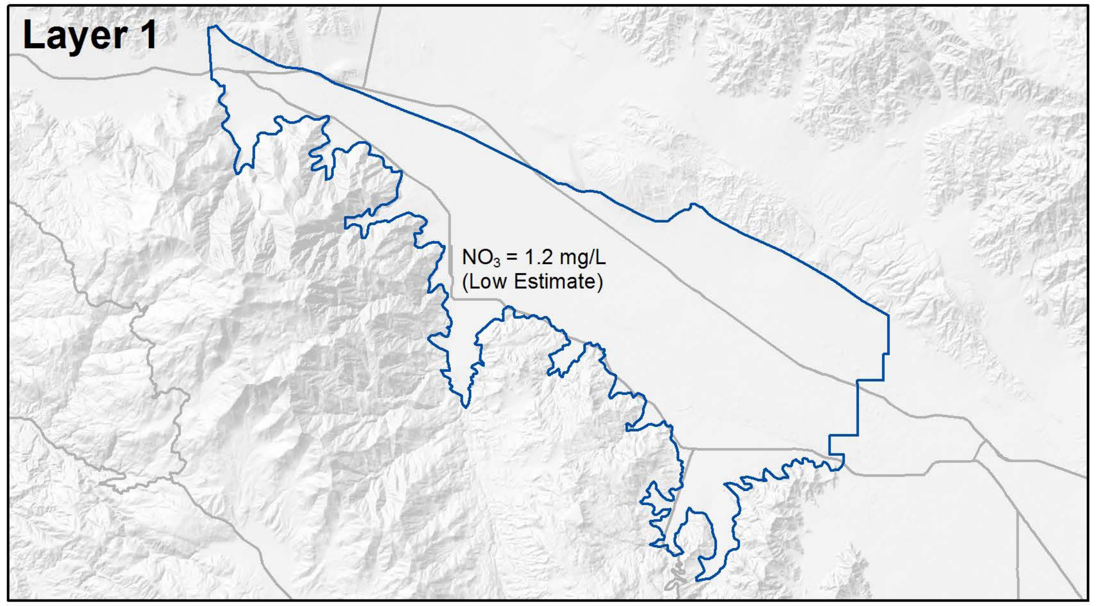
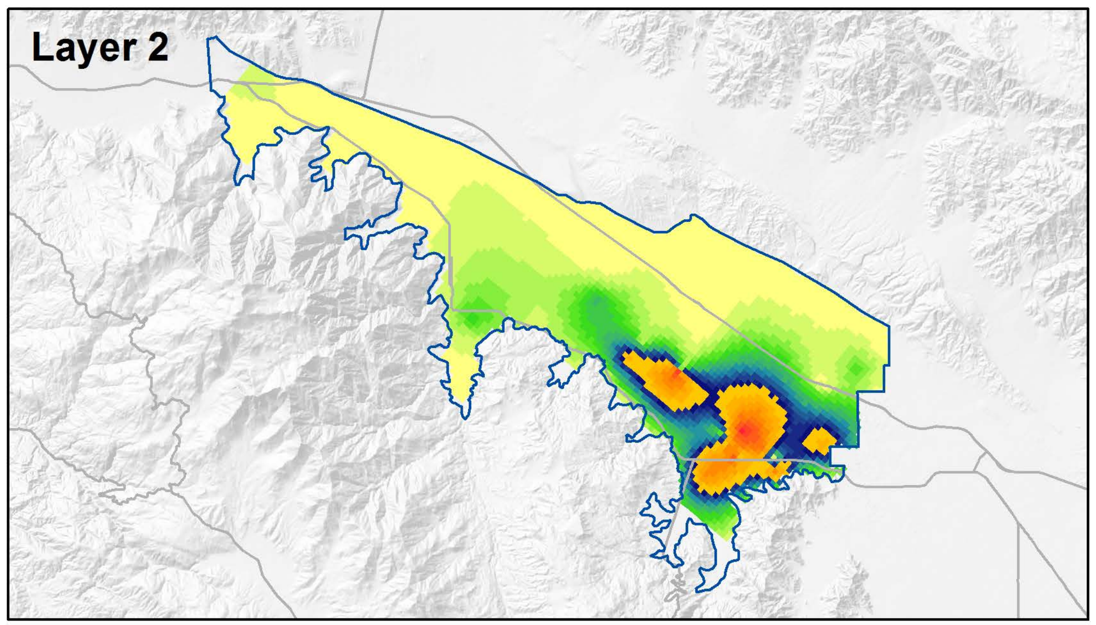
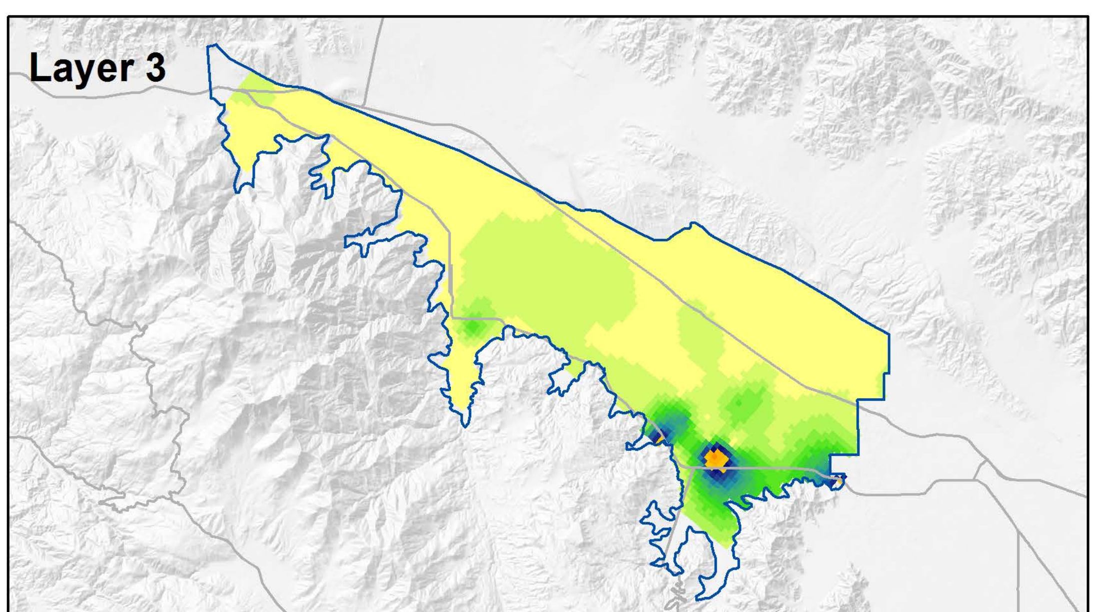
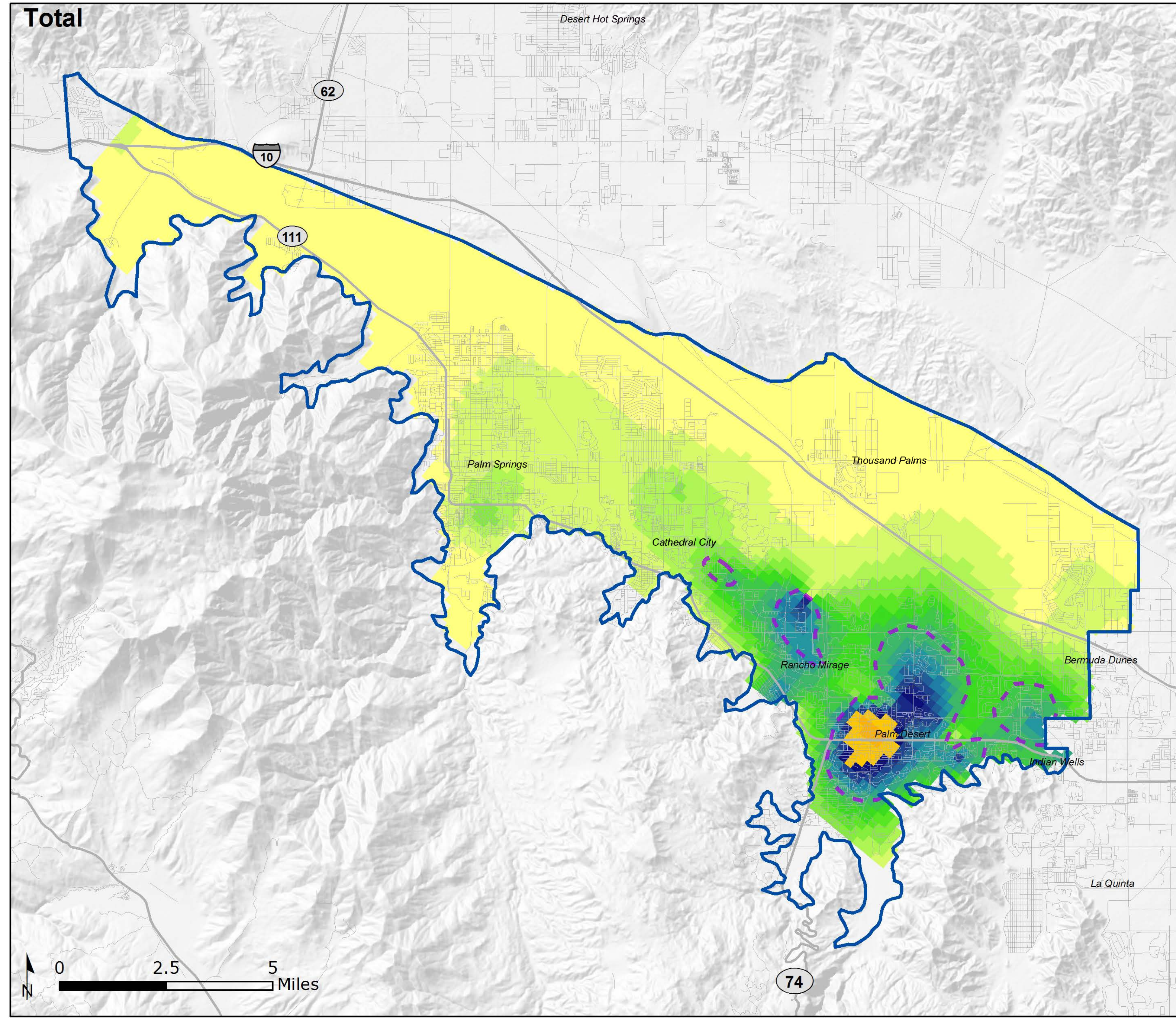








Nitrate (as NO_3)

Non-Detect

45 mg/L

45 mg/L

230 mg/L

Estimated Ambient Water Quality Contour

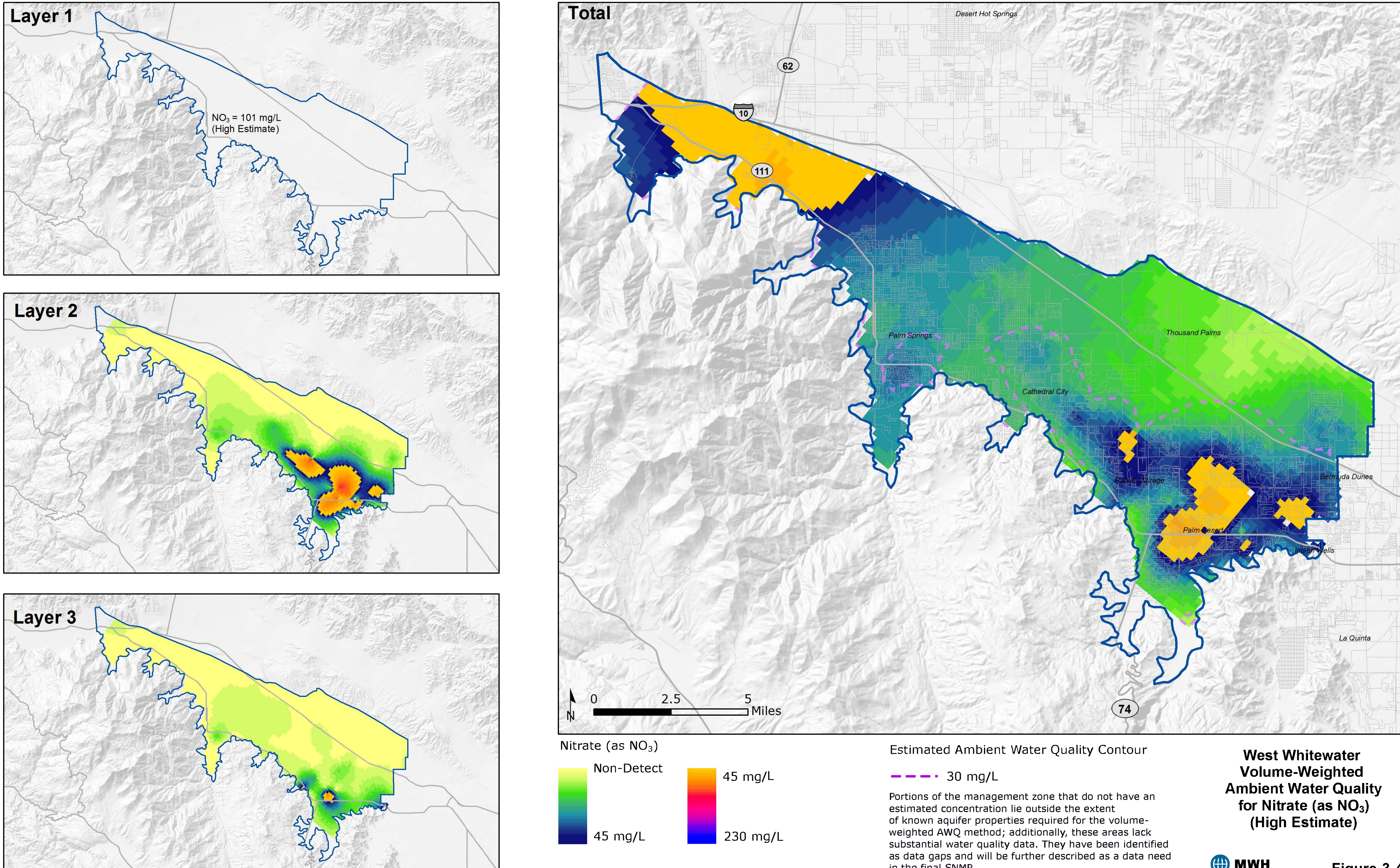
7 mg/L

Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

West Whitewater Volume-Weighted Ambient Water Quality for Nitrate (as NO_3) (Low Estimate)

MWH

Figure 3-4a



West Whitewater Volume-Weighted Ambient Water Quality for Nitrate (as NO_3) (High Estimate)

Figure 3-4b

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3.2 EAST WHITEWATER RIVER MANAGEMENT ZONE

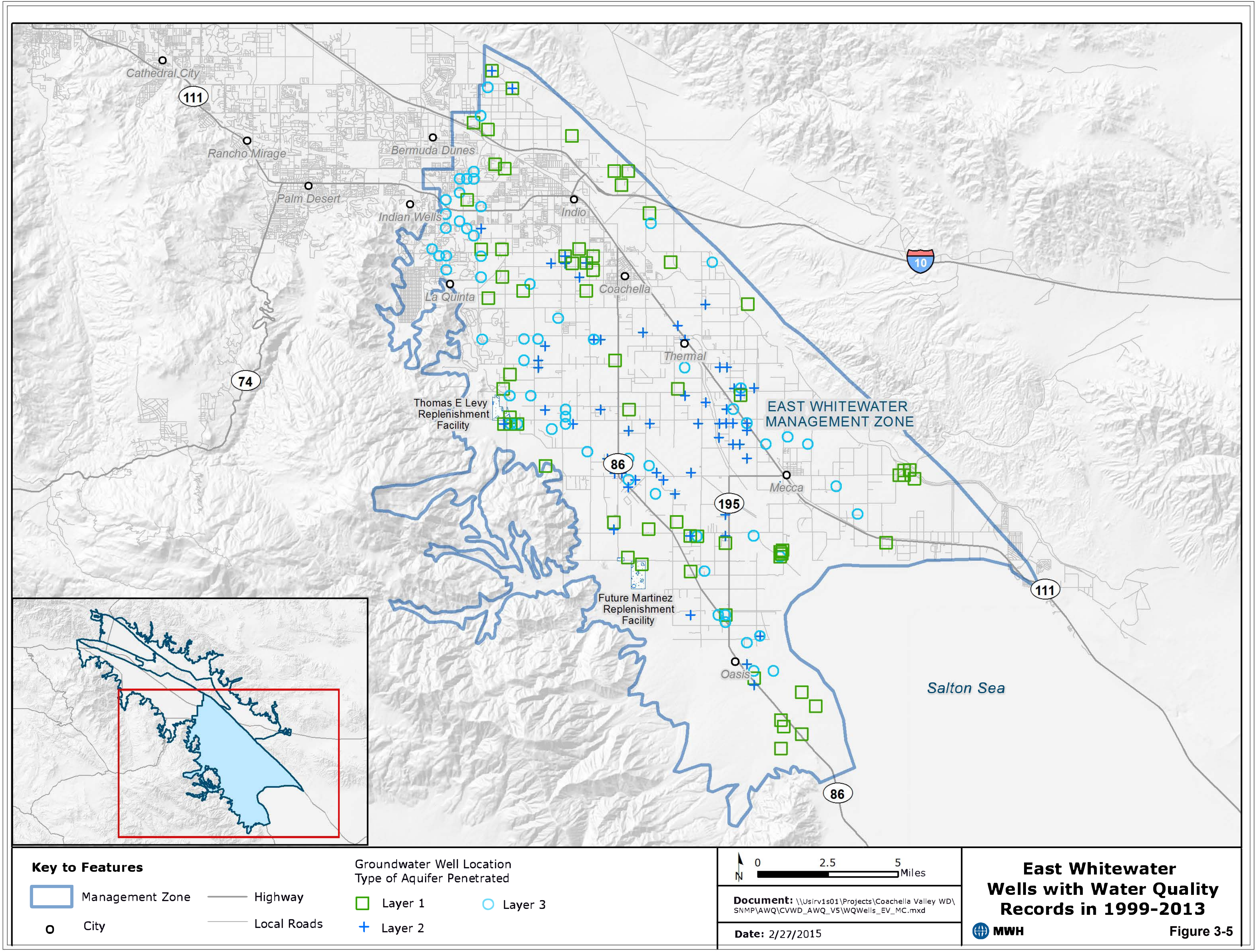
The East Whitewater River Management Zone is comprised primarily of the southern portion of the Thermal Subarea, the Oasis Subarea, and a small portion of the Thousand Palms Subarea of the Whitewater River Subbasin. This management zone is west of the San Andreas Fault zone, east of the San Jacinto Mountains and southeast of the West Whitewater River Management Zone. Groundwater travels southeastward through the interbedded sands, silts, and clays underlying the central portion of the East Whitewater River. The division between the West Whitewater River Management Zone and East Whitewater River Management Zone extends from Point Happy near the Indian Wells-La Quinta boundary and Highway 111 northeasterly to the Indio Hills at the northern extension of Jefferson Street.

Two aquifers separated by a zone of fine-grained materials were identified from well logs (DWR, 1964). An aquitard separates upper and lower aquifer zones in the management zone. In much of the management zone, the upper aquifer is capped at the ground surface with clays and silts with minor amounts of sand. Semi-perched groundwater occurs in this capping zone, which is up to 100 feet thick. No recent water quality data exists for the semi-perched aquifer as it is not used beneficially. Subsurface tile drainage systems were installed in the 1950s to control the high water table conditions, to allow reclamation of saline soils, and to intercept poor quality return flows. All agricultural drains empty into the Salton Sea, or into the Coachella Valley Stormwater Channel, which also flows into the Salton Sea. Each of the four water-bearing zones, from shallowest to deepest, is described earlier in TM-1.

All results are summarized by the layers used in the volume-weighted method. East Whitewater River Management Zone is separated into three layers. The upper aquifer, approximately less than 400 feet below ground surface, is grouped into Layer 1; a top portion of the confined aquifer, approximately 400 to 600 feet below ground surface, into Layer 2; and the bottom of the confined aquifer, depths greater than approximately 600 feet below ground surface, is Layer 3. Layer 1 also includes any data from the perched aquifer.

3.2.1 Summary of Unfiltered Data

The unfiltered dataset for the East Whitewater River Management Zone consists of 3,711 water quality records during the period of 1999 to 2013. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-5**. It should be noted that groundwater quality data in the semi perched aquifer is a known data gap and will be identified in the monitoring portion of the final SNMP. The unfiltered dataset for East Whitewater River Management Zone contains 1,765 TDS records and 1,946 nitrate records. Nitrate is more frequently monitored in wells than TDS because nitrate levels in groundwater can exhibit greater variability over shorter time periods. The statistical summary of unfiltered data for the East Whitewater River Management Zone is presented on **Table 3-4**.



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East Whitewater Wells with Water Quality Records in 1999-2013

MWH

Figure 3-5

Table 3-4
Descriptive Statistics of Unfiltered Data for East Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	1,017	992	201	201	547	753
Mean (mg/L)	1,497	23.7	621	4.7	2,191	3.5
Median (mg/L)	864	7.2	287	1.1	272	0.3
Mode (mg/L)	1,600	ND	980	ND	150	ND
Std. Dev. (mg/L)	2,986	32.3	587	7.8	3,644	10.7
Range (mg/L)	135 to 29,000	ND to 260	104 to 2,000	ND to 33	120 to 15,910	ND to 221
95% Confidence Interval (mg/L)	1,313 to 1,681	21.7 to 25.8	539 to 702	3.6 to 5.8	1,885 to 2,497	2.8 to 4.3

ND = non-detect

3.2.2 Statistical Description of Ambient Water Quality

The filtered dataset for East Whitewater River Management Zone consists of 132 TDS values and 131 nitrate values. The statistical summary of filtered data for the East Whitewater River Management Zone is presented on **Table 3-5**.

A particular deep nested monitoring well is included in this dataset that is located near the Salton Sea that is sampled much more frequently than other wells. High salinity is found in the lower two intervals, 1,220 to 1,260 feet and 1,430 to 1,470 below ground surface. These readings have a significant effect on the summary statistics of the unfiltered dataset. The filtered dataset minimizes the bias induced by the more frequent sampling at these wells.

Higher TDS readings appear in some lower aquifer wells between La Quinta and Coachella, as well as in Oasis Subarea, and west of the Salton Sea. High TDS also appears in the lower aquifer in areas between Thermal and Mecca, south of La Quinta, and in a deep monitoring well near the Salton Sea. Higher TDS reading are also found in the upper aquifer within the Thousand Palms Subarea, to the north of the management zone. Very high TDS measurements were found in shallow groundwater monitoring wells at the Mecca Landfill site.

Nitrate is generally low within East Whitewater River Management Zone except for high nitrate in the Oasis area and the upper aquifer west of Desert Hot Springs Management Zone. In general, nitrate decreases from the upper to the lower aquifer of East Whitewater River.

Table 3-5
Descriptive Statistics of Filtered Data for East Whitewater River (1999-2013)

	Layer 1		Layer 2		Layer 3	
Statistic	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**	**Total Dissolved Solids**	**Nitrate as NO_3**
Count	41	41	43	43	48	47
Mean (mg/L)	1,509	24.7	362	3.9	355	6.5
Median (mg/L)	698	3.6	202	0.8	180	2.2
Mode (mg/L)	665	ND	162	ND	160	ND
Std. Dev. (mg/L)	3,081	45.4	360	6.5	510	18.3
Range (mg/L)	152 to 19,100	ND to 230	104 to 1,750	ND to 28	123 to 3,270	ND to 111
95% Confidence Interval (mg/L)	537 to 2,482	10.4 to 39	251 to 472	1.9 to 5.9	207 to 503	1.1 to 11.8

ND = non-detect

The mean TDS of the filtered dataset falls within the interval of 537 to 2,482 mg/L, 251 to 472 mg/L, 207 to 503 mg/L for Layer 1, Layer 2, and Layer 3, respectively, with a 90 percent probability; for nitrate (as NO_3), this interval is from 10.4 to 39 mg/L, 1.9 to 5.9 mg/L, and 1.1 to 11.8 mg/L for Layer 1, Layer 2, and Layer 3, respectively. The filtered dataset provides a substantially different view of TDS in the statistical summary because the contribution of the frequently sampled nested monitoring well with high TDS is normalized to that of other wells in the East Whitewater River. As expected, **Table 3-5** strongly suggests that TDS concentrations are generally lower in the lower aquifer compared to the upper aquifer.

3.2.3 Volume-weighted Ambient Water Quality

For the determination of volume-weighted ambient water quality, the East Whitewater River Management Zone is separated into three layers. The upper aquifer (generally less than 400 feet below ground surface), inclusive of any perched aquifer data, is evaluated as one contoured layer. The top portion of the lower aquifer (extending from 400 to 600 feet below ground surface) is the next contoured layer. The bottom of the lower aquifer (generally greater than 600 feet below ground surface) is the final contoured layer. Note that these depths vary with location according to the model grid described in TM-1 to take advantage of known aquifer geometry.

Table 3-6 summarizes the results of the volume-weighted AWQ determination for East Whitewater River Management Zone. Water quality concentration is contoured in three layers: the upper, unconfined system and two subdivisions of the lower, confined aquifer due to its thickness. Concentrations are assigned to each cell in each layer. Layers are then aggregated using the volume-weighted method to generate the total volume-weighted AWQ. **Figure 3-6** and

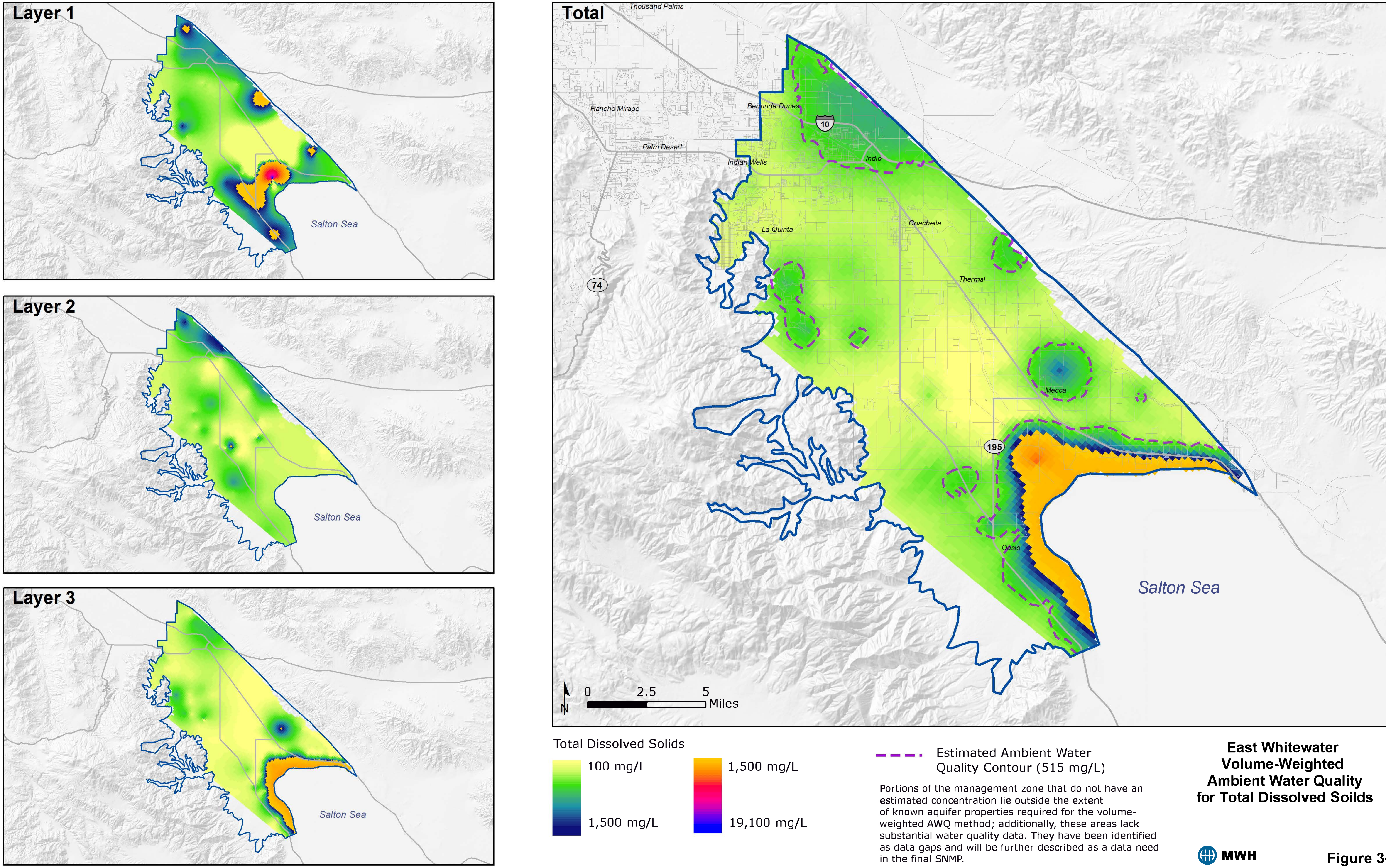
Figure 3-7 illustrate the relative TDS and nitrate concentrations, respectively, for each layer and the total management zone (an aggregate of all three layers, or the two aquifer systems) of East Whitewater River Management Zone.

Table 3-6
Volume-weighted Ambient Water Quality for East Whitewater River Management Zone

Aquifer Zone	Total Dissolved Solids (mg/L)	Nitrate as NO_3 (mg/L)
Layer 1	789	10.1
Layer 2	366	8.6
Layer 3	470	5.8
Total	**515**	**7.0**

The volume-weighted AWQ for TDS in East Whitewater River Management Zone is 515 mg/L. The lower aquifer generally has lower TDS than the upper aquifer; there are some locations in the lower aquifer near Salton Sea where high TDS concentrations have been observed with nested wells (e.g., nested well 07S09E30R01S screened at 1,430 to 1,470 feet below ground surface). It is not known if TDS concentration increases in very deep sediments farther from the Sea as there are no monitoring wells installed in this zone away from the Sea. Areas with TDS concentrations higher than the volume-weighted AWQ include: (1) areas near the Thousand Palms Subarea, (2) isolated zones southwest of Indio, (3) areas near Desert Hot Springs Management Zone, and (4) the east end of the Oasis Subarea.

The volume-weighted AWQ for nitrate (as NO_3) in East Whitewater River Management Zone is 7.0 mg/L. The lower aquifer has marginally less nitrate content than the upper aquifer, in general. Along the center of East Whitewater River, nitrate is generally below the volume-weighted AWQ with a large amount of undetected concentrations. Nitrate concentrations higher than the volume-weighted AWQ occur in: (1) the southern boundary of East Whitewater River at the border of West Whitewater River Management Zone extending to the southeast, (2) the southern parts of Thousand Palms Subarea, (3) the southern boundary with Desert Hot Springs Management Zone extending southeast to the Salton Sea, and (4) much of Oasis Subarea.



East Whitewater Volume-Weighted Ambient Water Quality for Total Dissolved Soilds

Figure 3-6

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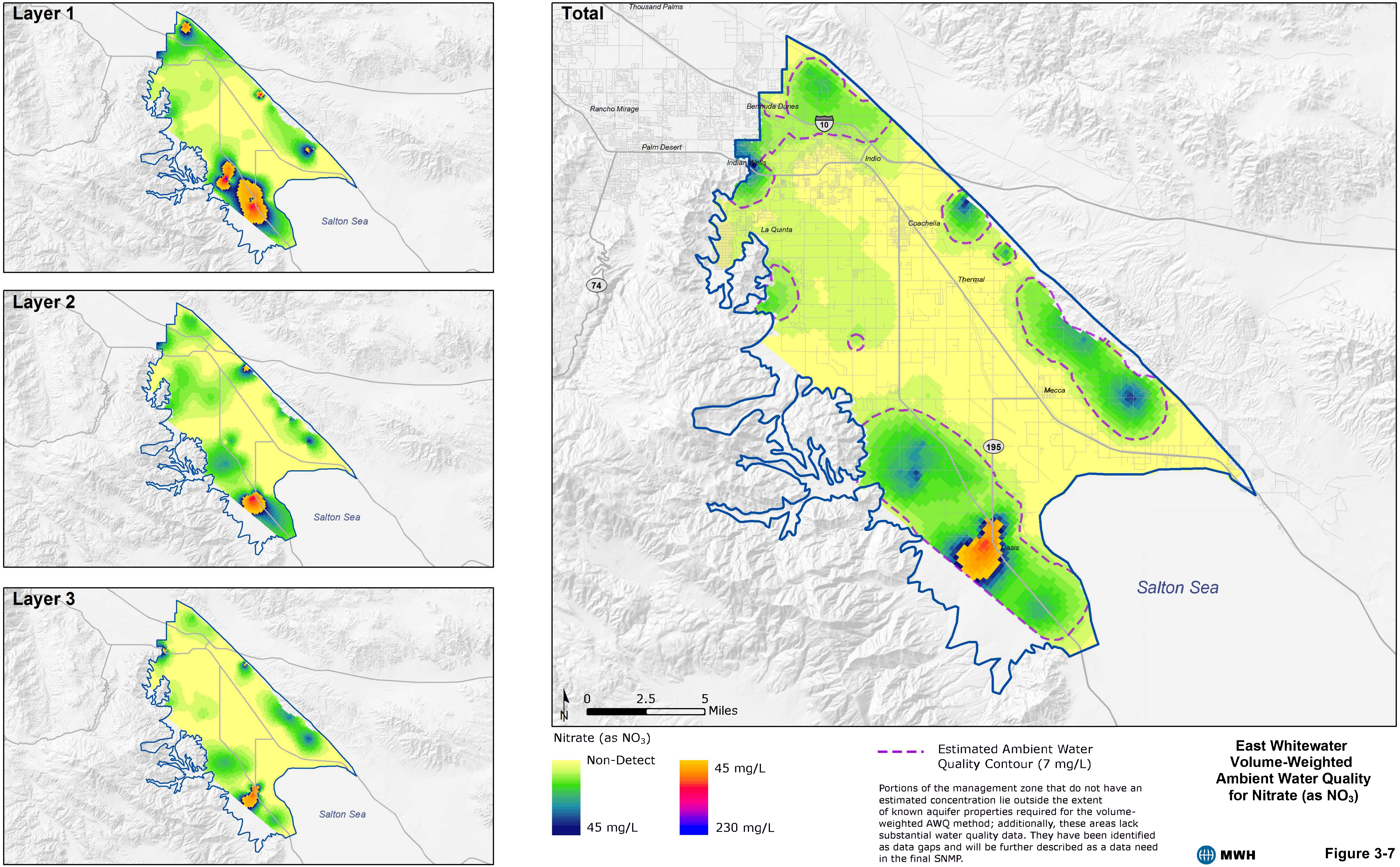

East Whitewater Volume-Weighted Ambient Water Quality for Nitrate (as NO_3)

Figure 3-7

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3.3 MISSION CREEK MANAGEMENT ZONE

The Mission Creek Management Zone is located in the northwestern Coachella Valley, north of the Garnet Hill Management Zone and west of the Desert Hot Springs Management Zone. The Mission Creek Fault and the Banning Fault form the northern and southern boundaries, respectively. Both faults act to limit groundwater movement as evidenced by groundwater level differences across the faults. The main water bearing units of the Mission Creek Management Zone are unconsolidated Holocene and late Pleistocene alluvial deposits forming a single unconfined aquifer with a saturated thickness of approximately 1,200 feet. An attempt was made to separate the aquifer into layers, but continuous well perforations limited the number of data points exclusive to a single layer; therefore, separation of aquifer layers could not be completed.

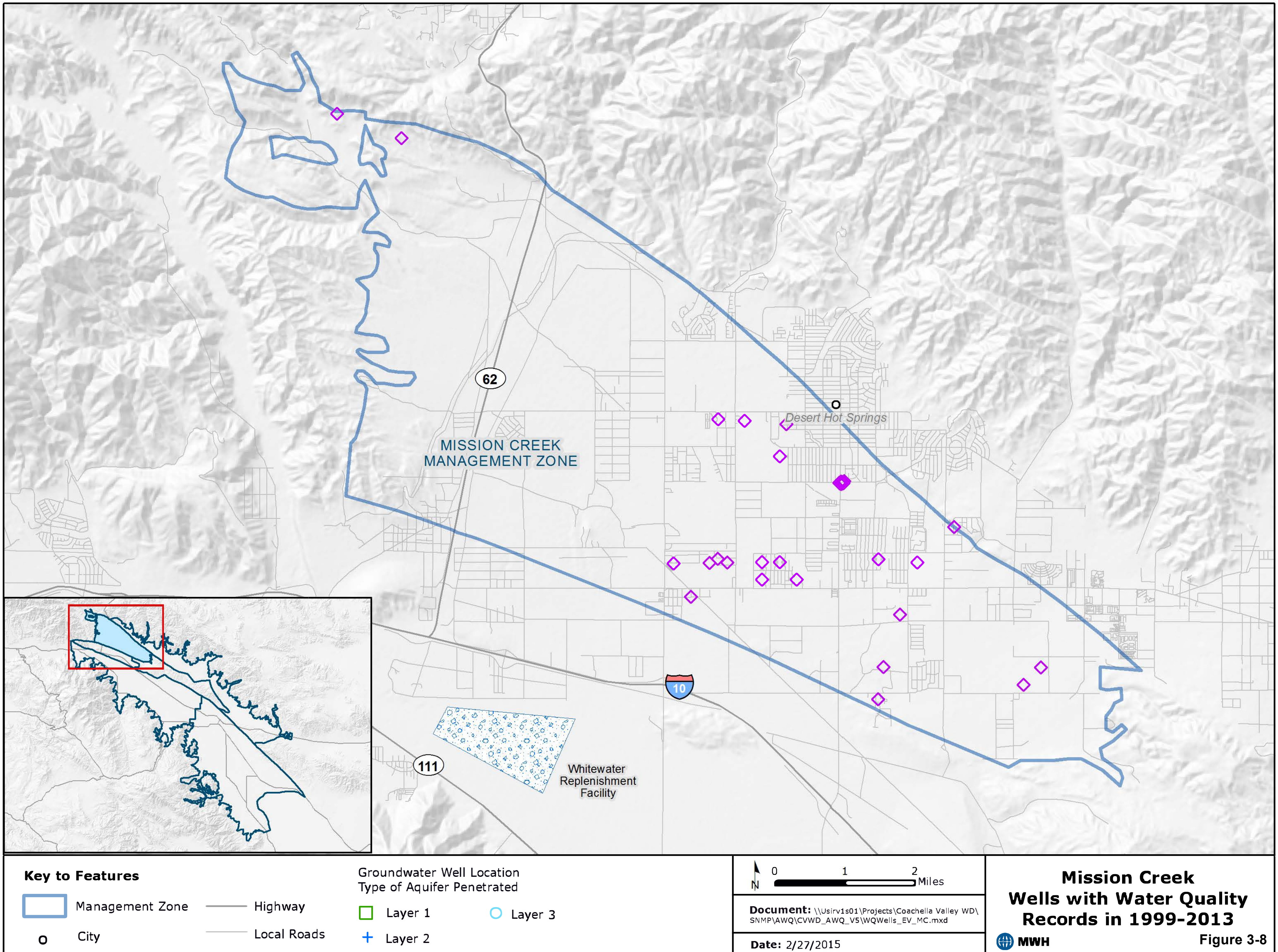
3.3.1 Summary of Unfiltered Data

The unfiltered dataset for the Mission Creek Management Zone consists of 391 water quality records during the baseline period of 1999 to 2013. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-8**. It should be noted that there is a lack of data on the western portion of the management zone. This is a known data gap and will be identified in the monitoring portion of the final SNMP. The unfiltered dataset for Mission Creek Management Zone contains 77 TDS records and 314 nitrate records. Nitrate is more frequently monitored in wells than TDS because groundwater is typically more likely to see short term changes in nitrate levels. One shallow well with high nitrate was sampled approximately once a month over a period of nine years. The statistical summary of unfiltered data for the Mission Creek Management Zone is presented on **Table 3-7**.

Table 3-7
Descriptive Statistics of Unfiltered Data for Mission Creek (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	77	314
Mean (mg/L)	516	27.5
Median (mg/L)	465	5.6
Mode (mg/L)	430	71
Std. Dev. (mg/L)	204	31.1
Range (mg/L)	270 to 1,100	ND to 86
95% Confidence Interval (mg/L)	470 to 563	24 to 30.9

ND = non-detect



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Date: 2/27/2015

Mission Creek Wells with Water Quality Records in 1999-2013

MWH

Figure 3-8

3.3.2 Statistical Description of Ambient Water Quality

The filtered dataset for Mission Creek Management Zone consists of 22 TDS values and 25 nitrate values. The statistical summary of filtered data for the Mission Creek Management Zone is presented on **Table 3-8**. The filtered dataset minimizes the effects of many of the biases discussed in Section 2.2, such as the abundance of high nitrate values from a single shallow well.

Influence from high salinity groundwater from Desert Hot Springs may contribute to the upper end of the range. TDS concentrations generally decrease from the Desert Hot Springs to the Garnet Hill management zones. Very few data exist in the northwest of the management zone.

High nitrate values in a shallow well sampled more frequently than others in this dataset are a cause for the large difference between the average and median nitrate.

Table 3-8
Descriptive Statistics of Filtered Data for Mission Creek (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	22	25
Mean (mg/L)	606	5.8
Median (mg/L)	499	3.8
Mode (mg/L)	N/A	3.6
Std. Dev. (mg/L)	242	8.1
Range (mg/L)	300 to 1,096	0.3 to 42.8
95% Confidence Interval (mg/L)	499 to 713	2.4 to 9.1

ND = non-detect

The mean TDS of the filtered dataset falls within the interval of 499 to 713 mg/L with a 95 percent confidence; for nitrate (as NO_3), this interval is between 2.4 and 9.1 mg/L.

3.3.3 Volume-weighted Ambient Water Quality

For the determination of volume-weighted AWQ, Mission Creek is contoured over a single layer using the filtered dataset for TDS and nitrate. It is determined after several iterations that insufficient data are available to contour multiple layers in Mission Creek Management Zone. Further, due to a lack of available data on the west end of the management zone, areas in excess of halfway between the west border of the management zone and the west-most filtered data points were not included in the AWQ calculation; this area is clearly shown on **Figure 3-9** and **Figure 3-10**.

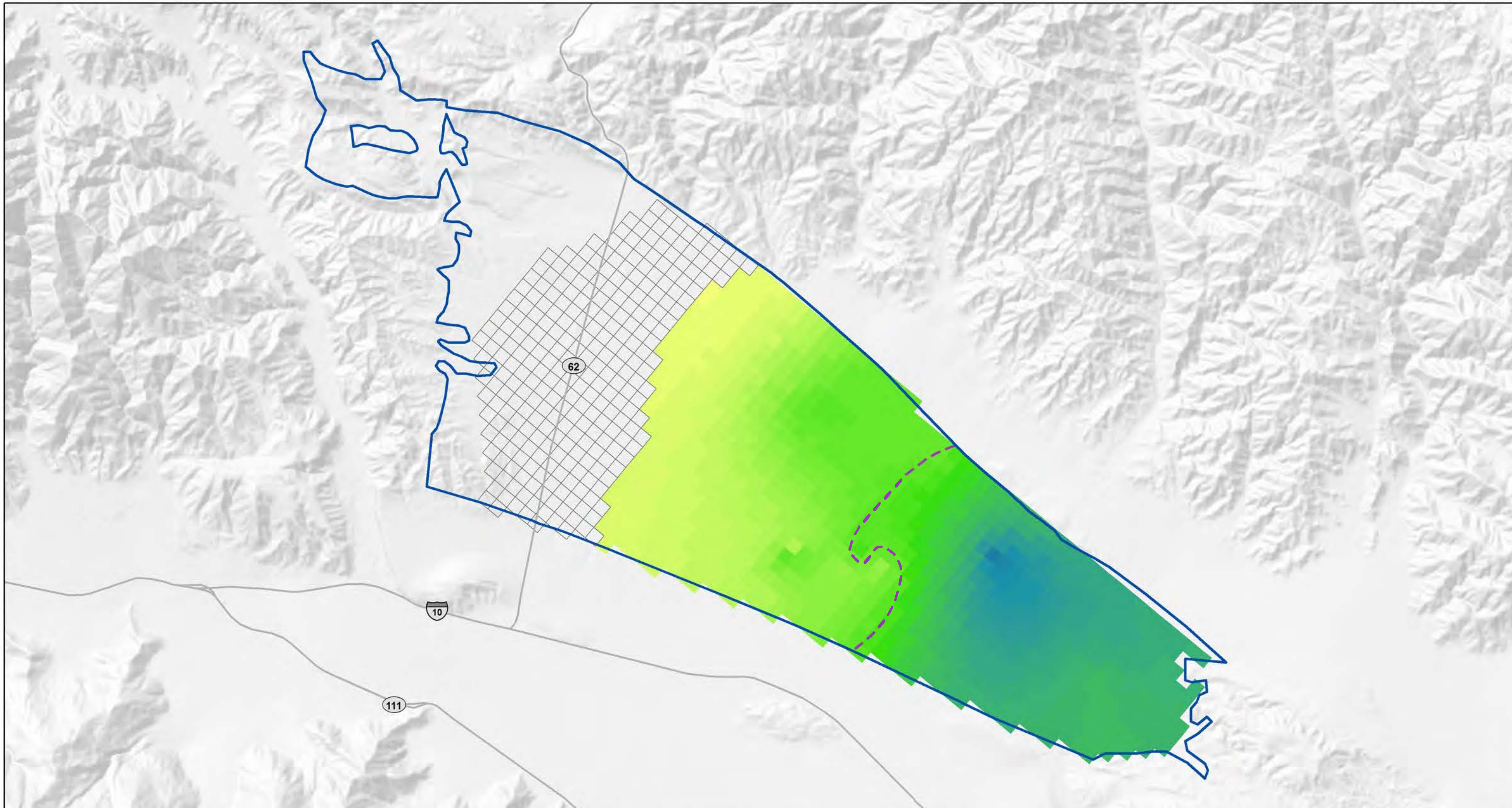
Table 3-9 summarizes the results of the volume-weighted AWQ determination for Mission Creek Management Zone. Water quality is contoured and TDS/nitrate concentrations are assigned to each cell. The layer cells are aggregated using the volume-weighted method to generate the volume-weighted AWQ. **Figure 3-9** and **Figure 3-10** illustrate the relative TDS and nitrate concentrations, respectively, in the Mission Creek Management Zone.

Table 3-9
Volume-weighted Ambient Water Quality for Mission Creek Management Zone (1994-2013)

Total Dissolved Solids (mg/L)	Nitrate as NO_3 (mg/L)
510	3.6

The volume-weighted AWQ for TDS in the Mission Creek Management Zone is 510 mg/L. TDS is above the volume-weighted AWQ towards the southeast of Mission Creek and where it borders Desert Hot Springs Management Zone. TDS decreases to the northwest end of Mission Creek Management Zone and near the Garnet Hill Management Zone. Few data are available in the western portion of Mission Creek Management Zone. Consequently, this area was excluded from the AWQ computation. Without data, it is uncertain how this exclusion impacts the AWQ.

The volume-weighted AWQ for nitrate (as NO_3) in the Mission Creek Management Zone is 3.6 mg/L. Nitrate is generally low throughout Mission Creek. The area above the volume-weighted AWQ is south of the Desert Hot Springs Management Zone extending to the Garnet Hill Subbasin, with the exception of the far southeast end of the Mission Creek Management Zone.



Total Dissolved Solids

100 mg/L

1,500 mg/L

1,500 mg/L

19,100 mg/L

Estimated Ambient Water Quality Contour (510 mg/L)

Area not included in AWQ determination

Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

Area not included in AWQ determination indicated by grey cells have aquifer properties but lack nearby data to contour.

N 0 1 2 Miles

Mission Creek Volume-Weighted Ambient Water Quality for Total Dissolved Soilds

MWH

Figure 3-9

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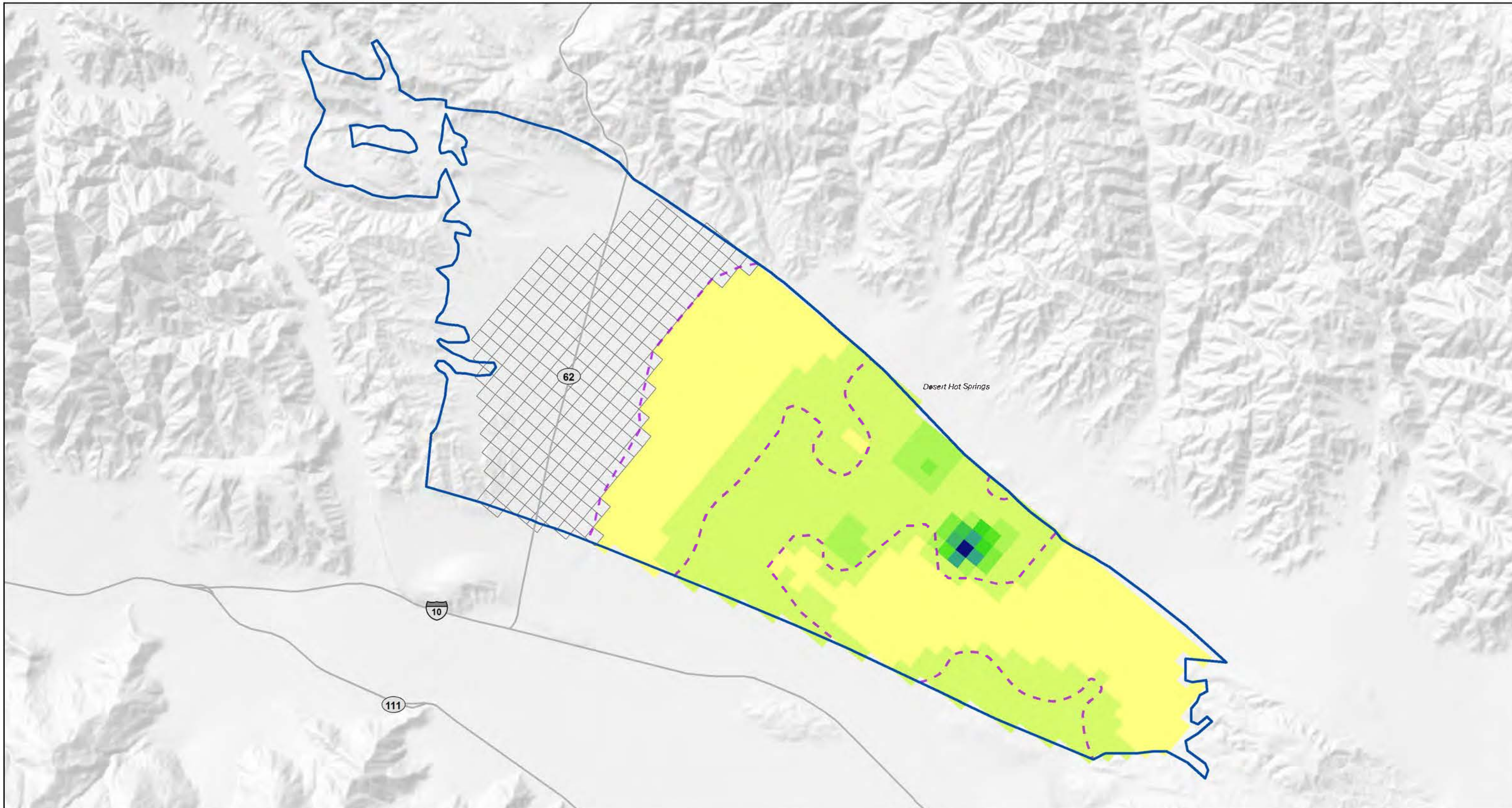

Nitrate (as NO_3)

Non-Detect

45 mg/L

45 mg/L

230 mg/L

Estimated Ambient Water Quality Contour (3.0 mg/L)

Area not included in AWQ determination

Portions of the management zone that do not have an estimated concentration lie outside the extent of known aquifer properties required for the volume-weighted AWQ method; additionally, these areas lack substantial water quality data. They have been identified as data gaps and will be further described as a data need in the final SNMP.

Area not included in AWQ determination indicated by grey cells have aquifer properties but lack nearby data to contour.

N

0 1 2 Miles

Mission Creek Volume-Weighted Ambient Water Quality for Nitrate (as NO_3)

MWH

Figure 3-10

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3.4 GARNET HILL MANAGEMENT ZONE

The area between the Garnet Hill Fault and the Banning Fault, named the Garnet Hill Subarea by DWR (DWR, 1964), was considered a distinct subbasin by the United States Geological Survey (USGS) because of the effectiveness of the Banning and Garnet Hill Faults as barriers to groundwater movement (Tyley, 1974). This subbasin is considered part of the Whitewater River (Indio) Subbasin in DWR Bulletin 118 (2003); however, CVWD and DWA consider it a separate subbasin based on USGS findings and water level observations. In 1964, when the initial DWR evaluation was completed, it was observed that limited data existed to characterize the hydrogeology of this subbasin (DWR, 1964). The Garnet Hill Subbasin is considered an unconfined aquifer with a saturated thickness of 1,000 feet or more based on well depths and has an estimated total storage capacity on the order of 1.0 million acre-feet.

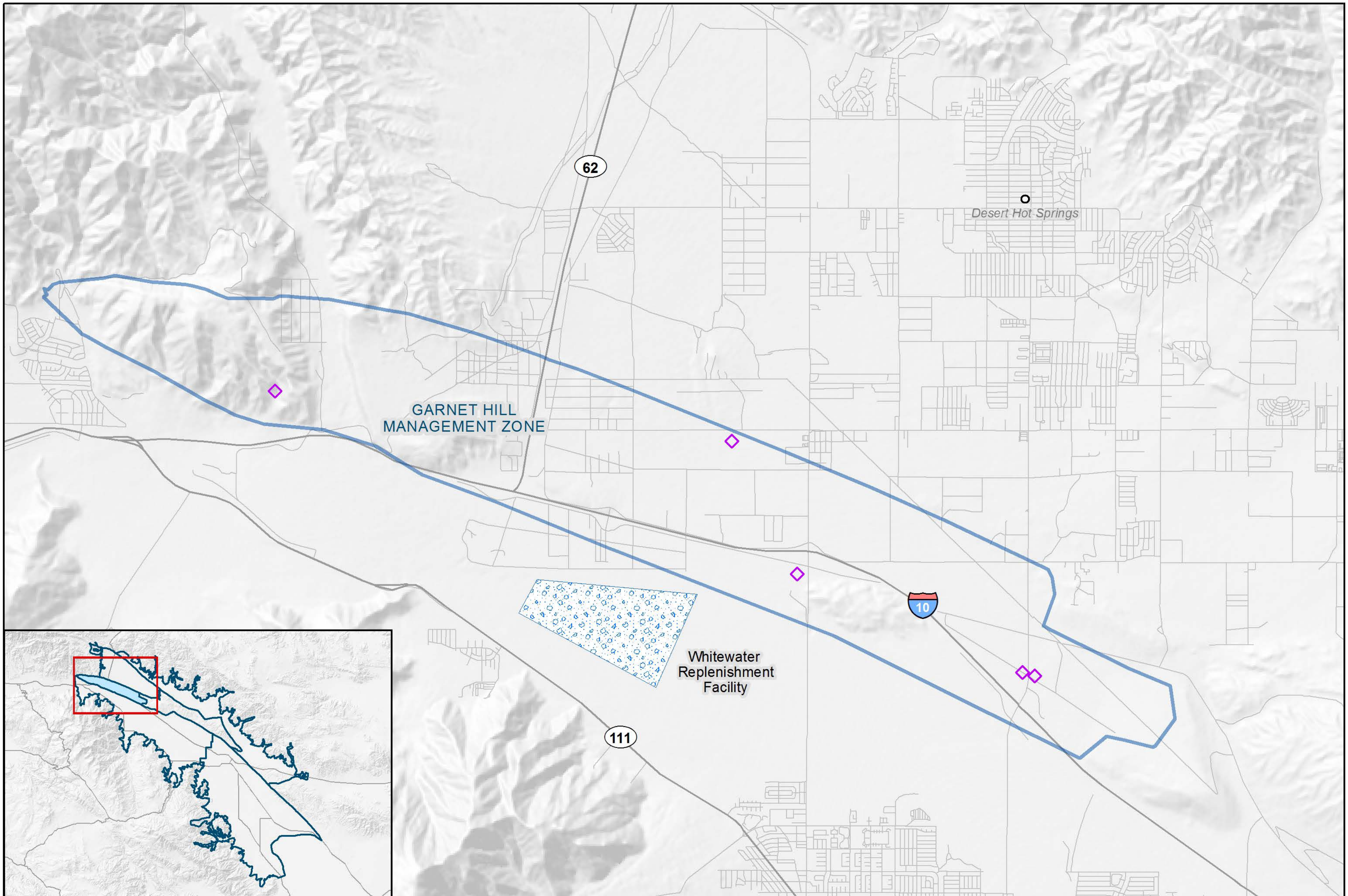
3.4.1 Summary of Unfiltered Data

The unfiltered dataset for the Garnet Hill Management Zone consists of 32 records during the baseline period of 1999 to 2013. Too few data points are available to compute the volume-weighted AWQ for Garnet Hill. The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-11**.The unfiltered dataset for Garnet Hill Management Zone contains 16 TDS records and 16 nitrate records. The statistical summary of unfiltered data for the Garnet Hill Management Zone is presented on **Table 3-10**.

Table 3-10
Descriptive Statistics of Unfiltered Data for Garnet Hill (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	16	16
Mean (mg/L)	269	3.5
Median (mg/L)	273	2.4
Mode (mg/L)	N/A	1.8
Std. Dev. (mg/L)	56	3.4
Range (mg/L)	156 to 376	ND to 14.3
95% Confidence Interval (mg/L)	239 to 299	1.7 to 5.4

ND = non-detect



Key to Features

Management Zone

City

Highway

Local Roads

Groundwater Well Location
Type of Aquifer Penetrated

Layer 1

Layer 2

Layer 3

0 1 2 Miles

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Garnet Hill Wells with Water Quality Records in 1999-2013

MWH

Figure 3-11

3.4.2 Statistical Description of Ambient Water Quality

The filtered dataset for Garnet Hill Management Zone consists of 4 TDS values and 4 nitrate values. The statistical summary of filtered data for the Garnet Hill Management Zone is presented on **Table 3-11**.

TDS concentrations within Garnet Hill Management Zone are very low compared to other management zones. Very few data are available for characterizing the spatial distribution of groundwater quality within Garnet Hill Management Zone. However, available data indicate that water quality is generally excellent.

Table 3-11
Descriptive Statistics of Filtered Data for Garnet Hill (1999-2013)

Statistic	Total Dissolved Solids	Nitrate as NO_3
Count	4	4
Mean (mg/L)	217	2.2
Median (mg/L)	212	1.8
Mode (mg/L)	N/A	N/A
Std. Dev. (mg/L)	58	1.6
Range (mg/L)	156 to 288	0.6 to 4.5
95% Confidence Interval (mg/L)	124 to 309	ND to 4.8

ND = non-detect

There are too few data points to draw meaningful conclusions within the Garnet Hill Management Zone. This is a known data gap and will be identified in the monitoring portion of the final SNMP.

3.5 DESERT HOT SPRINGS MANAGEMENT ZONE

The Desert Hot Springs Subbasin is located adjacent to the Mission Creek and Whitewater River Subbasins and runs northwest to southeast along the foothills of the Little San Bernardino Mountains. The Desert Hot Springs Subbasin is bounded to the north by the Little San Bernardino Mountains and to the southwest by Mission Creek Fault, the San Andreas Fault, and the semipermeable rocks of the Indio Hills. These faults act as groundwater barriers and direct the groundwater in a southeast direction. The subbasin has been divided into three subareas: Miracle Hill, Sky Valley, and Fargo Canyon. Based on limited groundwater data for this area, flow is generally to the southeast.

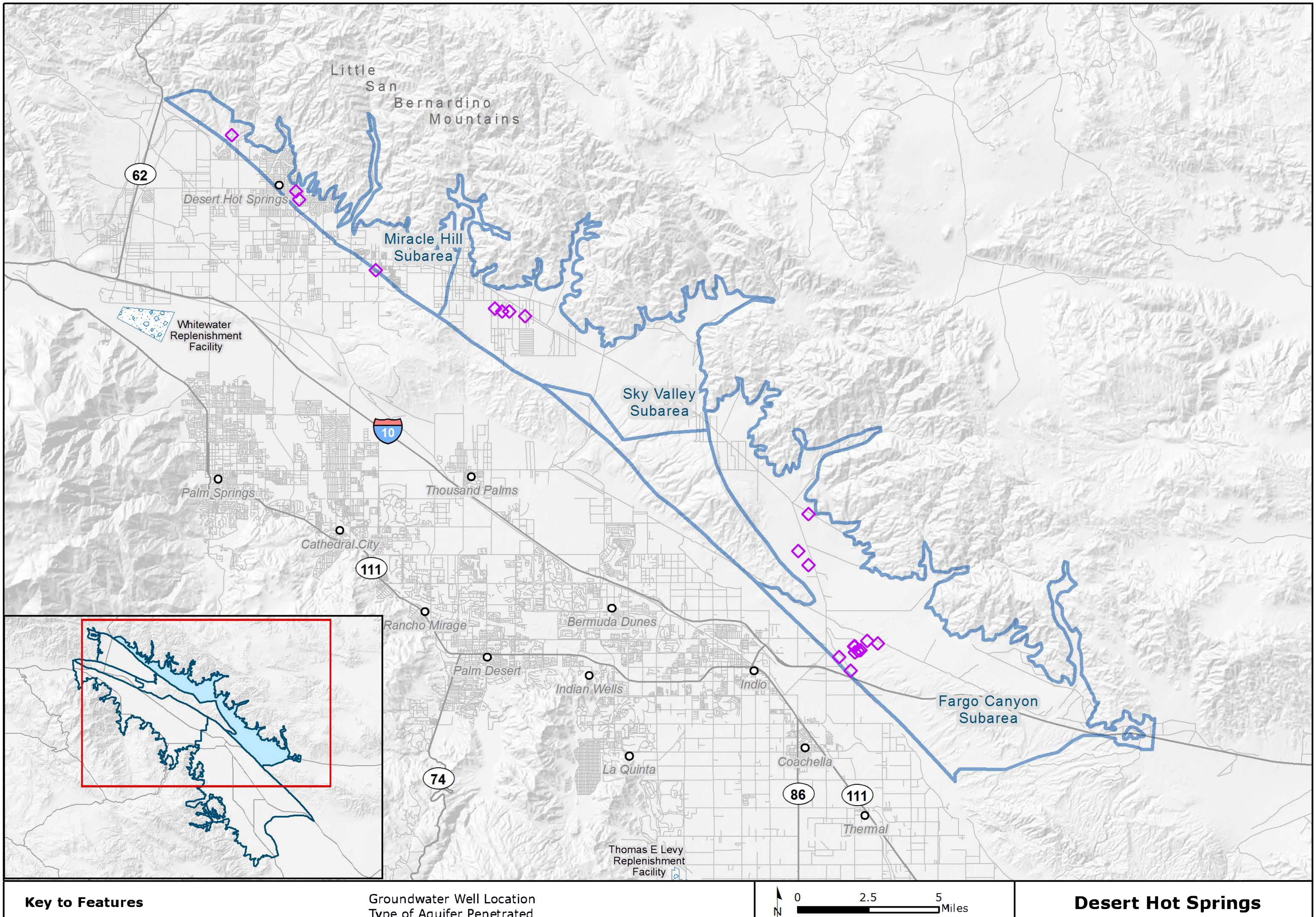
3.5.1 Summary of Unfiltered Data

The locations of wells with water quality records used in the AWQ determination are illustrated on **Figure 3-12**. The unfiltered dataset for the Desert Hot Springs Management Zone consists of 1,394 water quality records during the baseline period of 1999 to 2013 – 674 TDS records and 720 nitrate records. Most of these data points exist in the Fargo Canyon Subarea. Too few data points relative to the size of Desert Hot Springs are available to compute the volume-weighted AWQ. The statistical summaries of unfiltered data for the Desert Hot Springs Management Zone are presented on **Table 3-12**.

Table 3-12
Descriptive Statistics of Unfiltered Data for Desert Hot Springs (1999-2013)

Subarea	Statistic	Total Dissolved Solids	Nitrate as NO_3
Miracle Hill	Count	7	50
	Mean (mg/L)	471	10.5
	Median (mg/L)	440	9.4
	Mode (mg/L)	N/A	11
	Std. Dev. (mg/L)	185	8.1
	Range (mg/L)	240 to 845	0.5 to 44
	95% Confidence Interval (mg/L)	300 to 642	8.2 to 12.8
Sky Valley	Count	5	5
	Mean (mg/L)	1,294	20
	Median (mg/L)	1,300	20
	Mode (mg/L)	N/A	N/A
	Std. Dev. (mg/L)	168	15.7
	Range (mg/L)	1,070 to 1,500	0.4 to 40
	95% Confidence Interval (mg/L)	1,086 to 1,502	0.5 to 39.6
Fargo Canyon	Count	662	665
	Mean (mg/L)	1,384	18.7
	Median (mg/L)	1,400	13.3
	Mode (mg/L)	1,700	5.3
	Std. Dev. (mg/L)	445	16.7
	Range (mg/L)	256 to 2,570	ND to 101
	95% Confidence Interval (mg/L)	1,350 to 1,418	17.5 to 20

ND = non-detect



Key to Features

Management Zone
Highway
Local Roads
City

Groundwater Well Location
Type of Aquifer Penetrated

Layer 1
Layer 2
Layer 3

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Desert Hot Springs Wells with Water Quality Records in 1999-2013

MWH

Figure 3-12

3.5.2 Statistical Description of Ambient Water Quality

High TDS groundwater comprises much of the Desert Hot Springs Management Zone. Areas of the Fargo Canyon Subarea near the East Whitewater River Management Zone have the highest TDS values and values over 1,000 mg/L exist in the Sky Valley Subarea. The Miracle Hill Subarea has some of the lowest TDS in Desert Hot Springs. In general, nitrate is lower in the Miracle Hill Subarea while groundwater in the Sky Valley and Fargo Canyon subareas show higher nitrate concentrations.

The filtered dataset for Desert Hot Springs Management Zone consists of 20 TDS values and 21 nitrate values. The statistical summary of filtered data for the Desert Hot Springs Management Zone is presented on **Table 3-13**.

Table 3-13
Descriptive Statistics of Filtered Data for Desert Hot Springs (1999-2013)

Subarea	Statistic	Total Dissolved Solids	Nitrate as NO_3
Miracle Hill	Count	3	4
	Mean (mg/L)	558	4.8
	Median (mg/L)	440	4.2
	Mode (mg/L)	N/A	N/A
	Std. Dev. (mg/L)	250	4.1
	Range (mg/L)	390 to 845	0.5 to 10.2
	95% Confidence Interval (mg/L)	<100 to 1,178	ND to 11.2
Sky Valley	Count	4	4
	Mean (mg/L)	1,280	18.8
	Median (mg/L)	1,275	17.4
	Mode (mg/L)	N/A	N/A
	Std. Dev. (mg/L)	186	17.4
	Range (mg/L)	1,070 to 1,500	0.4 to 40
	95% Confidence Interval (mg/L)	984 to 1,576	ND to 46.5
Fargo Canyon	Count	13	13
	Mean (mg/L)	1,351	22.9
	Median (mg/L)	1,325	17.9
	Mode (mg/L)	1,800	24.8
	Std. Dev. (mg/L)	491	27
	Range (mg/L)	688 to 2,020	0.1 to 101
	95% Confidence Interval (mg/L)	1,054 to 1,648	6.6 to 39.3

ND = non-detect

There are too few data points to draw meaningful conclusions within the Desert Hot Springs Management Zone. This is a known data gap and will be identified in the monitoring portion of the final SNMP.

4 References

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Attachment A – Determination of Data Adequacy for Ambient Water Quality Calculation

ATTACHMENT A

Attachment A – Determination of Data Adequacy for Ambient Water Quality Calculation

1 Introduction

This attachment describes the methods applied and results obtained to evaluate the data adequacy of contouring water quality constituents for management zones and aquifer layers.

The volume-weighted method for determination of ambient water quality (AWQ) is used when an adequate amount of data exist for a particular management zone or aquifer layer. This method computes the average water quality based on the amount of mass of a particular constituent in storage. The mass of the constituent is determined by multiplying the water quality concentration by the amount of water in storage at a point of discrete "cell". The concentration of a discrete cell is based on either the actual data or an interpolation based on surrounding data using a water quality contour map. The contour maps are typically prepared with oversight from a professional geologist or engineer and completed in an iterative fashion using numerical and hand contouring methods.

During the stakeholder review process for Draft TM-2, the following comments were submitted:

- What is considered "sufficient" data for the volume weighted method of Ambient Water Quality determination? (Pages 9, 34, 39).
- S 2.2.3: The spatial filter is described as calculating a cell-layer average based upon the baseline well concentrations. This method does not account for water quality data that shows a trend in concentration.
- Section 2, Ambient Water Quality Methods: In response to "single concentration value that is representative of water quality within a management zone for a particular constituent and time period", MSWD does not agree. The management zones are essentially the sub basins which can have inherently different characteristics within different areas. More refinement is necessary to identify subareas within the management zones. Also more attention should be given to the production areas. The spatial and temporal approach does not accurately reflect actual conditions. It should be focused on pumping areas. In addition, averaging the data set over the past 20 years isn't appropriate. The present ambient levels are more relevant data sets.
- The use of water quality data collected from 1994 to 2013 for the calculation of AWQ is unacceptable particularly in the case of Coachella Valley because it blurs the effect of recent discharge/recharge activities.

Determination of data adequacy for contouring the water quality of an aquifer layer within a particular management zone is not a well-defined undertaking, but it is essential for applying the volume-weighted method. A determination of data adequacy through strictly quantitative methods has not been made within any other SNMPs within the state; typically, it is based on professional judgment. This attachment describes the methods applied to determine how management zones and aquifer layers ambient water quality will be represented, specifically, if there is sufficient data to contour water quality. The determination of adequacy is based on the following key factors:

- Spatial distribution of data points – the physical location of data points within a management zone or aquifer layer has a marked effect on the ability to approximate values with certainty
- Spatial autocorrelation – the assumption that one value is more related to nearby points and less related to distant points.
- Supporting statistics – the underlying summary statistics must support high or low autocorrelation and can assist in the decision to develop a contoured surface.

This attachment provides an evaluation of these factors for management zones and aquifer layers over different periods of time. At the conclusion of this attachment are recommendations for the most appropriate method of AWQ calculation—volume-weighted method or statistical summary—based on the available data.

2 Evaluation Methods

The following subsections provide a description of the evaluation methods applied to determine the suitability of data for contouring to calculate the ambient water quality. No single method can determine the suitability of data for contouring. When spatial distribution of data points is considered with autocorrelation and standard statistics, insight can be gained regarding whether it is reasonable to contour a data period for a particular management zone or aquifer layer.

2.1.1 Spatial Distribution

Unlike population or topographic data, which are usually obtainable in whatever quantity is needed to construct accurate contour maps; data from the subsurface is uncommon and not obtained without some cost. Therefore, any map of subsurface characteristics, including water quality in this case, is subject to individual interpretation. The two-dimensional areal extent of the data (spatial distribution of the data) used to prepare the map reduces uncertainty and drives the method of contouring (Tearpock and Bischke, 2003).

Spatial distribution is an important consideration when determining ambient water quality. Spatial distribution is the two-dimensional arrangement of data points within the desired area of analysis; this area may be a management zone or a particular aquifer layer within a management zone. A graphical display of spatial distribution summarizes the locations of data. Ideally, when approximating water quality concentration, data collected should be well-disturbed across the area of analysis. If the data is not well distributed spatially, ambient water quality determined from the data may be skewed, favoring the water quality of the particular area where data is available. Patterns of data points can be categorized into three classes, regular, random, and aggregated, as shown in **Figure 1**. The distribution patterns range from regular, the most uniform pattern where every point is equidistant, to an aggregated pattern where there probability of another point varies in some inverse manner with the distances of pre-existing points (Davis, 2002). To evaluate the spatial distribution, maps of data points for varying time periods and water quality constituents are plotted, evaluated and described as one of these patterns.

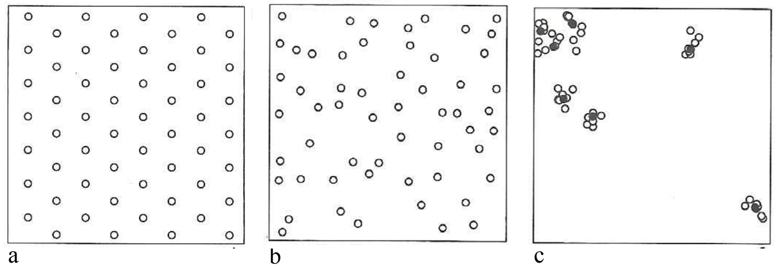


Figure 1
Spatial Distribution of Points, a) Regular, b) Random, and c) Aggregated (After Davis, 2002)

2.1.2 Spatial Autocorrelation

Spatial autocorrelation is a measure of dependency among data points with respect to geographic location. A common definition of spatial autocorrelation states that pairs of subjects that are close to each other are more likely to have values that are more similar, and pairs of subjects far apart from each other are more likely to have values that are less similar (Griffith, 1987). The spatial structure of the data refers to any patterns that may exist. Gradients or clusters are examples of spatial structures that are positively correlated, whereas negative correlation may be exhibited in a checkerboard pattern where subjects appear to be dispersed relative to each other. If no pattern is apparent, correlation lies between these two extremes and the data appears random. When a dataset has significant positive spatial autocorrelation, it suggests higher confidence in predicting the value at one location based on the value sampled from a nearby location when using data interpolation methods. Thus, a statistically significant positive autocorrelation supports the decision to contour. Note that data within a specific management zone that has very small variance will have a low spatial autocorrelation, but this does not necessarily imply that contouring is not appropriate.

ArcGIS, a geographic information system (GIS) for working with maps and geographic information, includes tools to evaluate spatial autocorrelation within a dataset. These tools evaluate the Global Moran's I statistic for a particular dataset and test the significance of the resulting statistic. This statistic measures spatial autocorrelation within a single quantitative variable. The Global Moran's I statistic takes the form of a correlation coefficient using the difference between each sample value and the mean of a variable at some distance threshold. The distance threshold is the distance been points being evaluated. The Moran's I for spatial autocorrelation is given as (ESRI, 2015):

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

Z_i is the deviation of an attribute (concentration in this case) for feature point *i* from its mean (x_i – X), $w_{i,j}$ is the spatial weight between features *i* and *j*, n is equal to the total number of features, so S_0 is the aggregate of all the spatial weights.

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j}$$

The z_I score for the statistic is computed as:

$$z_I = \frac{I - \mathrm{E}[I]}{\sqrt{\mathrm{V}[I]}}$$

Where,

$$\begin{aligned} \mathrm{E}[I] &= -1/(n-1) \\ \mathrm{V}[I] &= \mathrm{E}[I^2] - \mathrm{E}[I]^2 \end{aligned}$$

This results in coefficients ranging from (-1) to (+1), where values between (0) and (+1) indicate a positive association between variables, values between (0) and (-1) indicate a negative association, and (0) indicates there is no correlation (random) between variables. For statistical hypothesis testing, the Global Moran's I statistic can be transformed to z-scores in which values greater than 1.96 or smaller than -1.96 indicate spatial autocorrelation that is significant at the 5 percent significance level, or 95% confidence level (ESRI, 2015). Similarly, z-scores corresponding to values greater than 1.65 or smaller than -1.65 indicate spatial autocorrelation that is significant at the 10 percent significance level, or 90% confidence level. **Figure 2** illustrates spatial autocorrelation for an example dataset and the significance regions for the Global Moran's I statistic. In the evaluation of data for determination of AWQ, the resulting significance test on the positive Global Moran's I statistic is of greatest importance in determining evidence of spatial autocorrelation within the data.

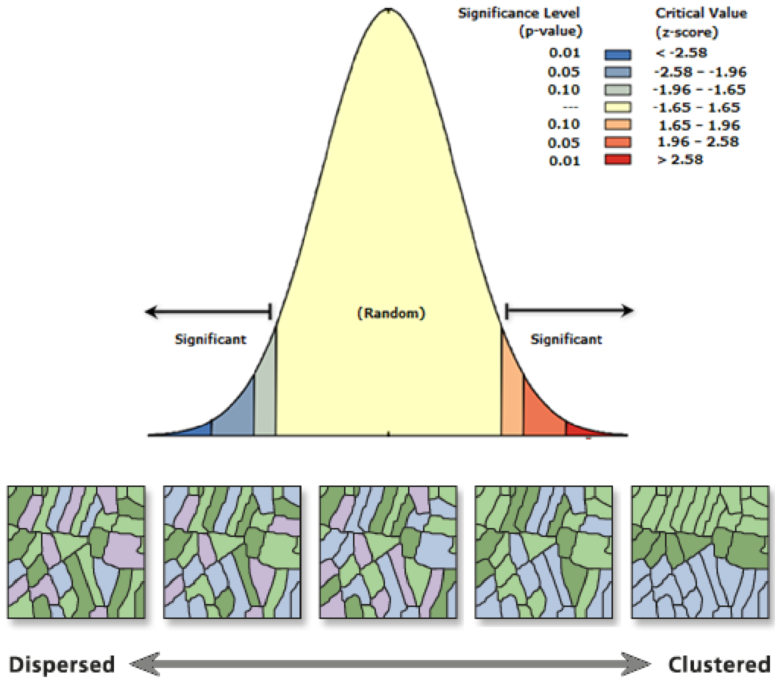


Figure 2
Spatial Autocorrelation Report Example (ESRI, 2015)

2.1.3 Descriptive Statistics

Statistical analyses of water quality data are performed and summarized for each management zone. The statistics computed in this evaluation are summarized in **Table 1**.

The statistical descriptions provide a summary of the filtered dataset, as described in Section 2.2 of TM-2, for a particular management zone, layer, and baseline period. These summaries are important for evaluating the results of the spatial autocorrelation tests and provide a general understanding of the data. Note that although statistical summaries can provide insight into the data at a macroscopic level, spatial relationships in the data are not considered.

3 Evaluation

The methods to evaluate data adequacy were presented in the previous section. These methods include evaluations of spatial distribution (two dimensional coverage of the area), spatial autocorrelation (relationship of data points that can be used for mapping/contouring given location and concentration), and descriptive statistics of each dataset. The following subsections summarize the results of these methods for each management zone and aquifer layer (when applicable) at the 5-Year, 10-Year, 15-Year, and 20-Year baseline periods.

Table 1
Summary of Statistical Values Determined for the Evaluation of Descriptive Statistics

Statistic	Description	Notes
Count	The number of data points in a given dataset	
Mean	The arithmetic mean, or average, of the dataset	Sum of the values divided by the number of values
Median	The numerical value separating the higher half of a dataset from the lower half	If there is an even number of observations, then there is no single middle value; the median is then defined to be the mean of the two middle values
Mode	The value that appears most often in a dataset	If the mode is not applicable (N/A), this indicates no value appeared more than once in a given dataset
Standard Deviation (Std. Dev.)	The standard deviation is a measure that is used to quantify the amount of variation or dispersion of a dataset	Standard deviation is the square root of the average of the squared differences of the values from their average value
Range	The minimum and maximum values of a dataset	
95% Confidence Interval (95% CI)	Two-tailed confidence interval on the mean using the t-distribution at a 0.05 significance level: uses t-distribution as the true population mean and standard deviation is unknown.	Interpreted as a 95% chance that the confidence interval contains the true population mean

It is the intent of this study to describe ambient water quality by aquifer layer when the data permits and aggregate each aquifer layer with a management zone. As described in TM-1 (MWH, 2014), two groundwater models were obtained for as the primary basis for quantifying the vertical and horizontal extent of the groundwater systems. These models cover the Whitewater, Garnet Hill, and Mission Springs subbasins. CVWD (Fogg *et al.*, 2002) developed a groundwater model of the Whitewater and Garnet Hill Subbasins as part the 2002 Water Management Plan (MWH, 2002). The geometry (cell size, layering, and orientation) for this model was used as the base for the recently completed Mission Creek and Garnet Hill Subbasins groundwater model (Psomas, 2013). The layering of these groundwater models was based on a best estimate of basin lithologic characteristics. The layering is used to categorize areas of the aquifer, e.g., perched aquifer, deep aquifer. When evaluating groundwater quality, well screen intervals were used to categorize a well into a particular model layer. This allows for a general quantification of measurements and quality with depth. Based on the available well construction information and water quality data, the West Whitewater and East Whitewater were separated into three layers. The Mission Creek management zone was evaluated as a two layer and single aquifer system to determine what the level of evaluation the data would allow. Results of the evaluation are listed by aquifer layer for the West and East Whitewater Management Zones as well as the Mission Creek Management Zone.

3.1 SPATIAL DISTRIBUTION OF DATA POINTS

Figure 3 through **Figure 7** provide the spatial data distribution of filtered data points, as described in Section 2.2, for TDS and nitrate (as NO_3) for management zones and aquifer layers at the 5-Year, 10-Year, 15-Year, and 20-Year baseline periods. The objective is to provide graphical representation of the spatial distribution for visual inspection.

For general reference, **Table 2** provides a listing of the data density, the square miles associated with each data point by management zone, aquifer layer (if applicable), and baseline period.

Listed below in **Table 3** through **Table 9** are descriptions of the spatial data distribution prepared following visual inspection of **Figure 3** through **Figure 7**. These tables present a qualitative summary of the spatial data distribution, as well as any specific observations. This qualitative summary is subjective and was prepared by a Professional Geologist. The description of the spatial data points is as follows:

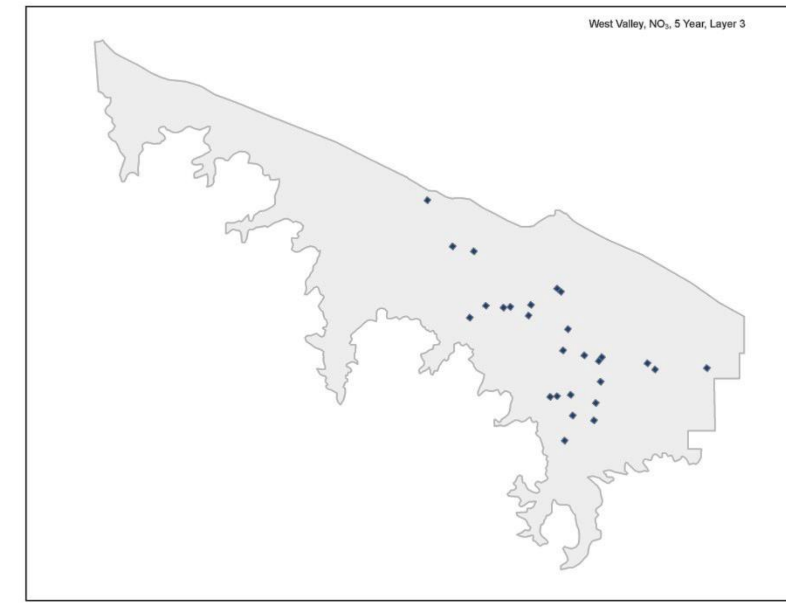
- Poor: Lack of data points or aggregated data points that would not lend themselves to approximating concentration across a management zone or aquifer layer.
- Fair: Data points are somewhat random or distributed in spatial distribution, areas lacking data are present.
- Good: Data points are random or distributed in spatial distribution

Table 2
Summary of Data Density (Square Miles per Data Point)

Management Zone	Baseline Period	5-Year Baseline					
		Layer 1		Layer 2		Layer 3	
		TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
West Whitewater	5-Year Baseline	21	21	30	25	5	5
East Whitewater		15	15	24	24	10	10
Mission Creek[1]		48	48	24	24	7	5
Garnet Hill		-	-	N/A	N/A	N/A	N/A
Miracle Hill		16	8	N/A	N/A	N/A	N/A
Sky Valley		11	11	N/A	N/A	N/A	N/A
Fargo Canyon		6	6	N/A	N/A	N/A	N/A
West Whitewater	10-Year Baseline	19	19	17	15	5	5
East Whitewater		9	9	11	11	8	8
Mission Creek1		8	8	24	24	3	2
Garnet Hill		7	7	N/A	N/A	N/A	N/A
Miracle Hill		16	8	N/A	N/A	N/A	N/A
Sky Valley		9	9	N/A	N/A	N/A	N/A
Fargo Canyon		5	5	N/A	N/A	N/A	N/A
West Whitewater	15-Year Baseline	11	11	5	5	4	4
East Whitewater		6	6	6	6	6	6
Mission Creek1		8	8	12	12	2	2
Garnet Hill		5	5	N/A	N/A	N/A	N/A
Miracle Hill		5	4	N/A	N/A	N/A	N/A
Sky Valley		9	9	N/A	N/A	N/A	N/A
Fargo Canyon		5	5	N/A	N/A	N/A	N/A
West Whitewater	20-Year Baseline	9	9	4	4	4	4
East Whitewater		4	4	4	4	4	4
Mission Creek1		8	8	12	12	2	2
Garnet Hill		5	5	N/A	N/A	N/A	N/A
Miracle Hill		5	4	N/A	N/A	N/A	N/A
Sky Valley		9	9	N/A	N/A	N/A	N/A
Fargo Canyon		5	5	N/A	N/A	N/A	N/A

1. Layer 3 represents the aggregated "No Layer" option for Mission Creek Management Zone

Figure 3
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

<table>
<tr><th>Baseline Period</th><th>Constituent</th><th>Layer 1</th><th>Layer 2</th><th>Layer 3</th></tr>
<tr><td rowspan="2">5-Year</td><td>Nitrate Data Points</td><td>
</td><td>
</td><td>
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<tr><td>TDS Dtata Points</td><td>
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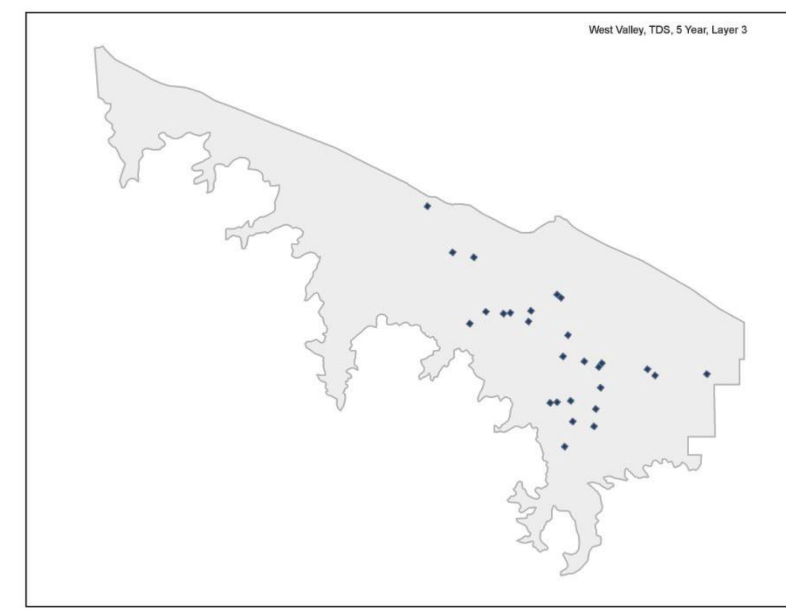
</td><td>
</td></tr>
</table>

Figure 3 (CONTINUED)
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

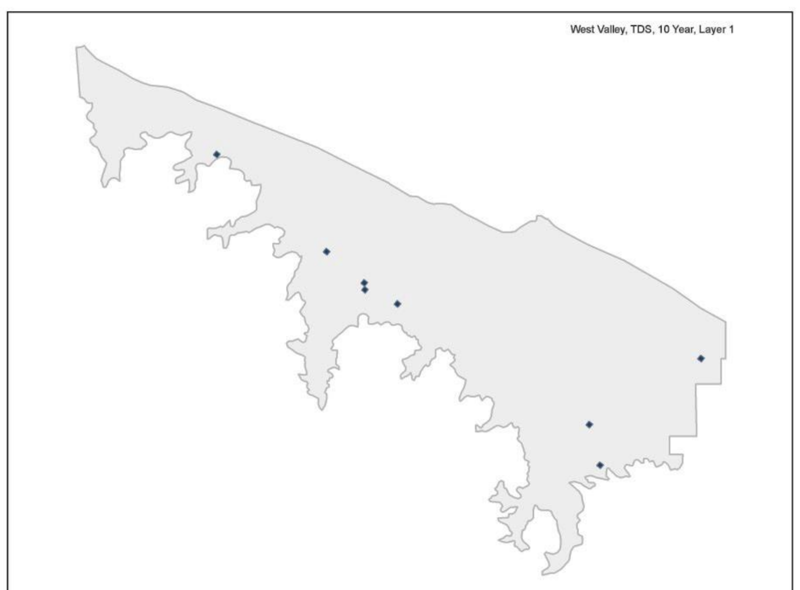
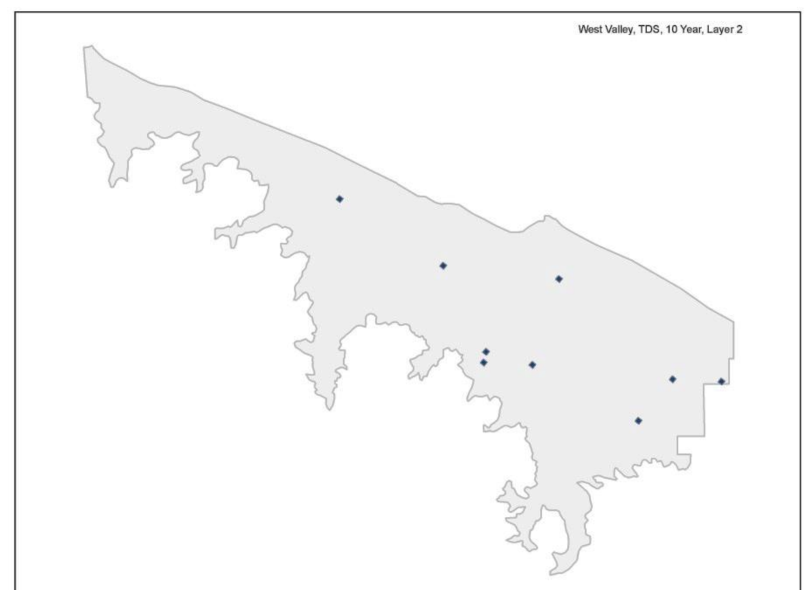
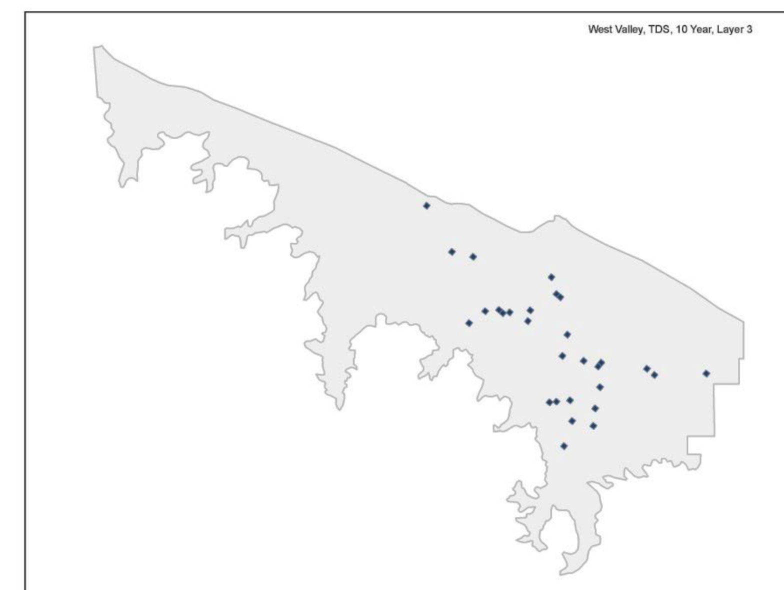
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
10-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 3 (CONTINUED)
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

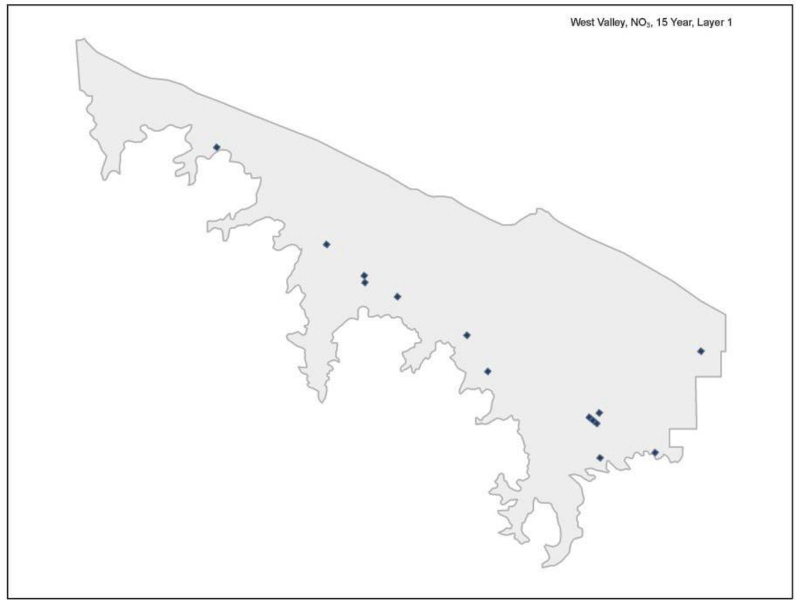
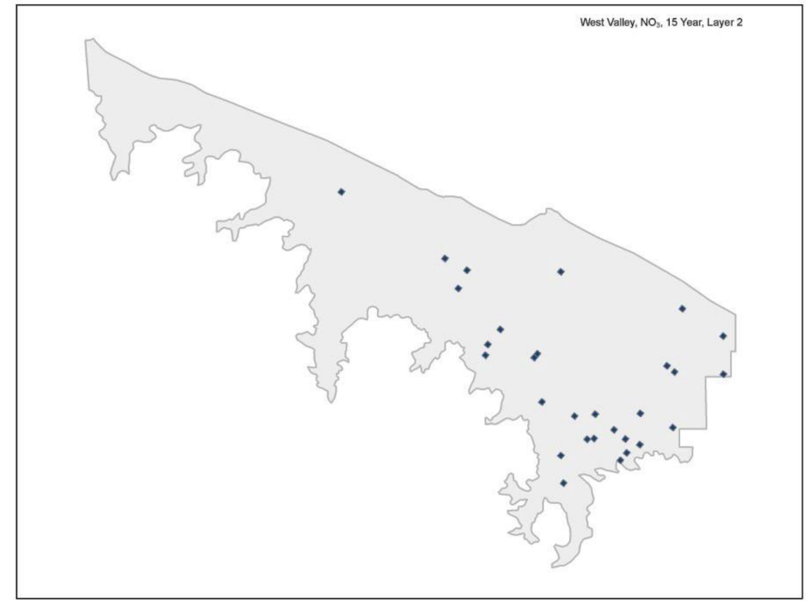
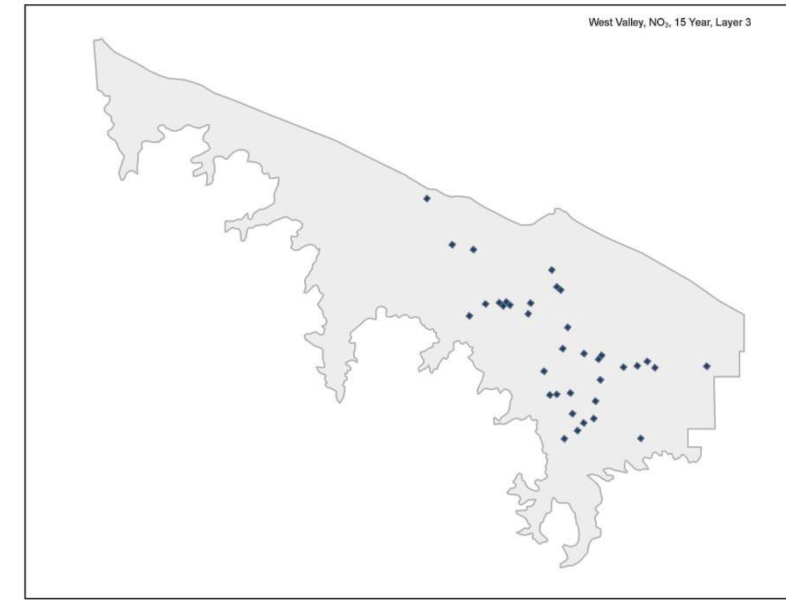
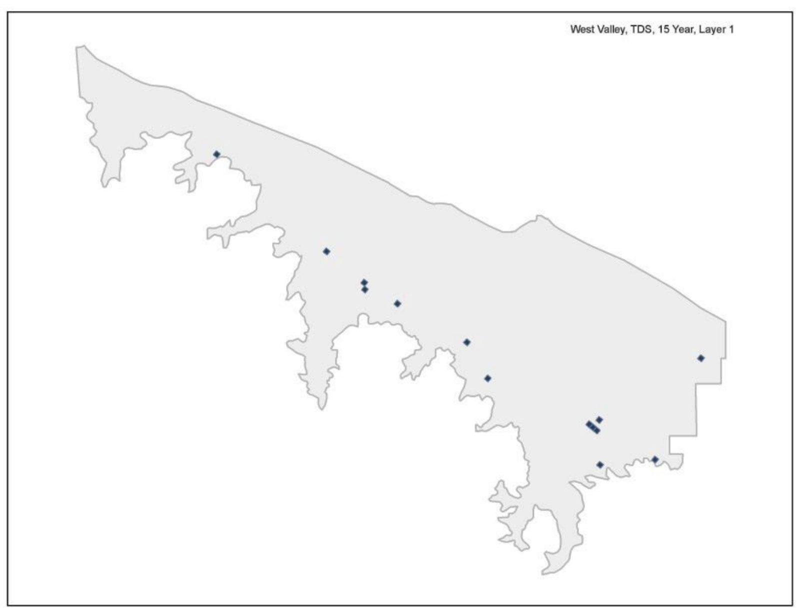
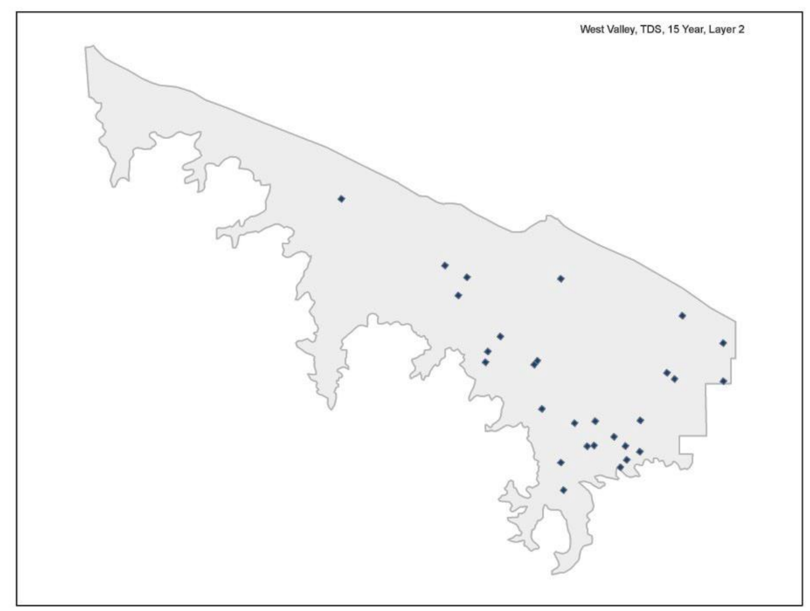
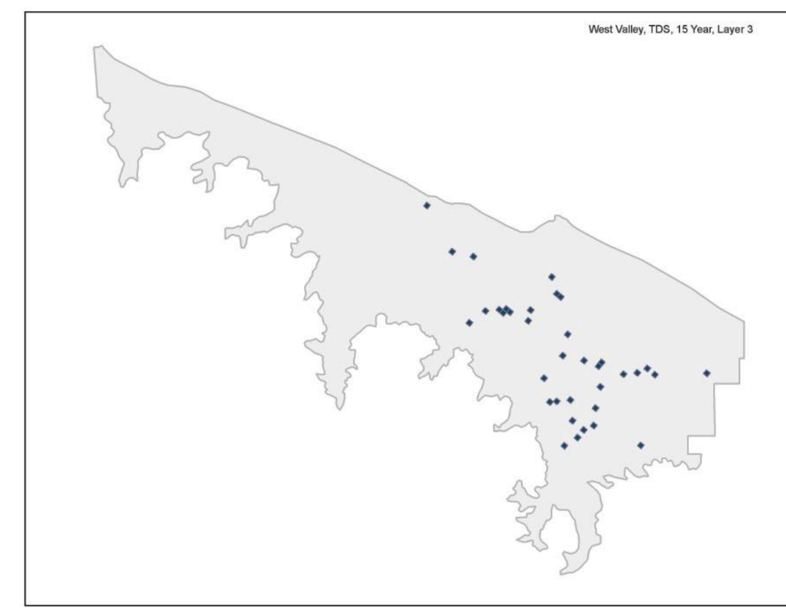
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
15-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 3 (CONTINUED)
West Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

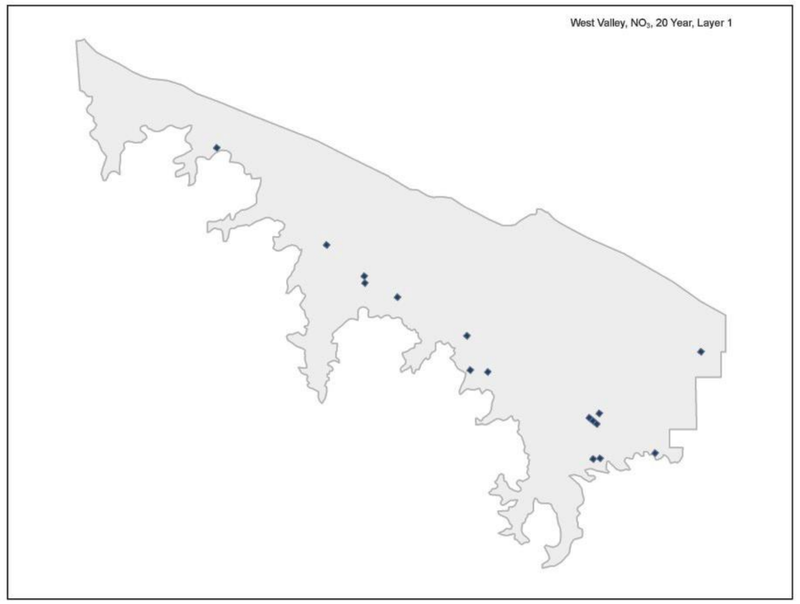
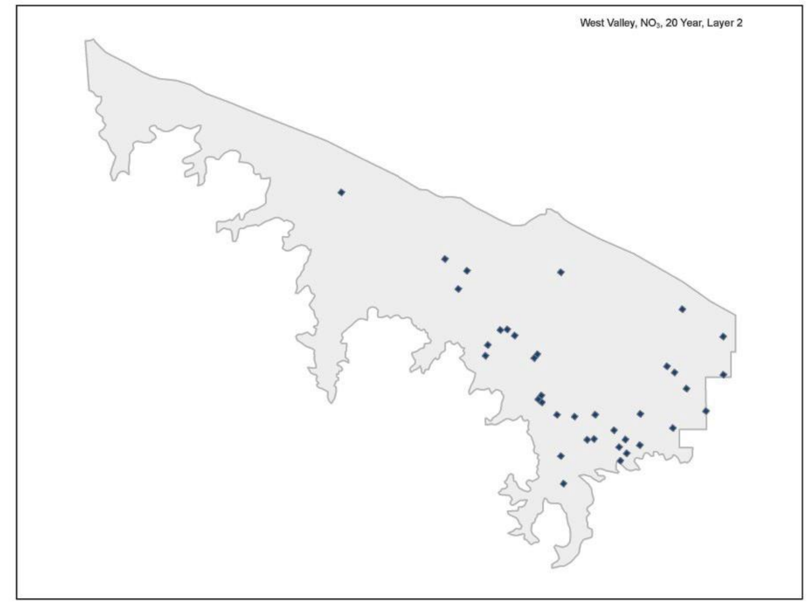
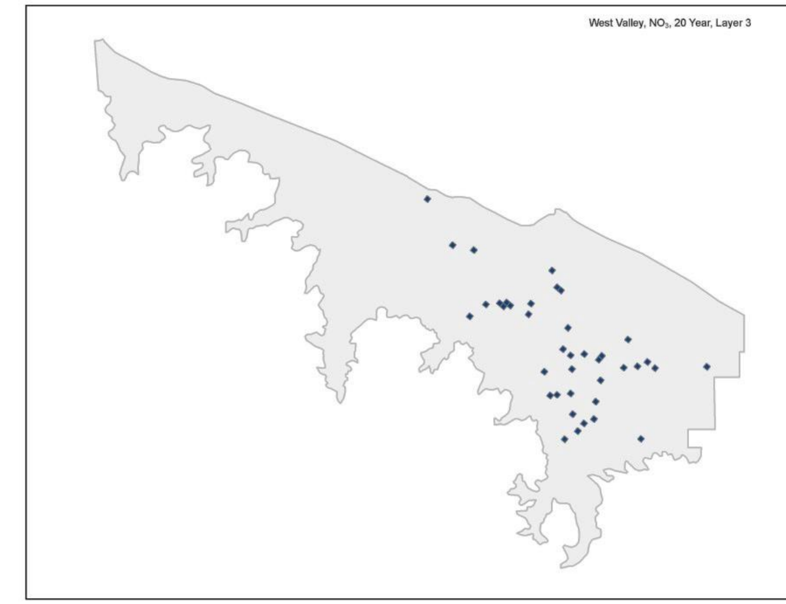
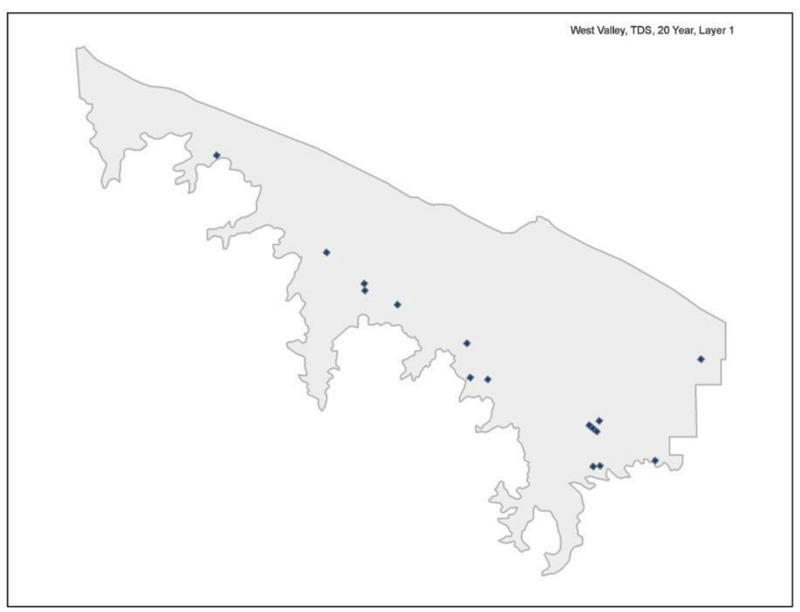
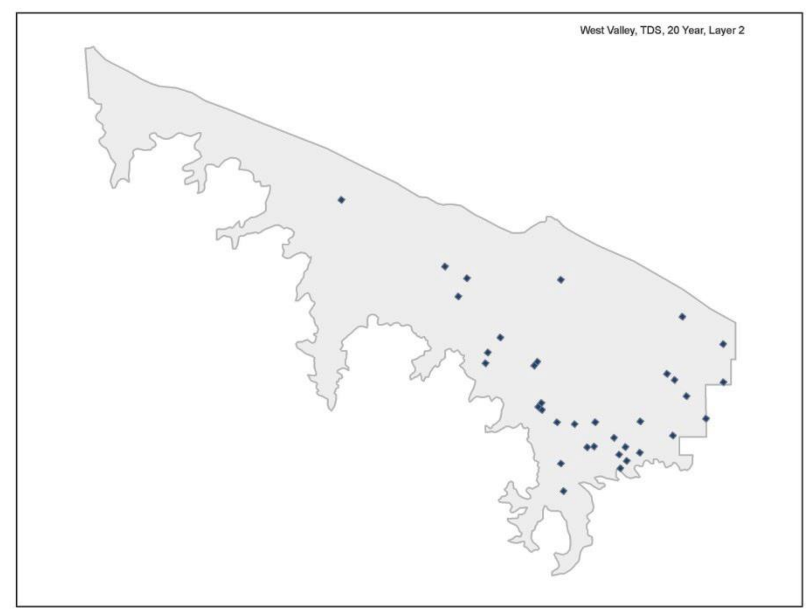
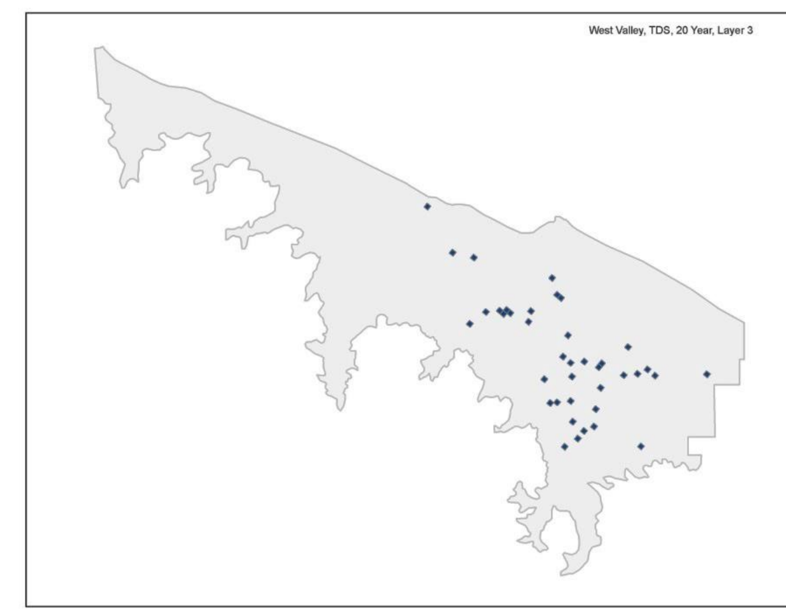
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
20-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4
East Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
5-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4 (CONTINUED)
East Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

(Three Aquifer Layers)

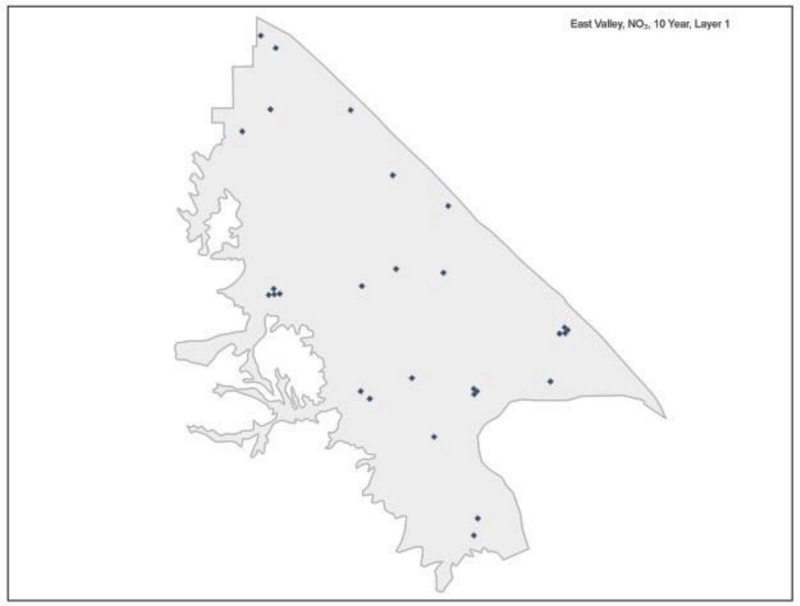
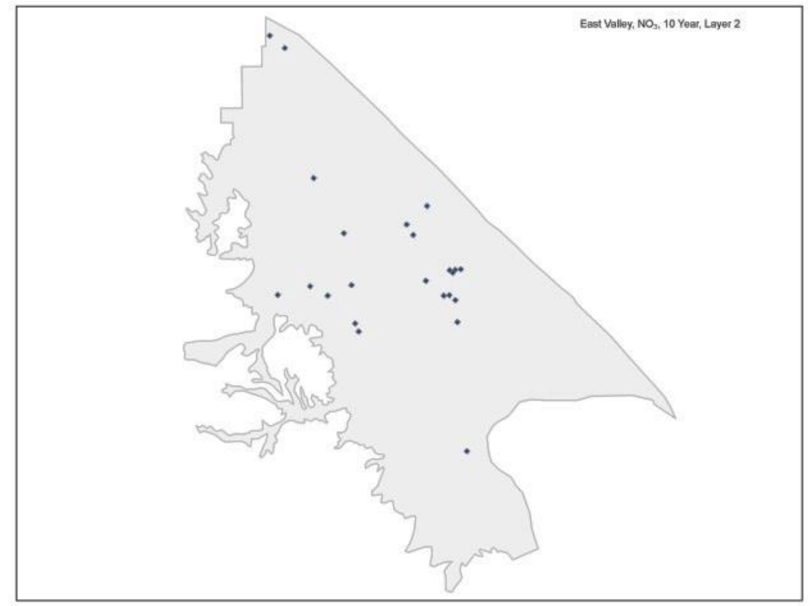
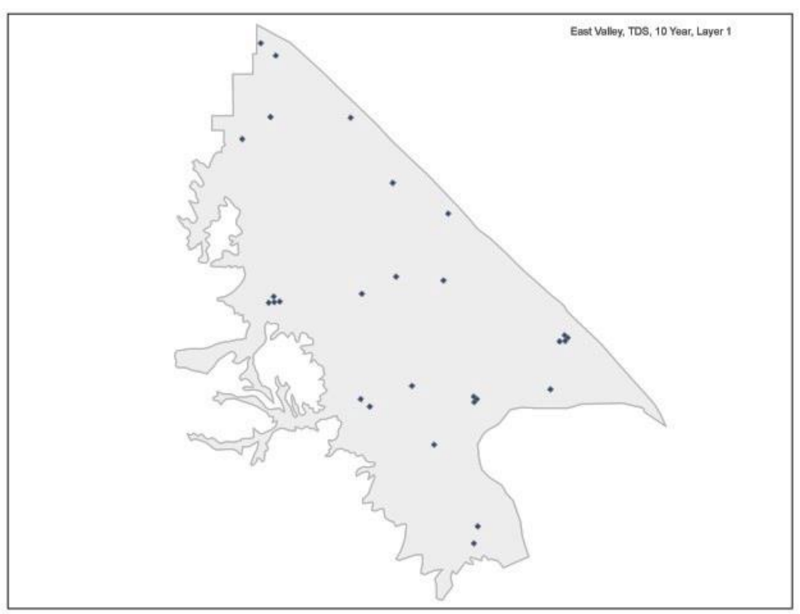
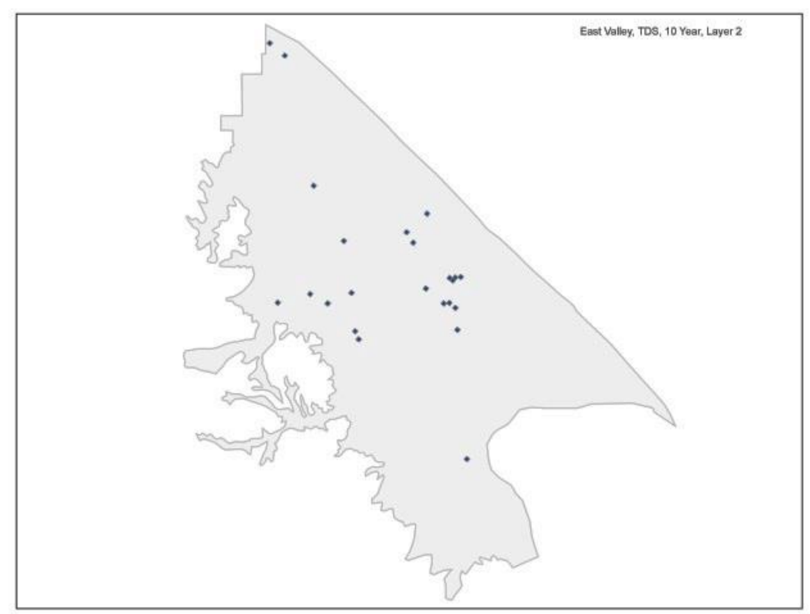
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
10-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4 (CONTINUED)
East Whitewater River Data Spatial Point Distribution for Different Baseline Periods
(Three Aquifer Layers)

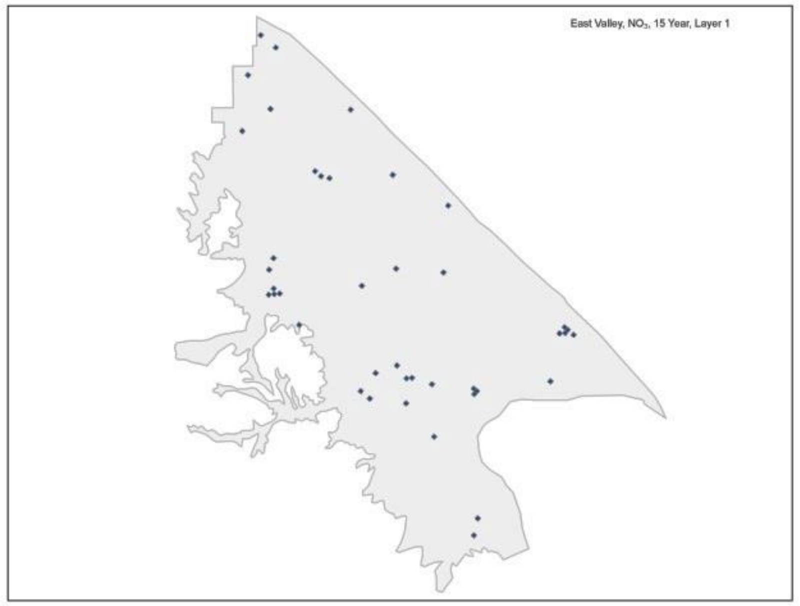
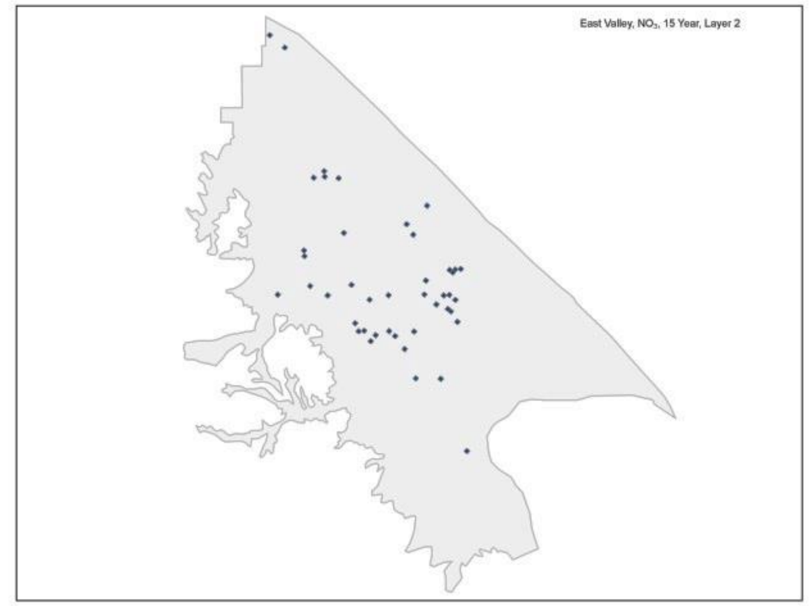
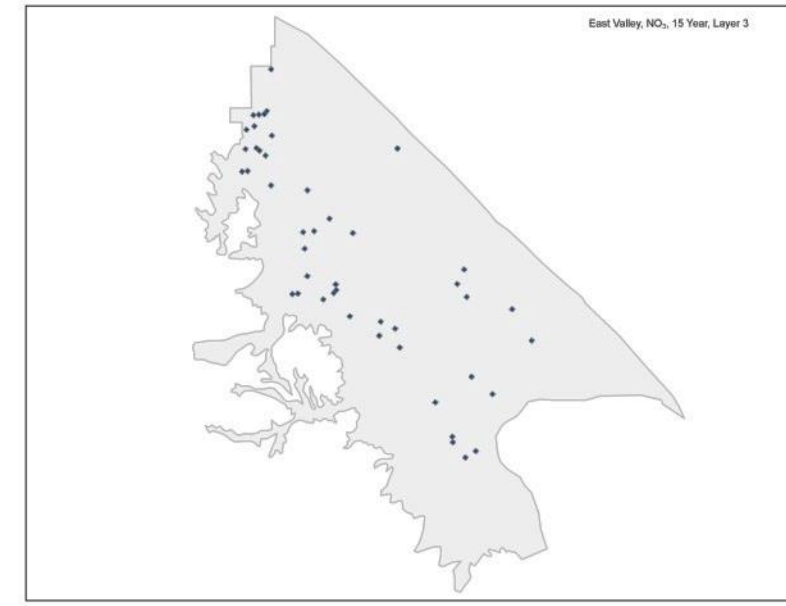
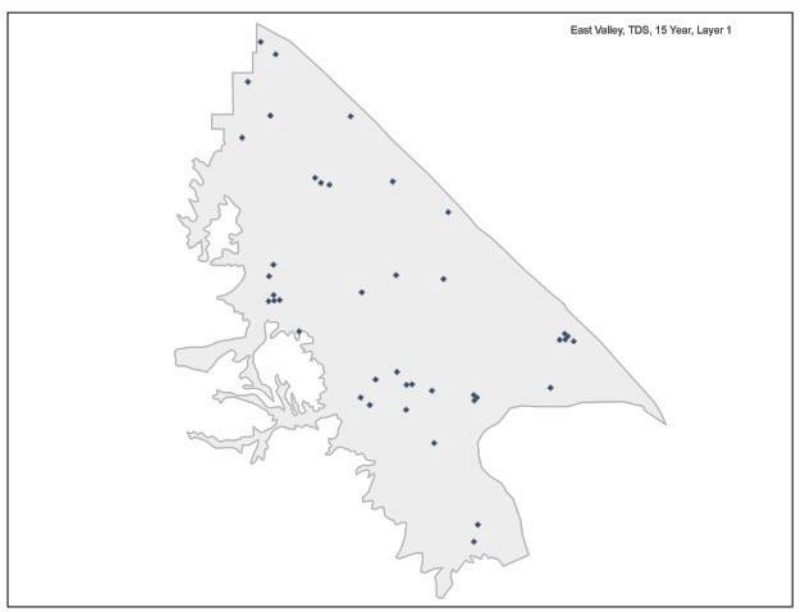
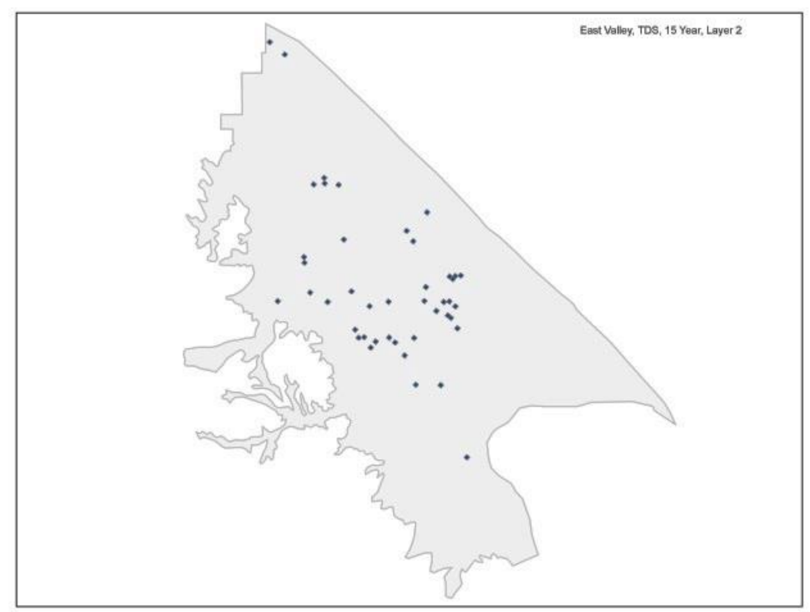
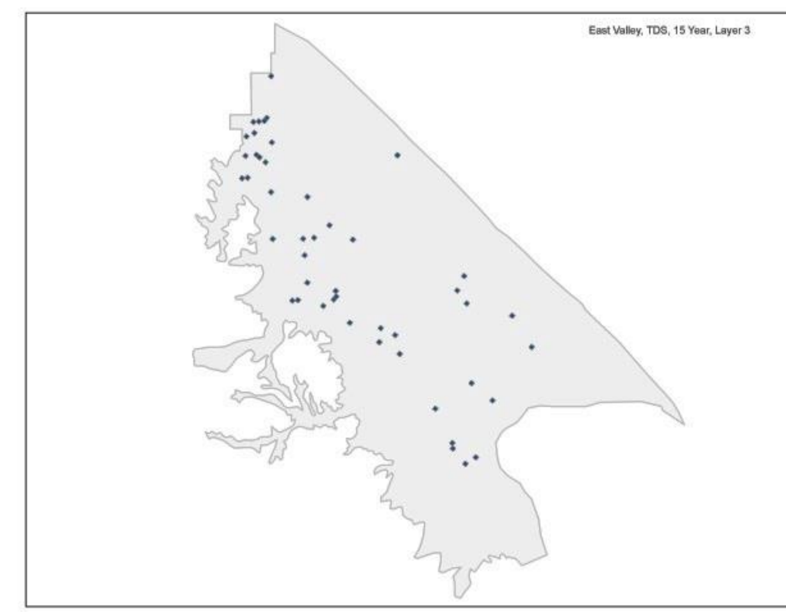
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
15-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 4 (CONTINUED)
East Whitewater River Data Point Spatial Distribution for Different Baseline Periods
(Three Aquifer Layers)

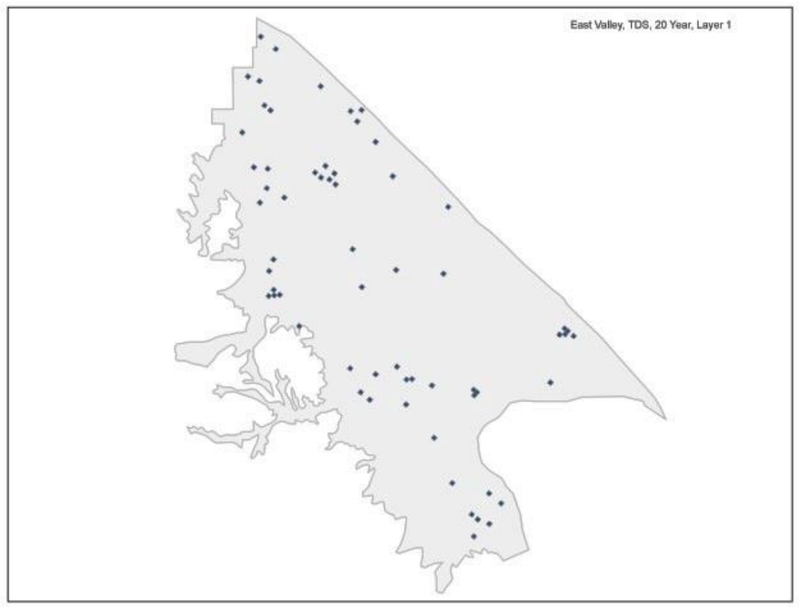
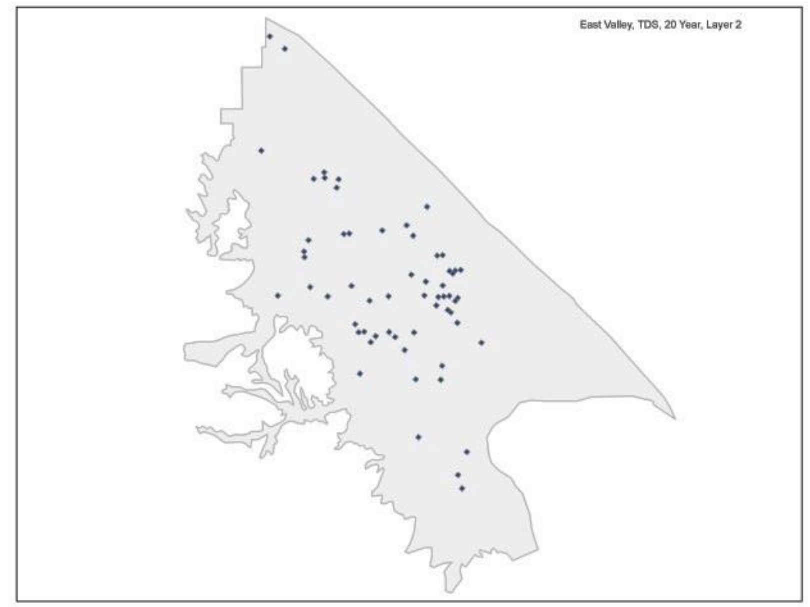
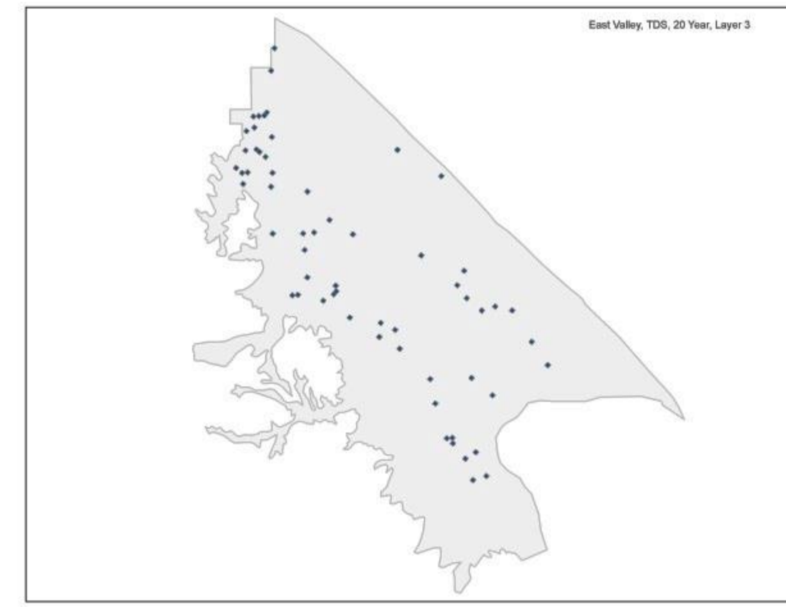
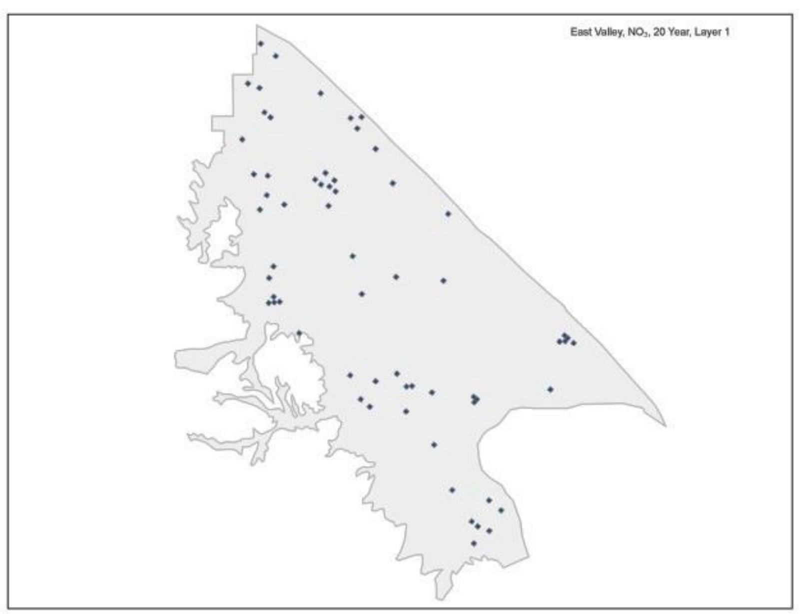
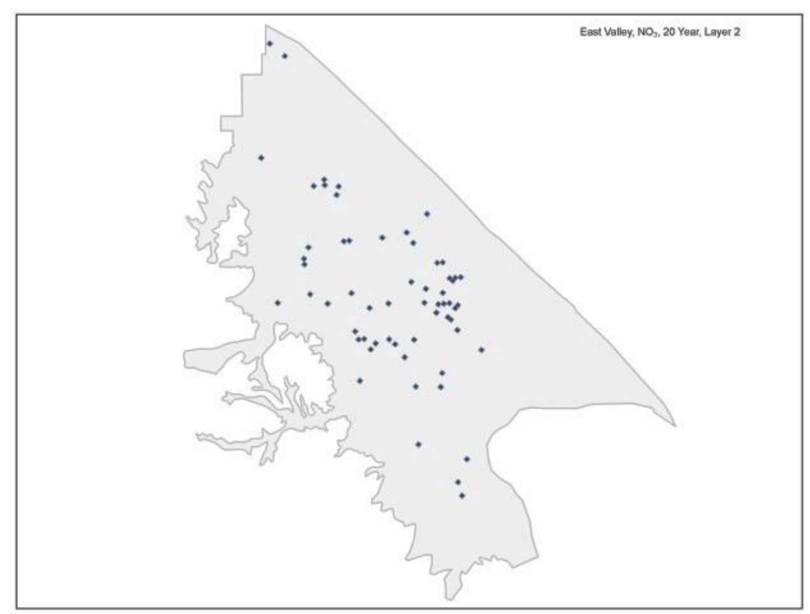
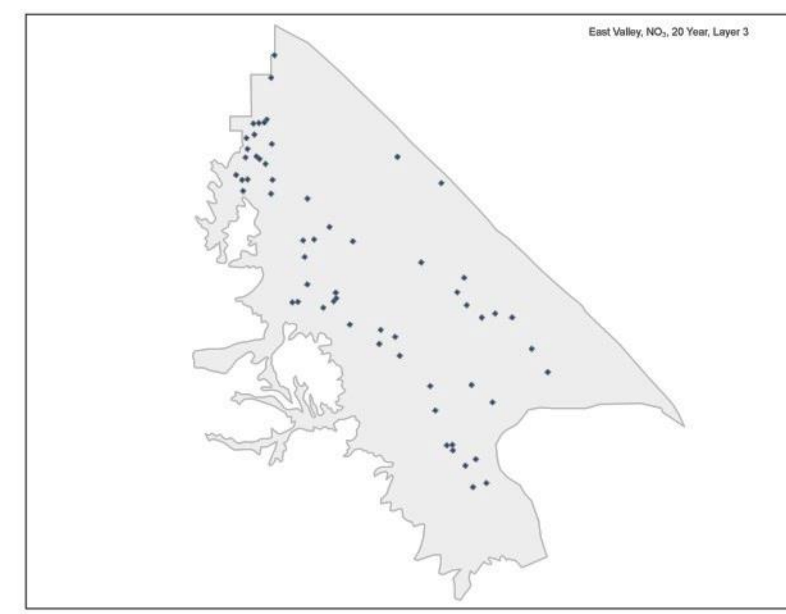
Baseline Period	Constituent	Layer 1	Layer 2	Layer 3
20-Year	Nitrate Data Points			
	TDS Dtata Points			

Figure 5
Mission Creek Data Point Spatial Distribution for Different Baseline Periods
(No Aquifer Layering)

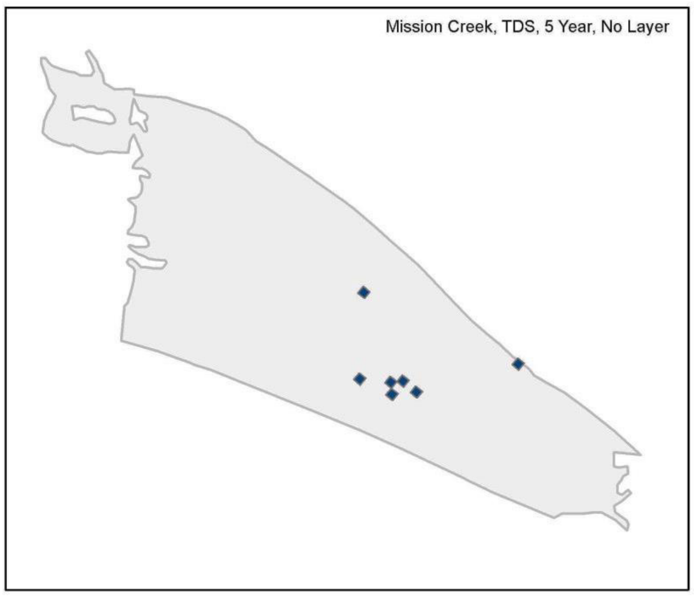
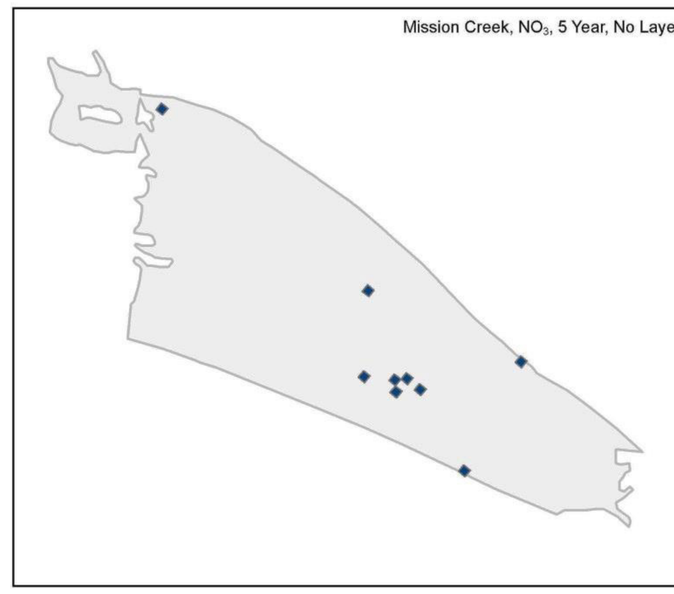
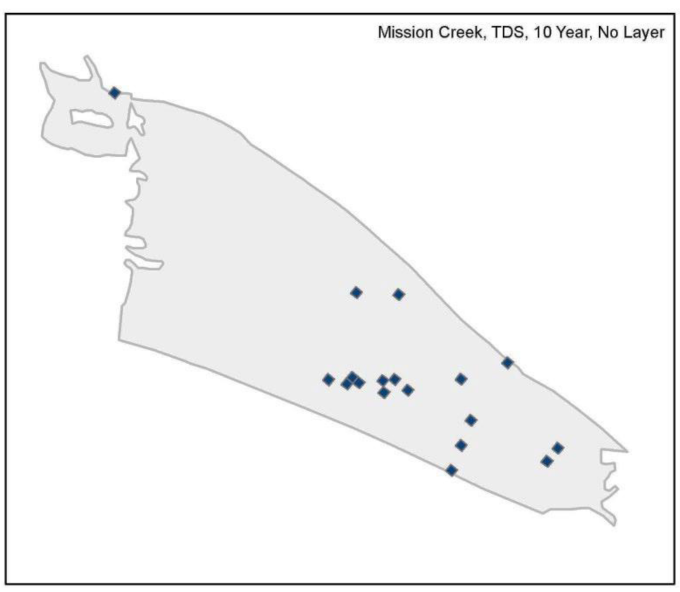
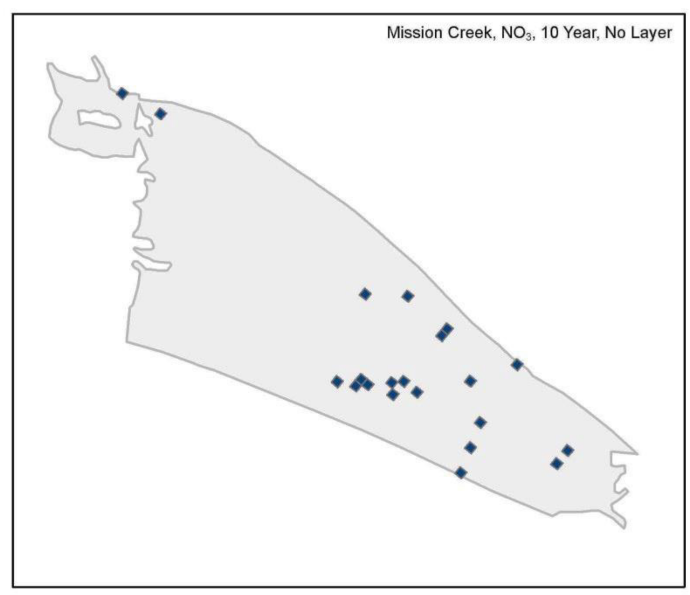
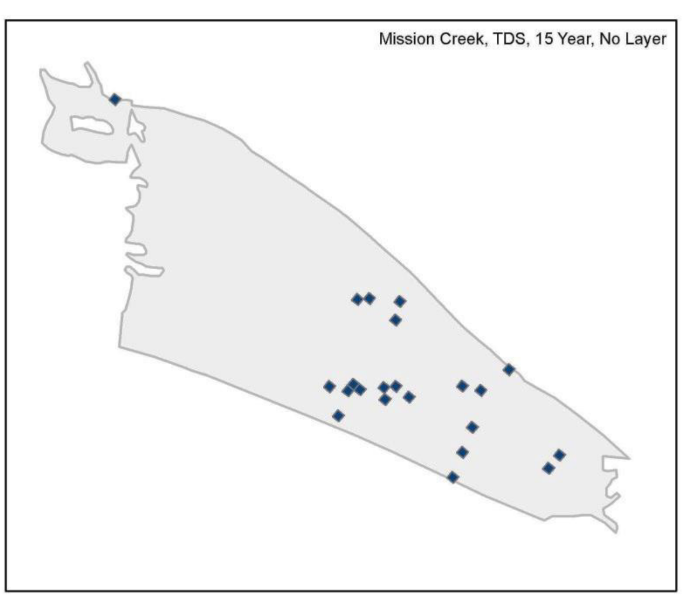
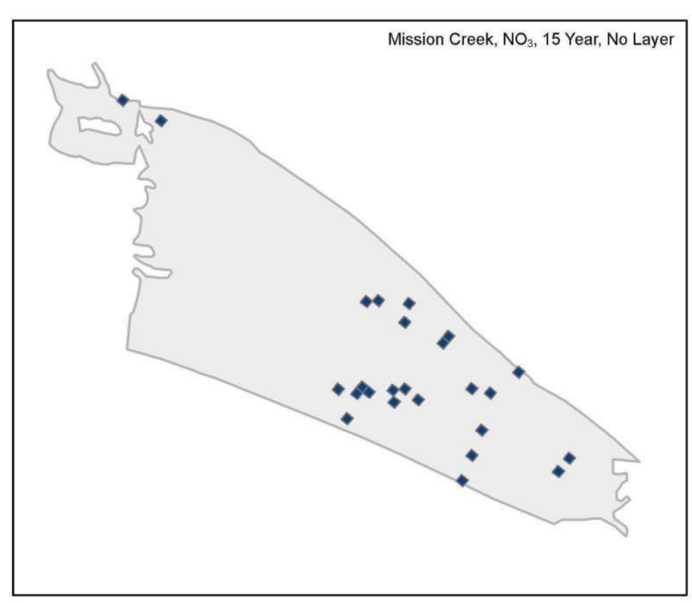
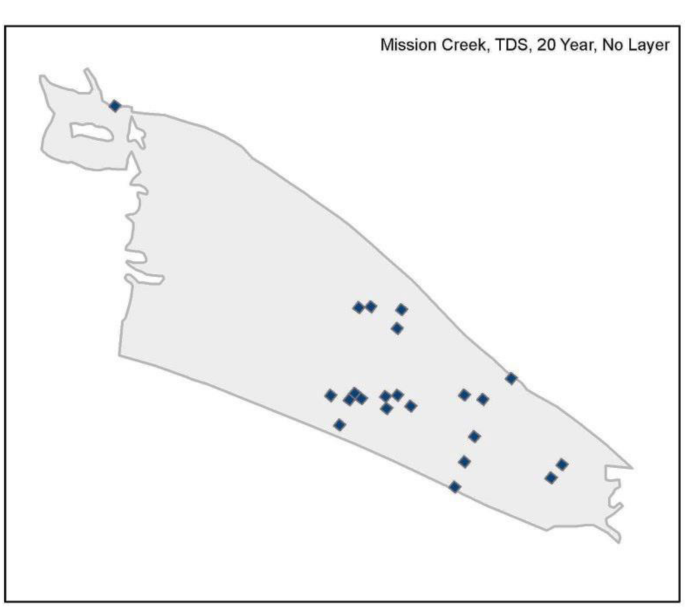
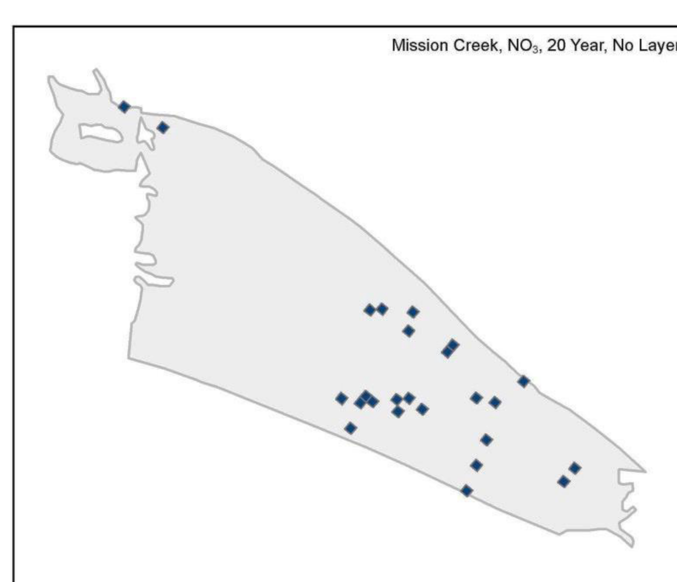
Baseline Period	TDS Data Point	Nitrate Data Points
5-Year		
10-Year		
15-Year		
20-Year		

Figure 6
Garnet Hill Data Point Spatial Distribution for Different Baseline Periods
(No Aquifer Layering)

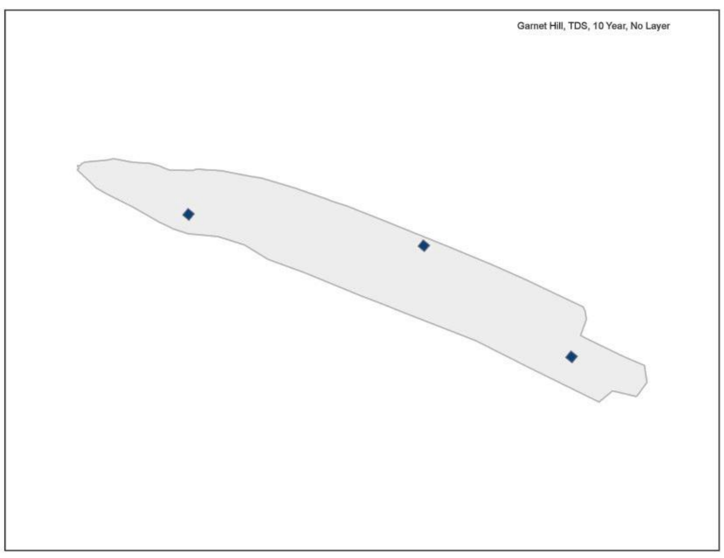
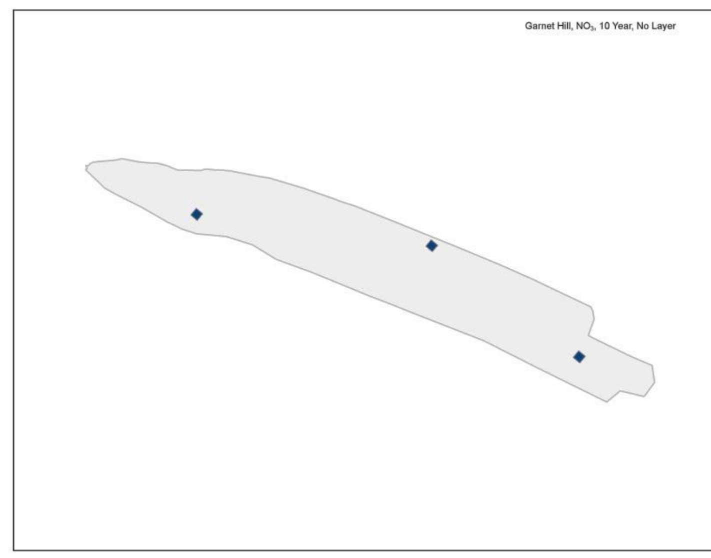
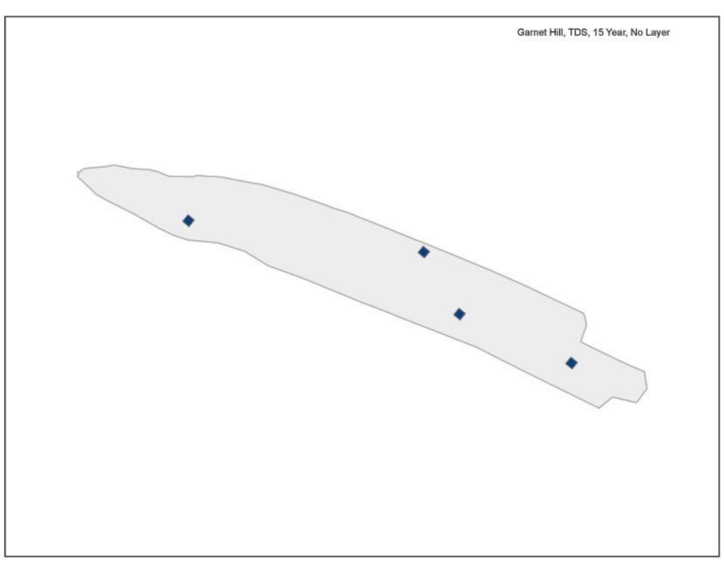
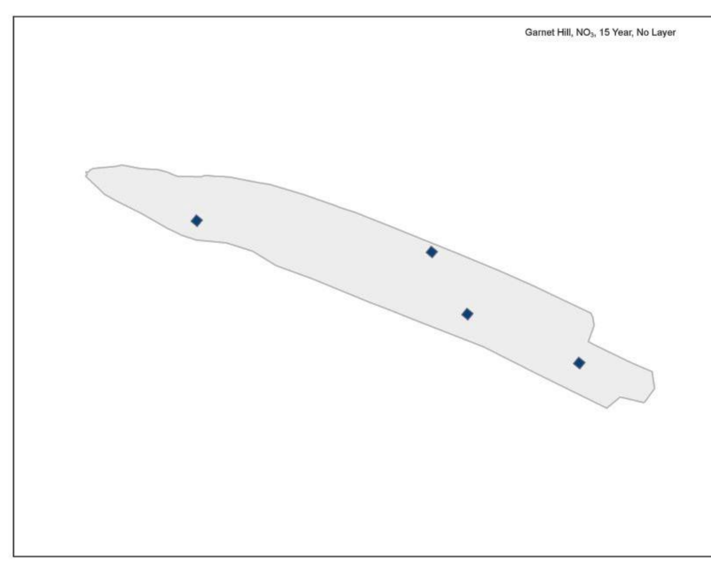
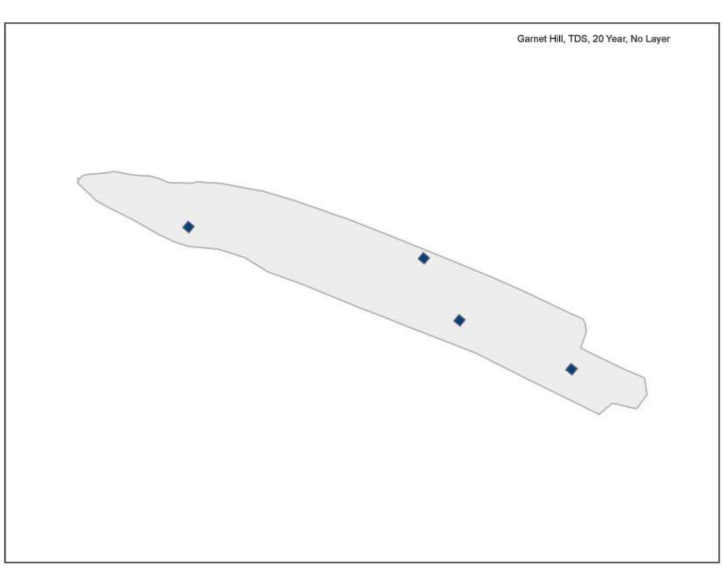
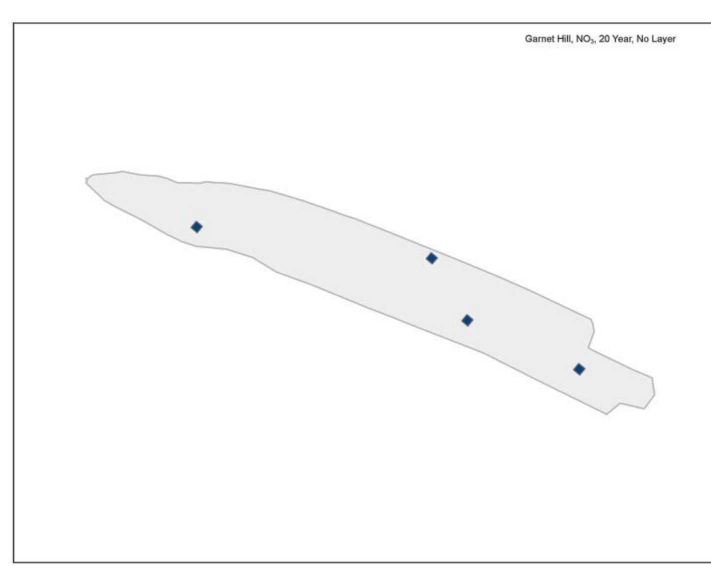
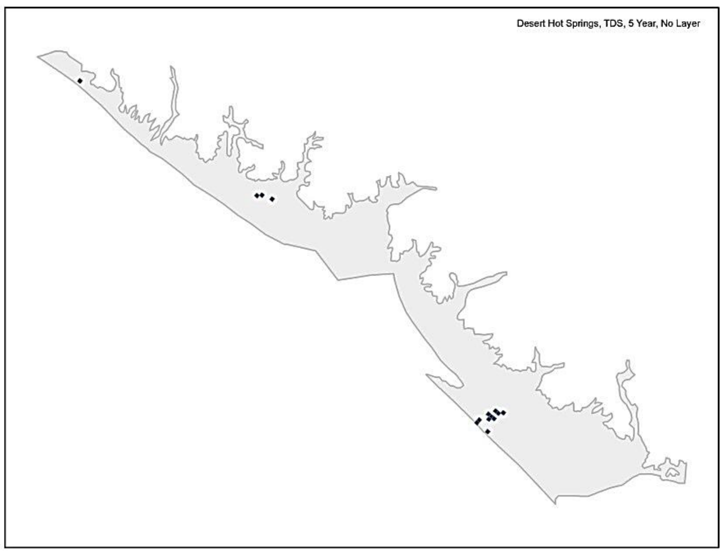
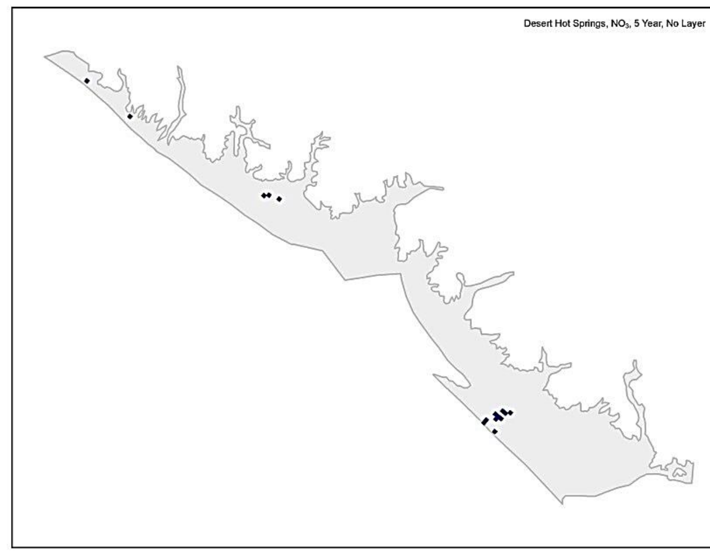
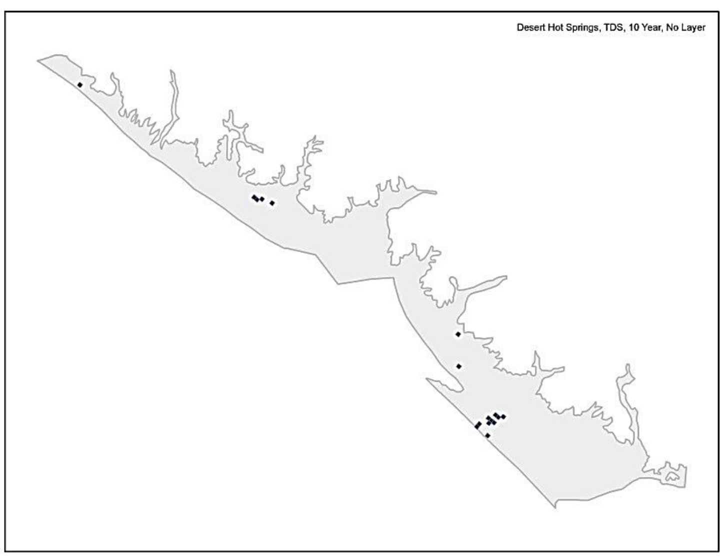
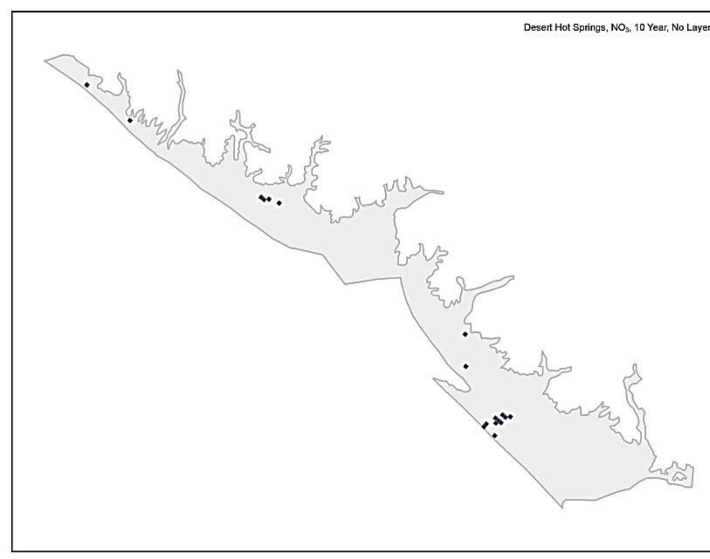
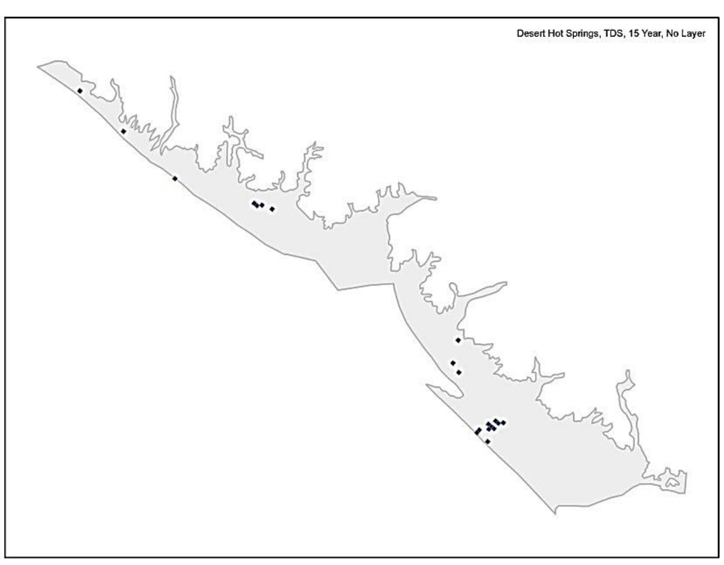
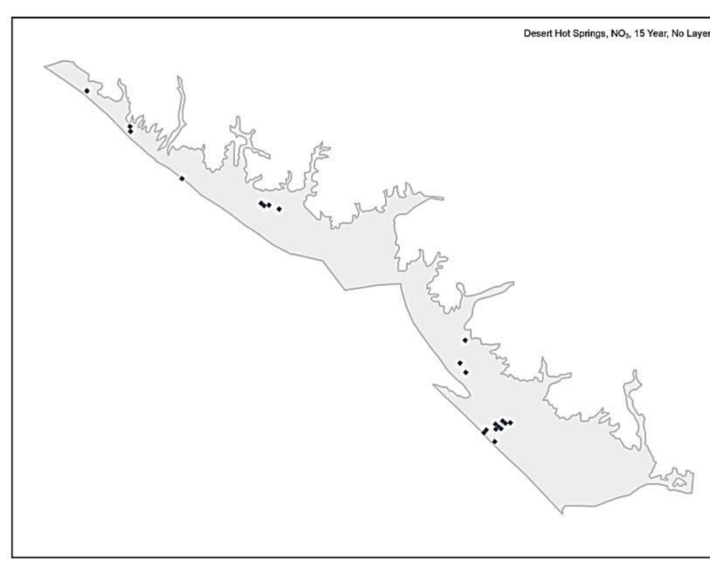
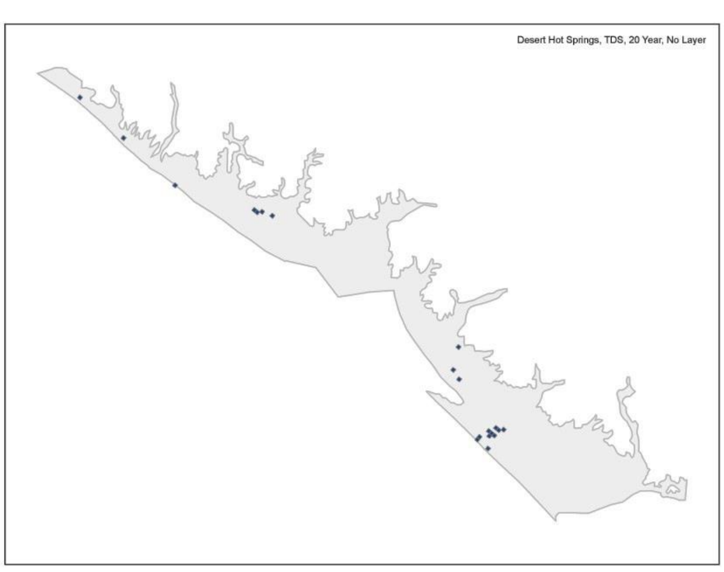
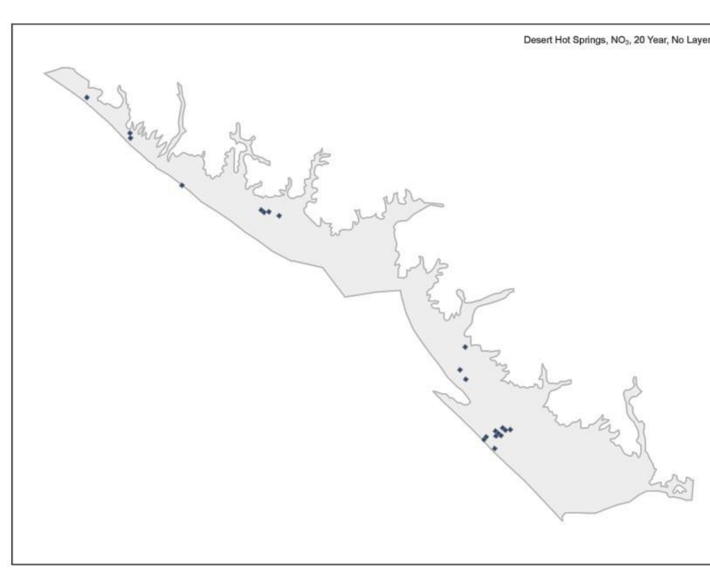
Baseline Period	TDS Data Point	Nitrate Data Points
5-Year	NO DATA POINTS	NO DATA POINTS
10-Year		
15-Year		
20-Year		

Figure 7
Desert Hot Springs Data Point Spatial Distribution for Different Baseline Periods
(No Aquifer Layering)

Baseline Period	TDS Data Point	Nitrate Data Points
5-Year		
10-Year		
15-Year		
20-Year		

3.1.1 West Whitewater Management Zone

Table 3 presents a description of the data distribution summary prepared from visual inspection of **Figure 3**. Listed below is a discussion of the spatial distribution of data points by aquifer layer.

- Layer 1: This layer lacks sufficient spatial distribution for contouring under any baseline. In particular, there are few data points in the northern portion of the management zone.
- Layer 2: This layer lacks sufficient spatial distribution for contouring until approximately the 15-Year baseline. The density of points is low, but the distribution is random in the eastern two thirds of the management zone.
- Layer 3: This layer has good density of data points, but is very limited in spatial distribution in the western portion of the management zone. The eastern portion could be contoured for the 10-Year baseline.

Table 3
West Whitewater Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points			Notes
	Layer 1	Layer 2	Layer 3	
5-Year	Poor	Poor	Fair	Layers 1 and 2 lack data points, Layer 3 lacks data points in western portion of management zone
10-Year	Poor	Poor	Fair	Layer 2 lacks many points, Layer 3 lacks data points in western portion of management zone
15-Year	Poor	Fair	Fair	Layer 2 lacks many points, Layer 3 lacks data points in western portion of management zone
20-Year	Poor	Fair	Fair	Layer 2 lacks many points, Layer 3 lacks data points in western portion of management zone

3.1.2 East Whitewater Management Zone

Table 4 presents a description of the data distribution summary prepared from visual inspection of **Figure 4**. Listed below is a discussion of the spatial distribution of data points by aquifer layer.

- Layer 1: This layer lacks sufficient spatial distribution for contouring until the 10-Year or 15-Year baseline. The spatial distribution appears random.
- Layer 2: This layer lacks spatial distribution for the full extent of the aquifer limits. Data is concentrated in the center of the aquifer. The majority of the layer could be contoured at the 15-Year baseline.
- Layer 3: This layer lacks sufficient spatial distribution for contouring until the 10-Year or 15-Year baseline. The spatial distribution appears random, although data gaps exist along the northern boundary of the aquifer layer.

Table 4
East Whitewater Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points			Notes
	Layer 1	Layer 2	Layer 3	
5-Year	Poor	Poor	Poor	
10-Year	Fair	Poor	Fair	Layer 2 lacks data outside the center of the management zone, layer 3 lacks data along its northern boundary
15-Year	Fair	Fair	Fair	Layer 2 lacks data outside the center of the management zone, layer 3 lacks data along its northern boundary
20-Year	Good	Fair	Fair	Layer 2 lacks data outside the center of the management zone, layer 3 lacks data along its northern boundary

3.1.3 Mission Creek Management Zone

Table 5 presents a description of the data distribution summary prepared from visual inspection of **Figure 5**. Listed below is a discussion of the spatial distribution of data points by aquifer layer and a combined single aquifer system.

- Layer 1: This layer lacks sufficient spatial distribution for contouring under any baseline.
- Layer 2: This layer lacks sufficient spatial distribution for contouring under any baseline.
- Combined/no layering: The data distribution is random in the eastern portion of the management zone. After the 5-Year baseline, this portion could be contoured; the western portion could be contoured only with significant uncertainty.

Table 5
Mission Creek Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points			Notes
	Layer 1	Layer 2	No Layering	
5-Year	Poor	Poor	Poor	
10-Year	Poor	Poor	Fair	Lacking western portion data
15-Year	Poor	Poor	Fair	Lacking western portion data
20-Year	Poor	Poor	Fair	Lacking western portion data

3.1.4 Garnet Hill Management Zone

Table 6 presents a description of the data distribution summary prepared from visual inspection of **Figure 6**. Listed below is a discussion of the spatial distribution of data points within the management zone

- Combined/no layering: The data distribution is random, although there are very few data points. There is no data in the 5-Year baseline. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 6
Garnet Hill Management Zone Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points	Notes
5-Year	N/A	No data
10-Year	Poor	Good distribution, although few data points
15-Year	Fair	Good distribution, although few data points
20-Year	Fair	Good distribution, although few data points

3.1.5 Desert Hot Springs Management Zone

Table 7 presents a description of the data distribution summary prepared from visual inspection of **Figure 7**. Listed below is a discussion of the spatial distribution of data points within the Miracle Hill area of the Desert Hot Springs Management Zone.

- Combined/no layering: The data distribution is random, although there are very few data points. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 7
Miracle Hill Area – Desert Hot Springs Management Zone
Baseline Period Data Spatial Distribution Summary

Baseline Period	Spatial Distribution of Data Points	Notes
5-Year	Poor	Single data point
10-Year	Poor	Good distribution, although few data points
15-Year	Fair	Good distribution, although few data points
20-Year	Fair	Good distribution, although few data points

Table 8 presents a description of the data distribution summary prepared from visual inspection of **Figure 7**. Listed below is a discussion of the spatial distribution of data points within the Sky Valley area of the Desert Hot Springs Management Zone.

- Combined/no layering: The data distribution is random, although there are very few data points. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 8
Sky Valley Area – Desert Hot Springs Management Zone
Baseline Period Data Spatial Distribution Summary

Baseline Period	Data Distribution	Notes
5-Year	Poor	Cluster of data points – poor spatial distribution
10-Year	Poor	Cluster of data points – poor spatial distribution
15-Year	Poor	Cluster of data points – poor spatial distribution
20-Year	Poor	Cluster of data points – poor spatial distribution

Table 9 presents a description of the data distribution summary prepared from visual inspection of **Figure 7**. Listed below is a discussion of the spatial distribution of data points within the Fargo Canyon area of the Desert Hot Springs Management Zone.

- Combined/no layering: The data distribution is not random and there are very few data points. Due to limited data points, this management zone lacks data for contouring under baseline period.

Table 9
Fargo Canyon Area – Desert Hot Springs Management Zone
Baseline Period Data Distribution Summary

Baseline Period	Spatial Distribution of Data Points	Notes
5-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion
10-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion
15-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion
20-Year	Poor	Poor spatial distribution, lacking data in southern/eastern portion

3.2 SPATIAL AUTOCORRELATION OF DATA POINTS

As mentioned in Section 2.1.2, a positive spatial autocorrelation suggests higher confidence in predicting the value at one location based on the value sampled from a nearby location when using data interpolation methods. A negative autocorrelation describes patterns in which neighboring patters are unlike and not related. **Table 10** though **Table 13** summarize the confidence levels associated with positive spatial autocorrelation by management zone.

3.2.1 West Whitewater Management Zone

Table 10 presents the autocorrelation results summary. The following bullets describe what the results mean relative to each aquifer layer and baseline period within the management zone.

- Layer 1: Positive spatial correlation is not observed for either TDS or nitrate. Spatial autocorrelation for the 5- and 10-Year baseline periods could not be evaluated due to the lack of data.
- Layer 2: The 15- and 20-Year baseline periods show strong positive autocorrelation for both TDS and nitrate; this indicates that the water quality data varies predictably. Similar to Layer 1, spatial autocorrelation could not be evaluated for the 5- and 10-Year baseline periods.
- Layer 3: High positive spatial correlation is observed for nitrate in all baseline periods and TDS in the 15- and 20-Year baseline periods, suggesting predictability in space.

Table 10
West Whitewater Management Zone Positive Spatial Autocorrelation Confidence Levels by Layer and Baseline Period

Baseline Period	Layer 1		Layer 2		Layer 3	
	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	-	-	-	-	< 90%	**95%**
10-Year	-	-	-	-	< 90%	**95%**
15-Year	< 90%	< 90%	**95%**	**95%**	**95%**	**95%**
20-Year	< 90%	< 90%	**95%**	**95%**	**95%**	**95%**

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.2.2 East Whitewater Management Zone

Table 11 presents the autocorrelation results summary. The following bullets describe what the results mean relative to each aquifer layer and baseline period within the management zone.

- Layer 1: TDS data shows positive spatial autocorrelation for all baseline periods and confidence increasing from the 5- to the 10-Year baseline period. Positive spatial autocorrelation is observed in the nitrate data for the 15- and 20-Year baseline periods.
- Layer 2: Spatial autocorrelation could not be evaluated for the 5-Year baseline period. Positive spatial autocorrelation is observed for TDS and nitrate in all other baseline periods except for TDS in the 15-Year baseline period; this may be due to increased random variability with the additional data gained between the 10- and 15-Year baseline periods, but strong positive spatial autocorrelation is again observed in the 20-Year baseline period.
- Layer 3: Positive spatial autocorrelation is observed in the TDS data except for the 5-Year baseline period where it cannot be evaluated. Nitrate is observed to have strong positive spatial autocorrelation in the 5-Year baseline period, but not for all other baseline periods; this together with the increased variance observed in the data suggests the nitrate data varies with less predictability in Layer 3.

Table 11
East Whitewater Management Zone Positive Spatial Autocorrelation Confidence Levels by Layer and Baseline Period

Baseline Period	Layer 1		Layer 2		Layer 3	
	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	90%	< 90%	-	-	-	**95%**
10-Year	95%	< 90%	**95%**	**95%**	**90%**	< 90%
15-Year	**95%**	**90%**	< 90%	**95%**	**95%**	< 90%
20-Year	**95%**	**90%**	**95%**	**95%**	**90%**	< 90%

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.2.3 Mission Creek Management Zone

Table 12 presents the autocorrelation results summary. The following bullets describe what the results mean relative to each aquifer layer and baseline period within the management zone.

- Layers 1 and 2: Spatial autocorrelation could not be evaluated for all baseline periods for Mission Creek Management Zone when separated into layers due to the lack of data.
- No Layering: If no layering is considered, strong positive spatial autocorrelation is observed for TDS and nitrate in all baseline periods except for the 5-Year baseline period for which spatial autocorrelation could not be evaluated.

Table 12
Mission Creek Management Zone Positive Spatial Autocorrelation Confidence Levels by Layer and Baseline Period

Baseline Period	Layer 1		Layer 2		No Layering	
	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	-	-	-	-	-	-
10-Year	-	-	-	-	**95%**	**95%**
15-Year	-	-	-	-	**95%**	**90%**
20-Year	-	-	-	-	**95%**	**90%**

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.2.4 Garnet Hill Management Zone

No spatial autocorrelation could be evaluated for any baseline period within Garnet Hill Management Zone due to a lack of data.

3.2.5 Desert Hot Springs Management Zone

No spatial autocorrelation could be evaluated for the Miracle Hill or Sky Valley Subareas within Desert Hot Springs Management Zone due to a lack of data.

Fargo Canyon (see **Table 13**): Strong positive spatial autocorrelation is observed for TDS in all baseline periods except for the 10-Year baseline period. Nitrate shows strong positive spatial autocorrelation in the 5-Year baseline period, but not in other baseline periods. Note that the spatial autocorrelation for the 10-Year baseline period could not be evaluated, but data in this period is very similar to the 5-Year baseline period with the addition of two filtered data points a small distance from the cluster that comprises the entire 5-Year baseline period.

Table 13
Fargo Canyon Subarea of the Desert Hot Springs Management Zone
Positive Spatial Autocorrelation Confidence Levels by Baseline Period

Baseline Period	TDS	Nitrate
5-Year	**95%**	**95%**
10-Year	-	-
15-Year	**95%**	< 90%
20-Year	**95%**	< 90%

Notes: no value (-) indicates that the spatial autocorrelation test failed due to lack of data.

3.3 SUMMARY STATISTICS

Table 14 through **Table 20** list summary statistics for the filtered data set, as described in Section 2.2 of TM-2, within each baseline period for each management zone and each aquifer layer, if applicable. These tables are provided for general reference and can be reviewed with the results in the previous two subsections. Basic statistical methods are described in the following: USGS, 2010. Statistical Methods in Water Resources, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4, Hydrologic Analysis and Interpretation.

Table 14
West Whitewater Management Zone Summary Statistics by Layer and Baseline Period

		Layer 1		Layer 2		Layer 3	
Baseline Period	**Statistic**	**TDS**	**Nitrate**	**TDS**	**Nitrate**	**TDS**	**Nitrate**
5-Year	Count	7	7	5	6	29	29
	Mean	640	25.2	368	28.6	198	5.6
	Median	610	7.9	450	21.5	190	3.3
	Mode	N/A	N/A	450	N/A	210	3
	Std. Dev.	199	33.8	130	28.9	34	6.3
	Range	450 to 1060	3 to 88.9	190 to 480	2.7 to 62.1	160 to 330	2.2 to 27
	95% CI	456 to 825	ND to 56.5	207 to 529	ND to 59	185 to 211	3.2 to 8
10-Year	Count	8	8	9	10	31	31
	Mean	606	22.2	359	32.2	198	5.4
	Median	590	6.4	303	21.2	191	3.2
	Mode	N/A	N/A	450	N/A	210	3
	Std. Dev.	208	32.4	121	36.6	33	6.1
	Range	367 to 1,060	1.2 to 88.9	190 to 536	1.59 to 109.0	160 to 330	1.9 to 27
	95% CI	432 to 780	ND to 49.3	266 to 452	6 to 58.4	186 to 210	3.1 to 7.6
15-Year	Count	14	14	28	29	38	38
	Mean	544	31.8	414	36.9	204	8.2
	Median	520	10.4	375	28.5	195	3.2
	Mode	N/A	N/A	302	2.7	210	3
	Std. Dev.	194	36.2	201	37	49	14
	Range	201 to 1,060	1.2 to 101	169 to 842	1.6 to 120	160 to 420	1.9 to 76
	95% CI	432 to 656	10.9 to 52.7	336 to 492	22.8 to 51	188 to 220	3.6 to 12.8
20-Year	Count	16	16	35	37	41	41
	Mean	590	41.2	379	31.8	202	7.8
	Median	548	17.9	302	15	190	3
	Mode	N/A	N/A	190	2.7	210	3
	Std. Dev.	224	44.6	196	34.8	47	13.6
	Range	201 to 1,060	1.2 to 145	169 to 842	1.6 to 120	160 to 420	1.6 to 76
	95% CI	470 to 709	17.4 to 65	312 to 447	20.2 to 43.5	187 to 217	3.5 to 12.1

Table 15
East Whitewater Management Zone Summary Statistics by Layer and Baseline Period

		Layer 1		Layer 2		Layer 3	
Baseline Period	**Statistic**	**TDS**	**Nitrate**	**TDS**	**Nitrate**	**TDS**	**Nitrate**
5-Year	Count	18	18	11	11	26	26
	Mean	2,553	32.2	494	3.5	343	3.4
	Median	1,400	14.6	260	0.7	175	2.6
	Mode	1,400	ND	N/A	ND	160	ND
	Std. Dev.	4,444	55.1	446	5.8	610	5
	Range	170 to 19,100	ND to 230	129 to 1,500	ND to 16	142 to 3,270	ND to 24.5
	95% CI	343 to 4,762	4.8 to 59.6	195 to 794	ND to 7.4	96 to 589	1.3 to 5.4
10-Year	Count	28	28	23	23	34	34
	Mean	1,938	29.6	363	2.5	354	7.8
	Median	979	8.5	202	0.6	180	2.6
	Mode	2,200	ND	N/A	ND	160	ND
	Std. Dev.	3,654	51.3	335	4.5	554	21.4
	Range	153 to 19,100	ND to 230	129 to 1,500	ND to 16	139 to 3,270	ND to 111
	95% CI	521 to 3,355	9.7 to 49.4	218 to 508	0.5 to 4.4	161 to 548	0.4 to 15.3
15-Year	Count	41	41	43	43	48	47
	Mean	1,509	24.7	362	3.9	355	6.5
	Median	698	3.6	202	0.8	180	2.2
	Mode	665	ND	162	ND	160	ND
	Std. Dev.	3,081	45.4	360	6.5	510	18.3
	Range	152 to 19,100	ND to 230	104 to 1,750	ND to 28	123 to 3,270	ND to 111
	95% CI	537 to 2,482	10.4 to 39	251 to 472	1.9 to 5.9	207 to 503	1.1 to 11.8
20-Year	Count	62	63	60	60	61	61
	Mean	1,233	19.1	360	4.8	356	7.2
	Median	665	4.4	201	1.2	190	2
	Mode	665	ND	162	ND	160	ND
	Std. Dev.	2,538	37.7	343	9.2	463	17.1
	Range	132 to 19,100	ND to 230	104 to 1,750	ND to 57.5	123 to 3,270	ND to 111
	95% CI	589 to 1,878	9.7 to 28.6	271 to 449	2.4 to 7.2	238 to 475	2.8 to 11.6

Table 16
Mission Creek Management Zone Summary Statistics by Layer and Baseline Period

		Layer 1		Layer 2		No Layering	
Baseline Period	Statistic	TDS	Nitrate	TDS	Nitrate	TDS	Nitrate
5-Year	Count	1	1	2	2	7	9
	Mean	820	4.2	350	1.9	473	4.6
	Median	820	4.2	350	1.9	420	4.1
	Mode	N/A	N/A	N/A	N/A	N/A	3.7
	Std. Dev.	N/A	N/A	28	2.6	172	1.7
	Range	N/A	N/A	330 to 370	ND to 3.7	300 to 820	2.9 to 8.2
	95% CI	N/A	N/A	96 to 604	ND to 25.3	314 to 632	3.2 to 5.9
10-Year	Count	6	6	2	2	18	21
	Mean	724	2.5	350	1.9	614	6.3
	Median	802	2.5	350	1.9	514	3.8
	Mode	N/A	N/A	N/A	N/A	N/A	3.7
	Std. Dev.	214	1.5	28	2.6	234	10.7
	Range	446 to 956	0.9 to 4.2	330 to 370	ND to 3.7	300 to 956	0.3 to 52
	95% CI	500 to 949	1 to 4.1	96 to 604	ND to 25.3	498 to 730	1.4 to 11.2
15-Year	Count	6	6	4	4	22	25
	Mean	724	2.5	421	2.4	606	5.8
	Median	802	2.5	423	3	499	3.8
	Mode	N/A	N/A	N/A	N/A	N/A	3.6
	Std. Dev.	214	1.5	85	1.7	242	8.1
	Range	446 to 956	0.9 to 4.2	330 to 509	ND to 3.7	300 to 1,096	0.3 to 42.8[1]
	95% CI	500 to 949	1 to 4.1	286 to 556	ND to 5.2	499 to 713	2.4 to 9.1
20-Year	Count	6	6	4	4	22	25
	Mean	724	2.5	421	2.4	606	5.5
	Median	802	2.5	423	3	499	3.8
	Mode	N/A	N/A	N/A	N/A	N/A	3.6
	Std. Dev.	214	1.5	85	1.7	242	7
	Range	446 to 956	0.9 to 4.2	330 to 509	ND to 3.7	300 to 1,096	0.25 to 37[1]
	95% CI	500 to 949	1 to 4.1	286 to 556	ND to 5.2	499 to 713	2.7 to 8.4

[1] The range decreases from the 10-Year to the 15-Year baseline period and again from the 15-Year to the 20-Year baseline period. This is due to wells being added to the database because their records only exist for earlier years, bringing the maximum filtered data point lower as they exist in the same grid cell and layer used in spatial filtering.

Table 17
Garnet Hill Management Zone Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	-	-
	Mean	-	-
	Median	-	-
	Mode	-	-
	Std. Dev.	-	-
	Range	-	-
	95% CI	-	-
10-Year	Count	3	3
	Mean	237	2.3
	Median	237	1.8
	Mode	N/A	N/A
	Std. Dev.	51	2
	Range	186 to 288	0.6 to 4.5
	95% CI	111 to 363	ND to 7.3
15-Year	Count	4	4
	Mean	217	2.2
	Median	212	1.8
	Mode	N/A	N/A
	Std. Dev.	58	1.6
	Range	156 to 288	0.6 to 4.5
	95% CI	124 to 309	ND to 4.8
20-Year	Count	4	4
	Mean	217	2.2
	Median	212	1.8
	Mode	N/A	N/A
	Std. Dev.	58	1.6
	Range	156 to 288	0.6 to 4.5
	95% CI	124 to 309	ND to 4.8

Table 18
Miracle Hill Subarea of Desert Hot Springs Management Zone
Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	1	2
	Mean	390	7.7
	Median	390	7.7
	Mode	N/A	N/A
	Std. Dev.	N/A	3.5
	Range	N/A	5.2 to 10.2
	95% CI	N/A	ND to 39.1
10-Year	Count	1	2
	Mean	390	7.7
	Median	390	7.7
	Mode	N/A	N/A
	Std. Dev.	N/A	3.5
	Range	N/A	5.2 to 10.2
	95% CI	N/A	ND to 39.1
15-Year	Count	3	4
	Mean	558	4.8
	Median	440	4.2
	Mode	N/A	N/A
	Std. Dev.	250	4.1
	Range	390 to 845	0.5 to 10.2
	95% CI	< 100 to 1,178	ND to 11.2
20-Year	Count	3	4
	Mean	558	4.8
	Median	440	4.2
	Mode	N/A	N/A
	Std. Dev.	250	4.1
	Range	390 to 845	0.5 to 10.2
	95% CI	< 100 to 1,178	ND to 11.2

Table 19
Sky Valley Subarea of Desert Hot Springs Management Zone
Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	3	3
	Mean	1,350	24.9
	Median	1,350	25
	Mode	N/A	N/A
	Std. Dev.	150	15.2
	Range	1,200 to 1,500	9.7 to 40
	95% CI	977 to 1,723	ND to 62.5
10-Year	Count	4	4
	Mean	1,280	18.8
	Median	1,275	17.4
	Mode	N/A	N/A
	Std. Dev.	186	17.4
	Range	1,070 to 1,500	0.4 to 40
	95% CI	984 to 1,576	ND to 46.5
15-Year	Count	4	4
	Mean	1,280	18.8
	Median	1,275	17.4
	Mode	N/A	N/A
	Std. Dev.	186	17.4
	Range	1,070 to 1,500	0.4 to 40
	95% CI	984 to 1,576	ND to 46.5
20-Year	Count	4	4
	Mean	1,280	18.8
	Median	1,275	17.4
	Mode	N/A	N/A
	Std. Dev.	186	17.4
	Range	1,070 to 1,500	0.4 to 40
	95% CI	984 to 1,576	ND to 46.5

Table 20
Fargo Canyon Subarea of Desert Hot Springs Management Zone
Summary Statistics by Baseline Period

Baseline Period	Statistic	TDS	Nitrate
5-Year	Count	10	10
	Mean	1,486	17.9
	Median	1,650	17.4
	Mode	1,800	24.8
	Std. Dev.	469	14.5
	Range	780 to 2,020	0.1 to 40.85
	95% CI	1,150 to 1,821	7.5 to 28.2
10-Year	Count	12	12
	Mean	1,406	24.8
	Median	1,463	19.1
	Mode	1,800	24.8
	Std. Dev.	469	27.3
	Range	780 to 2,020	0.1 to 101
	95% CI	1,108 to 1,704	7.4 to 42.2
15-Year	Count	13	13
	Mean	1,351	22.9
	Median	1,325	17.9
	Mode	1,800	24.8
	Std. Dev.	491	27
	Range	688 to 2,020	0.1 to 101
	95% CI	1,054 to 1,648	6.6 to 39.3
20-Year	Count	13	13
	Mean	1,351	22.9
	Median	1,325	17.9
	Mode	1,800	24.8
	Std. Dev.	491	27
	Range	688 to 2,020	0.1 to 101
	95% CI	1,054 to 1,648	6.6 to 39.3

4 Summary and Recommendations

During the stakeholder process and review of the Draft TM-2, comments were received regarding the determination of when contouring of water quality constituents should be applied. The preparation of a contour map is integral to the application of the volume-weighted method for determination of AWQ, and therefore can determine which AWQ method is applied. Key concerns included (1) whether there was enough data to contour and represent the physical system, and (2) what is the earliest baseline period that can be used to ensure the most recent data is represented in the AWQ calculation. Although what baseline to use depends on when there is enough data to use, the ultimate question is how much is enough?

Determining what is an adequate amount of data to prepare contour maps is not a simple question to answer. As noted earlier, no other SNMP in the state has made such a quantification. The decision to contour is typically based on professional judgment. The basis of this determination is based primarily on the spatial distribution of data points and autocorrelation. Spatial distribution of data points evaluates the arrangement of the data points, are they randomly distributed and do the data points cover the extent of the management zone. Spatial autocorrelation is used to evaluate whether known nearby data points can be used to approximate unknown points.

This section provides a summary of the analytical results and recommendations for the method AWQ calculation based on data availability to represent the physical system. Based on review of the analyses, the following general recommendations can be made with specific recommendations described in each management zone subsection:

- Using the 5-Year baseline period alone is not feasible in any management zone or aquifer layer for a volume weighted AWQ calculation. Data is typically scarce with poor spatial distribution in the 5-Year baseline period while only four cases show statistically significant positive spatial autocorrelation.
- If contouring cannot be completed, provide summary statistics only.

4.1.1 West Whitewater Management Zone Recommendations

Layer 1 lacks sufficient spatial distribution for contouring under any baseline; this is consistent with the autocorrelation analysis. Layer 2 lacks sufficient spatial distribution for contouring until approximately the 15-Year baseline. The spatial autocorrelation results found the 15- and 20-Year baseline periods have a strong positive autocorrelation for both TDS and nitrate, meaning data points have relationships and estimation between points (contours) is reasonable. The density of points is low, but the distribution is random in the eastern two thirds of the management zone. For Layer 3, data points are randomly distributed, but there is very limited data in the western portion of the management zone. The eastern portion could be contoured at the 10-Year baseline. This layer has a high positive spatial correlation for nitrate in all baseline periods and TDS in the 15- and 20-Year baseline periods, suggesting predictability in space.

Recommendation: For Layer 2 and Layer 3, use the most current data in any cell. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years or 20 only if needed to fill areas of poor spatial distribution. Provide a summary that communicates the number of points used within each baseline period.

Regarding Layer 1, all baseline periods failed to provide enough data for contouring. Given the lack of available data, it is recommended that in place of contouring a range of constants value be assumed for Layer 1 to calculate the volume weighted AWQ. Use of the minimum and maximum for the 15-Year baseline is proposed. Using these single values for Layer 1 will provide a range of AWQ for the aggregated West Whitewater Management Zone AWQ value.

4.1.2 East Whitewater Management Zone Recommendations

Within Layer 1, the spatial distribution is random, but lacks sufficient quantity for contouring until the 10- or 15-Year baseline. TDS data shows positive spatial autocorrelation for all baseline periods and confidence level of the positive spatial autocorrelation increasing from the 5- to the 10-Year baseline period. Positive spatial autocorrelation is observed in the nitrate data for the 15- and 20-Year baseline periods.

Layer 2 lacks spatial distribution for the full extent of the aquifer in any period. Data is concentrated in the center of the aquifer. The majority of the layer could be contoured with the most recent data limited by the 15-Year baseline. Spatial autocorrelation could not be evaluated for the 5-Year baseline period. Positive spatial autocorrelation is observed for TDS and nitrate in all other baseline periods except for TDS in the 15-Year baseline period.

Similar to Layer 2, Layer 3 lacks sufficient spatial distribution for contouring until the 10- or 15-Year baseline. The spatial distribution appears random, although data gaps exist along the northern boundary of the aquifer layer. Positive spatial autocorrelation is observed in the TDS data except for the 5-Year baseline period where insufficient data prevents evaluation. Nitrate is observed to have strong positive spatial autocorrelation in the 5-Year baseline period, but not for all other baseline periods. This is likely due to increased range in values with minimal spatial distribution.

Recommendation: For Layers 1 through 3, use the most current data in any cell. Check the most current data point to determine if it is an outlier or consistent with older records or continuing a trend. Use older records to 15 years or 20 only if needed to fill areas of poor spatial distribution. Provide a summary that communicates the number of points used within each baseline period.

4.1.3 Mission Creek Management Zone Summary and Recommendations

When the management zone was divided into two vertical layers, the spatial autocorrelation could not be evaluated for all baseline periods. Similarly, the spatial distribution was poor for all baseline periods when the layers are subdivided. Without layering, assuming a single aquifer, strong positive spatial autocorrelation is observed for TDS and nitrate in all baseline periods except for the 5-Year baseline period for which spatial autocorrelation could not be evaluated. Similarly, after the 5-Year baseline, the eastern portion on the management zone has random spatial distribution and could be contoured. The primary issue in this management zone is the lack of data in the western third of the management zone.

Recommendation: Limit the contouring and AWQ calculation to the eastern portion of the management zone. To limit the area, use half the distance between a boundary and the nearest well with water quality data. For this portion, use the most current data in any cell. Check the most current data point to determine if it is an outlier or constant with older records or continuing a trend. Use older records to 15 years or 20 years only if needed to fill areas of poor spatial distribution – likely not necessary. Provide a summary that communicates the number of points used within each baseline period.

4.1.4 Garnet Hill Management Zone Summary and Recommendations

No spatial autocorrelation could be evaluated for any baseline period within Garnet Hill Management Zone due to a lack of data.

Recommendation: Provide a statistical summary and range for AWQ.

4.1.5 Desert Hot Springs Management Zone Summary and Recommendations

Spatial autocorrelation could not be evaluated for the Miracle Hill or Sky Valley Subareas within Desert Hot Springs Management Zone due to a lack of data. Similarly, spatial distribution in these areas is limited by data availability.

Within Fargo Canyon, a strong positive spatial autocorrelation is observed for TDS in all baseline periods. Nitrate shows strong positive spatial autocorrelation in the 5-Year baseline period. Spatial distribution in these areas is poor due to limited data availability.

Recommendation: Provide a statistical summary and range of AWQ.

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Attachment B – Effective Porosity Approximation for the Volume Weighted Average Calculation

Attachment B - Effective Porosity Approximation for the Volume Weighted Average Calculation

1 Introduction

The volume-weighted method for determination of the ambient water quality (AWQ) uses the volume of water in storage to assign weights to water quality concentration within the basin. For estimation of the volume of water in a management zone the management zone is discretized into cells. For each cell, the water level surface, aquifer thickness, and effective porosity are needed. A grid is used to delineate cells for calculations. The volume being approximated is not the total volume in storage (based on porosity) or the total volume that can be pumped (based on specific yield), but the amount available for mixing (based on effective porosity). In this case, the effective porosity is the portion of the interconnected void space of a porous material that is capable of transmitting (and mixing) a fluid.

This document summarizes the definition for effective porosity used to determine the AWQ, published effective porosity values for similar hydrogeologic conditions, and results of an approximation of effective porosity for the Coachella Valley.

2 Definition

Total porosity is defined as the ratio of void space to the total volume of a geologic formation. The effective porosity is the portion of the void space of a porous material that is capable of transmitting (and thereby mixing) a fluid and excludes clay-bound water (water that is electrochemically attached to clay particles that does not contribute to flow). Effective porosity occurs because a fluid in a saturated porous media will not flow through all voids, but only through the voids which are interconnected. Effective porosity is typically higher than specific yield (the volume of water that can be drained by gravity).

3 Representative Effective Porosity Values

A literature search has been conducted to determine effective porosity values for similar hydrogeologic conditions. This section provides a summary of the results of the literature search.

The USGS conducted a modeling study in an area of alluvial and fluvial sand and gravel aquifers to evaluate groundwater vulnerability. As part of their study, they estimated effective porosity. The three-dimensional distribution of effective porosity for the model was estimated by using an empirical relationship between hydraulic conductivity and effective porosity developed by Ahuja, et al. (1989) and modified using information from Morris and Johnson (1967). The application of these methods was completed by Hinkle (1997). A summary of the effective porosities used are presented in **Table 1**.

Table 1
Effective porosities of hydrogeological units in Clark County, Washington
(Snyder et al., 1989)

Material	Minimum	Maximum	Mean
Unconsolidated sedimentary aquifer	0.19	0.31	0.31
Troutdale gravel aquifer	0.18	0.31	0.28
Confining unit 1	0.13	0.3	0.19
Troutdale sandstone aquifer	0.18	0.31	0.29
Confining unit 2	0.13	0.3	0.2
Sand and gravel aquifer upper coarse-grained subunit	0.22	0.31	0.28
Sand and gravel aquifer lower fine-grained subunit	0.2	0.24	0.24
Undifferentiated fine-grained sediments	0.13	0.31	0.23

McWorter and Sunada (1977) prepared a summary of values in their text for sedimentary materials. **Table 2** summarizes total porosity and effective porosity values for various sedimentary materials.

Table 2
Representative porosity values
(McWorter and Sunada, 1977)

Material	Total Porosity, *n*		Effective Porosity, n_e	
	Range	Arithmetic Mean	Range	Arithmetic Mean
Sandstone (fine)			0.02 - 0.40	0.21
Sandstone (medium)	0.14 - 0.49	0.34	0.12 - 0.41	0.27
Siltstone	0.21 - 0.41	0.35	0.01 - 0.33	0.12
Sand (fine)	0.25 - 0.53	0.43	0.01 - 0.46	0.33
Sand (medium)			0.16 - 0.46	0.32
Sand (coarse)	0.31 - 0.46	0.39	0.18 - 0.43	0.3
Gravel (fine)	0.25 - 0.38	0.34	0.13 - 0.40	0.28
Gravel (medium)			0.17 - 0.44	0.24
Gravel (coarse)	0.24 - 0.36	0.28	0.13 - 0.25	0.21
Silt	0.34 - 0.51	0.45	0.01 - 0.39	0.2
Clay	0.34 - 0.57	0.42	0.01 - 0.18	0.06

Urumovic, et al. (2014) researched effective porosity based on geometric mean grain size and measured hydraulic conductivity. This paper suggested procedures for calculating referential grain size and determining effective (flow) porosity result with parameters that reliably determine specific surface area and permeability. The work was based on data from sandy and gravely aquifers to clayey-silty deposits. Representative values for different materials are summarized in **Table 3**.

Table 3
Calculated effective porosity based on geometric mean grain size
(Urumovic et al., 2014)

Material	Grain Size (mm)	Effective Porosity
Gravel	> 2	0.16 - 0.31
Sand	0.1 - 2	0.24 - 0.36
Silt	0.01 - 0.1	0.06 - 0.24
Clay	< 0.01	< 0.06

4 Method for Estimating Effective Porosity

There is little published information of the effective porosity in the Coachella Valley. Two groundwater models were obtained for quantifying the vertical and horizontal extent of the groundwater systems. These models cover the Whitewater, Garnet Hill, and Mission Springs subbasins. CVWD (Fogg *et al.*, 2002) developed a groundwater model of the Whitewater and Garnet Hill Subbasins as part of the 2002 Water Management Plan (MWH, 2002). The geometry (cell size, layering, and orientation) for this model was used as the base for the recently completed Mission Creek and Garnet Hill Subbasins groundwater model. Significant effort went into characterizing hydrostratigraphy and areas of similar hydraulic properties. The layering of these groundwater models was based on a best estimate of basin lithologic characteristics. The calibrated hydraulic conductivity from these models was used to estimate the effective porosity.

Referencing the empirical method developed by Ahuja, et al. (1989), Hinkle and Snyder (1997) estimated effective porosity values for different hydrogeologic units. Ahuja, et al. (1989) analyzed 473 samples and related effective porosity to hydraulic conductivity values. Though the linear regression ranges over five orders of magnitude of the hydraulic conductivity value, the calculated effective porosity value deviates from measured data for large hydraulic conductivity values. Therefore, Hinkle and Snyder (1997) set a maximum effective porosity value of 0.31 for any hydraulic conductivity values that are greater than or equal to 15 feet per day.

The linear relation derived by Ahuja, et al (1989) is:

$$K_S = 764.5 \times n_e^{3.29} \qquad (1)$$

Where K_S is saturated hydraulic conductivity, in centimeters per hour, n_e is effective porosity. Equation (1) can be rewritten as:

$$n_e = 10^{(logK_S - 2.88)/3.29} \qquad (2)$$

Using the hydraulic conductivity for each model cell, the effective porosity is estimated for the Coachella Valley lithology using equation (2).

4.1 Results

Calibrated groundwater model hydraulic conductivity values are exported from the groundwater models. These conductivity values for each individual cell are inserted into equation (2) for each cell. Similar to Snyder et al. (1998), the maximum effective porosity value is set to 0.31, when hydraulic conductivity value is greater or equal to 15 feet per day. Only calibrated hydraulic conductivity is used; therefore, any decrease in effective porosity with depth due to compaction is not necessary. Zones of like material type are aggregated for summary and comparison to published values of the same material type.

Table 4
Estimated Effective Porosity Value Range for Model
Calibrated Hydraulic Conductivity Compared to Literature Data

Material	K	n_e (-)	
	(ft/day)	Estimated	Literature
Clay, Silty Clay	0.005 - 1	0.027-0.133	0.01-0.18
Silt	1 - 11	0.133 - 0.275	0.01-0.39
Sand	11-187	0.275-0.31	0.19-0.31
Gravel	107 - 602	0.31	0.21-0.31

5 References

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Attachment C – Response to Comments on the Draft Technical Memorandum No.2

Coachella Valley SNMP - TM-2, Response to Comments

General Notes:	**Based on comments from stakeholders, revisions were made to Technical Memorandum No.2 (TM-2). Two key comments were fundamental to process, these include the use of a 20-year baseline period and the adequacy of data for contouring water quality. As such, general comments are provided herein to address these key issues independent of specific stakeholder comments.**
Adequacy of Data	An attachment to TM-2 was prepare that describes the methods applied and results obtained to evaluate the data adequacy of contouring water quality constituents for management zones and aquifer layers. The volume-weighted method for determination of ambient water quality (AWQ) is used when an adequate amount of data exist for a particular management zone or aquifer layer. This method computes the average water quality based on the amount of mass of a particular constituent in storage. The mass of the constituent is determined by multiplying the water quality concentration by the amount of water in storage at a point of discrete "cell". The concentration of a discrete cell is based on either the actual data or an interpolation based on surrounding data using a water quality contour map. The contour maps are typically prepared with oversight from a professional geologist or engineer and completed in an iterative fashion using numerical and hand contouring methods. Determination of data adequacy for contouring the water quality of an aquifer layer within a particular management zone is not a well-defined undertaking, but it is important for applying the volume-weighted method. The determination of adequacy is based on the following key factors, spatial distribution of data points – the physical location of data points within a management zone or aquifer layer has a marked effect on the ability to approximate values with certainty; spatial autocorrelation – the assumption that one value is more related to nearby points and less related to distant points; and supporting statistics. The attachment provides an evaluation of these factors for management zones and aquifer layers over different periods of time. At the conclusion of the attachment are recommendations for the most appropriate method of AWQ calculation—volume-weighted method or statistical summary—based on the available data.
Baseline Period	When considering the time period for the AWQ calculation, the quantity of data points gained from using older records must be balanced with the desire characterize current water quality (less data). To evaluate the potential impact of older data a trend analysis was completed. Water quality trends were reviewed in TM-1 that considered historical and vertical records throughout the Valley. In addition, a Mann-Kendall analysis was completed within TM-2. A Mann-Kendall trend analysis tests for statistically significant trending in water quality records. A Mann-Kendall test is a widely used method for evaluating trends that compares samples for a particular well and tests for a positive (increasing) or negative (decreasing) trend result for a particular level of statistical significance; see Data Quality Assessment: Statistical Methods for Practitioner (EPA, 2006). Only records with a prescribed number of well records could be considered - not all wells could be evaluated. The results of the Mann-Kendall trend analyses for TDS and nitrate indicate an increasing trend in concentration with time. Based on this consistent result, using older records, generally speaking, decreasing the accuracy of an AWQ calculation or statistical summary if the objective is to represent current water quality. Although due to the size of the Valley, using "current" or even records for all wells within the last 5 years in not feasible due the effort and cost associated with sampling. Based on this consistent result, using older records may underestimate the AWQ if the objective is to represent current water quality. To obtain the most representative AWQ, the most recent measurements are used for each well. The use of the most recent measurements is a change in approach from the first draft of TM-2. . The most recent data point is considered the yearly median if there are multiple data points for a well in a single year. Based on the results of data adequacy (Attachment A), no records will be used that are older than 15 years.

Stakeholder	No.	Comment	General Topic	Response
BIA	1	The baseline TDS and Nitrate concentrations used for establishing the Assimilative Water Quality numbers should be included as well as a citation from the document from which they were sourced.	General	The data, and their sources, are being provided on the SNMP website.
BIA	2	The basins are being described by the data blocks of one thousand square feet. The total number of blocks as well as a conversion to square miles (or kilometers) within each basin description would be informative information.	Filtering	Commented noted. Text was modified to reflect the comment by adding spatial statistics for each management zone.
VSD	3	The TM is thorough and well prepared.	General	Comment noted.
VSD	4	The non-detect sample results explanation on page 6 is thorough and acceptable. As stated, this treatment will cause a computed "average" value of the data set to be less than or equal to the actual average value. In actuality, it will always be less than the actual value. The only concern that remains is what impact this will have on assimilative capacity and permit levels.	Data	For datasets with significantly more non-detect results, the skewing effect of this substitution is magnified. However, substitution with zero is consistent with recommended standard practices found in EPA's Data Quality Assessment based on the number of non-detects in the SNMP dataset; this suggests that the effects of this substitution for the determination of AWQ is minimal. To minimize this risk, substitution with half of the most common (mode) nitrate detection limit is used. Because a majority of the records are not accompanied with a method detection limit, using half the detection limit (the other recommended method by EPA) is not possible for all records. Instead, half of the mode of the listed detection limits for all records was used. One half of the mode detection limit (0.02 mg/L) is 0.01 mg/L.
VSD	5	What is considered "sufficient" data for the volume weighted method of Ambient Water Quality determination? (Pages 9, 34, 39).	Data	An attachment has been included that provides an evaluation of data adequacy or data "sufficiency" within the study area for use in the ambient water quality calculation.
VSD	6	All of the information regarding unfiltered data sets, filtered data sets, and volume weighted calculations (where available) are presented in a thorough and deliberate way to present the process of filtering the data and illustrate how the filtering affects the AWQ result. However, a summary table at the end of each section that compares the mean or median and range for each of the data review methods would be beneficial.	General	A summary table was prepared for the volume weighted method (when applicable) and the filtered data within the TM (including mean, median, range, count, mode, standard deviation, and 95 percent confidence interval). The unfiltered data is presented within the text for the purpose of transparency. These data should not be used for conclusion purposes as the results can be misleading (skewed by location, skewed by data frequency etc.) as described in section 2 of the TM.

Stakeholder	No.	Comment	General Topic	Response
VSD	7	On page 15, Section 3.1 , last sentence: the word "Recent" should not be capitalized.	Editorial	In this context, "Recent" is used as a proper noun describing the current geologic time period, the last 11,700 years of the Earth's history — the time since the end of the last major glacial epoch, or "ice age." The term is modified to "Holocene (Recent)" to avoid confusion with the adjective use of the word.
VSD	8	On page 23, Section 3.2.2, second paragraph, last sentence should read: "Higher TDS readings ..... "	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	9	On page 25, Section 3.2.3, first full paragraph, third sentence: replace "further" with "farther."	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	10	On page 28, Section 3.3, last sentence: the third word "is" should be replaced with "was".	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	11	On page 28, Section 3.3.1, fourth sentence: the phrase "data gap" is repeated.	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	12	On page 39, Section 3.5.2, the word "values" should be added between "TDS" and "and".	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	13	Attachment A, Section 3, second paragraph, last sentence: the word "are" should be added between "used" and "presented".	Editorial	Commented noted. Text is modified to reflect the comment.
VSD	14	Attachment A, Section 4, first paragraph, fourth sentence: the word "of" should be added between "part" and "the".	Editorial	Commented noted. Text is modified to reflect the comment.
ACBCI	15	S 2. 1; P 6: The referenced USEPA guidelines for addressing ND in analysis of water quality data provides a more conservative method using half of the detection limit. What effect would this have on the resulting AWQ calculation? Would this be more appropriate method to safeguard the aquifer? The EPA document entitled: Data Quality Assessment: Statistical Methods for Practitioners EPA QA/G-9S, EPA/240/8-06/003 notes on page 131: "If a small proportion of the observations are non-detects, then these may be replaced with a small number, usually DU/2, and the usual analysis performed. Alternative substitution values are 0 (see Aitchison's Method below) or the detection limit"	Data	See response to VSD's comment (No. 4). Based on comments, the half of the mode of the listed detection limits was applied for all non-detects to be conservative. This is consistent with your proposed conservative approach.
ACBCI	16	S 2.2.2: Temporal filter 2 calculates a baseline well concentration using a median (frequency statistic) versus an average (volume statistic). Does this method provide a less conservative value for the AWQ? The temporal filters do not account for wells with clear trends in water quality such as the Palm Springs area wells (04S05E04N01 S and 04S05E09N03S) with TDS, or the Palm Desert wells with nitrate. Should the AWQ at these wells be the most recent data for a baseline determination of ambient water quality?	Filtering	The median does not necessarily favor lower values for AWQ. The reason this statistic is chosen for the filter is that it arguably provides some protection against outliers for a particular dataset.
ACBCI	17	S 2.2.3: The spatial filter is described as calculating a cell-layer average based upon the baseline well concentrations. This method does not account for water quality data that shows a trend in concentration.	Filtering	Commented noted. AWQ is intended to quantify ambient conditions. Water quality trends were evaluated using a Mann-Kendall trend analysis which indicates which wells have increasing, decreasing or no statistical trends. Several increasing trends were observed. As such, the AWQ calculation method was revised to take the most recent yearly median for each well. Using the most recent data should improve the representation of current water quality.
ACBCI	18	Figure 3-1: This figure shows the 20-year unfiltered data statistics for each Management Zone. Please add the average statistics to these graphs. The median value plots closer to the 25-percentile than the mid-point between the 25- and 75-percentiles. Does the median statistic introduce a bias towards a lower AWQ?	Editorial	By definition, the upper and lower limits of the central box are defined using quartiles. Quartiles are the 25th, 50th and 75th percentiles of a data set. The observation that the median plots closer to the 25th percentile indicates that the dataset is not normally distributed; instead it is skewed toward the lower end of the range. The box plot is simply a way to summarize the data. The mean is added to the figure for convenience.
ACBCI	19	Table 3-3: Please provide the volume-weighted AWQ by layer.	AWQ	Comment noted. Managing or regulating at the aquifer level is not consistent with the Recycled Water Policy. The mass of constituents is calculated for separate zones and then aggregated together. This is consistent with the Recycled Water Policy that states salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis. However, it is still useful to understand how water quality varies with depth. Therefore the volume-weighted AWQ by layer has been incorporated into the TM.

Stakeholder	No.	Comment	General Topic	Response
MSWD	20	Section 1, Introduction: The first paragraph indicates "TM-2 summarizes the results…based on the methodology described in TM-1" must also recognize that if MSWD disagrees with the methodology in TM-1 then, of course, MSWD disagrees with the summary of results. In addition, based on paragraph 2, a majority of the SNMP scope of services is still to be completed. Yet, during the October workshop, it was indicated that only one workshop remains. MSWD requests that workshops continue until the plan is complete. Also, the second paragraph refers to tasks to be completed but does not identify needed projects to manage salt and nutrients.	General	A significant portion of the SNMP scope of work is still being completed, this scope of work includes identification of projects and strategies to manage salt and nutrients. This task will be documented in the final SNMP. An Additional workshop has been added to the project schedule to address this. Six stakeholders meetings have been planned for the project, as well as a workshop with the Regional Water Quality Control Board. Stakeholder meetings will continue until the plan is completed.
MSWD	21	Section 1.1, Background: The paragraph states "One objective of the Policy is that salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis that ensures meeting water quality objectives and protection of beneficial uses." First, water quality objectives and beneficial uses are two distinctly different outcomes. Secondly, to date, the neither technical memorandum discusses "all sources". Third, prior to completing the SNMP, RWQCB position on these issues must be incorporated. Is it the intent of MWH to advise the RWQCB what their direction is, instead of asking them what their direction is?	General	Yes, meeting water quality objectives and protecting beneficial uses can be considered different goals. The project technical team continues to work with stakeholders and the RWQCB to get their feedback on this issue. The development of an SNMP is a stakeholder driven process.
MSWD	22	Section 1.2, Salt and Nutrient Management Planning Area: A portion of MSWD's service area overlies SGPWA jurisdictional boundaries.	General	Commented noted.
MSWD	23	Section 1.3, Salt and Nutrient Management Plan Development: The title of this section is misleading. The discussion is describing the contents of TM 2, not the SNMP.	Editorial	Commented noted. Text is modified to reflect the comment.
MSWD	24	Section 2, Ambient Water Quality Methods: In response to "single concentration value that is representative of water quality within a management zone for a particular constituent and time period", MSWD does not agree. The management zones are essentially the sub basins which can have inherently different characteristics within different areas. More refinement is necessary to identify subareas within the management zones. Also more attention should be given to the production areas. The spatial and temporal approach does not accurately reflect actual conditions. It should be focused on pumping areas. In addition, averaging the data set over the past 20 years isn't appropriate. The present ambient levels are more relevant data sets.	AWQ	For each management zone, the AWQ by cell is shown in graphical form, as well as areas above and below the AWQ. The areas where more data is needed will be linked to the Recycled Water Policy-required monitoring plan. Assimilative capacity is a single number per management zone and provides one method of assessing recycled water projects and other discharges at the basin/subbasin level. This approach is consistent with approaches used in at least five other regions around the state. Basin Plan Amendments have been prepared relying on this approach. The RWQCB still maintains the flexibilit to evaluate projects having unique site-specific conditions in the permitting process consistent with Items 2c and 2d of the Recycled Water Policy. Many of the suggested methods in the Coachella Valley SNMP, from volume-weighted averaging, contouring, layering, etc., are also applied in other SNMPs throughout California. In some areas of the Valley, a 20-year period may be appropriate while in others it may not. Therefore, the approach was revised. The approach now conducts an annual temporal filter, uses the most recent annual data point for each well, then filters spatially by grid cell for contouring and AWQ calculation.
MSWD	25	Section 2.2, Filtering: The temporal and spatial discussions are certainly informative but application of unfiltered and filtered datasets is not fully explained as they were at the stakeholde meeting. This is clear as to how the calculations are done but the reasoning seems to be short. Clustered wells may skew the results but the argument can be made that these clusters represer a management area important to the pumpers.	Filtering	Commented noted. Text is modified to reflect the comment. The Mission Creek Management Zone was reduced to reflect the area where data is present and the area most important for municipal supply. The reduced Mission Creek MZ for volume-weighted AWQ in Section 3.3.3.
MSWD	26	Section 2.2.1, Temporal Filter 1 – Frequency Bias: The section discusses nitrate concentrations indicating that between 1994 and 2009, levels do not exceed the MCL; however, after 2009, samples do exceed the MCL. It is inappropriate to apply a 20-year average when levels already exceed the MCL.	AWQ	Comment noted. The hypothetical case presented was intended as an example to illustrate the effects of filtering. This example was removed to avoid confusion.
MSWD	27	Section 3.3.2, Statistical Description of Ambient Water Quality, and Section 3.3.3, Volume Weighted Ambient Water Quality: Provide the methods used for data filtering together with explanations for methods used. For example, TDS (90% Confidence Interval for the Mean) in the Mission Creek Subbasin/Management Zone ranges from 466 to 547 mg/l for unfiltered while the filtered data ranges from 493 to 706 mg/l. The range of 270-1100 seems to be high and the standard deviation of 240 seems incorrect.	Statistical	The filtering methods are described in TM-1 and TM-2 (section 2.2, pages 7 and 8). Statistical methods, such as standard deviation are standard and not modified. Statistical results will be checked. Basic statistical methods are descried in the following: USGS, 2010. Statistical Methods in Water Resources, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4, Hydrologic Analysis and Interpretation.

Stakeholder	No.	Comment	General Topic	Response
RWQCB	28	While we agree with the concept of separating the Basin into management zones (MZ) due to variations in water quality and/or geologic conditions, we do not agree with the number of proposed MZs or the methodology for determining AWQ conditions within each MZ. The resulting single concentration value to represent the water quality within an entire MZ for a particular constituent is of little value.	Management Zone	The Recycled Water Policy states that the plan is to be completed at a "basin/subbasin" level. The Implementation Strategies section of the SNMP will highlight areas of a management zones contributing the most to available assimilative capacity for future project consideration. The Regional Board still maintains the flexibility to evaluate projects having unique site-specific conditions in the permitting process consistent with Items 2c and 2d of the Recycled Water Policy. See also the response to comment no. 24.
RWQCB	29	We strongly believe that a more complex numeric modeling approach should be applied to each MZ that generates data driven concentration contours illustrating both horizontal and vertical variability for any given constituent, at any given location/time. This approach will allow the Distric to identify areas (subzones) within MZs that possess or lack assimilative capacity as it provides more accurate approximation of mean constituent concentrations.	Numerical Model	Comment noted. Numerical modeling would allow for incorporation of a comprehensive data history, although at significant cost and impact to project schedule. The Integrated Regional Water Resources Planning Group, for which the RWQCB was a part of, evaluated this issue and determined it was not feasible. For determination of the ambient water quality, a numerical model is used to leverage information on aquifer layer and hydraulic properties. A numerical model for planning would need calibration; this would pose more significant data adequacy problems than currently exist. Dynamic or long-term project evaluation with a numerical model would be useful, although not required. Non numerical modeling/methods have been used successfully for SNMPs throughout the state. Using a model for the ambient water quality will provide the same result as the volume weighted method. The spreadsheet model being developed for planning purposes is conservative and has been useful throughout the state. It is also important to note that this plan is likely a living document. As models are updated and calibrated they can be incorporated.
RWQCB	30	In short, the application of statistics to homogenize a heterogeneous groundwater basin is not appropriate. This is exemplified in TM-2, Table 3-5, which provides descriptive statistics used to determine the volume-weighted TDS AWQ for the East Valley MZ.	AWQ	Table 3-5 lists the filtered dataset for East Valley Management Zone. Statistics are provided for summary reference. Note that the mass of constituents is calculated for three separate vertical layers and then aggregated together. Using the groundwater flow model layering, well construction information, hydraulic properties from the groundwater flow model, and the filtered database, the aquifer heterogeneity is considered at the 1,000 by 1,000-foot horizontal scale and up to three vertical layers. The results of individual cells are then aggregated first by layer and then by management zone. This is consistent with the Recycled Water Policy that states salts and nutrients from all sources be managed on a basin-wide or watershed wide basis.
RWQCB	31	For the sake of transparency, please provide all data used for scientific interpretations (i.e., summaries of raw data, sampling locations, MZ and subzone delineation, sampling date, map, etc.) in an acceptable and usable format (digital or otherwise) in all future submittals, including th final versions of TM-1 and TM-2.	General	All data has been provided in electronic format to the RWQCB, these data have also been reviewed on two occasions with RWQCB staff and MWH staff at RWQCB offices. All data is presented in TM-2 as filtered and unfiltered for transparency. Please note the response to comment No. 1.
RWQCB	32	The use of water quality data collected from 1994 to 2013 for the calculation of AWQ is unacceptable particularly in the case of Coachella Valley because it blurs the effect of recent discharge/recharge activities.	Period	Based on feedback from stakeholders, the AWQ calculation method was revised. The current method determines the annual median for each well. Within each cell the yearly cell mean is calculated based on yearly well medians within the cell. This determines a value for each cell for each year. The most recent annual value for each cell is used, all values are less than 15 years old. Shortening this period of data used will reduce the data available for the AWQ calculation. An attachment has been included to provide an investigation of data adequacy or data "sufficiency" within the study area that includes an evaluation of different baseline periods and the effect on data adequacy. As noted, the filtering method has been modified to use the most recent yearly median available for each well, as opposed to the median of all data points over a chosen baseline period.

Stakeholder	No.	Comment	General Topic	Response
RWQCB	33	The District's consultant (MWH) states there is insufficient recent data for statistical analysis if a 20-year data span is not utilized. If the District feels recent data (i.e., data collected in the last five years) is insufficient to develop a SNMP for the Coachella Valley Basin, then the District needs to collect more data.	Data	Please note response to comment No. 32. The reference to the approved 5-Year baseline period is in Policy under section 9.c.1, this subsection refers to groundwater recharge with recycled water, as opposed to irrigation that occurs in this region. The "5-year or approved" baseline is not applicable in this case, regardless, the stakeholders have and will continue to work with RWQCB staff to determine an applicable period. The revised AWQ is an example. The Policy makes reference to data needs and monitoring to improve available data for analysis in the form of a monitoring plan. The basin wide monitoring plan is to include an appropriate network of monitoring locations. The scale of the plan is dependent upon the site-specific conditions and "shall be adequate to provide a reasonable, cost-effective means of determining whether the concentrations of salt, nutrients, and other constituents of concern as identified in the salt and nutrient plans are consistent with applicable water quality objectives." Note the Policy does not accept a perfect data history for calculations. At this time, it would not be reasonable or cost-effective to install a monitoring network. A monitoring plan will be a part of the final SNMP with monitoring and implementation recommendations.
RWQCB	34	As a final note, while it is commendable the District has taken the initiative to develop a SNMP for the Coachella Valley Basin, We are concerned with the absence or limited participation by other major stakeholders in the Technical Advisory Group. The Recycled Water Policy views this endeavor as locally driven and encourages the participation of all stakeholders.	Stakeholder	The Technical Advisory Group (CVWD, DWA, and IWA), that funds the plan and manages the consultant, has made it a primary emphasis to encourage stakeholders to participate. Four stakeholder meetings have been conducted, two more are planned, and others can be added if needed. All recycled water permittees, all wastewater agencies, all tribes, all water purveyors, and all golf courses have been invited. A website has been set up to publicly post deliverables, comments, and meeting information. Fifteen meetings have been conducted with RWQCB. It has been the intent of the Technical Advisory Group to manage a locally-driven SNMP. A list of stakeholders will be included in the SNMP.

Appendix C – Stakeholder List

Coachella Valley Salt and Nutrient Management Plan
Stakeholder List -April 2015

CITIES	Name	Organization	Email
	Bill Simons	City of Cathedral City	bsimons@cathedralcity.gov
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Ellen Lloyd Trover		etrover@gmail.com
Ben Olson		Ben@oe-ca.com
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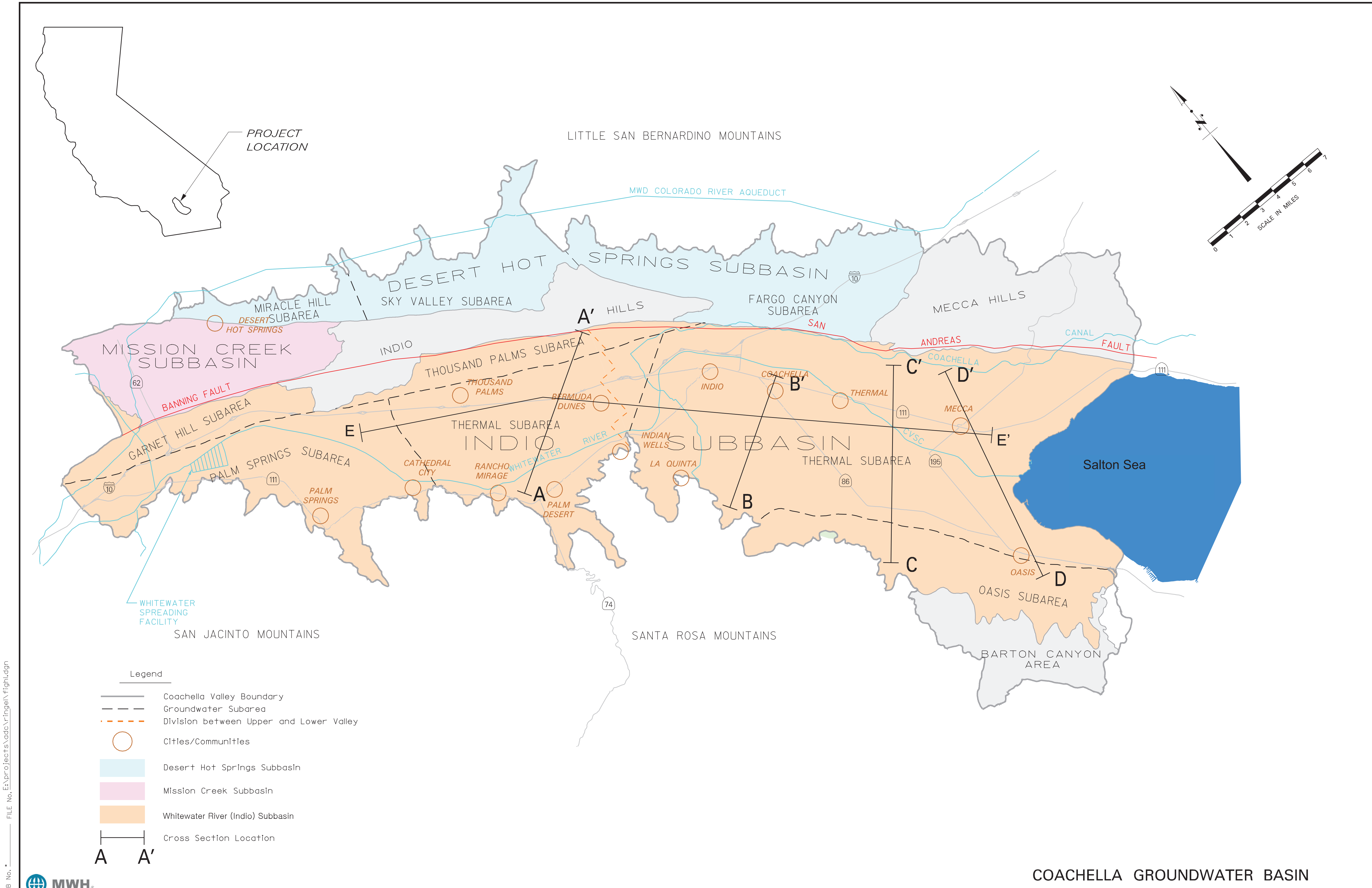
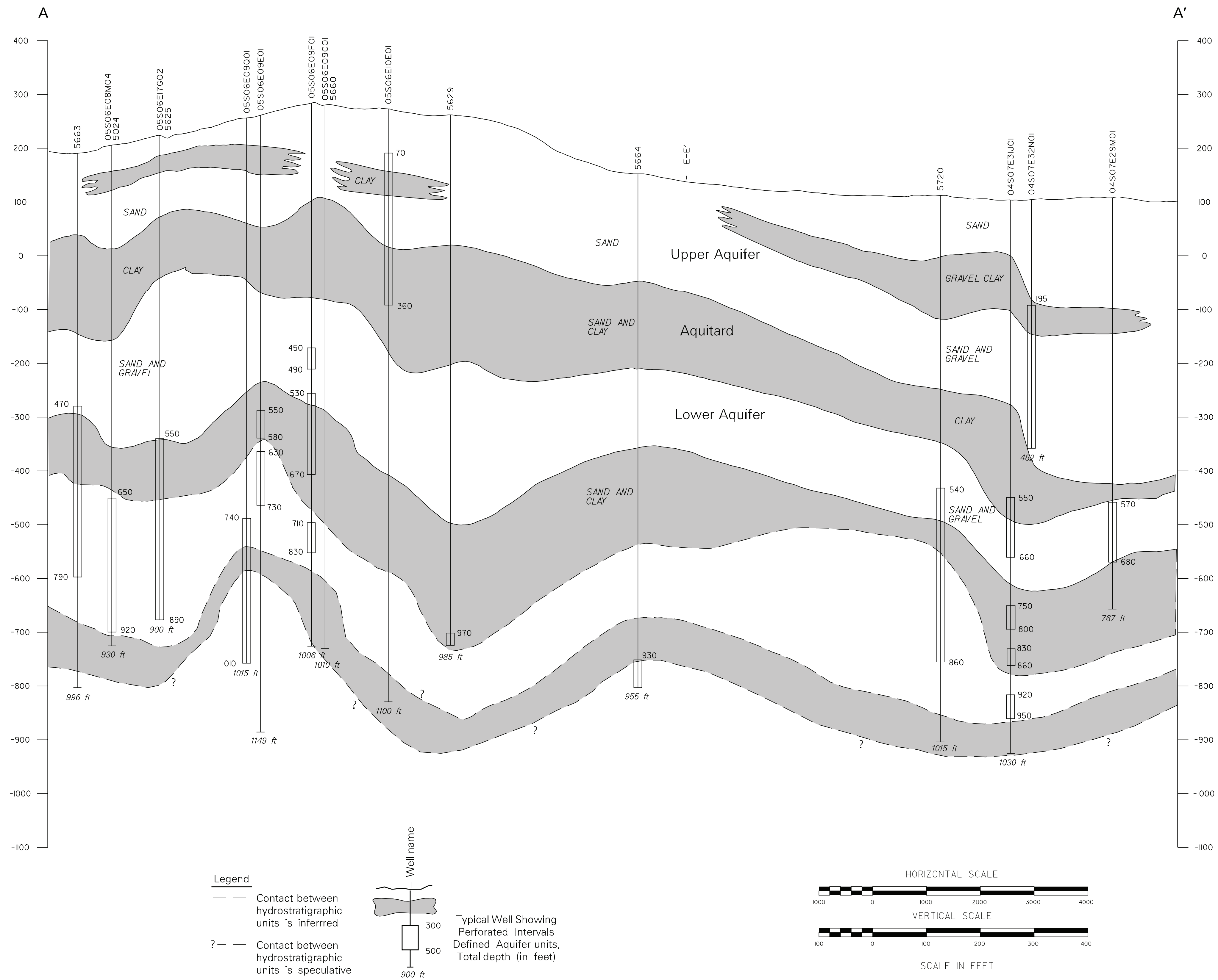
Micahel Thornton	TKE	

Appendix D – Cross Sections



COACHELLA GROUNDWATER BASIN



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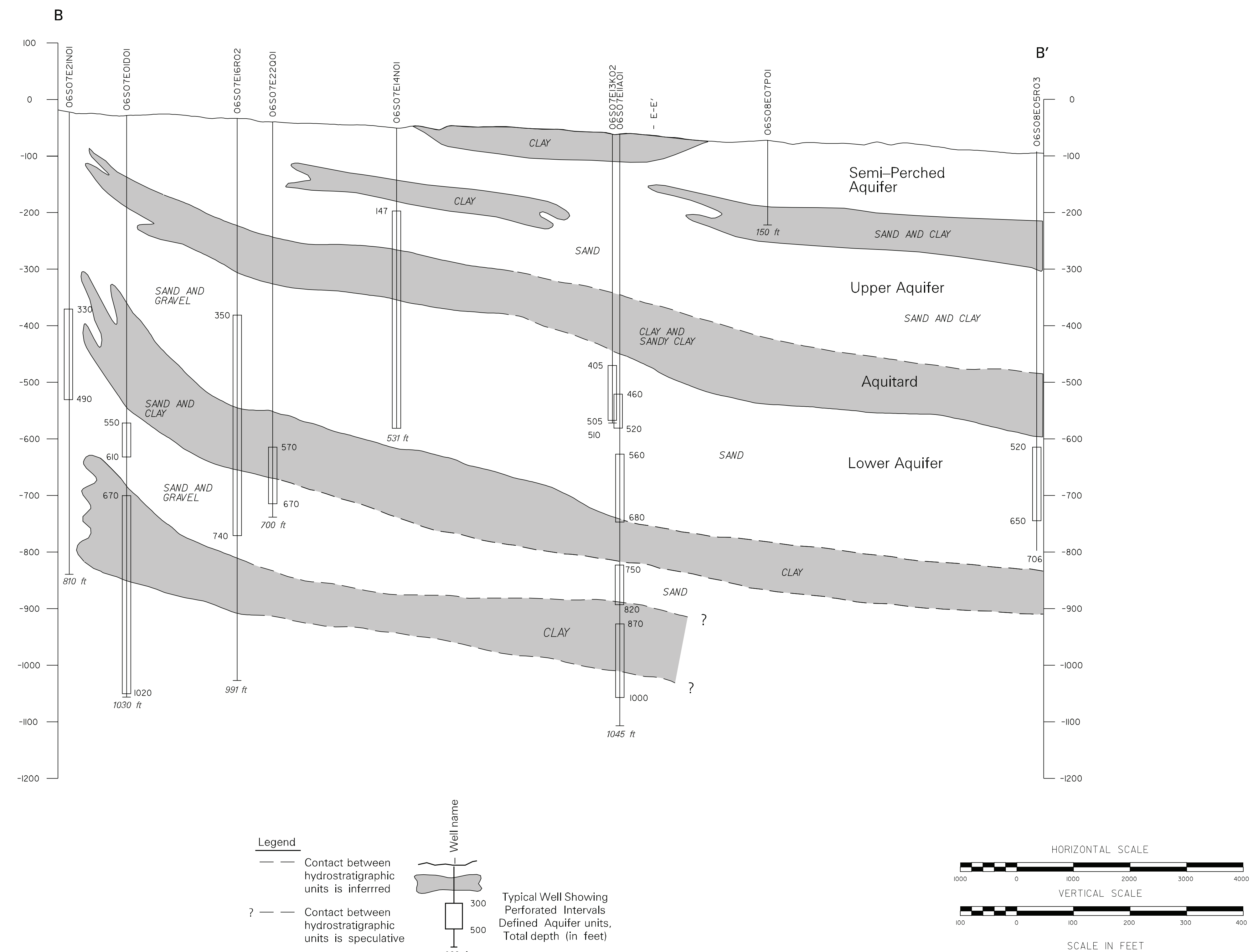
Appendix



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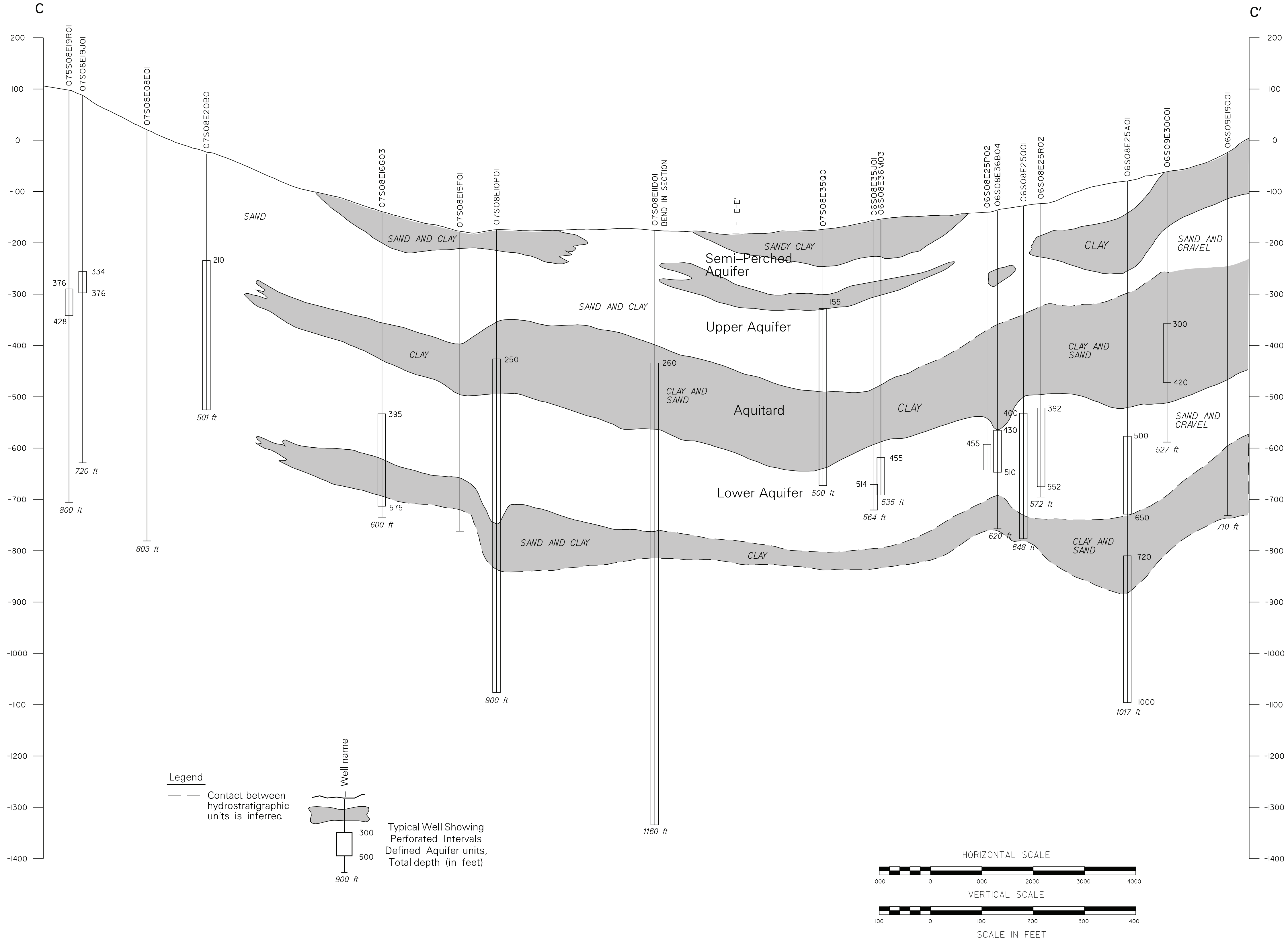
Appendix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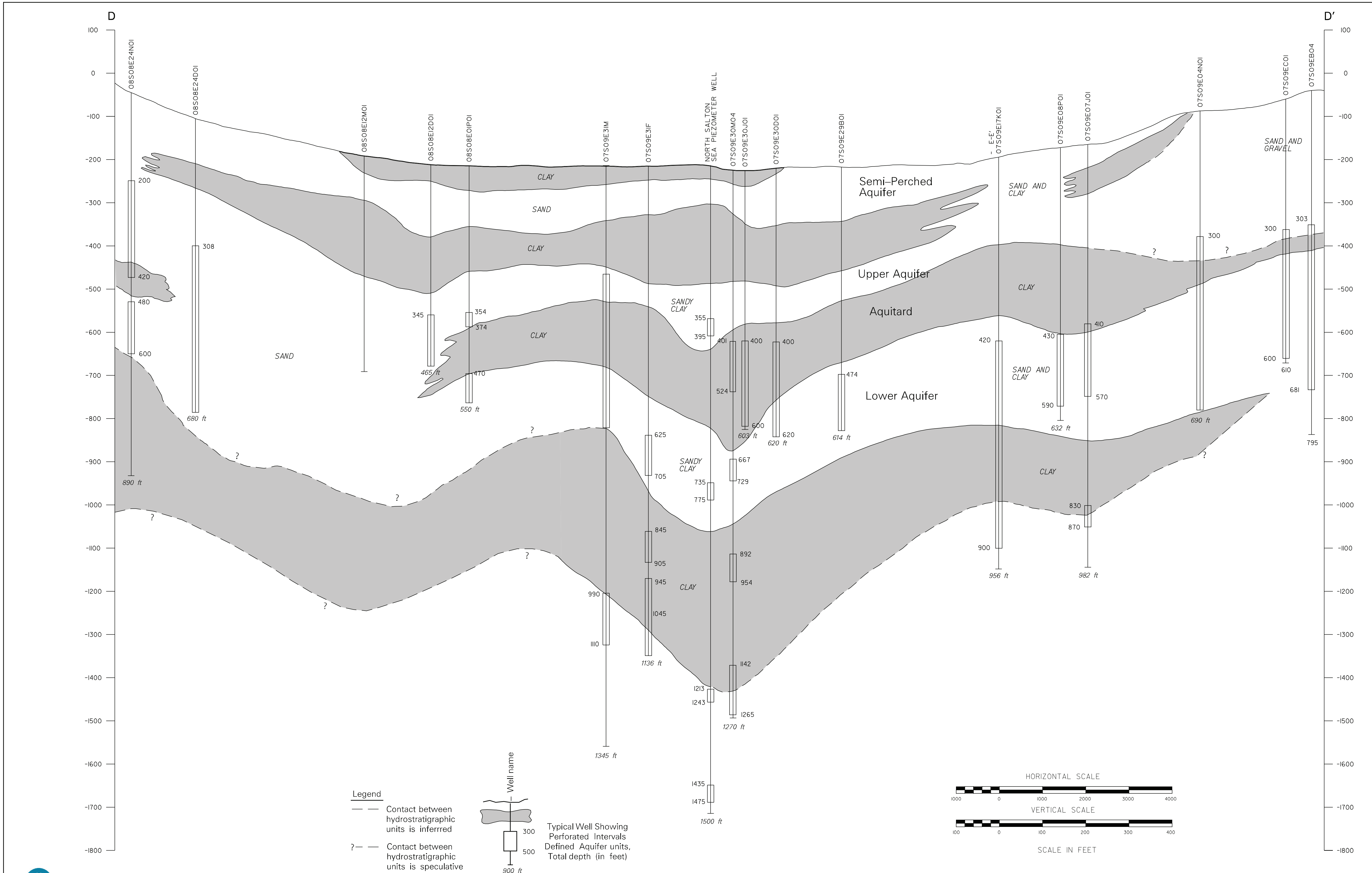
06SO8E36M03
06SO8E25P02
06SO8E36B04
06SO8E25Q01
06SO8E25R02
06SO8E25A01
06SO9E30C01
06SO9E19Q01
SAND
SAND AND CLAY
SANDY CLAY
Semi-Perched Aquifer
Upper Aquifer
CLAY
CLAY AND SAND
Aquitard
Lower Aquifer
SAND AND GRAVEL
CLAY AND SAND
800 ft
720 ft
803 ft
501 ft
600 ft
900 ft
1160 ft
500 ft
564 ft
535 ft
620 ft
648 ft
572 ft
527 ft
710 ft
1017 ft
Legend
Contact between hydrostratigraphic units is inferred
Well name
Typical Well Showing Perforated Intervals Defined Aquifer units, Total depth (in feet)
300
500
900 ft
HORIZONTAL SCALE
1000 0 1000 2000 3000 4000
VERTICAL SCALE
100 0 100 200 300 400
SCALE IN FEET



Appendix

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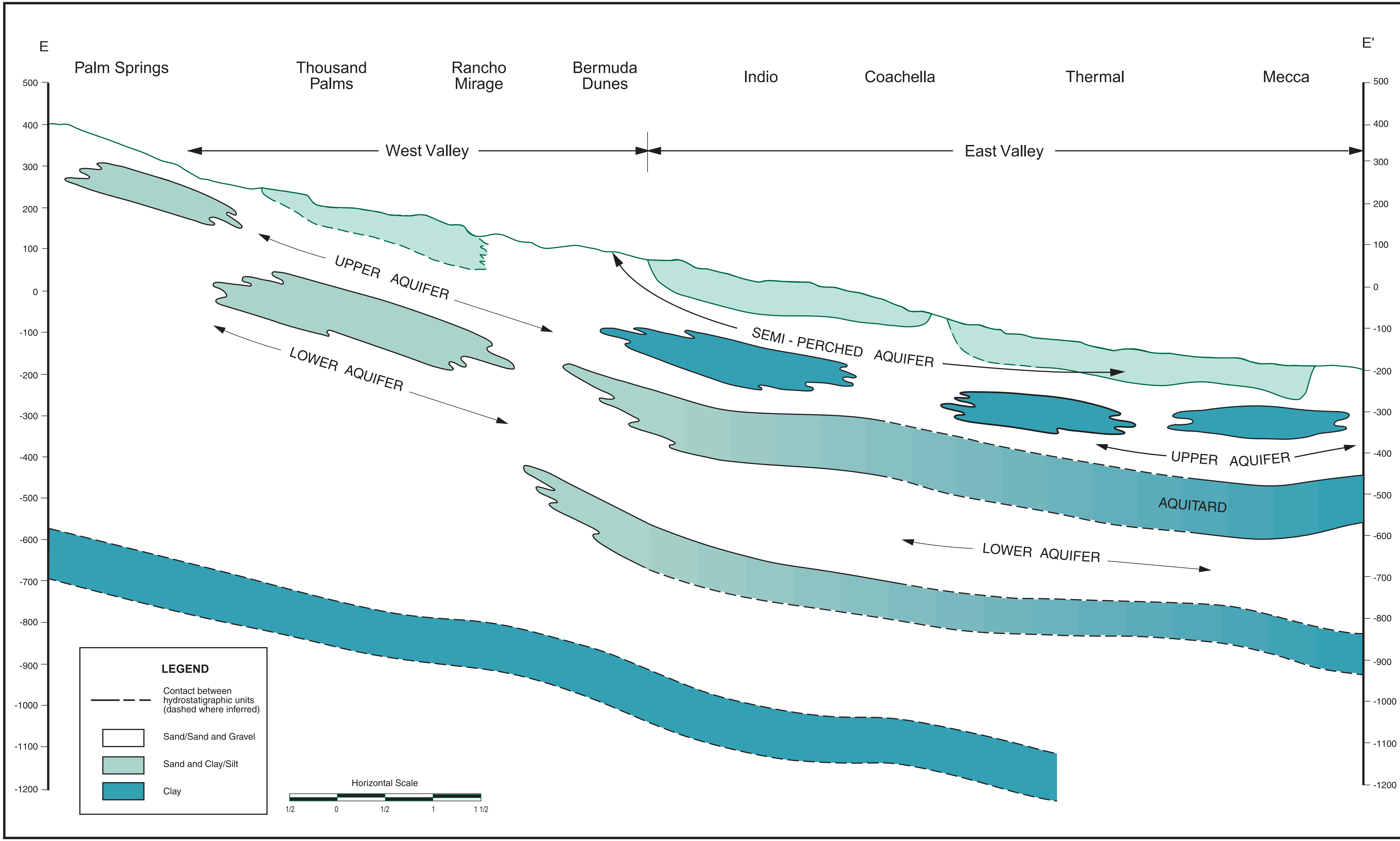
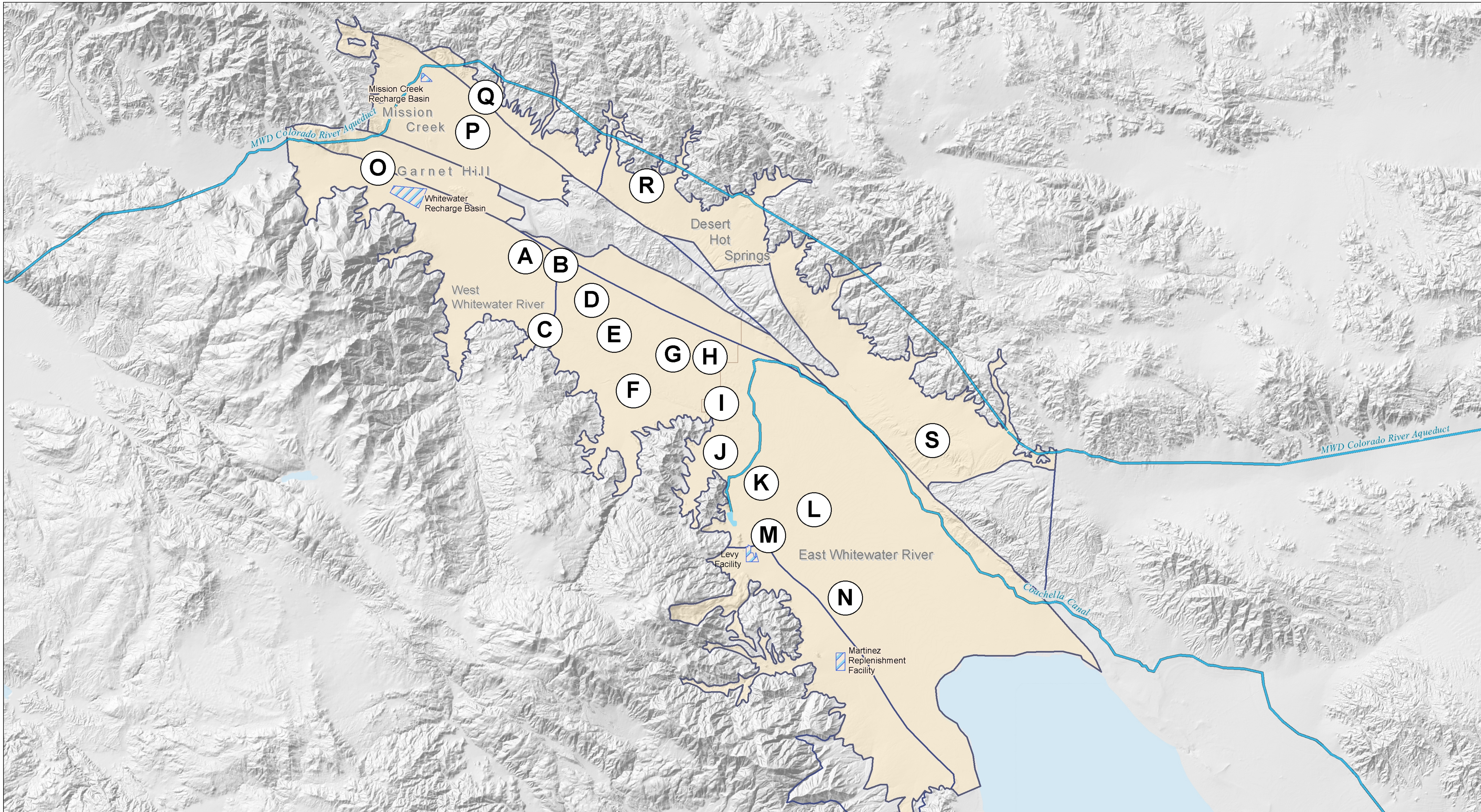


Conceptual Hydrogeologic Cross Section of the Coachella Valley

Appendix E – Water Quality Plots



Key to Features

Highway
Group Name
Minor Drainage
Canal / Aqueduct
Spreading Facility
Water Body
Management Zone

N
0 5 10 Miles

Document: \\uspas1s01\MUNI\Clients\Coachella Valley WD\Salt Nutrient Management Plan\14 Electronic Files - Modeling\GIS\AppendixMaps\AppendixGroups.mxd

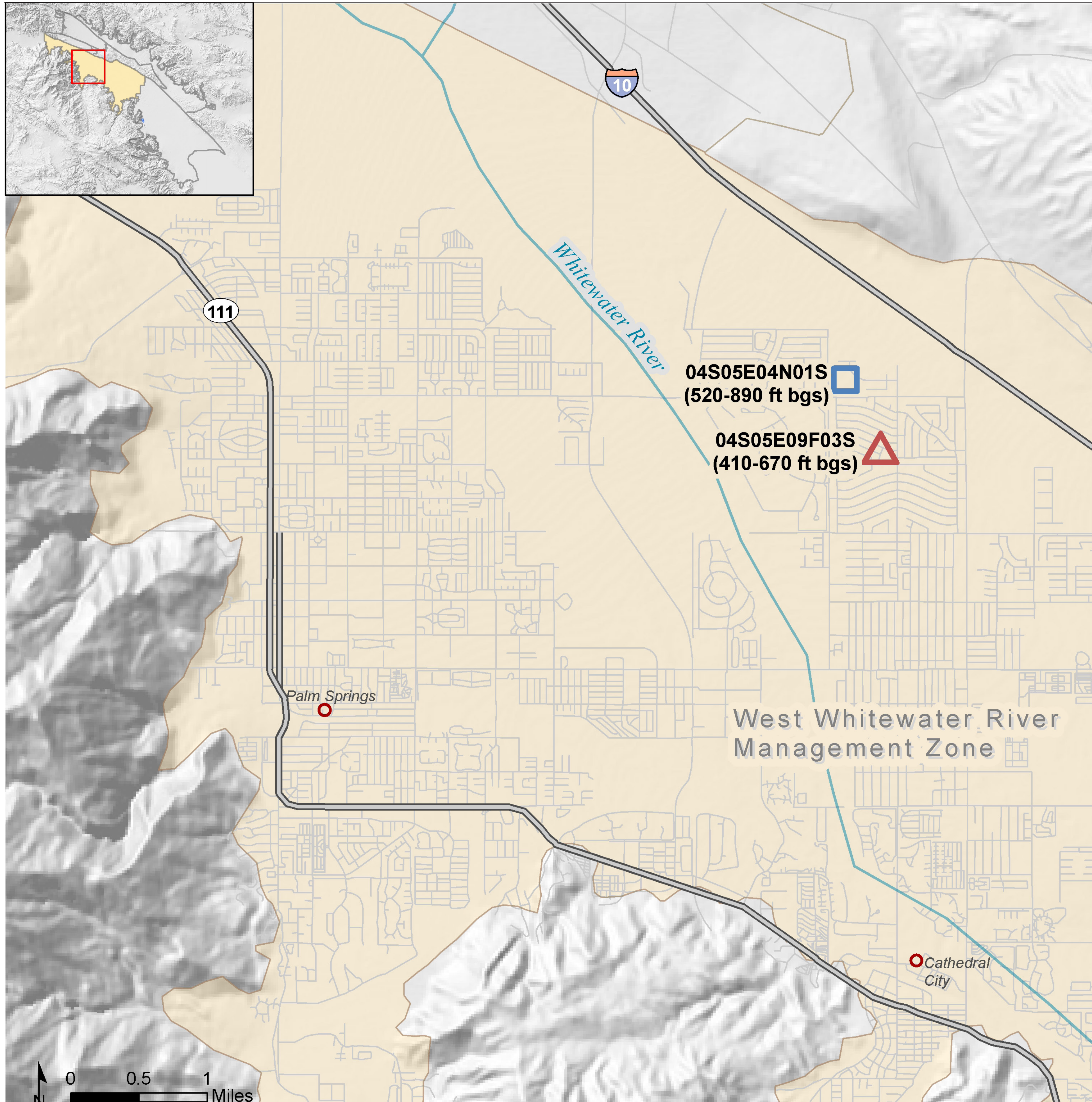
Date: Apriil 1, 2015

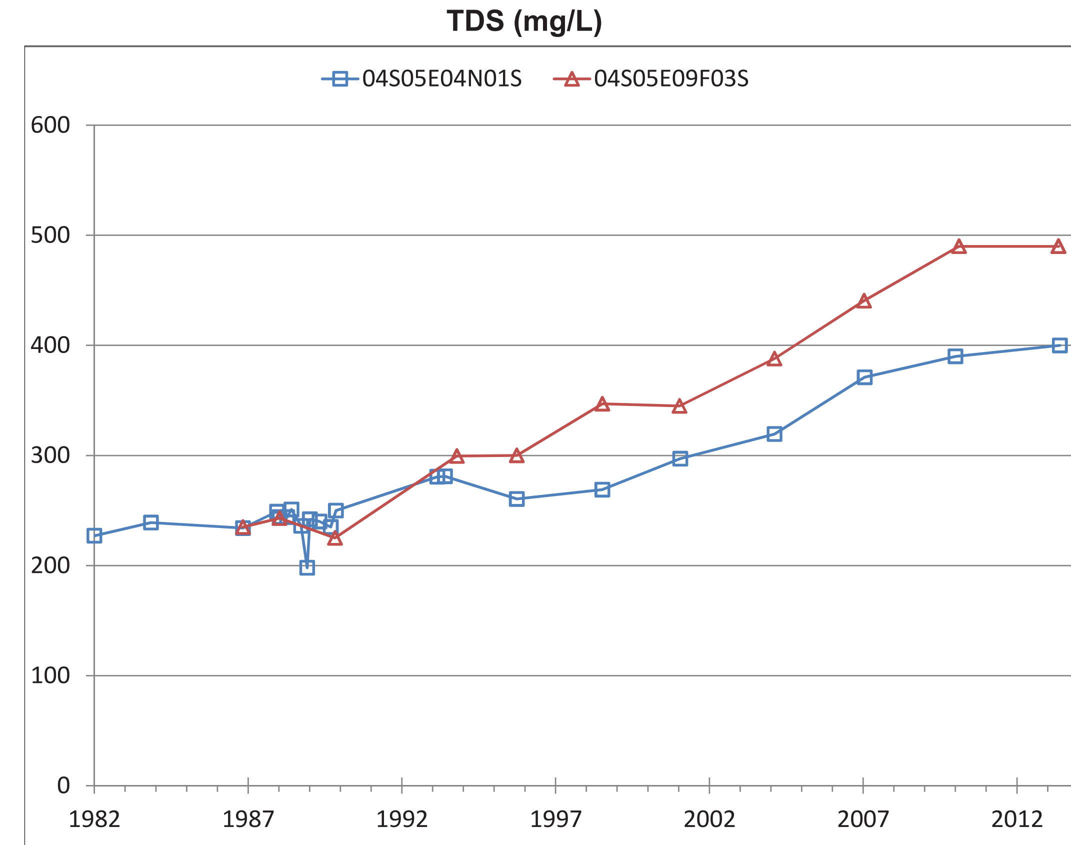
Water Quality Well Group Location Map

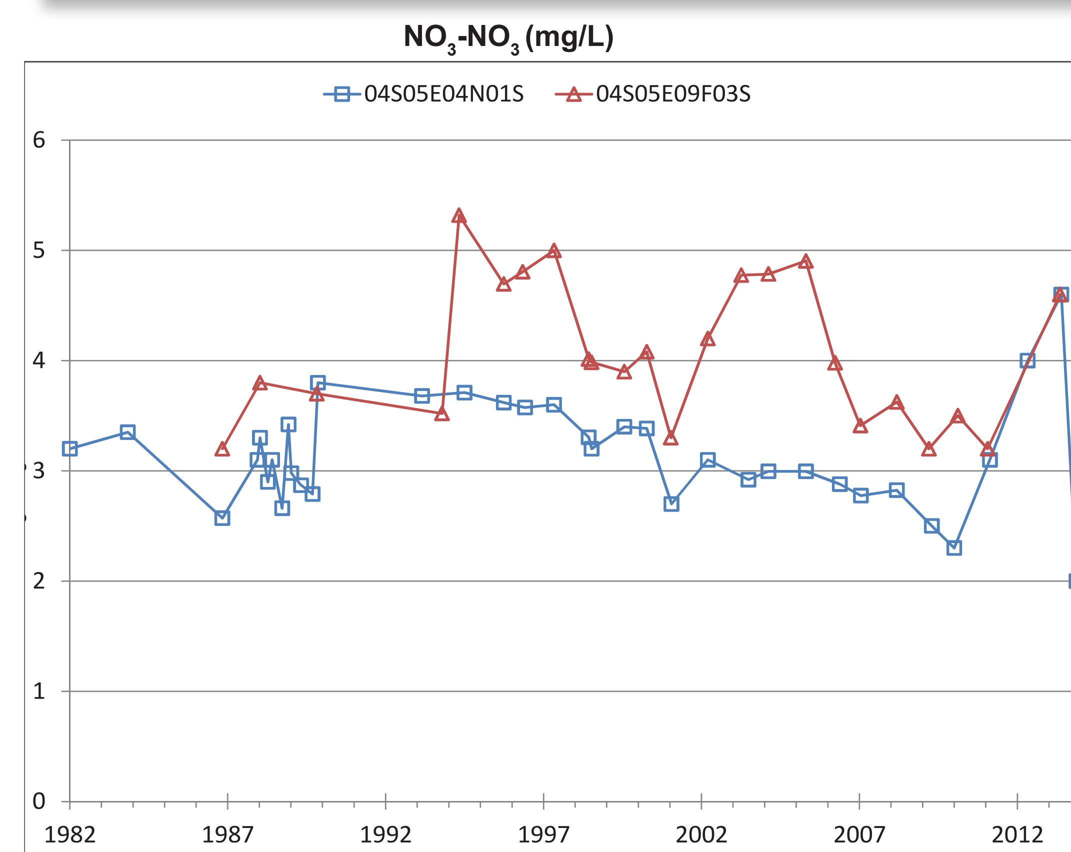
MWH

Appendix A-1

This map has been designed to print size 11'' by 17''.



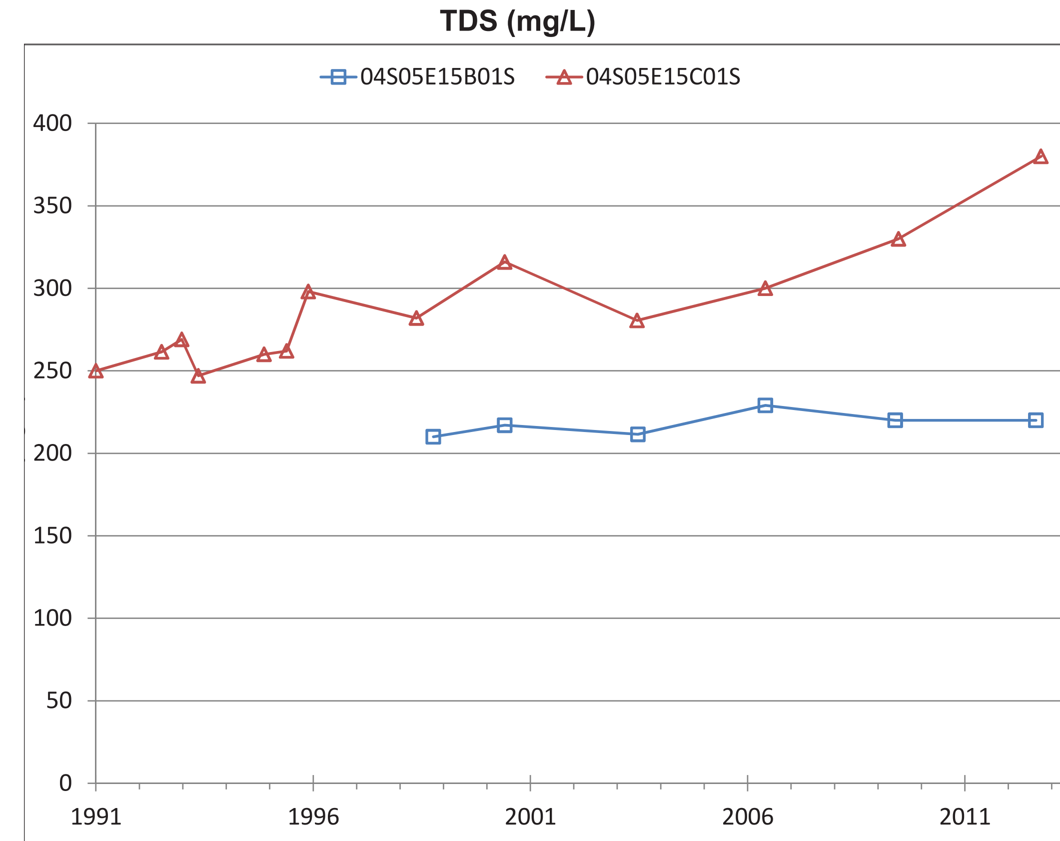


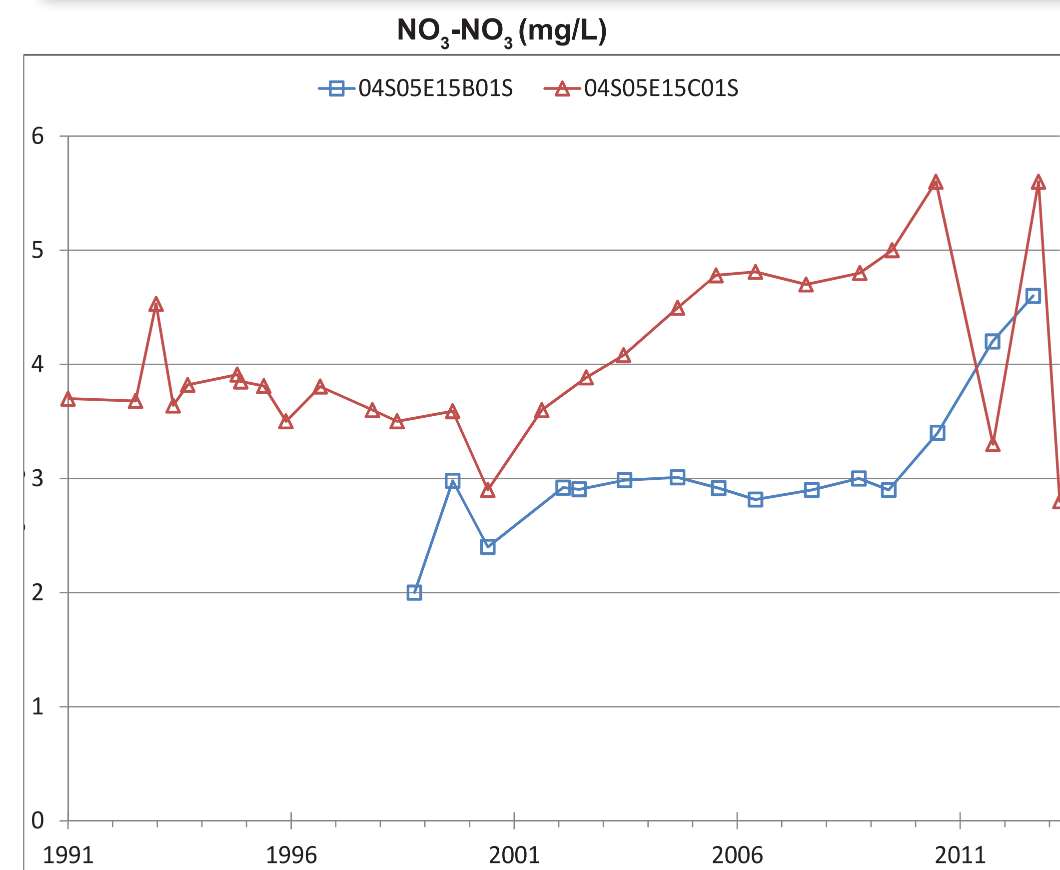


MWH

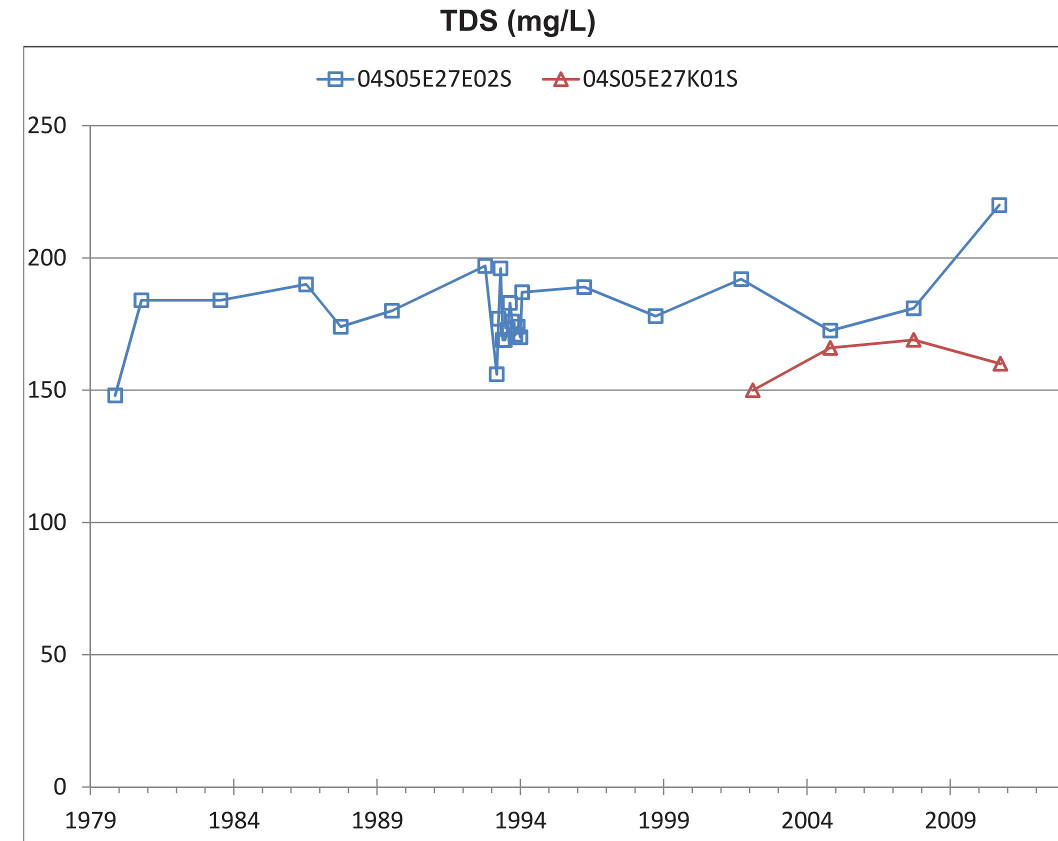
Appendix A-2

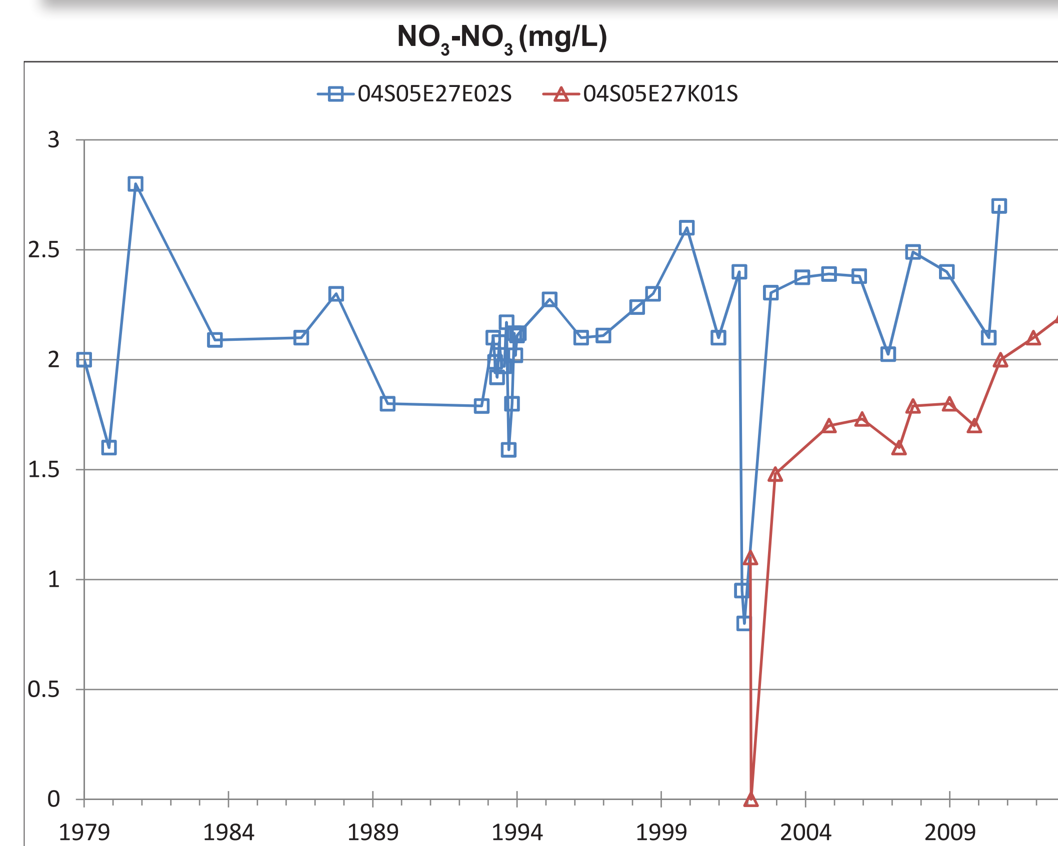
Group A - West Whitewater River Management Zone





Appendix A-3
Group B - West Whitewater River
Management Zone





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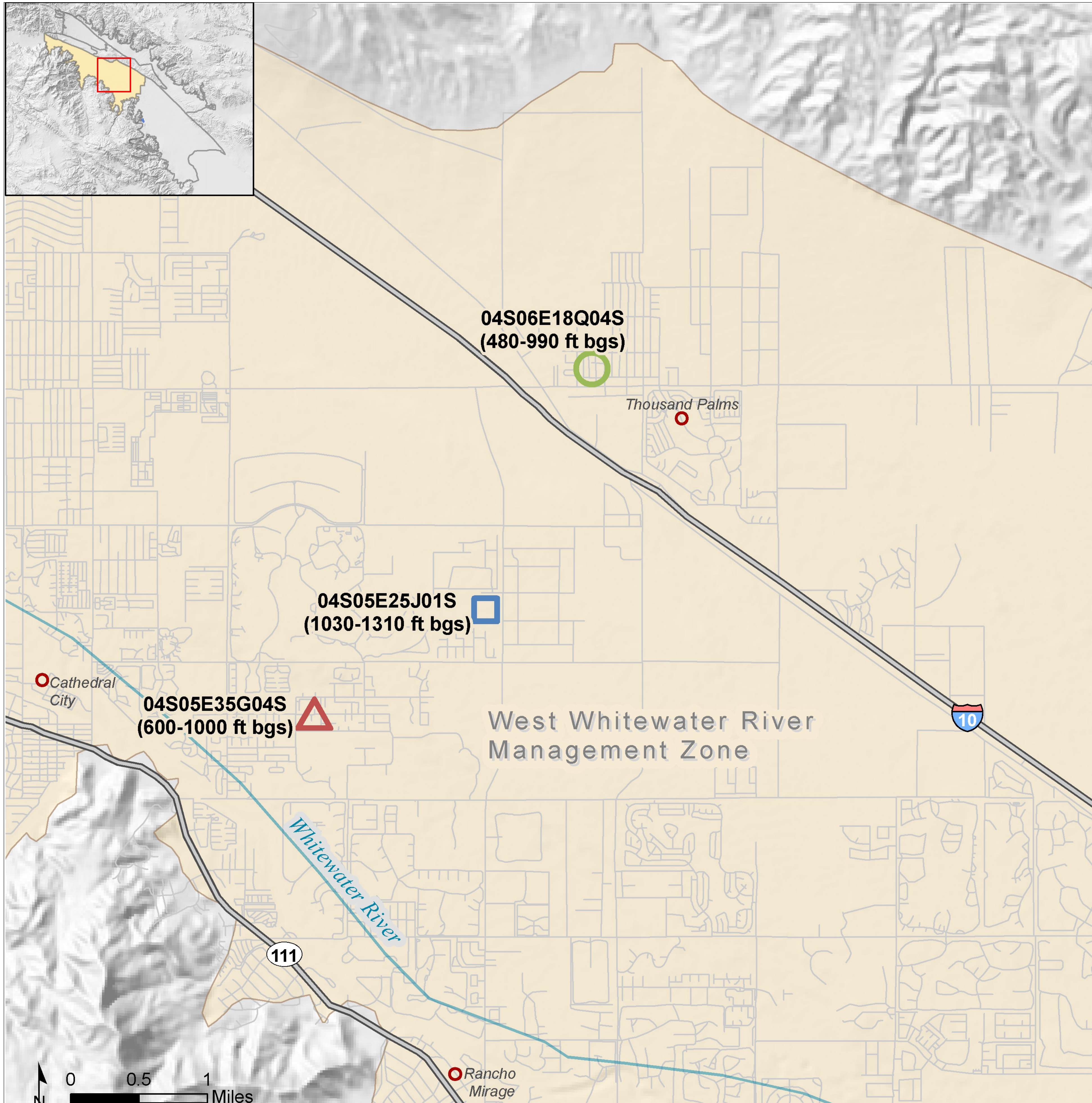
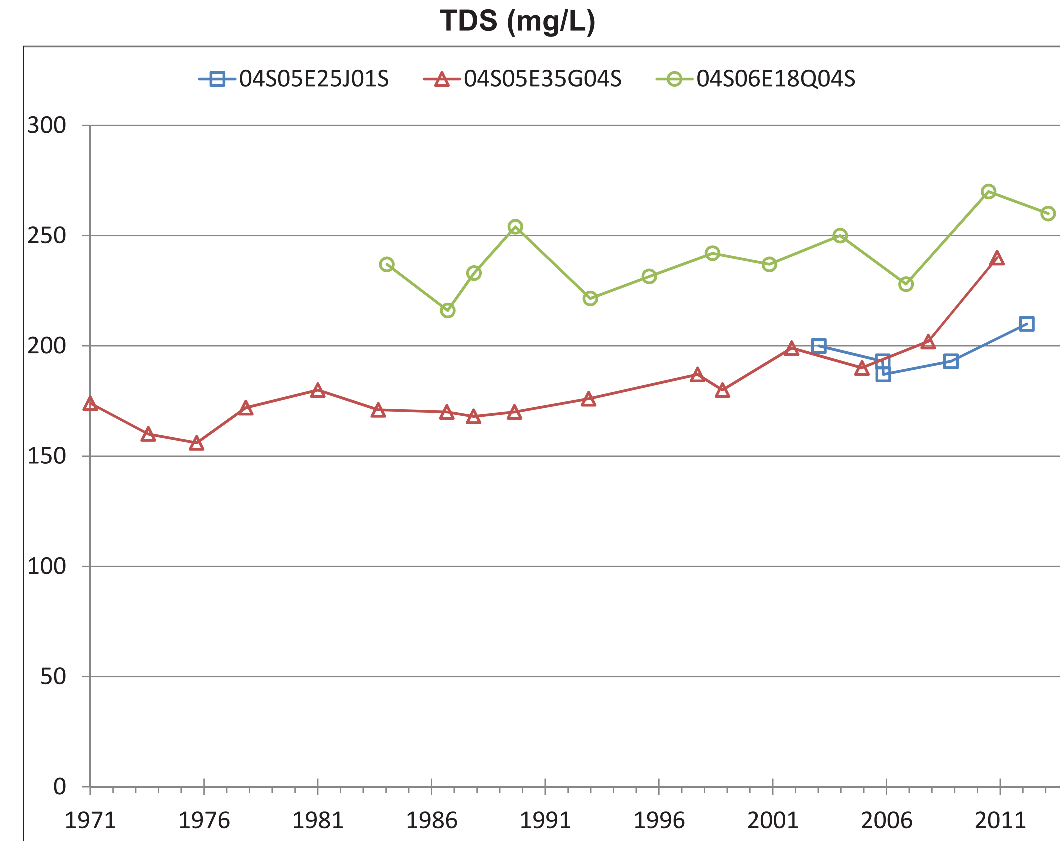
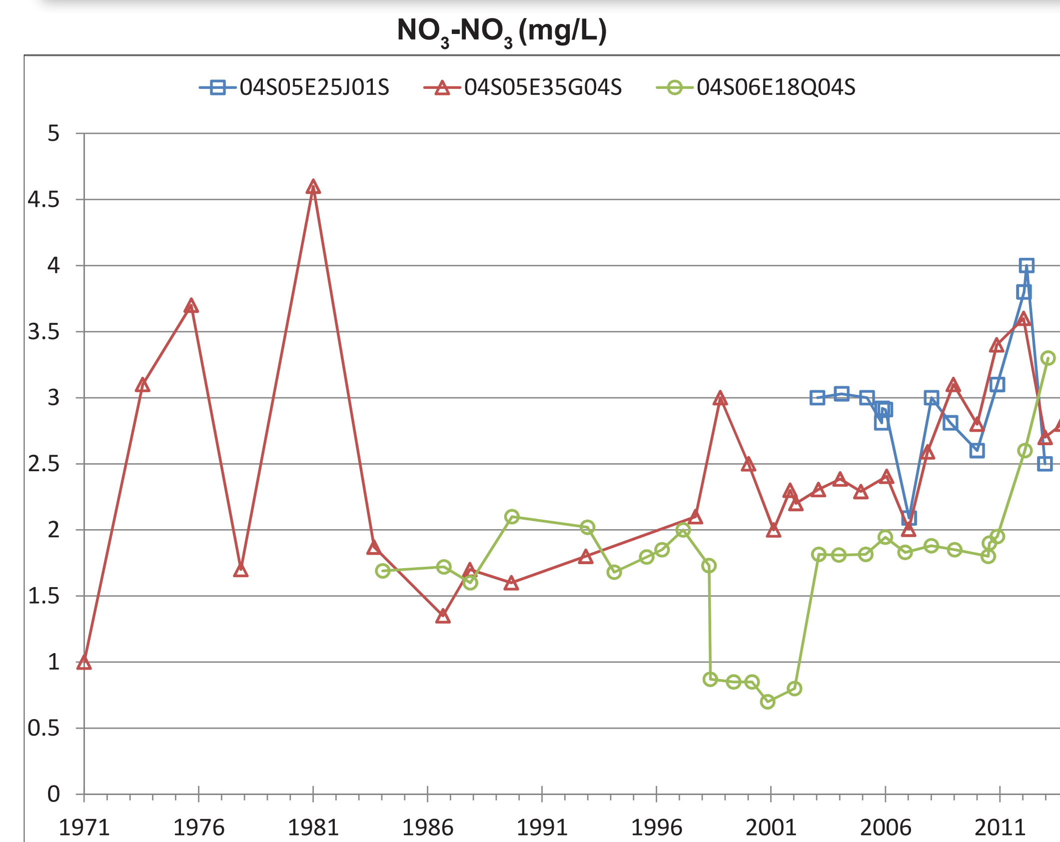
Appendix A-4
Group C - West Whitewater River Management Zone







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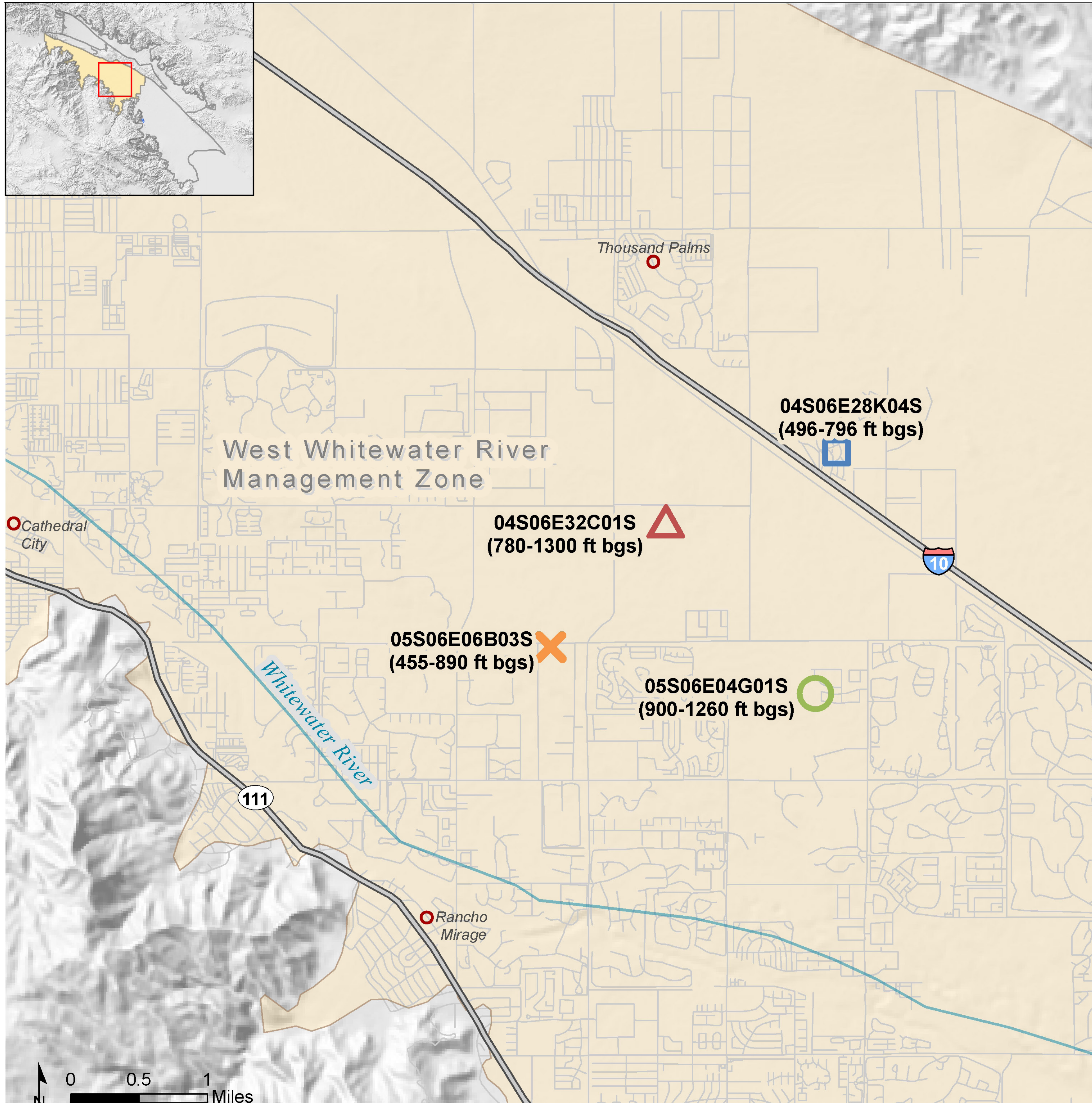
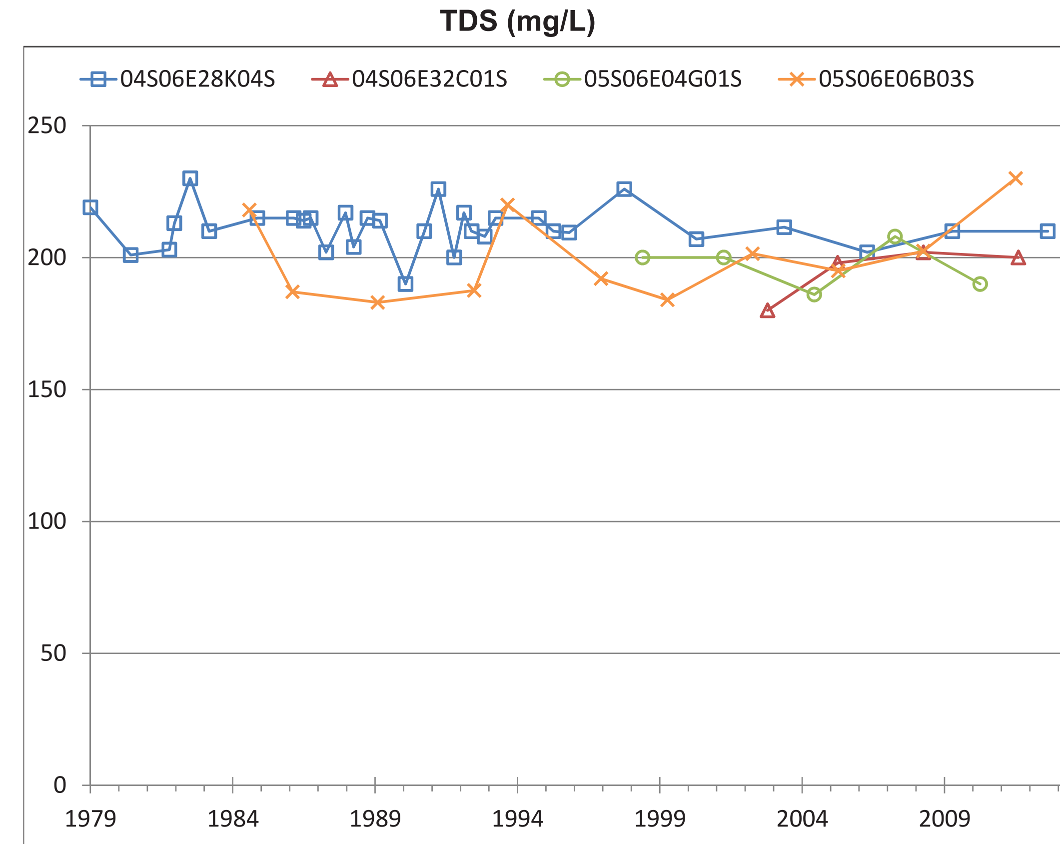
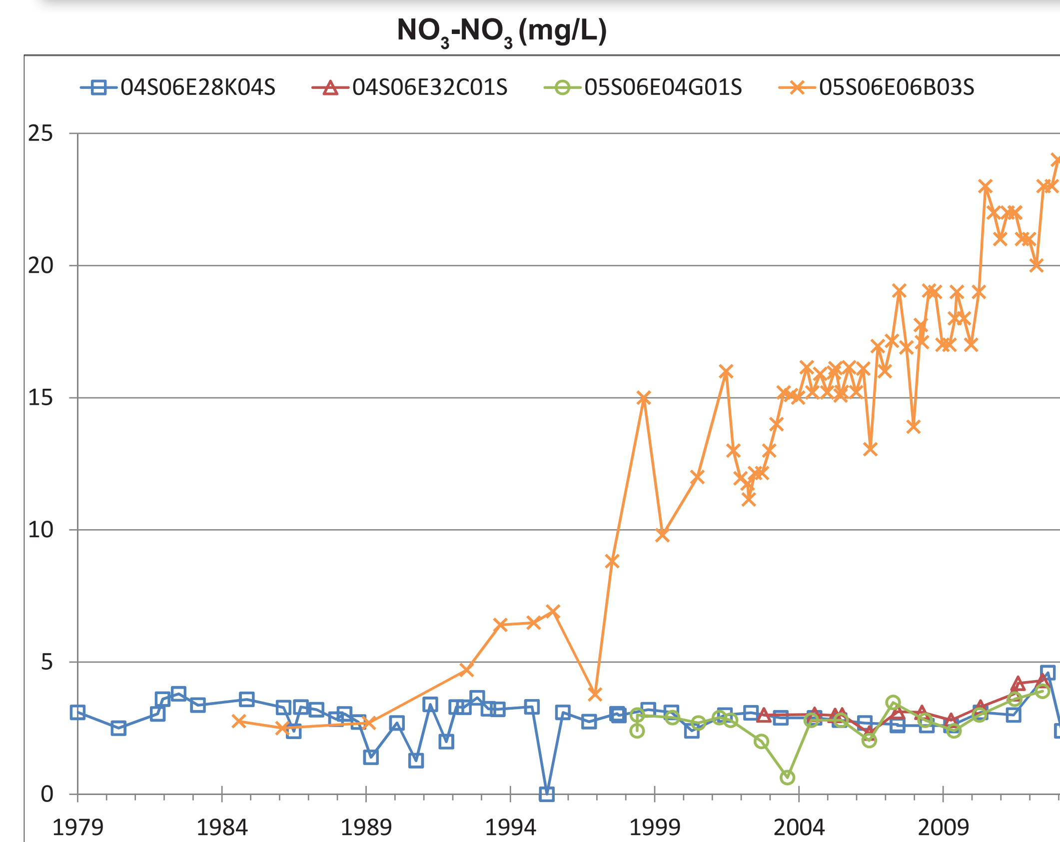
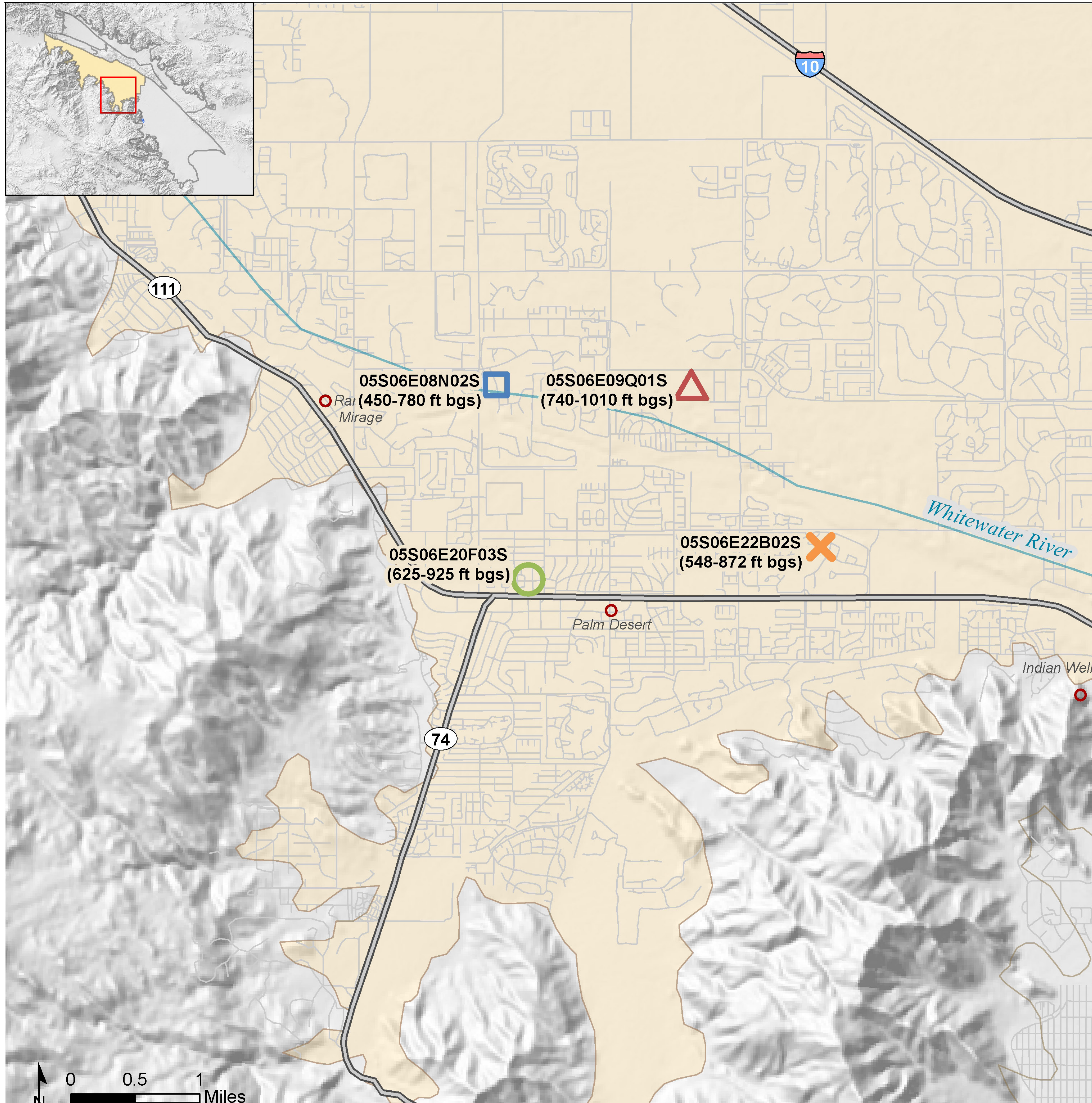
Appendix A-5
Group D - West Whitewater River Management Zone

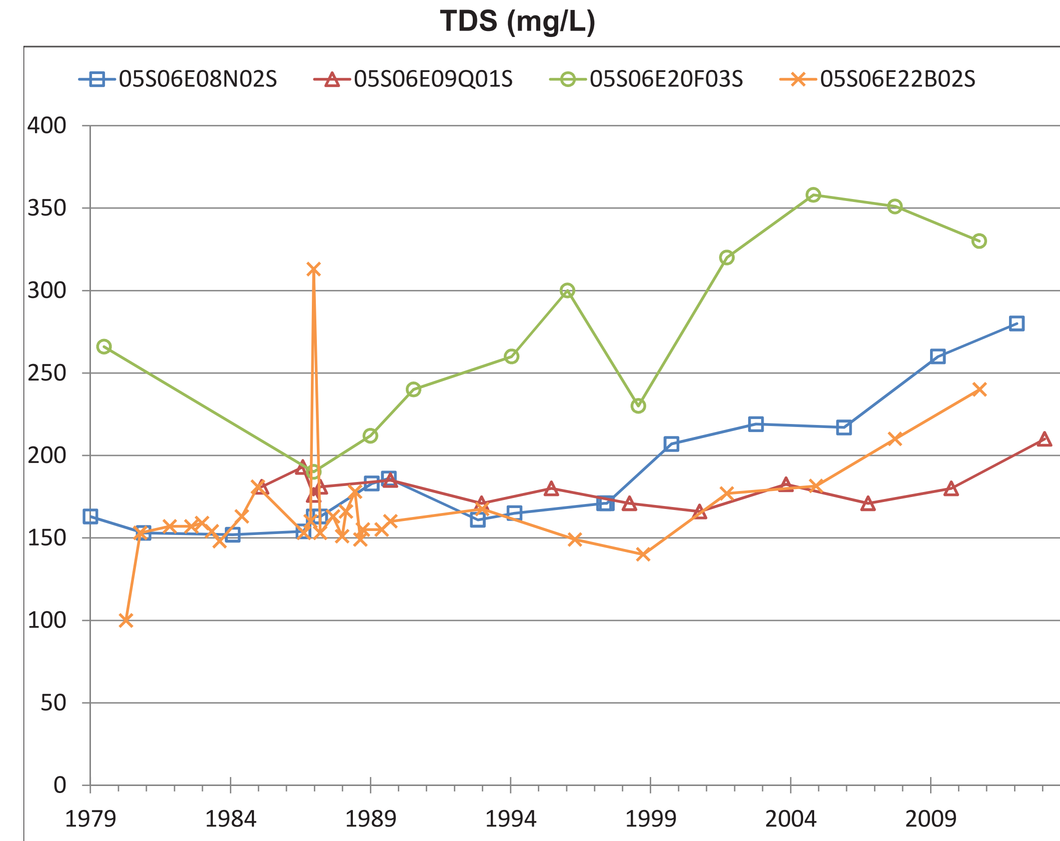


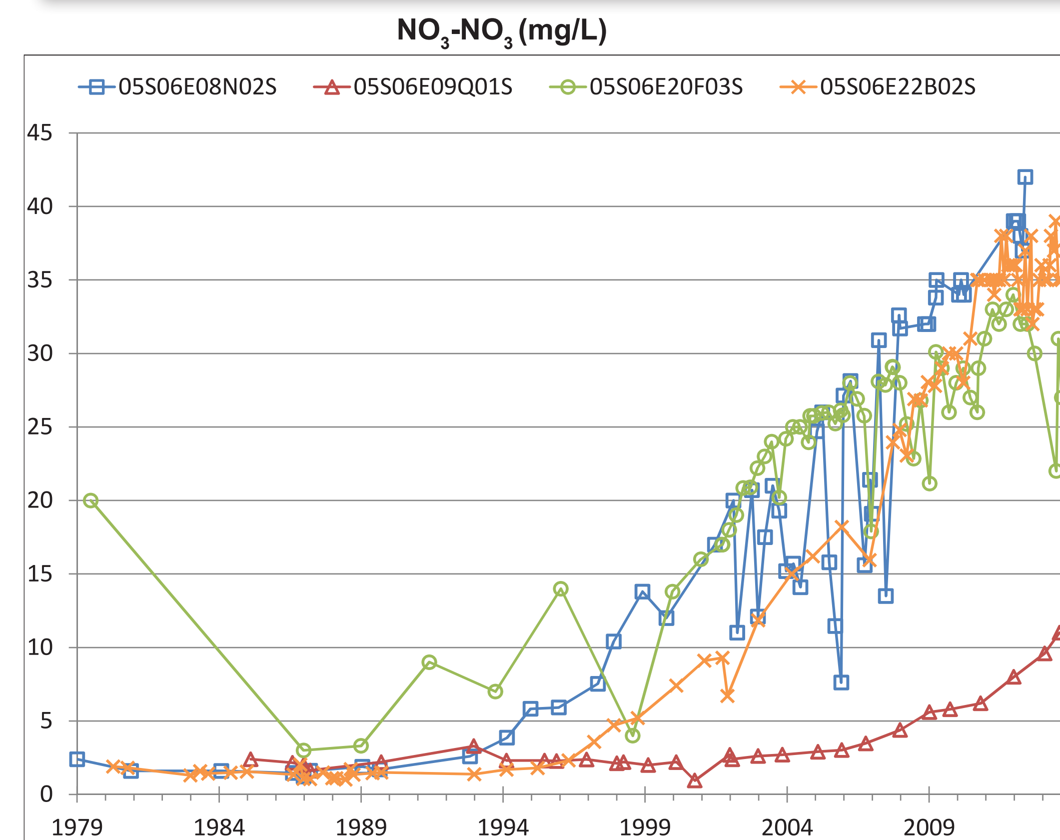




Appendix A-6
Group E - West Whitewater River
Management Zone







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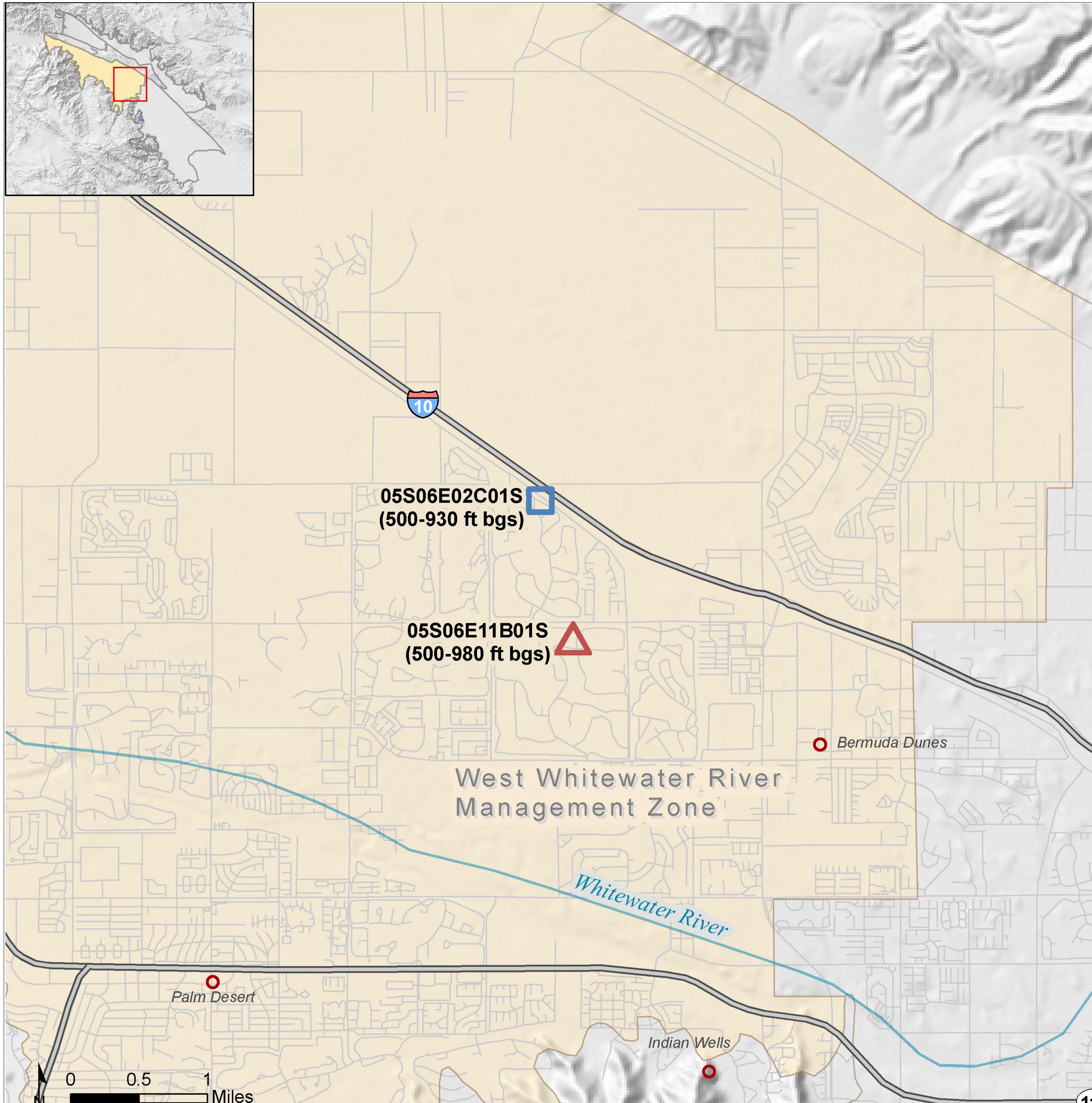
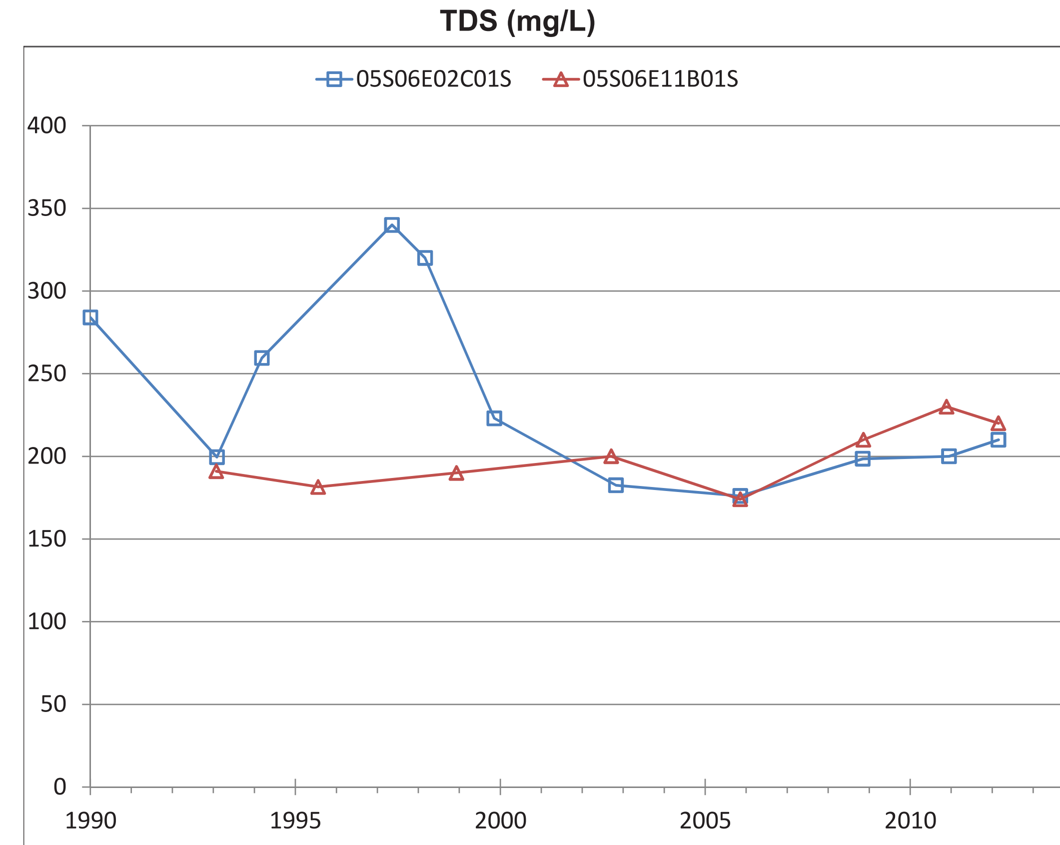
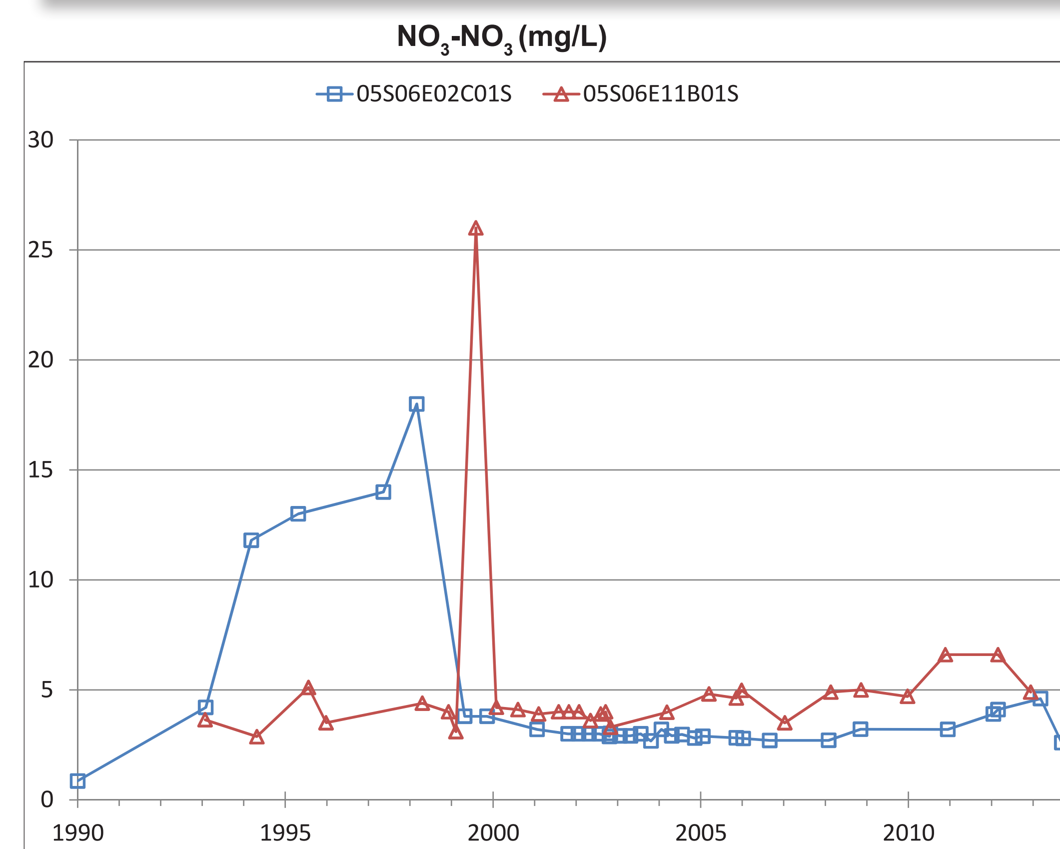
Appendix A-7
Group F - West Whitewater River Management Zone







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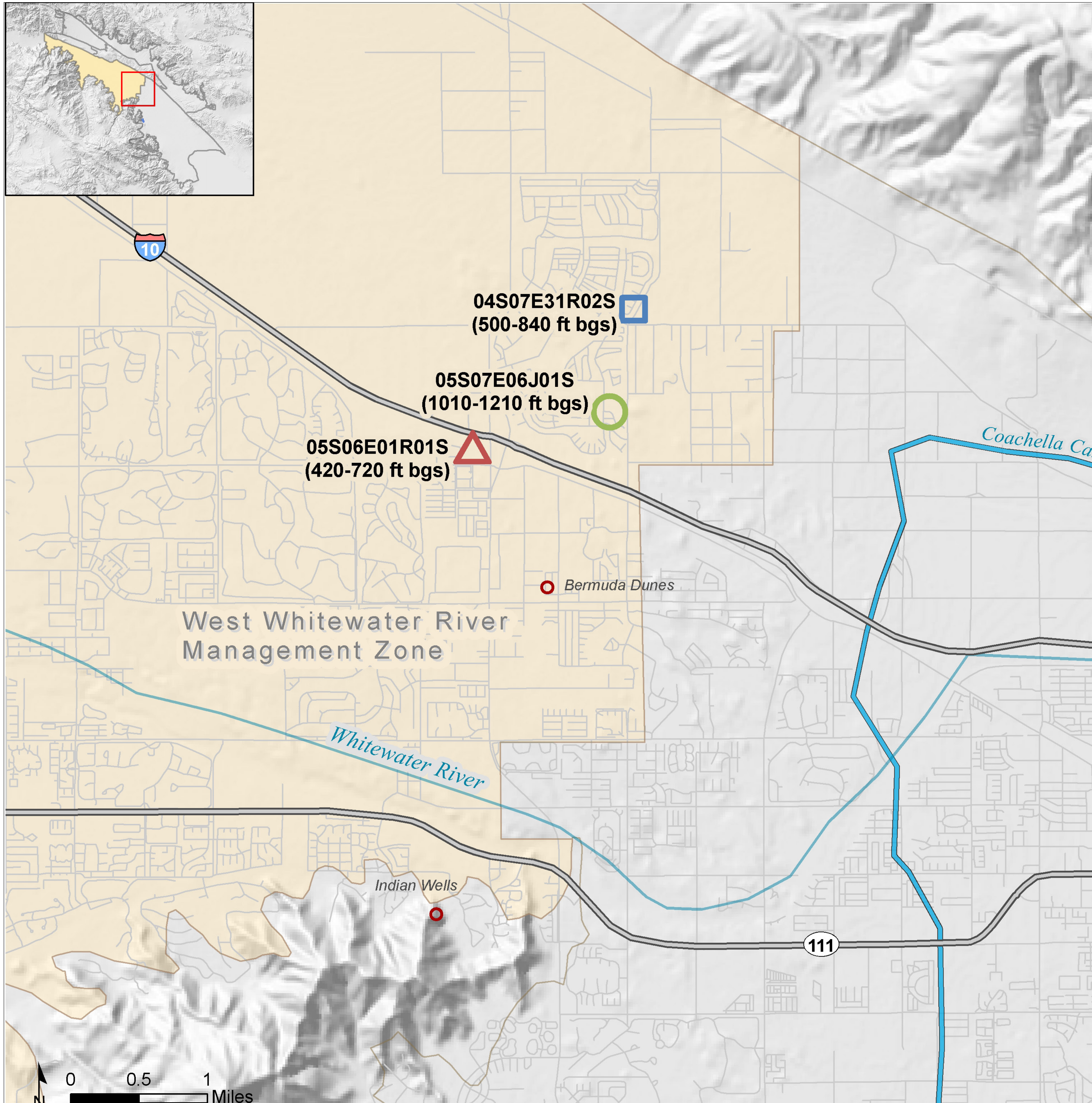
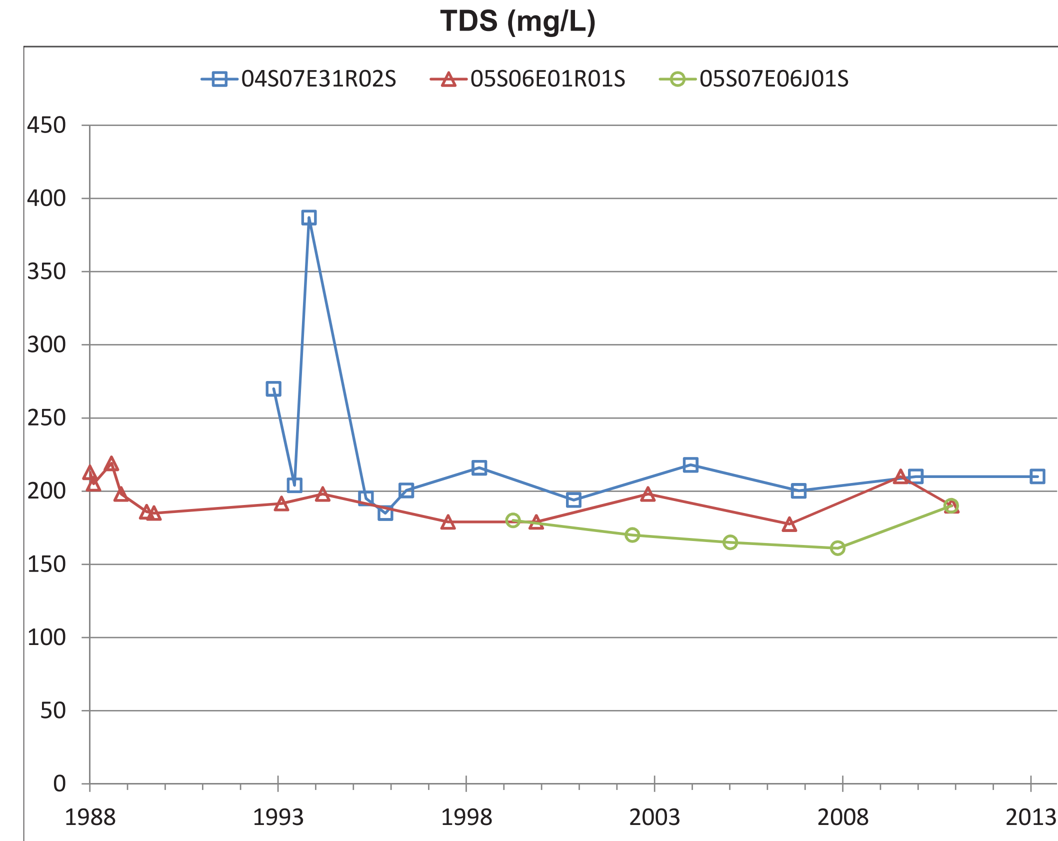
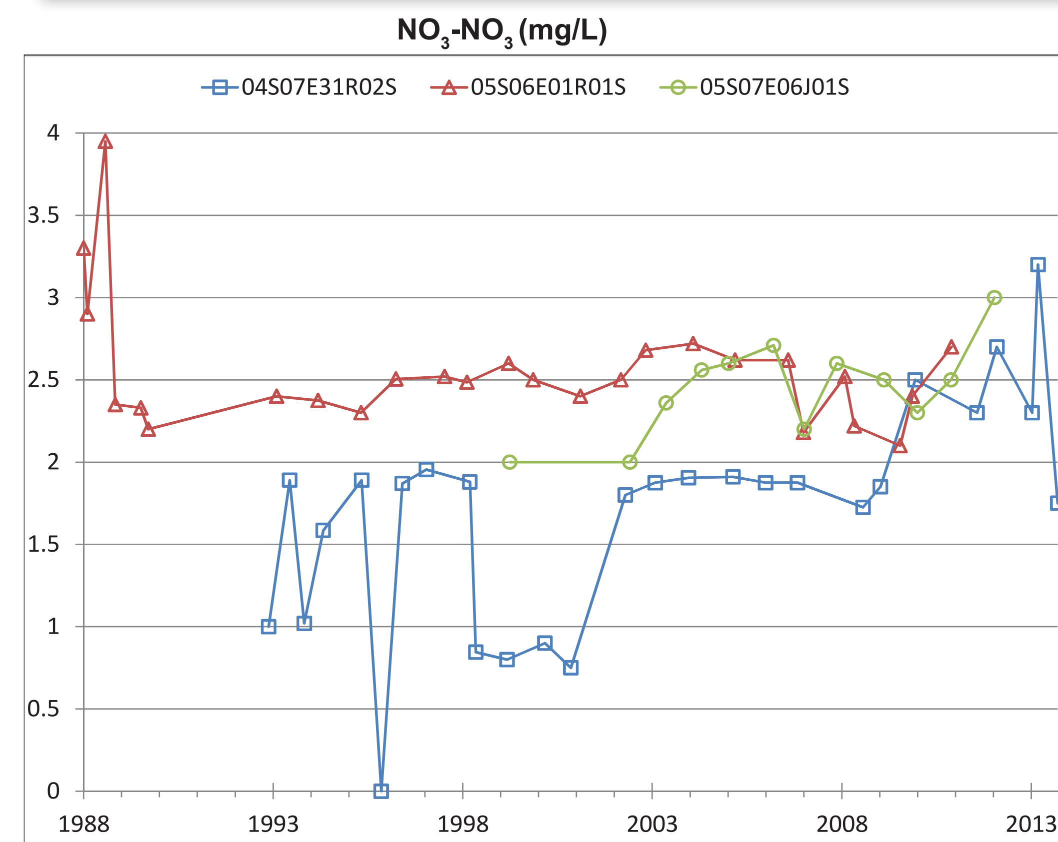
Appendix A-8
Group G - West Whitewater River Management Zone







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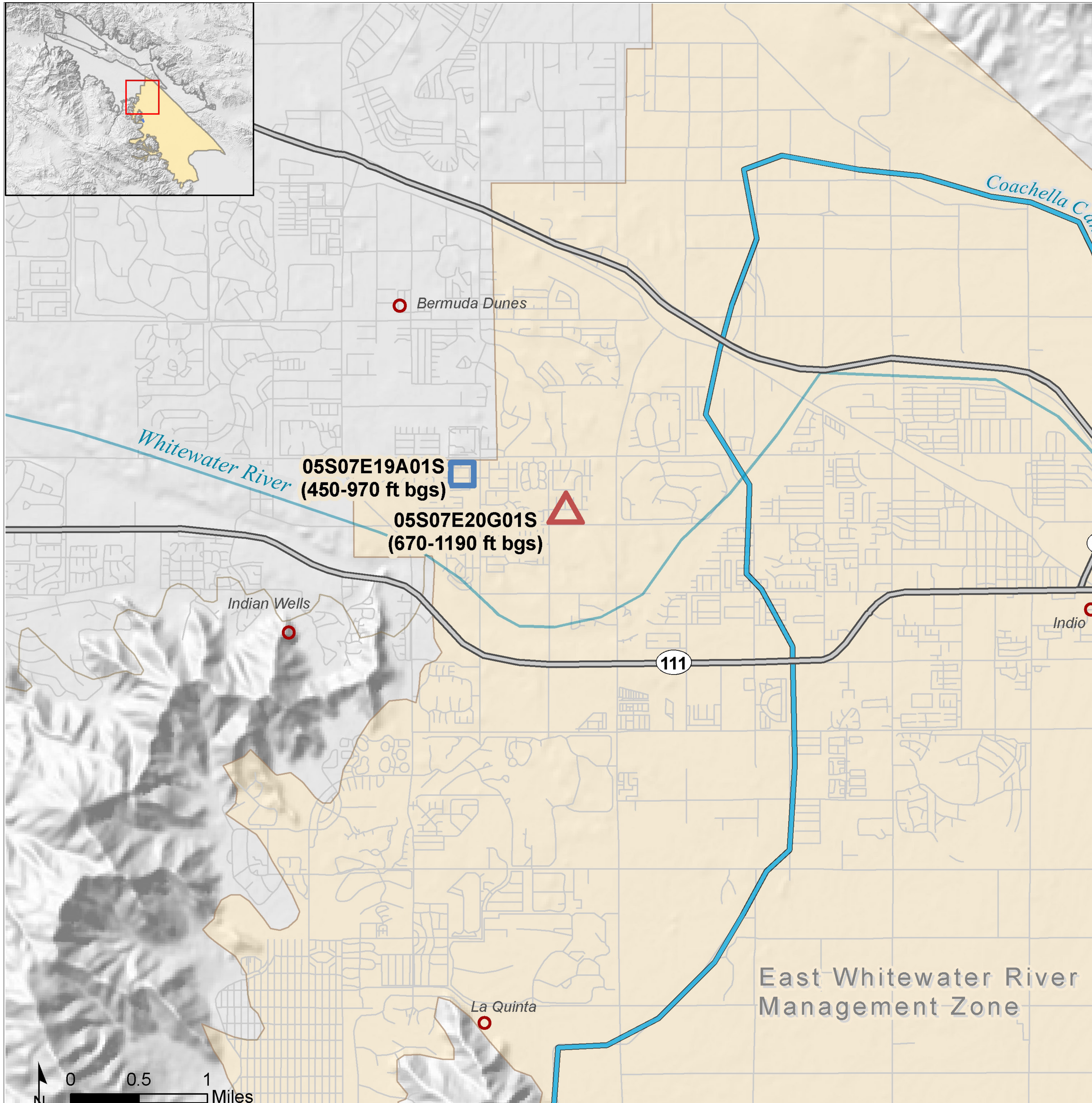
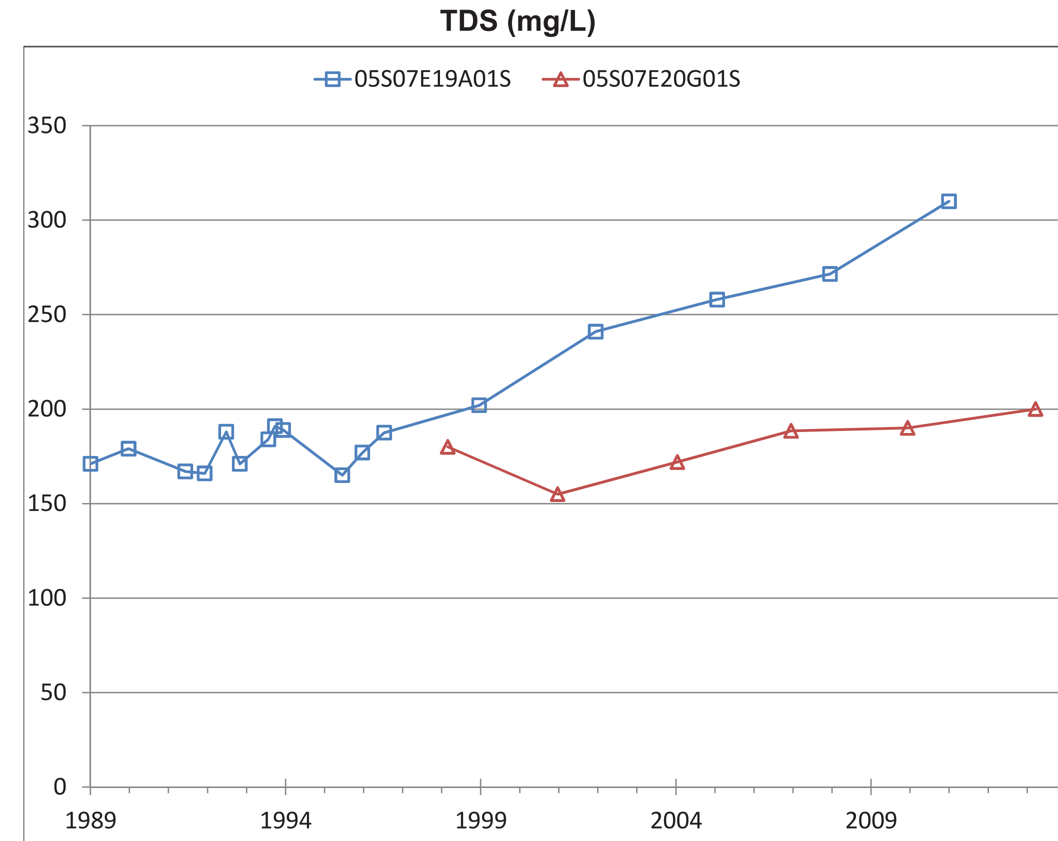
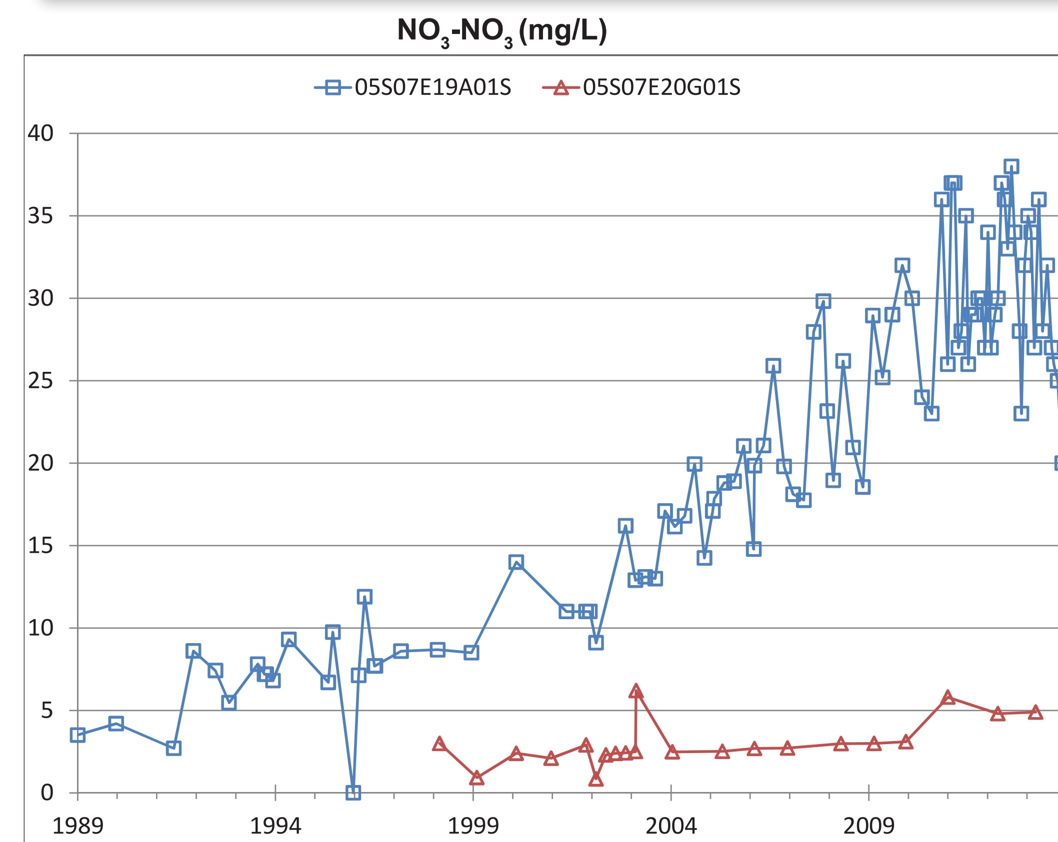
Appendix A-9
Group H - West Whitewater River Management Zone







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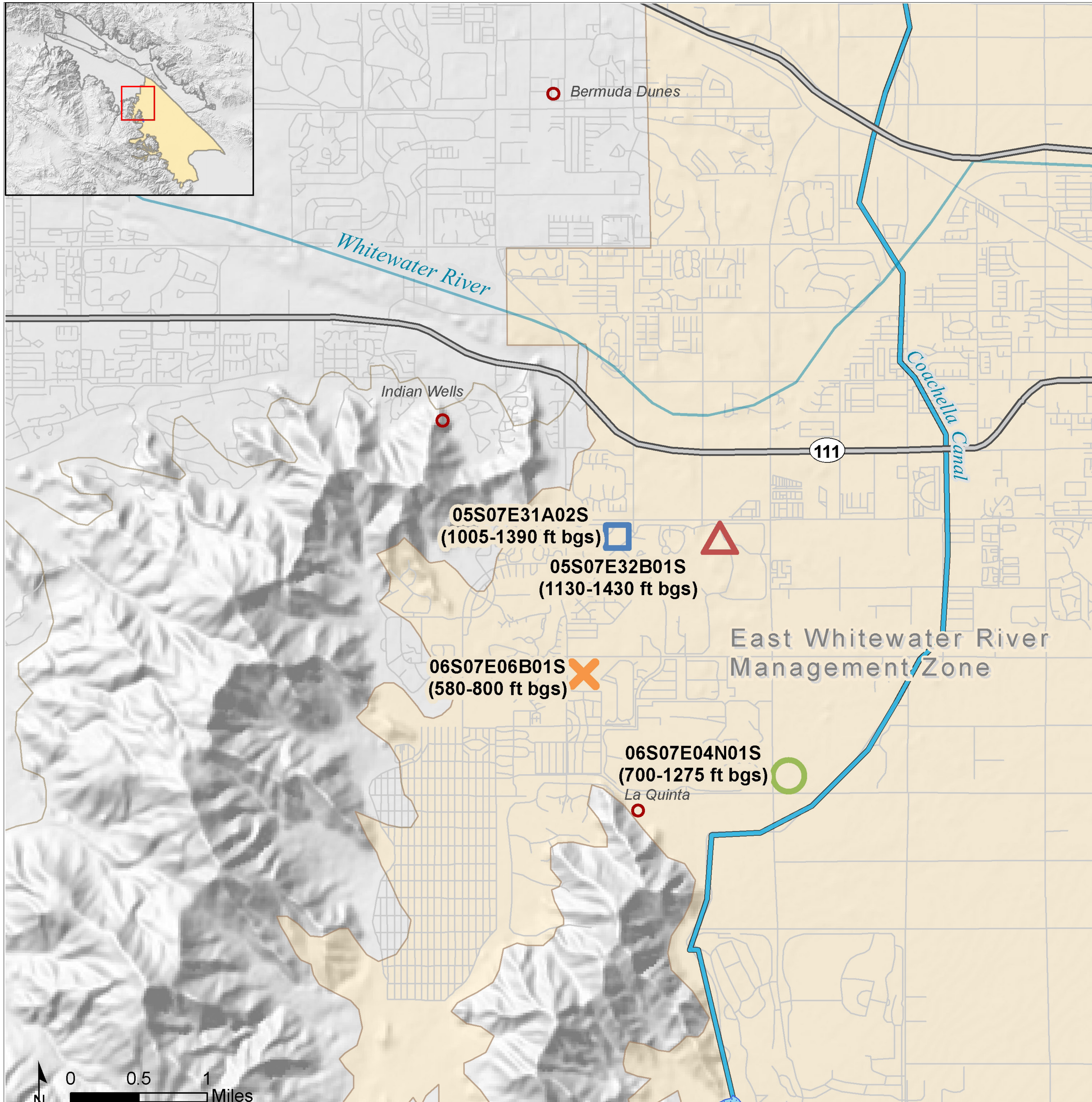
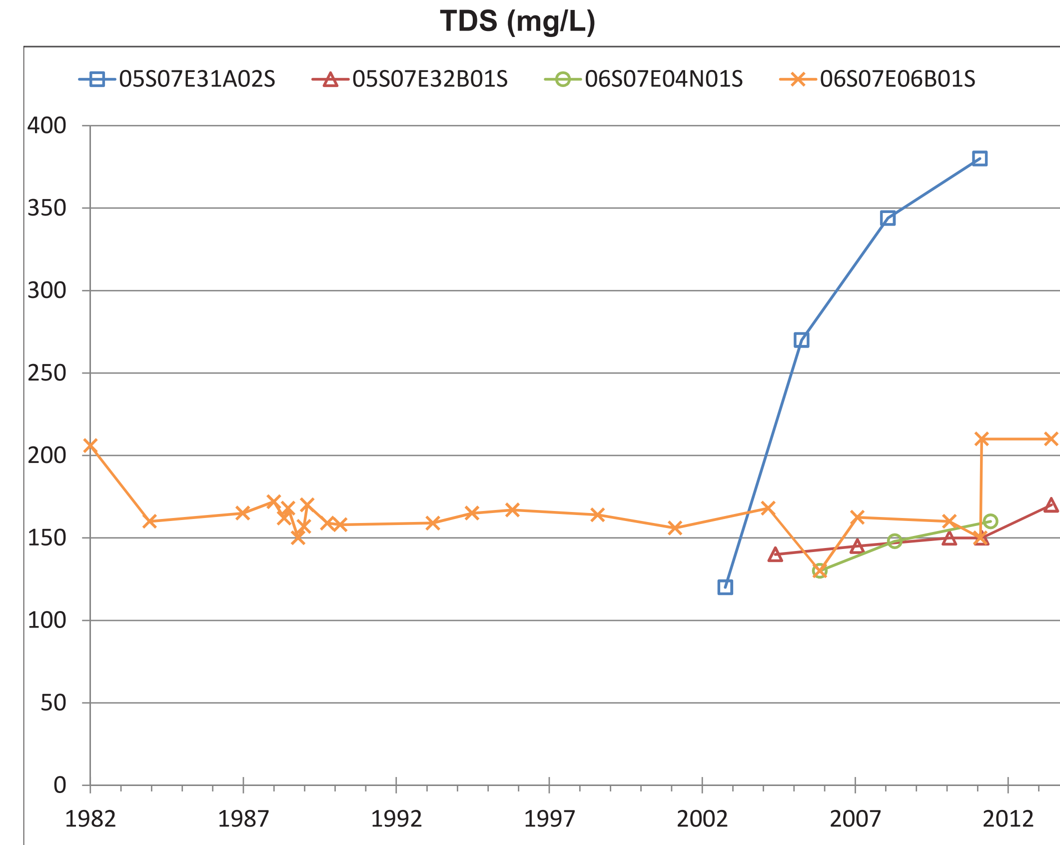
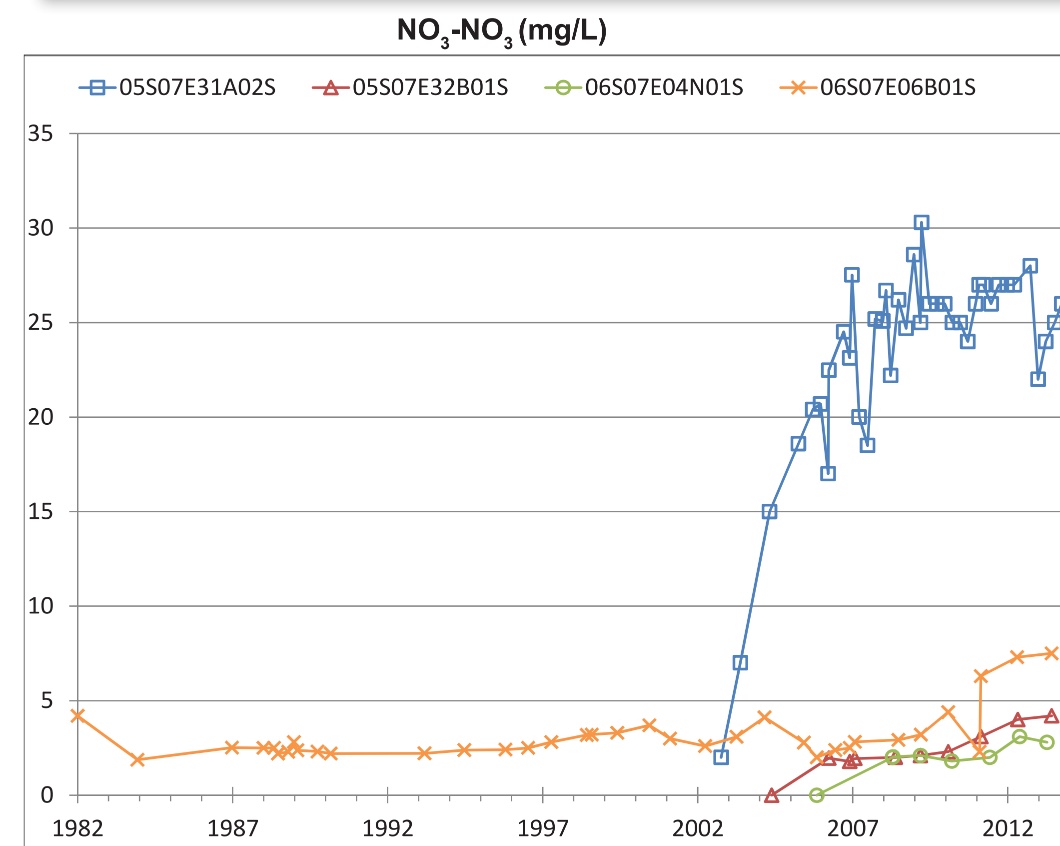
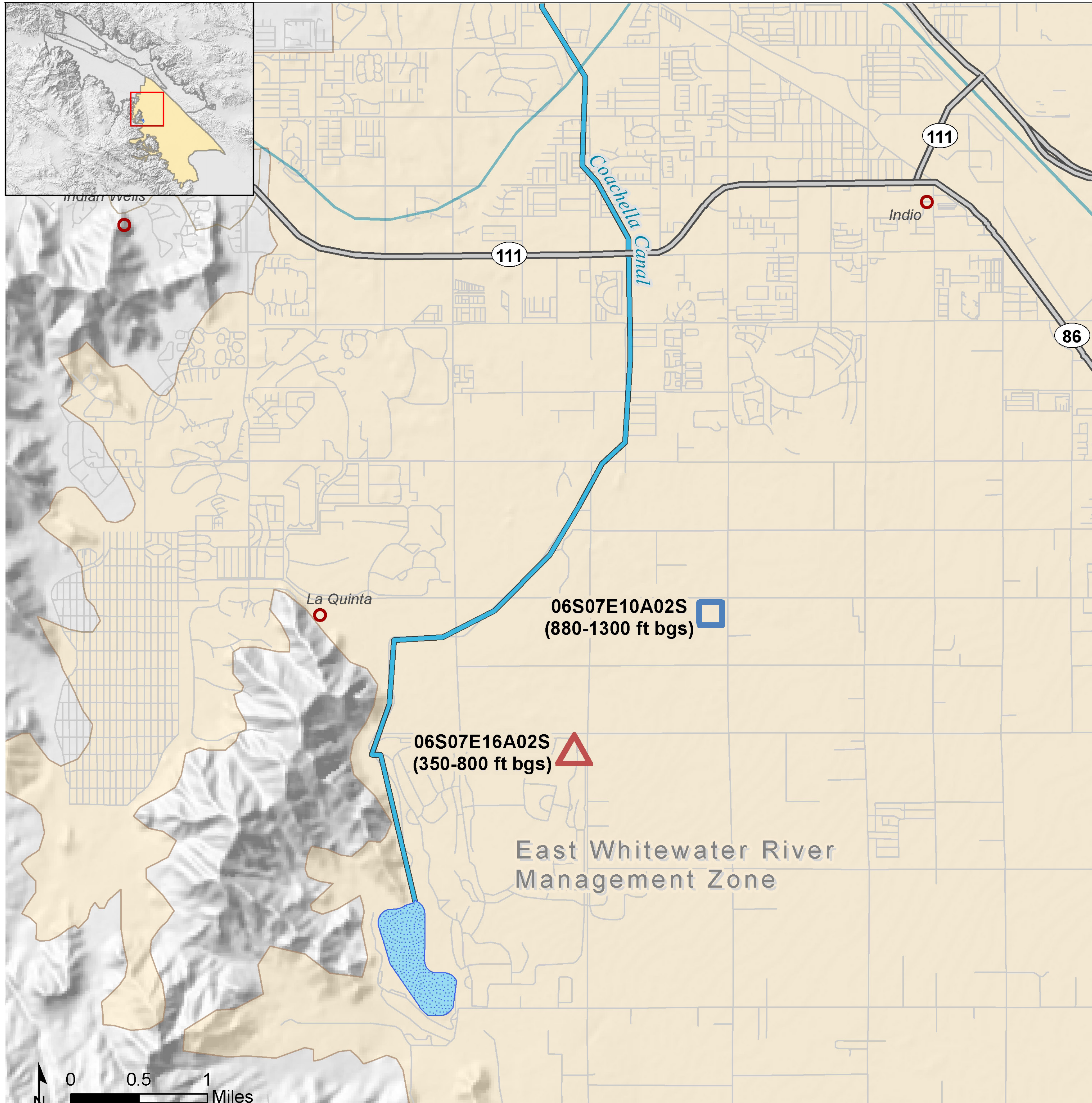
Appendix A-10
Group I - East Whitewater River Management Zone

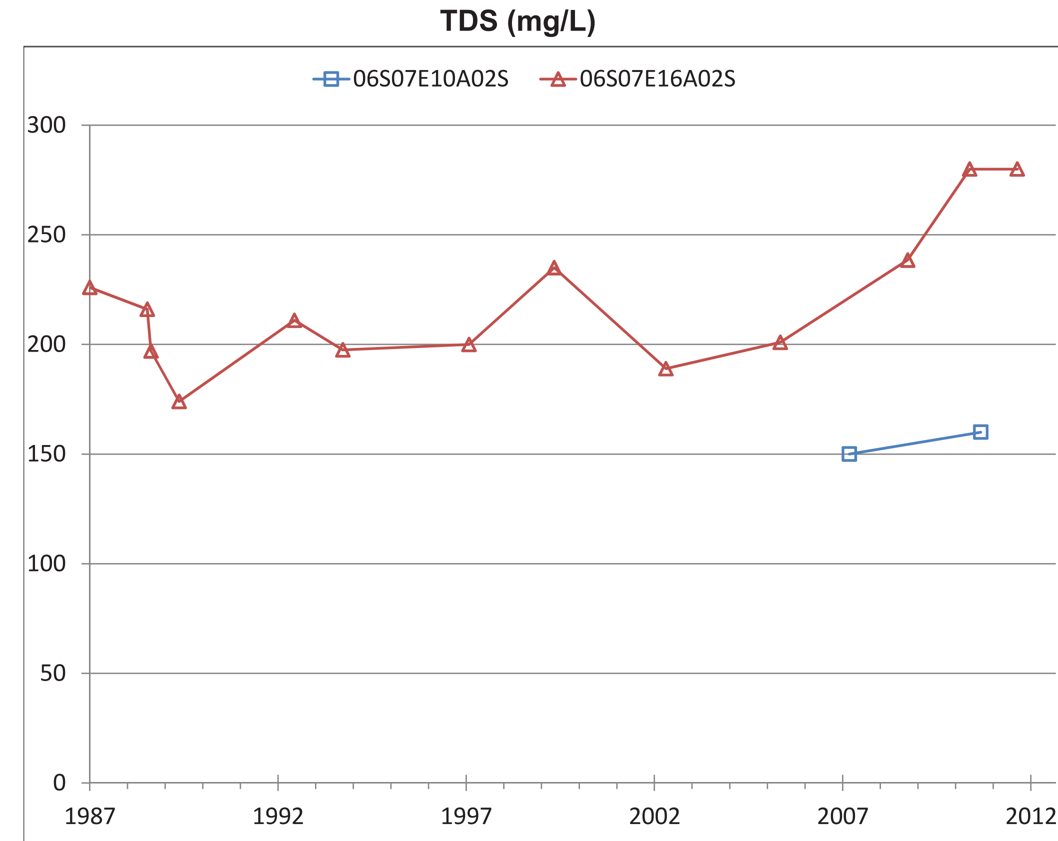


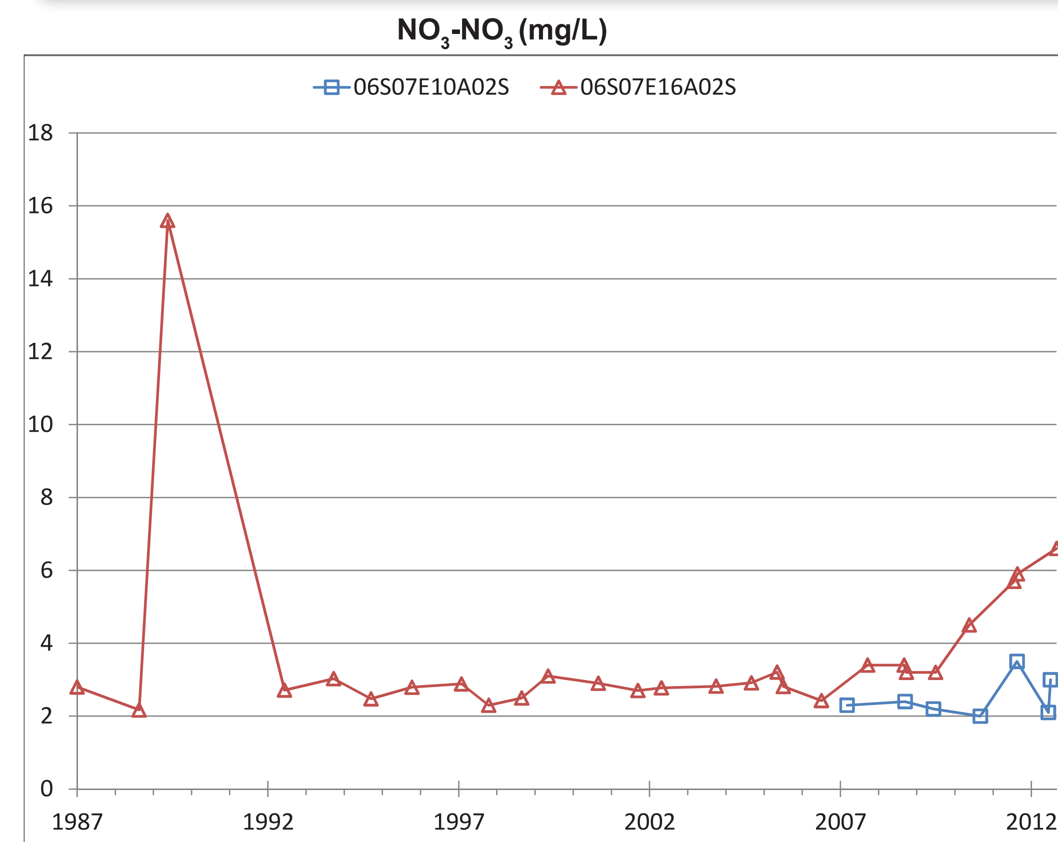




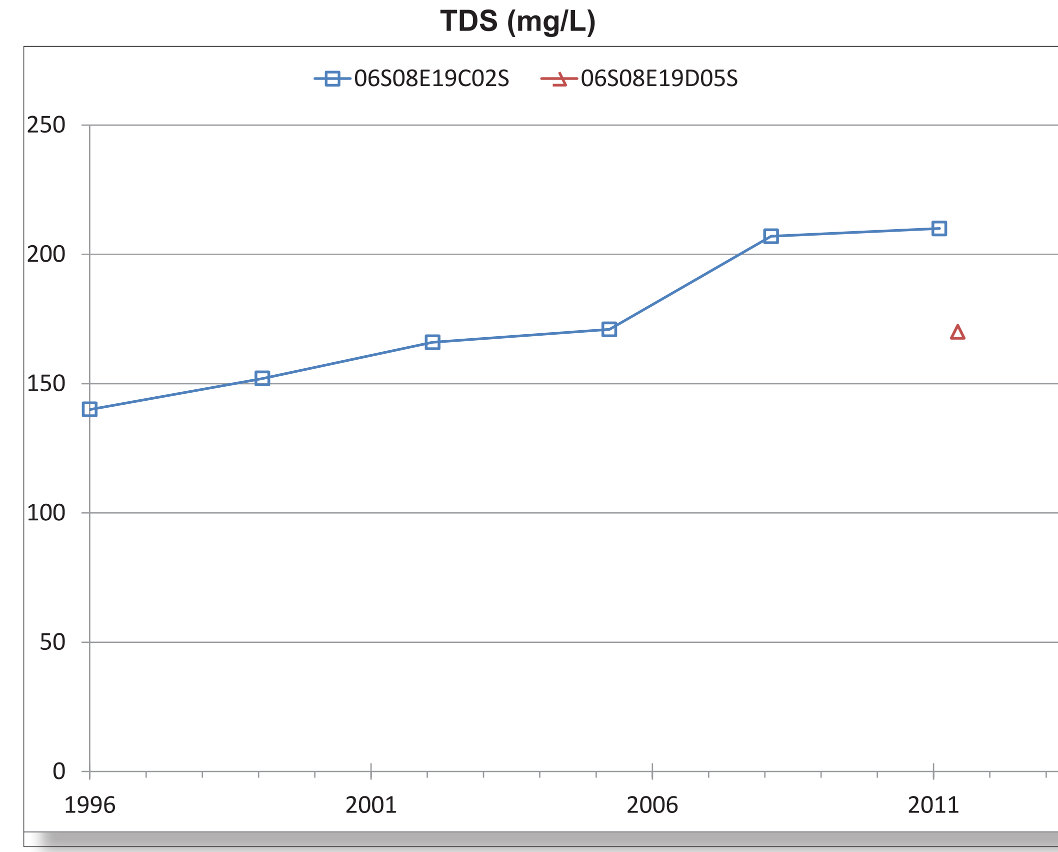
Appendix A-11
Group J - East Whitewater River
Management Zone

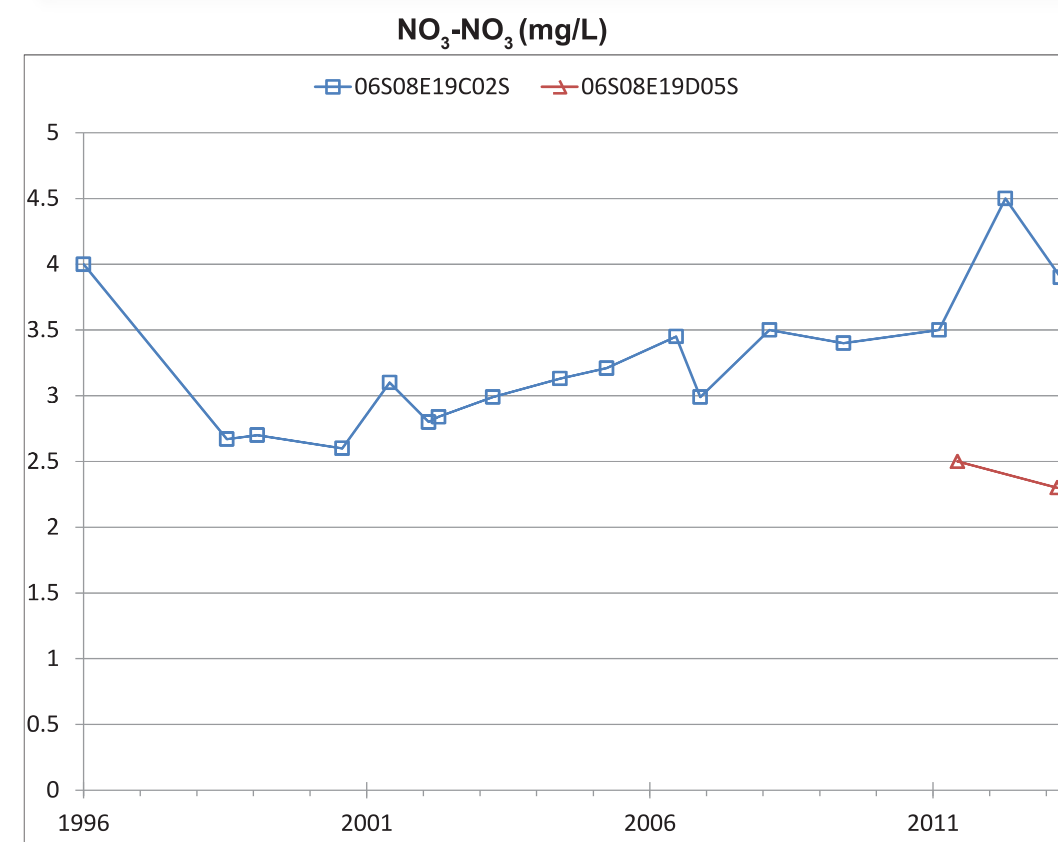






Appendix A-12
Group K - East Whitewater River
Management Zone





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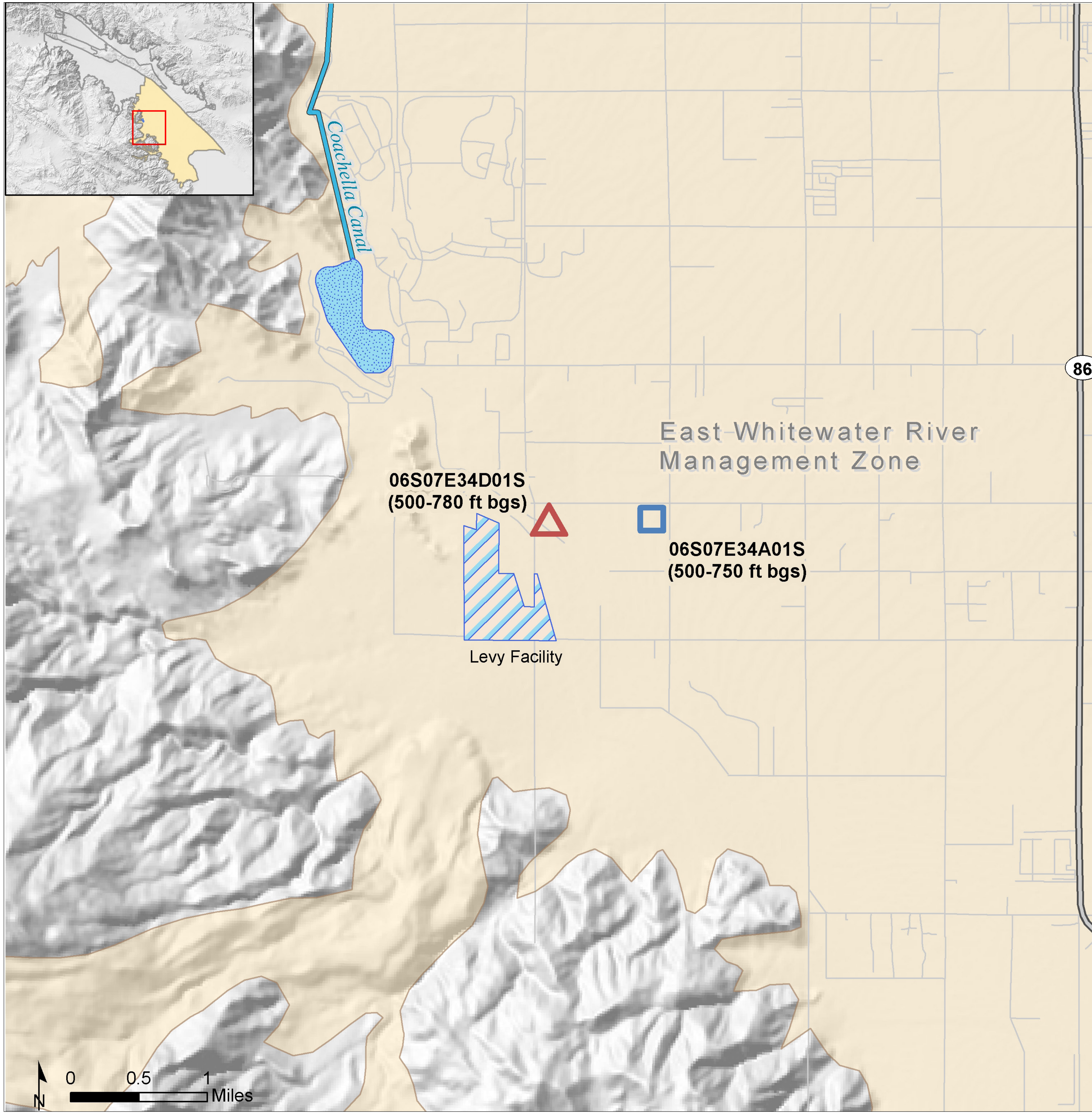
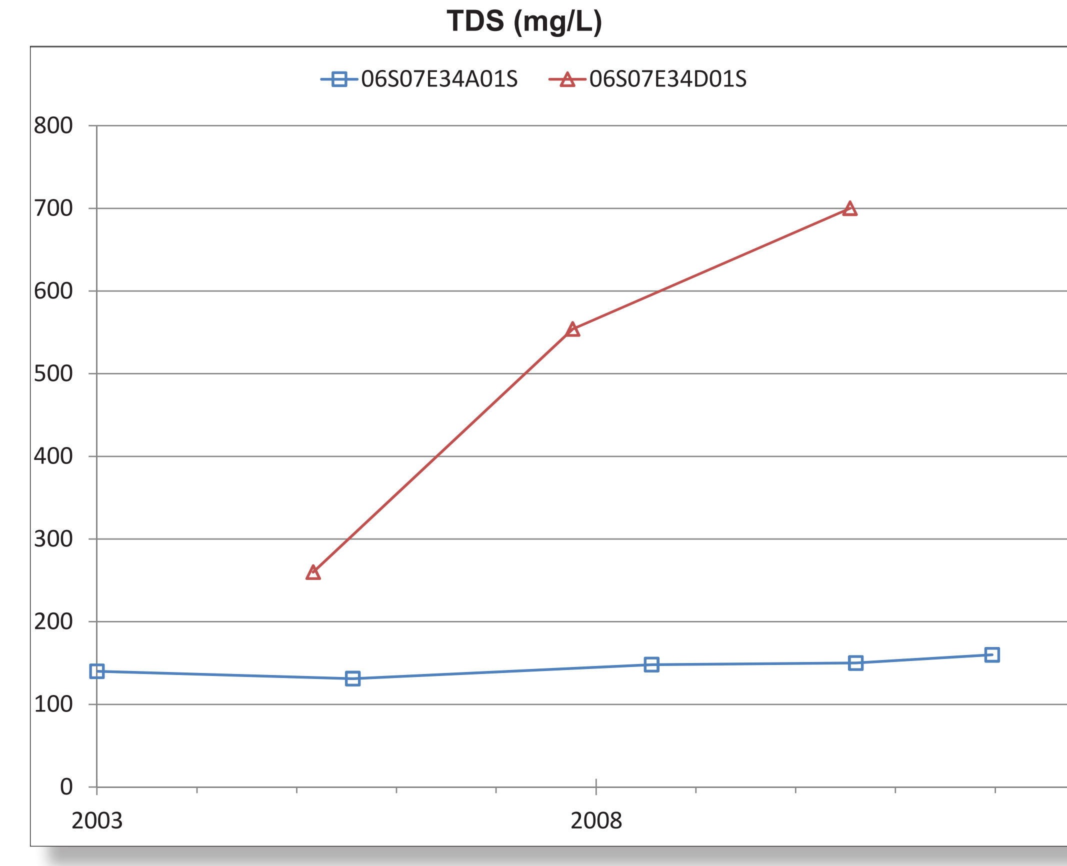
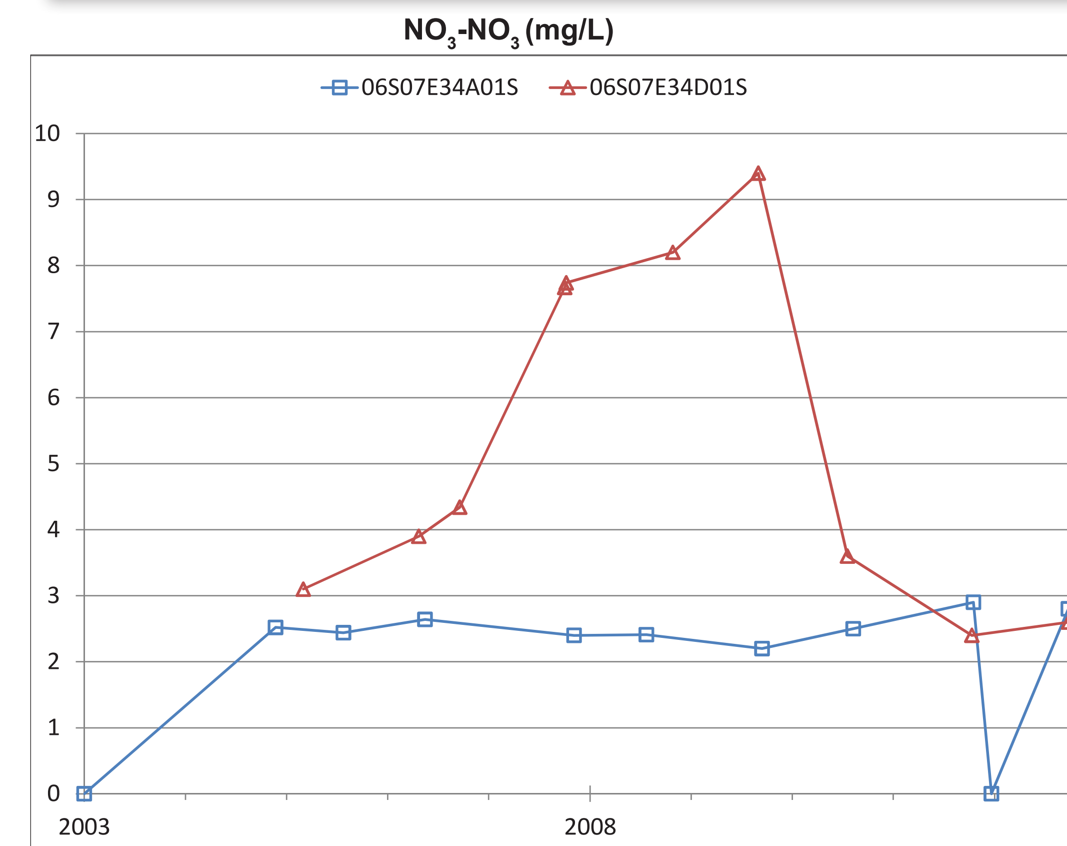
Appendix A-13

Group L - East Whitewater River Management Zone







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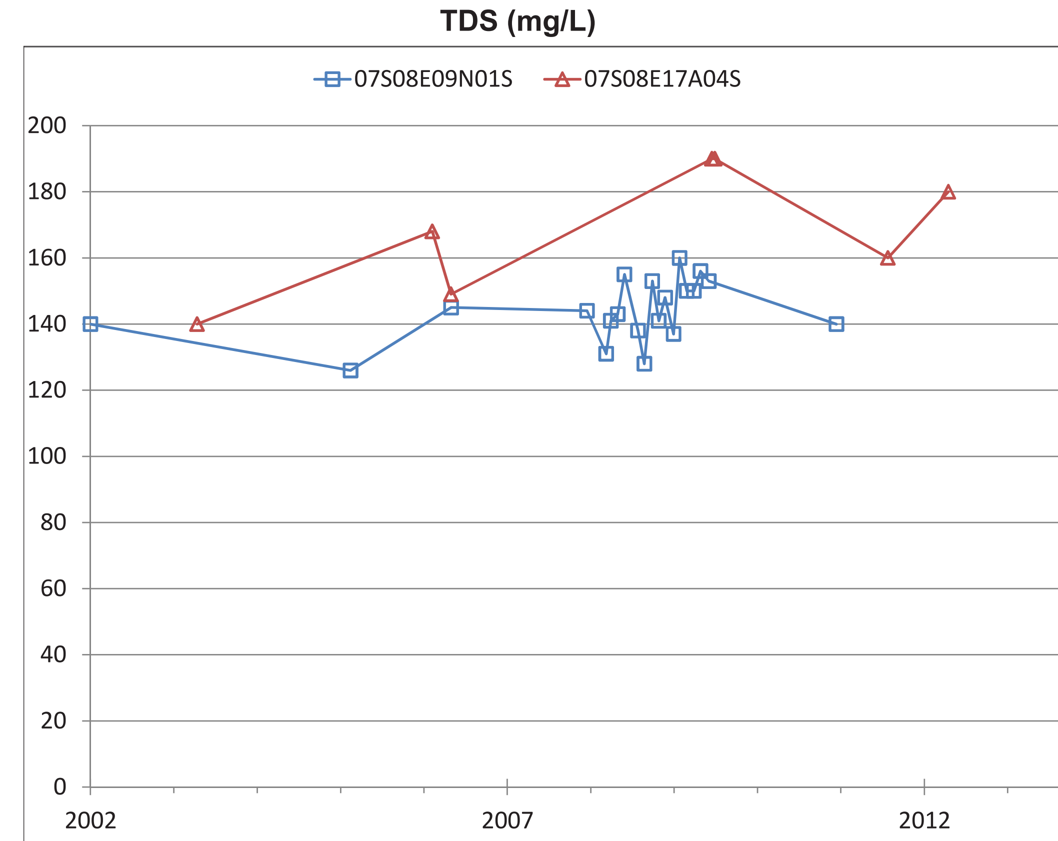
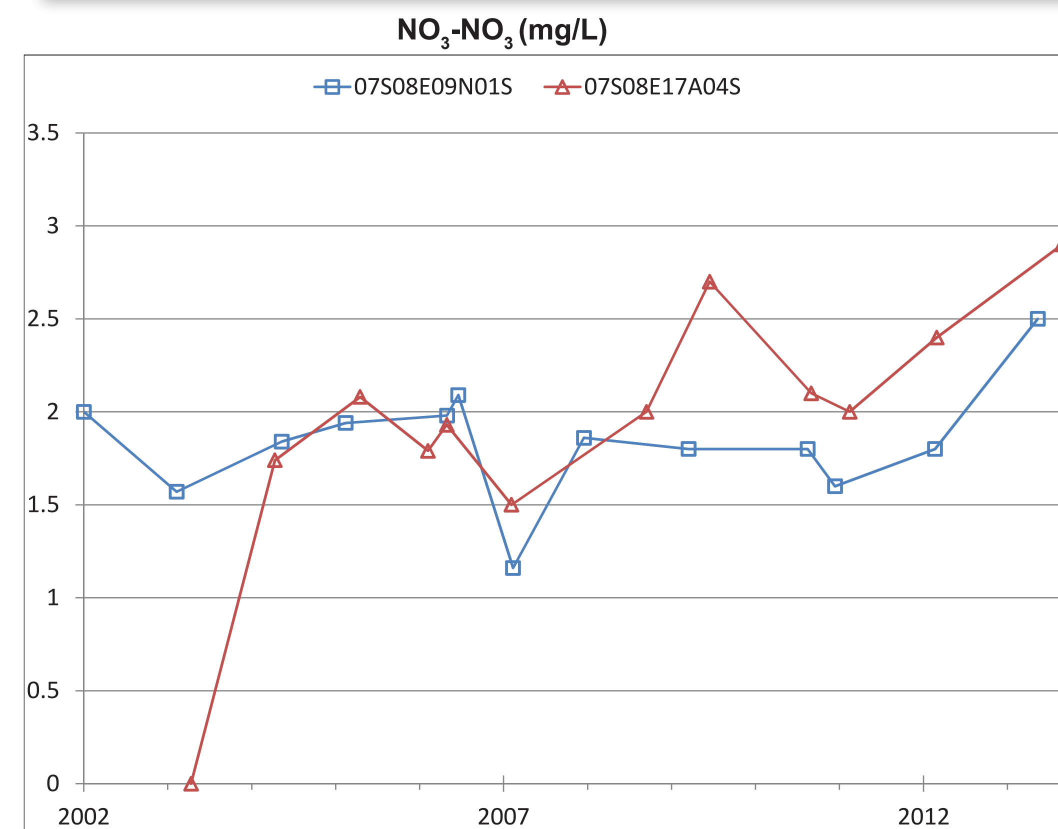
Appendix A-14
Group M - East Whitewater River Management Zone





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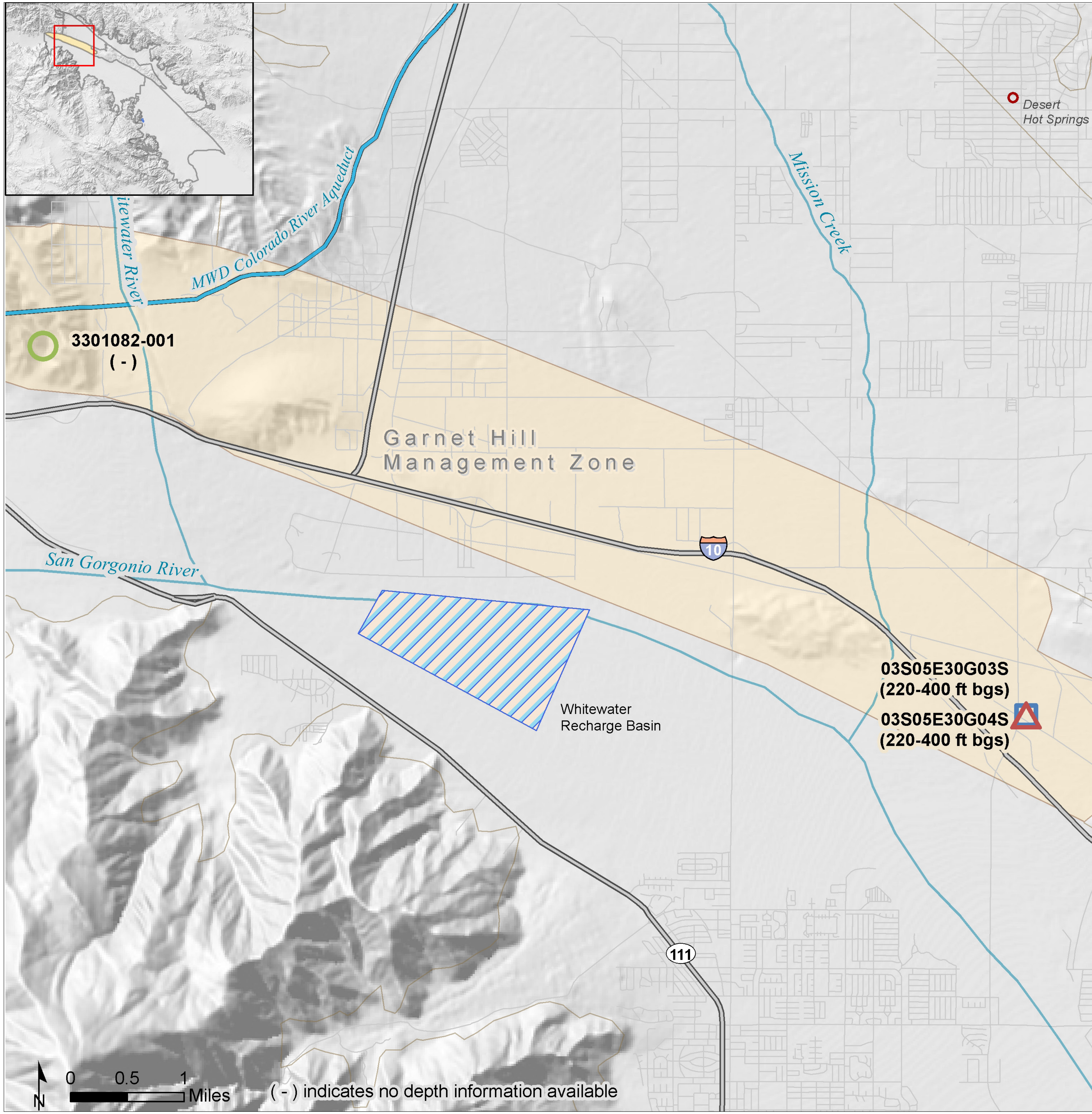
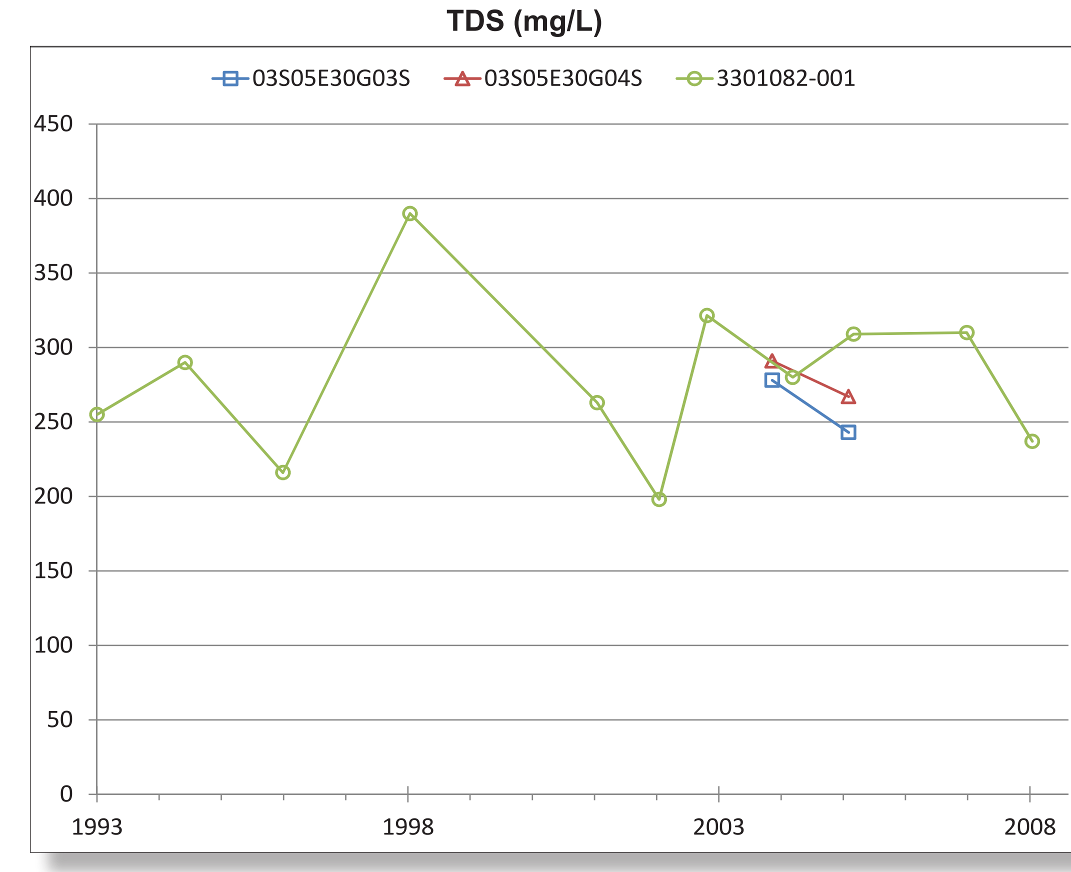
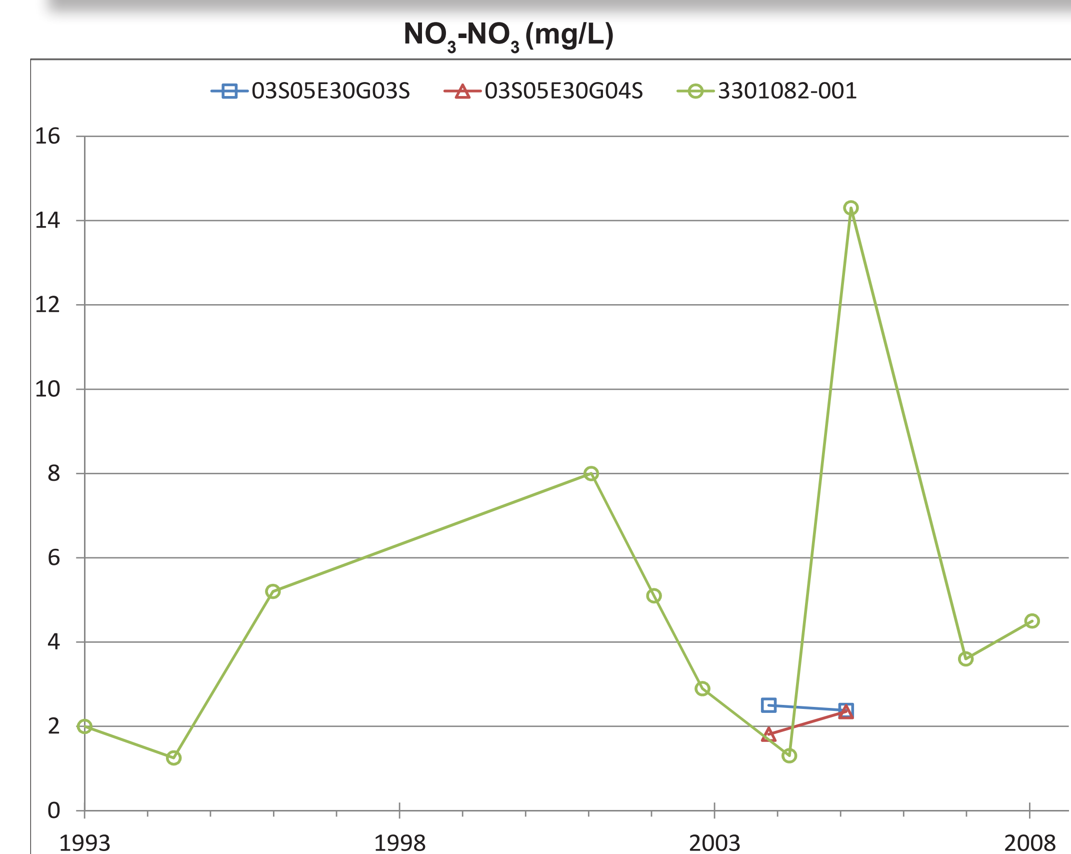
Appendix A-15
Group N - East Whitewater River
Management Zone







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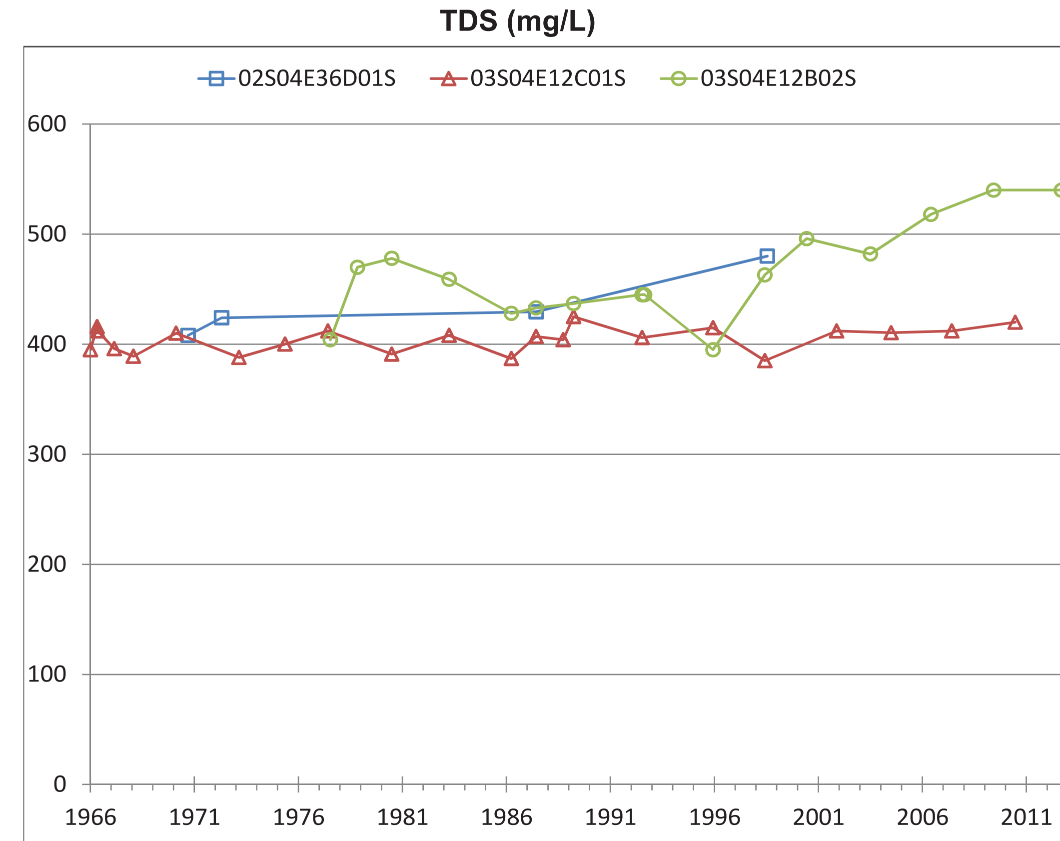
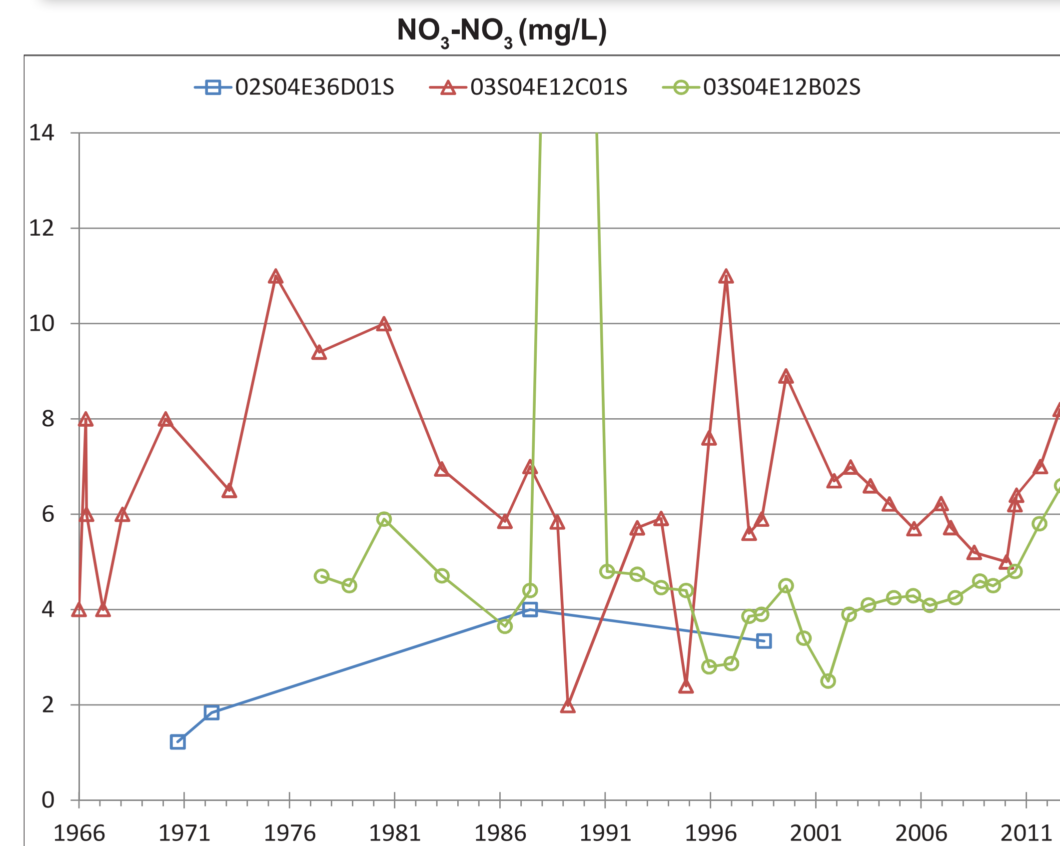
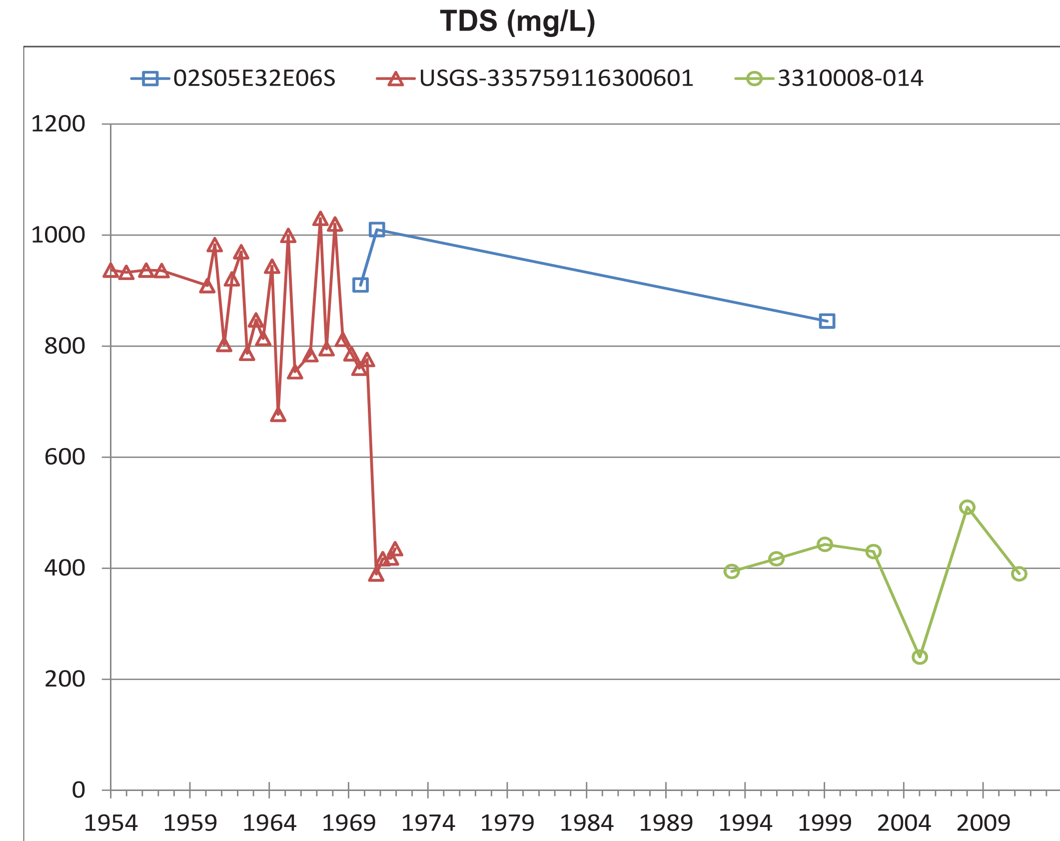
Appendix A-16

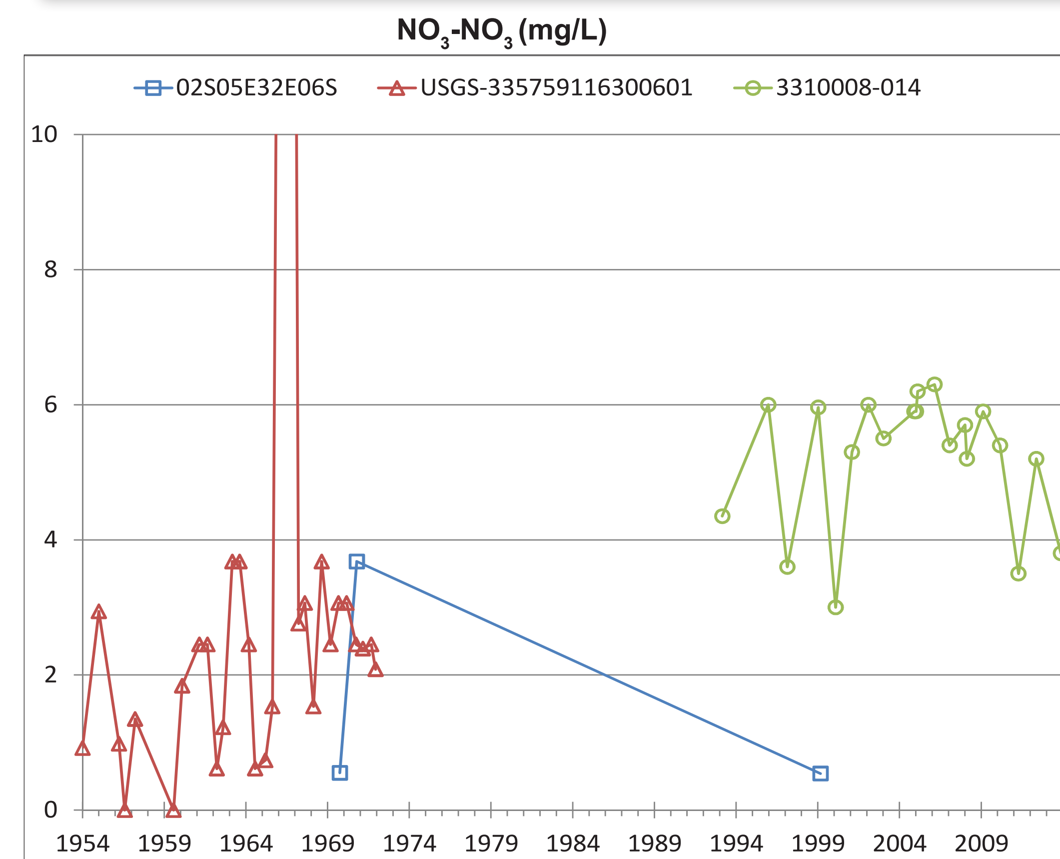
Group O - Garnet Hill Management Zone





Appendix A-17
Group P - Mission Creek Management Zone





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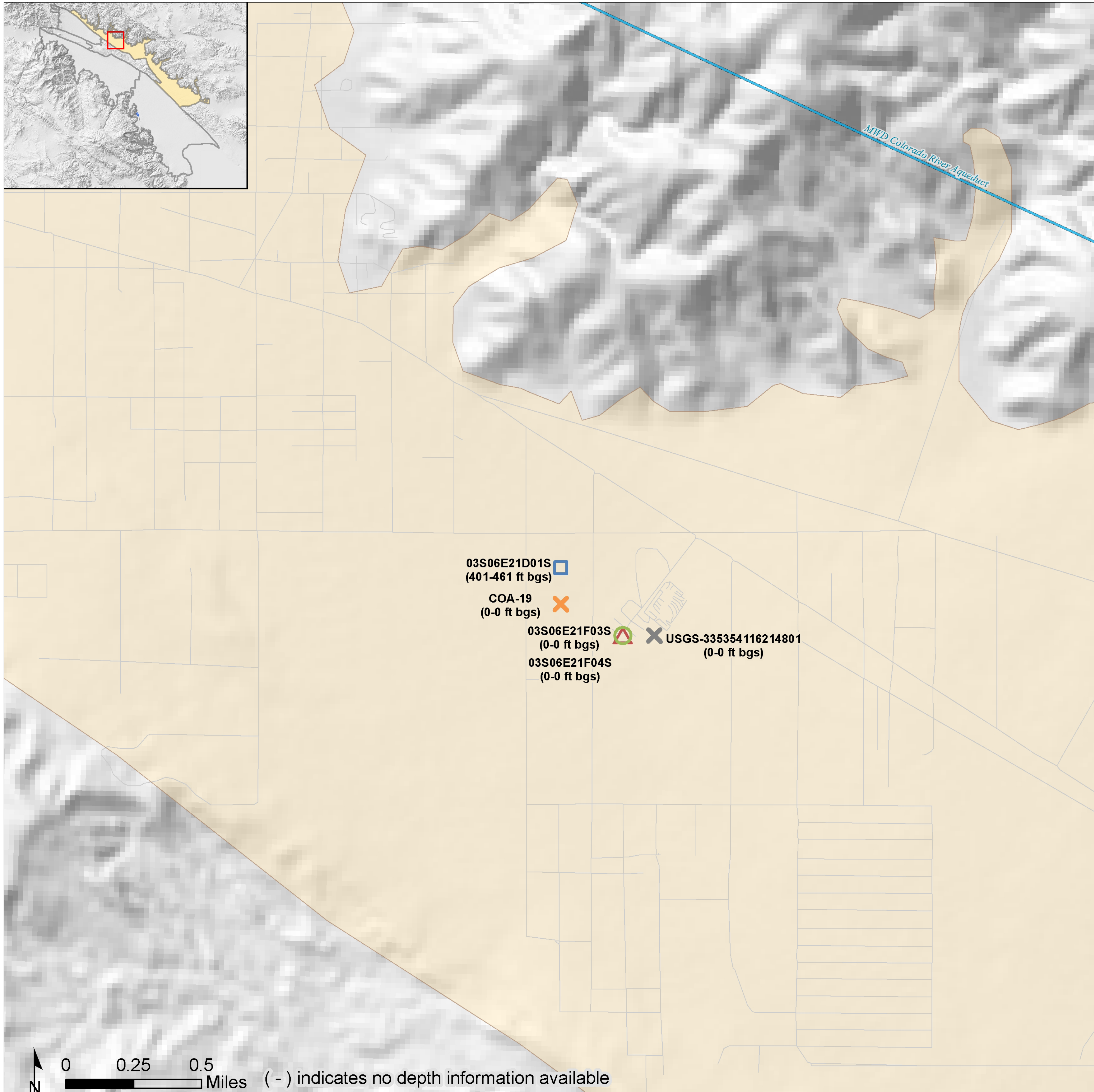
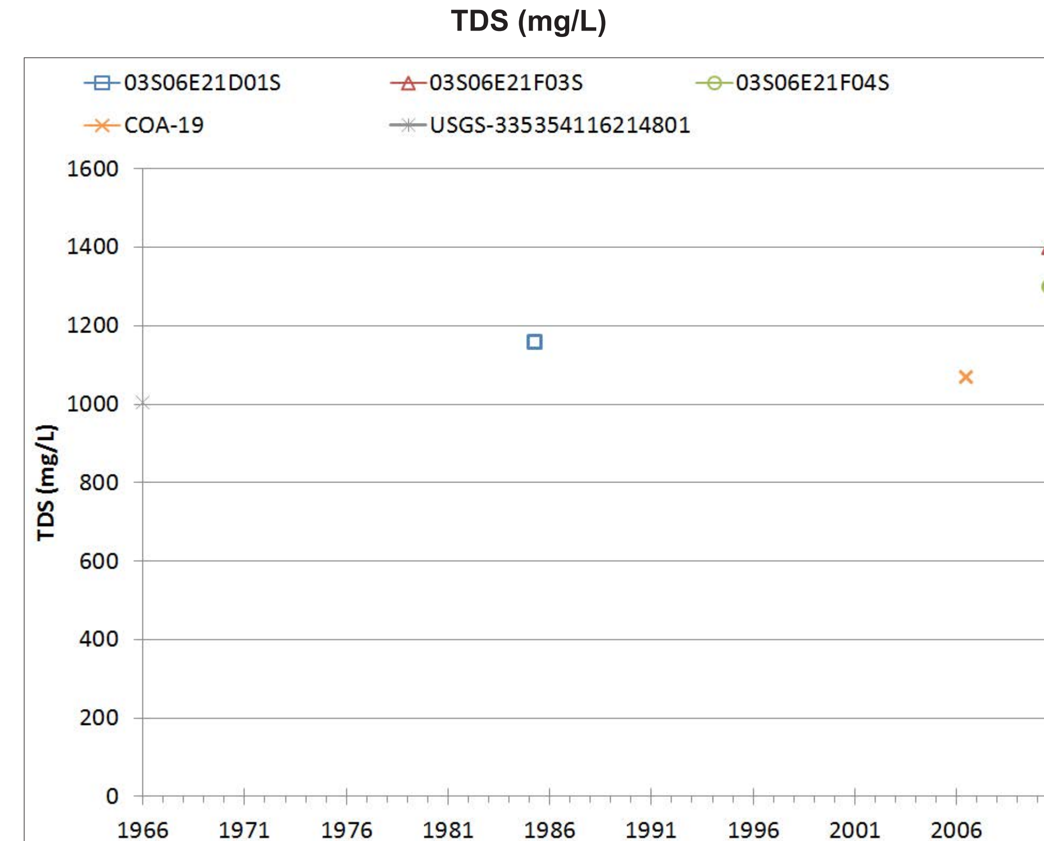
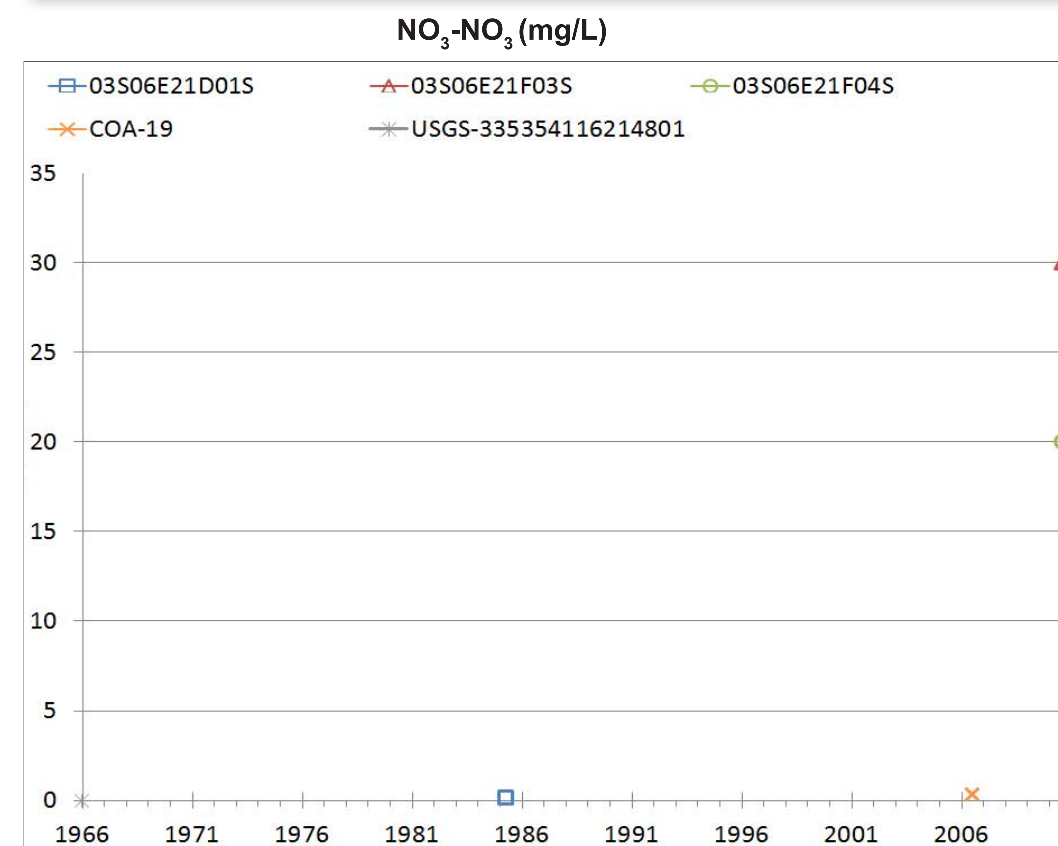
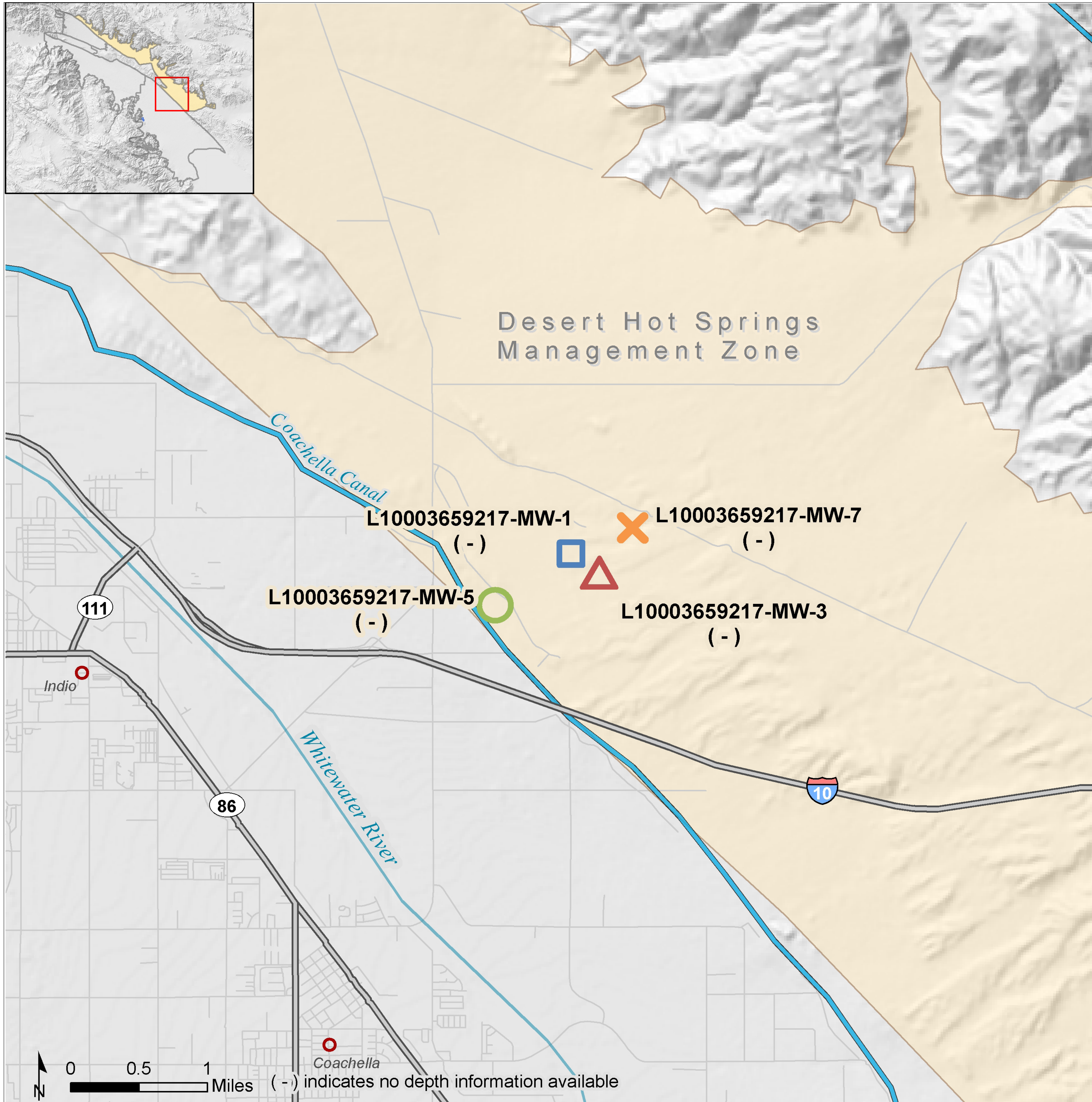
Appendix A-18
Group Q - Desert Hot Springs
Management Zone

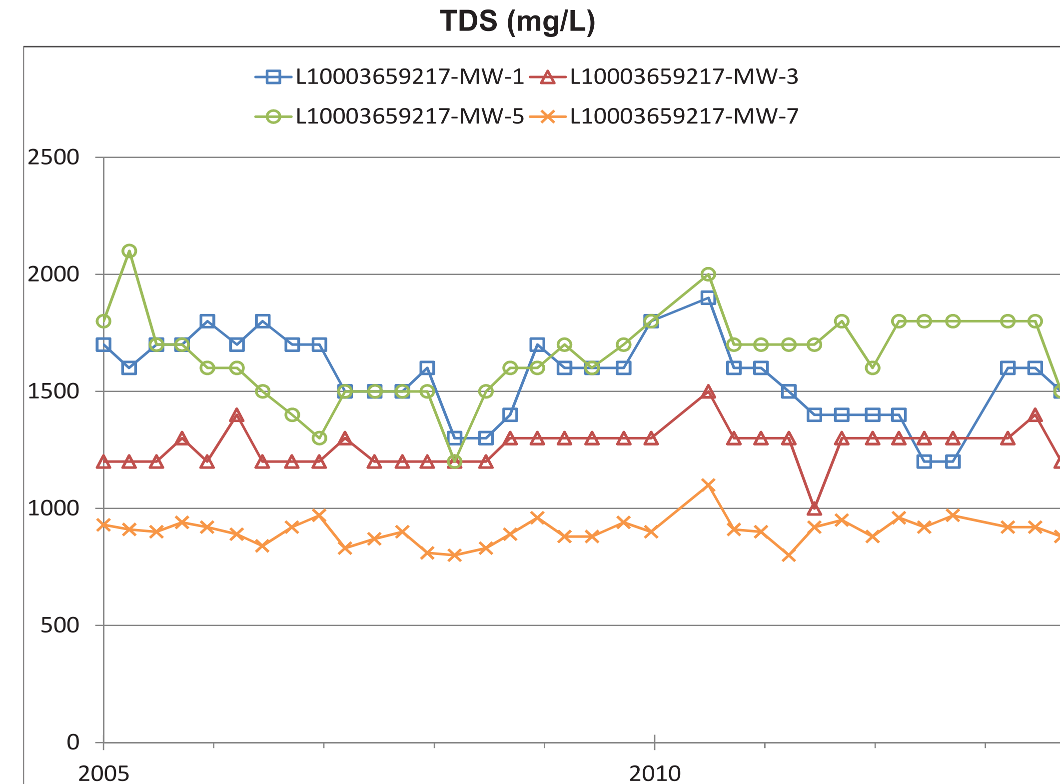


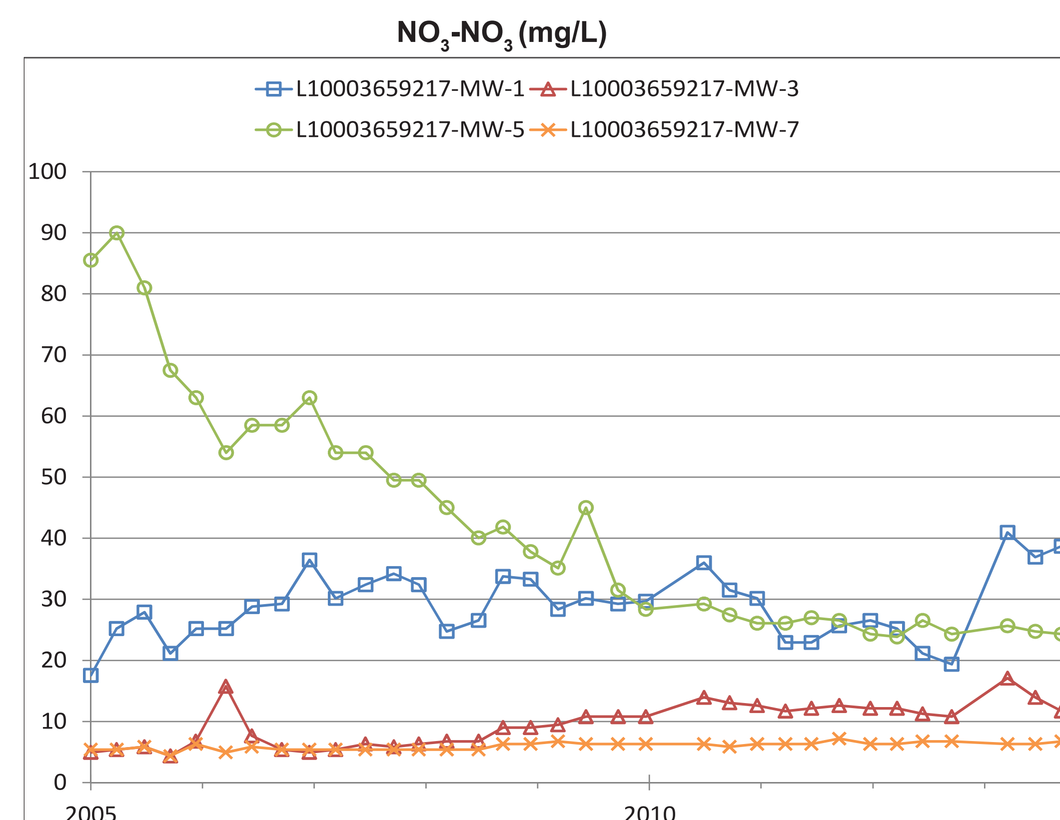




Appendix A-19
Group R - Desert Hot Springs Management Zone







Appendix A-20
Group S - Desert Hot Springs
Management Zone

Appendix F – Planned Projects

Potential Projects for Consideration in Coachella Valley Salt Nutrient Management Plan
INITIAL DRAFT

CVRWMG Project No.	CVRWMG Date Submitted	Organization	Project Title	Project Summary	IRWMP Functional Area	Project Capacity (Amount of Water Used or Disposed)	Estimated Startup Year and Estimated Buildout Year	Potential Effect on Salt/ Nutrient Loading	Total Costs	Project Information Source
233	7/30/2010	City of Cathedral City	Bridge Drainage System Design for 3 Whitewater River Bridges	Construction of a new 4 lane bridge at Cathedral Canyon Drive as well as widening to six lanes of the Ramon Road Bridge and the Date Palm Drive Bridge. All bridges are over the Whitewater River and within 3 miles of each other. Cathedral Canyon Drive Bridge is to replace a low water crossing and the widening of the other two bridges are to improve traffic circulation and emergency response during times of floods and accidents or other life threatening situations.	Water Quality/Stormwater			Uncertain effect	$70,000,000	CVRWMG Project Website
241	8/19/2010	City of Cathedral City	Cathedral City North City Specific Plan - East Sub-Region	A primary goal of the North City Specific Plan - East Subregion is to provide for sustainably-designed infrastructure in new development. Ensure that an adequate infrastructure system is in place for future development in the East-Subregion. To conserve precious water resources, an area-wide reclaimed water system would be desirable. Per the CVWD Master Plan, a new sewer system will be installed to the east of the Specific Plan area that will direct the flow on the north side of the I-10 freeway to the Thousand Palms area. There is currently no storm drain infrastructure within the planning area. CVWD will own and maintain future storm drain systems. Two major storm drain system backbone lines that are recommended in the North City Specific Plan would be continued eastward to the Thousand Palms area and sized for the future planned area.	Other, Water Supply, Water Quality/Stormwater, Wastewater, Flood Control, Recharge			Potential recycled water use and stormwater capture	$180,000,000	CVRWMG Project Website
237	7/30/2010	City of Cathedral City	Flood Control and Recycling of Storm, Non Storm Run Off Water - Desert Cove Golf Course	The project consists of a 158 acre - 18 hole golf course located in the Whitewater River Storm Channel and the East Cathedral Canyon Wash including a 6000 SF Clubhouse and a 14,000 SF maintenance facility.	Flood Control			Potential recycled water use and stormwater capture	$24,000,000	CVRWMG Project Website

Potential Projects for Consideration in Coachella Valley Salt Nutrient Management Plan
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CVRWMG Project No.	CVRWMG Date Submitted	Organization	Project Title	Project Summary	IRWMP Functional Area	Project Capacity (Amount of Water Used or Disposed)	Estimated Startup Year and Estimated Buildout Year	Potential Effect on Salt/ Nutrient Loading	Total Costs	Project Information Source
240	7/30/2010	City of Cathedral City	Groundwater Protection- Cathedral City Cove Drainage System 4	Construct new storm drain pipe to serve an area on the south side of Cathedral City Cove. This project is required to complete the Cathedral City Cove Sewer (Septic Tank Removal) Project. The constructed system will convey stormwater to the east Cathedral Canyon Channel which, in turn, discharges to the Whitewater River. BMPs will be implemented to remove gross pollutants.	Water Quality/Stormwater			Stormwater recharge; pollutant reduction	$450,000	CVRWMG Project Website
235	7/30/2010	City of Cathedral City	Groundwater Quality Protection - West Cathedral City Septic Tank Replacement	This project provides sewer improvements in a portion of Cathedral City served by septic tanks to protect drinking water in the Coachella Valley. These projects are located in the western part of Cathedral City north and south of East Palm Canyon Drive. The four un-sewered areas include a 24 acre, 200 unit, mobile home park, 25 acres of commercial property, and 48 acres of residential property.	Wastewater			Salt and nutrient load reduction; increased recycled water supply	$4,900,000	CVRWMG Project Website
231	7/30/2010	City of Cathedral City	Groundwater Quality Protection and Floodplain Management - Eagle Canyon Dam and Lines 43 and 41	The project will provide flood detention and flood hazard mitigation for the developed portion of Cathedral City located downstream of Eagle Canyon.	Flood Control			Stormwater recharge	$22,000,000	CVRWMG Project Website
229	8/19/2010	City of Cathedral City	Groundwater Quality Protection Perez Road Sewers	Perez Road is a major commercial corridor within the City of Cathedral City that developed using septic tanks rather than sanitary sewers. It is necessary to install sewers to assist businesses experiencing failing septic systems. Septic tanks disposal systems south of the Whitewater Channel in Cathedral City have been identified as a significant threat to public potable groundwater resources. This project will permanently remove these known pollution sources (septic tanks) and will sustain and improve local and regional water supply reliability.	Wastewater			Nitrogen and salt load reduction; increased recycled water supply	$4,700,000	CVRWMG Project Website

Potential Projects for Consideration in Coachella Valley Salt Nutrient Management Plan
INITIAL DRAFT

CVRWMG Project No.	CVRWMG Date Submitted	Organization	Project Title	Project Summary	IRWMP Functional Area	Project Capacity (Amount of Water Used or Disposed)	Estimated Startup Year and Estimated Buildout Year	Potential Effect on Salt/ Nutrient Loading	Total Costs	Project Information Source
230	8/19/2010	City of Cathedral City	Groundwater Quality Protection South City Improvement District (SCID)	The South City Improvement District involves constructing municipal wastewater collection systems and eliminating septic tanks that overlie regional aquifers. The project will build over five miles of wastewater pipelines and eliminate approximately 500 septic tanks extending the municipal wastewater collection system to over 700 properties.	Wastewater			Nitrogen and salt load reduction; increased recycled water supply	$16,500,000	CVRWMG Project Website
236	7/30/2010	City of Cathedral City	Master Drainage Plan Implementation - Cathedral City South	The project will prepare a master drainage plan for the southern portion of Cathedral City. The area currently does not have any drainage infrastructure. The planned improvements will include detention and retention basins, pipelines, and BMPs for treatment. The improvements will provide a permanent solution to reducing the amount of nitrates, bacteria, viruses and Total Dissolved Solids (TDS) migrating towards the Coachella Valley's underground aquifer, which provides the drinking water supply in the region.	Water Quality/Stormwater			Nitrogen and salt load reduction; stormwater capture and recharge	$14,400,000	CVRWMG Project Website
234	8/19/2010	City of Cathedral City	Master Drainage Plan Implementation - Ramon Road Corridor	The project would intercept runoff flows along Ramon Road between the White Water River and Date Palm Drive by utilizing the combination of storm drain pipe, and detention basin systems. However, due to the significant size of drainage facilities required to intercept all the flows reaching Ramon Road further studies of viable alternatives to intercept runoff flows along Ramon Road between the White Water River and Canyon Vista Road, east of existing high point along Ramon Road should be accomplished.	Flood Control			Nitrogen and salt load reduction; stormwater capture and recharge	$32,000,000	CVRWMG Project Website

Potential Projects for Consideration in Coachella Valley Salt Nutrient Management Plan
INITIAL DRAFT

CVRWMG Project No.	CVRWMG Date Submitted	Organization	Project Title	Project Summary	IRWMP Functional Area	Project Capacity (Amount of Water Used or Disposed)	Estimated Startup Year and Estimated Buildout Year	Potential Effect on Salt/ Nutrient Loading	Total Costs	Project Information Source
239	7/30/2010	City of Cathedral City	Palm Springs Unified School District - Storm Drain Outflow Transport Contamination	Detention basin contamination from unknown sources upstream from the Cathedral City Elementary School require field research, development of corrective actions and detailed planning to correct a public health and safety hazard. The source of the contamination is not known. The first phase of this project will conduct field research to establish the source or sources and develop corrective actions to eliminate the problem. Once the source of the contamination has been determined and the contamination stopped, the existing catch basins, storm drain piping, distribution boxes, and drywells would have to be cleaned and disinfected. If surface contamination flowing down the curb and gutter is the cause, then a group of filtration systems could be designed and constructed to accept nuisance and storm water.	Water Quality/Stormwater			Pollutant load reduction; uncertain effect on salt/nutrient loading	$1,500,000	CVRWMG Project Website
238	7/30/2010	City of Cathedral City	Ramon Road Corridor - Improve Flood Protection	Implement improved flood protection along Ramon Road from Date Palm Drive to the Whitewater River. The project drainage area extends from the Union Pacific Railroad right of way to the north, Ramon Road to the South, the Whitewater River Levee to the west and Date Palm Drive to the east. The Whitewater River serves as the backbone drainage infrastructure facility providing flood protection in the Coachella Valley. Due to the significant size of drainage facilities required to intercept all flows reaching Ramon Road, additional alternatives provide the City the opportunity to develop a phased implementation plan to intercept runoff flow tributary to Ramon Road at Date Palm Drive via a future system along Date Palm Drive.	Flood Control			Nitrogen and salt load reduction; stormwater capture and recharge	$10,000,000	CVRWMG Project Website

Potential Projects for Consideration in Coachella Valley Salt Nutrient Management Plan
INITIAL DRAFT

CVRWMG Project No.	CVRWMG Date Submitted	Organization	Project Title	Project Summary	IRWMP Functional Area	Project Capacity (Amount of Water Used or Disposed)	Estimated Startup Year and Estimated Buildout Year	Potential Effect on Salt/ Nutrient Loading	Total Costs	Project Information Source
232	7/30/2010	City of Cathedral City	Water, Sewer and Drainage - North City Specific Plan	A primary goal of the North City Specific Plan is to provide for sustainably-designed infrastructure in new development. Ensure that an adequate infrastructure system is in place for future development in North City. To conserve precious water resources, an area-wide reclaimed water system would be desirable. Per the CVWD Master Plan, a new sewer system will be installed to the southeast of the Specific Plan area that will direct the flow on the north side of the I-10 freeway to the Thousand Palms area. There is currently no storm drain infrastructure within the Specific Plan area. CVWD will own and maintain future storm drain systems. Two major storm drain system backbone lines are recommended: (1) To serve the Edom Hill-Light Industrial District (2) To serve all new development along I-10. Two major channels are recommended to carry the runoff to a detention system or to the Whitewater Wash: (1) Morongo Wash and (2) Long Canyon/Willow Hole.	Other, Water Supply, Water Quality/Stormwater, Wastewater, Flood Control, Recharge			Nitrogen and salt load reduction; stormwater capture and recharge; recycled water use	$250,000,000	CVRWMG Project Website
211	7/27/2010	City of Palm Springs	Little Tuscany Sewer Improvements	Extension of 4,200 linear feet of public sewer lines to over 70 homes to convert privately maintained septic systems to a publicly maintained sewer system. The project includes sewer extension in Milo Drive, Janis Drive, Vista Drive, Palermo Drive and Leonard Road, giving residents the ability to directly connect to a public sewer that is currently unavailable.	Wastewater, Recycled Water			Salt and nitrogen load reduction; increased recycled water supply	$2,100,000	CVRWMG Project Website
209	8/18/2010	City of Palm Springs	Tahquitz Creek Levee Reconstruction	Repair and reconstruction of the Tahquitz Creek levee, including 1) regarding of landside slopes to a gradient of approximately 2.7:1 (H:V); 2) the placement of compacted fill in those areas on top of the levee where there is inadequate freeboard; and 3) excavation and replacement required to construct the concrete revetment as necessary to meet the requirements set forth in 44 CFR 65.10.	Flood Control			Uncertain effect	$1,600,000	CVRWMG Project Website

Potential Projects for Consideration in Coachella Valley Salt Nutrient Management Plan
INITIAL DRAFT

CVRWMG Project No.	CVRWMG Date Submitted	Organization	Project Title	Project Summary	IRWMP Functional Area	Project Capacity (Amount of Water Used or Disposed)	Estimated Startup Year and Estimated Buildout Year	Potential Effect on Salt/ Nutrient Loading	Total Costs	Project Information Source
		Coachella Valley Water District	Agricultural Conversion to Canal Water Use (excluding Oasis Area)	Connection of existing agricultural groundwater pumpers to the Canal water system	Water Supply	20,000 AFY		Overdraft reduction; increased salt load from Canal water use May beneficially change the location of salt loading if project results in increased groundwater levels which act to reduce salt water intrusion to the deep aquifer. This may also apply to other overdraft reduction projects in the East Valley.		CVWMP
		Coachella Valley Water District	Agricultural Water Conservation Programs	Agricultural water conservation including irrigation water scheduling, scientific leaching, and conversion to drip irrigation	Water Supply			Overdraft reduction; salt/nutrient load reduction		CVWMP
		Coachella Valley Water District	Artesian Well Management and Capping Program	Cap existing unused artesian wells and enforce installation of pressure control on active artesian wells.	Water Supply, Water Quality			Water quality protection; reduced loss of high quality groundwater		CVWMP
		Coachella Valley Water District	Chromium Treatment for Groundwater	Potential treatment of groundwater having chromium 6 levels exceeding the State MCL.	Water Supply			Water quality protection, nitrate reduction. May require increased salt use		Other

Potential Projects for Consideration in Coachella Valley Salt Nutrient Management Plan
INITIAL DRAFT

CVRWMG Project No.	CVRWMG Date Submitted	Organization	Project Title	Project Summary	IRWMP Functional Area	Project Capacity (Amount of Water Used or Disposed)	Estimated Startup Year and Estimated Buildout Year	Potential Effect on Salt/ Nutrient Loading	Total Costs	Project Information Source
		Coachella Valley Water District	Colorado River Water for Non-potable Urban Use	Construction of a dual source water distribution system to provide Coachella Canal water for future urban landscape irrigation.	Water Supply			Overdraft reduction. Increased salt load from Canal water use		CVWMP
		Coachella Valley Water District	Desalinated Drain Water for Agricultural Use	Construction of shallow groundwater wells or drain water diversion, treatment using reverse osmosis and conveyance to the existing Canal water distribution system	Water Supply			Overdraft reduction; salt and nutrient removal; brine disposal required		CVWMP
		Coachella Valley Water District	Domestic Treatment of Colorado River Water	Construction of conventional and/or desalination treatment facilities for domestic use of Colorado River water. May be implemented in conjunction with treatment of groundwater for chromium 6 removal.	Water Supply			Overdraft reduction; increased salt load from Canal water use		CVWMP
207	7/23/2010	Coachella Valley Water District	Eastern Coachella Valley Water Supply Project	The purpose of this project is to extend CVWD's existing urban water distribution system to East Valley disadvantaged communities whose only source of drinking water is private wells with arsenic levels that exceed the Maximum Contaminant level for drinking water. This project consists of planning, design, environmental review and permitting for construction of ductile iron water distribution pipelines to serve safe drinking water to east valley mobile home communities.	Water Supply			Water quality protection; nitrate reduction. May require increased salt use	$25,000,000	CVRWMG Project Website

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		Coachella Valley Water District	Golf Course Conversion to Canal Water Use	Connection of existing golf course groundwater pumpers to the Canal water system.	Water Supply			Overdraft reduction; increased salt load from Canal water use		CVWMP
		Coachella Valley Water District	Increased groundwater recharge in West Whitewater River Subbasin	Construct facilities to deliver imported Colorado River water from the Coachella Canal to groundwater replenishment facilities located in the West Whitewater River Subbasin Area of Benefit.	Water Supply, Water Quality	20,000-40,000 AFY		Overdraft reduction; increased salt load from Canal water use; would reduce chromium concentrations		CVWMP
		Coachella Valley Water District	Martinez Canyon Groundwater Recharge Facility	Construct a groundwater replenishment facility near Martinez Canyon using Colorado River water.	Water Supply, Water Quality	20,000 - 40,000 AFY	Start Year: 2021 Buildout Year: 2025	Overdraft reduction; increased salt load from Canal water use; increased groundwater levels would reduce potential salt water intrusion		CVWMP
182	7/12/2010	Coachella Valley Water District	Mid Valley Pipeline Phase II	The Mid Valley Pipeline is a non-potable water distribution system to convey recycled water and Colorado River water to Golf Courses for irrigation in lieu of groundwater. Colorado River water augments the recycled water supply in summer months when golf course irrigation demand exceeds recycled water supply. Phase II consists of expansion of the WRP 10 distribution system to serve 50 golf courses with an average demand of 1000 AFY each.	Water Supply, Water Quality	2,000 AFY Existing 50,000 AFY Buildout	Start Year: 2009 Buildout Year: 2025	Overdraft reduction; increased salt load from Canal water use; increased recycled water use; reduces nutrient load	$35,000,000	CVRWMG Project Website
		Coachella Valley Water District	Oasis Agricultural Water Delivery System	Extension of the Coachella Canal distribution system to unserved areas on the Oasis slope. Would offset of groundwater pumping.	Water Supply	20,000 - 30,000 AFY		Overdraft reduction; increased salt load from Canal water use; increased groundwater levels would reduce potential salt water intrusion		CVWMP

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		Coachella Valley Water District	Potential Nitrate Remediation/Treatment	Potential ion exchange treatment of groundwater having elevated nitrate concentrations.	Water Quality			Nutrient reduction		CVWMP
		Coachella Valley Water District	Recycled Water System - WRP-4	Construction of tertiary treatment facilities and conveyance to deliver recycled water for non-potable use.	Water Supply			Overdraft reduction; increased recycled water use; increased salt loading from use of RW previously discharged to CVSC		CVWMP
		Coachella Valley Water District	Sewering of Sky Valley and Indio Hills	Potential construction of sewers and wastewater treatment for septic areas of Sky Valley and Indio Hills served by CVWD.	Wastewater, Water Quality			Nutrient reduction		MCGHWMP
		Coachella Valley Water District	Stormwater Capture Feasibility	Conduct a feasibility study to evaluate the capture and recharge of stormwater in the Coachella Valley.	Water Supply			Potential increased stormwater use; overdraft reduction		CVWMP
		Coachella Valley Water District	Urban Water Conservation Programs	Implementation of urban water conservation programs	Water Supply			Overdraft reduction		CVWMP

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		Coachella Valley Water District, Desert Water Agency	Golf Course Water Conservation Programs	Implementation of golf course water conservation programs	Water Supply			Overdraft reduction		CVWMP
		Coachella Valley Water District, Desert Water Agency	Increased imported water recharge to stabilize long-term water levels in Mission Creek Subbasin	Delivery of additional imported water to the Mission Creek Replenishment Facility	Water Supply, Water Quality			Overdraft reduction; increased salt load; would reduce chromium levels		MCGHWMP
		Coachella Valley Water District, Desert Water Agency	Potential State Water Project Extension to the Coachella Valley	Construction of 40 - 90+ miles of large diameter water pipelines, pump stations and energy recovery facilities to convey SWP water from the East Branch of the California Aqueduct to the Coachella Valley.	Water Supply, Water Quality			Salt load reduction		Other
		Coachella Valley Water District, Desert Water Agency, Mission Springs Water District	Manage groundwater levels in MCSB to minimize migration of warm brackish water from DHSSB	Potential program to manage pumping and recharge to minimize water quality impacts of high salinity groundwater from the Desert Hot Springs subbasin.	Water Supply, Water Quality			Salt load reduction		MCGHWMP
		Coachella Water Authority	Chromium Treatment for Groundwater	Potential treatment of groundwater having chromium 6 levels exceeding the State MCL.	Water Supply, Water Quality			Water quality protection, nitrate reduction. May require increased salt use		Other

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		Coachella Water Authority	Non-potable Recycled Water System	Construction of tertiary treatment facilities and conveyance to deliver recycled water for non-potable use.	Water Supply			Recycled water use, salt loads		CVWMP
		Coachella Water Authority	Recycled Water Use - La Entrada Development	Construction of tertiary treatment facilities and conveyance to deliver recycled water for non-potable use.	Water Supply			Recycled water use, salt loads		CVWMP
		Coachella Water Authority	Urban Water Conservation Programs	Implementation of urban water conservation programs	Water Supply			Reduced demands and supplies; potential effect on salt/nutrient load		CVWMP
221	7/29/2010	College of the Desert	College Of the Desert MTC Infrastructure	Extension of water, sewer and other infrastructure for a large development in the east Whitewater River Subbasin	Water Quality/Stormwater			Change in loading due to transition from agriculture to urban	$10	CVRWMG Project Website
192	7/29/2010	CVRWMG	Groundwater Elevation Monitoring--Regional project of CVRWMG	Develop the groundwater elevation monitoring for the groundwater basins/subbasins in the Coachella Valley Water Management Region, so as to better manage the resource during normal, wet and dry water years.	Water Supply			Minimal effect	$100,000	CVRWMG Project Website
		Desert Water Agency	Urban Water Conservation Programs	Implementation of urban water conservation programs	Water Supply			Reduced demands and supplies; potential effect on salt/nutrient load		CVWMP

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187	8/18/2010	Desert Water Agency	Water Recycling Efficiency and Capacity Improvement Project	This project will offset high-quality potable ground water consumption at a Tribal owned golf course, by connecting the golf course to the recycled water system. To meet the proposed recycled water demands, capacity and production will be increased at the Agency owned water reclamation plant. The Agency proposes to install two wells to pump non-potable groundwater. This groundwater will be fed into the recycled water plant to supplement the water currently being treated during high demand water periods. A new 500,000-gallon water reservoir is being added, along with a new hydro pneumatic tank, increasing the water storage capacity at the plant. The project will also increase energy efficiency, through the installation of solar power generating modules. The solar power created will be used to offset power costs, reduce the electrical grid demand and carbon footprint of the recycled water plant.	Wastewater			Nutrient reduction	$14,600,000	CVRWMG Project Website
190	8/18/2010	Desert Water Agency	Well Pumping Plants 44 and 45 of the Palm Springs Main Well Field	The project consists of construction of two wells, followed by the construction and operation of associated pumping plants. Each well will be drilled to a depth of approximately 1,000 feet, and will have a 20 inch diameter casing fitted with about 400 feet of perforations. Each pumping plant will be designed to produce approximately 2,000 to 2,500 gallons per minute (gpm), and will be driven by a 400 horsepower electric motor.	Water Supply			Minimal effect	$2,000,000	CVRWMG Project Website
		Indio Water Authority	Chromium Treatment for Groundwater	Potential treatment of groundwater having chromium 6 levels exceeding the State MCL.	Water Supply			Water quality protection; potential nitrate reduction. May require increased salt use		Other

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		Indio Water Authority	Recycled Water Use - Citrus Ranch Development	Construction of tertiary treatment facilities and conveyance to deliver recycled water for non-potable use.	Water supply			Effect depends on water supply sources; future nutrient reduction		CVWMP
		Indio Water Authority	Urban Water Conservation Programs	Implementation of urban water conservation programs	Water Supply			Reduced demands and supplies; potential effect on salt/nutrient load		CVWMP
		Indio Water Authority - CVWD	Groundwater Recharge with Canal Water	Construction of a groundwater replenishment facility using Coachella Canal water.	Water Supply			Increased salt loading		CVWMP
		Indio Water Authority-Valley Sanitary District	Indirect Potable Reuse - Groundwater Recharge	Construction of advanced treatment facilities and conveyance to deliver recycled water for indirect potable use.	Water Supply, Recycled Water			Salt and nutrient load reduction with desalination		Other
		Indio Water Authority-Valley Sanitary District	Non-potable Recycled Water System	Construction of tertiary treatment facilities and conveyance to deliver recycled water for non-potable use.	Water Supply, Recycled Water			Increased recycled water use; increased salt loading from use of RW previously discharged to CVSC		CVWMP

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218	7/29/2010	Mission Springs Water District	1400 Zone Facilities	Provide potable water supply within densely populated pressure zone, by replacing existing well which has high uranium levels. Construct storage and transmission facilities for new well.	Water Supply			Minimal effect	$7,700,000	CVRWMG Project Website
225	7/29/2010	Mission Springs Water District	Desert Hot Springs Community Gardens	Construct and install a community garden as part of a Community Garden program led by the City of Desert Hot Springs Build raised beds for one community garden location and install irrigation equipment needed for each plot in the garden; construct demonstration area in which to teach about soils, irrigation techniques, mulch, plant selection.	Water Supply			Minimal effect	$40,000	CVRWMG Project Website
		Mission Springs Water District	Expand Horton WWTP Capacity and Add Nitrogen Removal	Expand the capacity of the Horton WWTP to meet increased wastewater flows resulting from septic system conversion to sewers. Nitrogen removal would protect groundwater quality.	Water Supply, Recycled Water, Water Quality			Nutrient reduction; potential change in location of salt loading		MCGHWMP
189	10/7/2010	Mission Springs Water District	Groundwater Quality Protection Project	Complete construction of wastewater collection system in Assessment District 12 Sub Areas M, F, D1, which will connect 2600 parcels to the MSWD system and abate 1000 onsite septic systems. Provide partial funding for expansion of wastewater treatment plant. Areas M. F, D1 are part of a larger assessment district, which voters passed in 2004. In creating the Assessment District, voters provided $28 million of match funding which expires in 2014. Engineering design of the 10 sub areas that make up the assessment district is almost complete and funds are needed for construction. The project will abate septic systems and protect both the drinking water supply and the hot water that is the basis of the spa economy for the city of DHS and the Coachella Valley.	Wastewater			Nutrient reduction; potential change in location of salt loading to wastewater percolation ponds or recycled water use	$68,000,000	CVRWMG Project Website

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220	7/29/2010	Mission Springs Water District	Identification of Septic Wastewater Plumes in the MSWD Service Area	Study and analysis of movement of septic wastewater that threatens the Mission Creek and Garnet Hill Subbasins. Investigate the transport of septic wastewater at key sites. Study rate of wastewater movement and changes in concentration of selected contaminants with depth in the unsaturated zone and the saturated zone to be monitored at each site.	Water Quality/Stormwater			Improved understanding of salt/nutrient loads from septic systems	$500,000	CVRWMG Project Website
217	7/29/2010	Mission Springs Water District	Implement projects in the Desert Hot Springs Area Master Drainage Plan	Related to RCFC&WCD project. Project should investigate recharge of flood waters into Mission Creek Subbasin, as a source of "new water" for the basin and to offset high TDS of Colorado River Aqueduct water that is currently being percolated.	Flood Control			Uncertain; stormwater capture could affect salt loads if new water is captured	$30,504,000	CVRWMG Project Website
222	7/29/2010	Mission Springs Water District	Mission Creek/ Garnet Hill Subbasins Monitoring Program	Improve the understanding of local hydrologic and geologic conditions, especially with respect to overdraft conditions in the Mission Creek and Garnet Hill Subbasins and artificial recharge of the subbasins.	Water Supply			Minimal effect	$300,000	CVRWMG Project Website
		Mission Springs Water District	Potential Recycled Water System	Construction of tertiary treatment facilities and conveyance to deliver recycled water for non-potable use.	Water Supply, Recycled Water			Nutrient load reduction; minimal effect on salt loads		MCGHWMP
		Mission Springs Water District	Regional Wastewater Treatment Facility and Effluent Recharge	Construction of a new wastewater treatment and effluent facility to serve southern and western portions of MSWD service area.	Wastewater Treatment, Recycled Water			Nutrient load reduction; minimal effect on salt loads unless desalination occurs		MCGHWMP

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224	7/29/2010	Mission Springs Water District	Resource Action Programs	MSWD will sponsor a RAP program which provides conservation kits containing water efficient fixtures such as a low flow showerhead and faucet aerators. Program is administered in part thru partner agencies that provide free financial counseling to families in disadvantaged communities. Customers learn about the water saving fixtures they are being supplied with and how, along with good conservation habits, installing the efficient fixtures will reduce their monthly utility bills.	Water Supply			Significant conservation could increase salt load in wastewater	$10,000	CVRWMG Project Website
		Mission Springs Water District	Urban Water Conservation Programs	Implementation of urban water conservation programs	Water Supply			Reduced demands and supplies; uncertain effect on salt/nutrient load		MCGHWMP
248	7/30/2010	Pueblo Unido CDC	Harrison Street (Sunbird and surrounding cluster)	Build an extension in Harrison Street to connect the impacted mobile home parks to the CVWD main lines to provide drinking water to residents. In addition given the major septic system leaks that have occurred in this area, there is a need to add sewer system. A connection to the CVWD main line needs to be constructed to connect these mobile home parks to CVWDs water. There are 158 mobile home units, that are home to 1,100 residents. Aside from the drinking water infrastructure, there is also a need to convert the current septic systems into sewer. Currently places like Sunbird Mobile Home Park suffer from serious septic system leaks which could also contribute to the groundwater contamination. Both the water quality and wastewater issues are a public health issue for the residents.	Water Quality/Stormwater			Nutrient load reduction from septic conversion to sewer	$5,000,000	CVRWMG Project Website

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245	7/30/2010	Pueblo Unido CDC	Pierce Community Infrastructure - Regional Water Treatment Facility (North)	The proposed Pierce Community Infrastructure - Regional Water Treatment Facility consists of extending approximately 20,000 linear feet of pipeline from the nearest connection point located at Avenue 74 and Harrison Rd. The pipeline will be extended east along Av. 74, and north along Pierce St.	Water Supply			Minimal effect	$12,000,000	CVRWMG Project Website
249	7/30/2010	Pueblo Unido CDC	Pierce Community Infrastructure - Sewer Sanitary Collection System (North)	Existing mobile home parks in the community of Oasis along Pierce Street, typically utilize individual on-site wastewater facilities that are inadequate and do not meet current minimum standards and are in need of replacement. The proposed project will provide sewer sanitary collection system to existing mobile home parks in the vicinity and address the substandard septic systems, and sewage lagoons. Wastewater will be treated at CVWD's WRP-4.	Wastewater			Nutrient load reduction from septic conversion to sewer	$7,900,000	CVRWMG Project Website
247	7/30/2010	Pueblo Unido CDC	Pierce Community Infrastructure -- Water Extension Supply (South Section)	The proposed Pierce Community Infrastructure Water Extension Supply consist of extending approximately 9,915 linear feet of pipeline from the nearest connection point located at Avenue 74 and Harrison Rd. The existing pipeline is 30 inches in diameter. The intention is to connect at this point, and then south along Harrison Rd, then east along Avenue 74 to Pierce Street, then south and north along Pierce Street as indicated in the attached Figure 1. The project will provide safe reliable drinking water to approximately 1,300 residents.	Water Quality/Stormwater			Minimal effect	$2,100,000	CVRWMG Project Website
254	9/21/2010	Pueblo Unido CDC	Short Term Arsenic Treatment Program	Provide short term implementation of treatment for Arsenic contamination of waters that are not readily connectable to municipal systems. Point of Entry and Point of Use systems are proposed.	Water Quality/Stormwater, Groundwater Treatment			Minimal effect	$550,000	CVRWMG Project Website

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246	7/30/2010	Pueblo Unido CDC	St. Anthony of the Desert - Water Treatment Facility	The proposed St. Anthony of the Desert Water Treatment Facility Project is a decentralized small community water drinking system that will utilize Reverse Osmosis technology to remove high levels of arsenic and supply drinking water to 650 residents at the park.	Water Supply			Salt load reduction from desalination	$600,000	CVRWMG Project Website
205	7/30/2010	Riverside County Flood Control and Water Conservation District	Eagle Canyon Dam	The proposed Eagle Canyon Dam project is southerly of Canyon Plaza Drive in the city of Cathedral City, Riverside County, California. The Dam will be an earthfill embankment constructed of locally available materials. The proposed earthen dam is designed to accommodate 100-year (3-hour and 6-hour) storm events. The project would provide protection from flood and debris flows to Palm Springs and Cathedral City. The project would also result in the restoration and reconstruction of areas historically subject to illegal dumping.	Flood Control			Stormwater capture could affect local salt loads	$7,643,000	CVRWMG Project Website
202	7/29/2010	Riverside County Flood Control and Water Conservation District	East Cathedral Canyon Channel Levee Restoration	The District with Cathedral City is constructing storm drains and working on the Terrace Road Lateral and levee restoration.	Flood Control, Urban runoff management			Minimal effect	$1,222,000	CVRWMG Project Website

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213	8/18/2010	Riverside County Flood Control and Water Conservation District	Evaluate Stormwater Recharge Opportunities within the Desert Hot Springs MDP	The proposed project would conduct a planning level study to evaluate, with the cooperation and partnership of Mission Springs Water District, opportunities to use existing and proposed flood control infrastructure to additionally facilitate stormwater capture and recharge and surface water quality improvements. The project would also investigate the viability of recharging stormwater into the Mission Creek Subbasin as a source of new water and to offset high TDS Colorado River Water that is currently being percolated. The evaluation will include consideration of retrofit of existing flood control infrastructure, modification of proposed flood control infrastructure plans, and consideration of new and/or supplemental projects. Projects that are determined to be viable will be incorporated into the Desert Hot Springs MDP.	Water Quality/Stormwater			Uncertain effect	$1,200,000	CVRWMG Project Website
201	7/29/2010	Riverside County Flood Control and Water Conservation District	Implement projects in the Desert Hot Springs Area Master Drainage Plan	Construct and maintain debris basins, levees and open channels and underground storm drains. The community needs adequate flood protection. Uncontrolled flood waters impacting this alluvial fan area can be very devastating, primarily due to the unpredictability of their flow path and their high velocities. Silt and debris can cause damage to property. Construct and maintain debris basins, levees and open channels and underground storm drains. Maintain existing facilities, included but not limited to, Desert Hot Springs channel, line e-1, e-2, and c-1.	Flood Control			Stormwater Capture	$30,504,000	CVRWMG Project Website
196	7/29/2010	Riverside County Flood Control and Water Conservation District	Implementation of projects for Cathedral City Master Plan	South of Terrace Road in Cathedral City is subject to flooding from local storm runoff due to inadequate drainage systems. The Cathedral City has flooding problems that impact properties. Streets, channels and other flood infrastructure need to be installed or maintained to minimize or prevent flooding problems.	Flood Control			Stormwater Capture	$1,600,000	CVRWMG Project Website

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195	7/30/2010	Riverside County Flood Control and Water Conservation District	Implementation of Projects in East Wide Channel, Long Canyon and Tributaries Master Plan	Detention dams, levees and reservoirs near the mouths of Long Canyon and West Wide Canyon and tributaries. Also includes improvements to channels.	Flood Control			Uncertain effect	$1,628,000	CVRWMG Project Website
194	7/30/2010	Riverside County Flood Control and Water Conservation District	Implementation of Projects in Garnet Wash and Tributaries Master Plan	The District will construct flood control channels and culverts to control storm waters in the area. Project will implement one or more stormwater management projects identified in the MDP.	Flood Control			Uncertain effect	$645,000	CVRWMG Project Website
200	7/29/2010	Riverside County Flood Control and Water Conservation District	Implementation of projects in the Palm Springs Area Master Drainage Plan	Drainage problems in Palm Springs need improvement for flood protection of both existing development and potential future development. Maintain Palm Canyon Levees, Whitewater River Levee, Tahquitz Creek Flood Control. Improve open channels, underground storm drains. Include new retention basins and existing basins like Victoria, Ruth Hardy, Airport, Farrell and Eagle debris basin and retention basins.	Flood Control			Uncertain effect	$71,482,000	CVRWMG Project Website
212	7/30/2010	Riverside County Flood Control and Water Conservation District	Implementation of Total Maximum Daily Load Best Management Practices	Implementation of structural and/or treatment BMPs to help reduce pollutant loading to the CVSC. The proposed project would assist the City of Coachella with the implementation of Best Management Practices (BMPs) to reduce and/or eliminate discharges of bacterial indicators from within the city to the CVSC, which has been identified as impaired due to bacterial indicators. The City has identified specific projects that can be implemented to achieve these goals. The projects include low impact development approaches to retrofitting urban areas, such as dry wells, infiltration swales and similar.	Water Quality/Stormwater			Potential salt/nutrient load reduction	$200,000	CVRWMG Project Website

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242	7/30/2010	Riverside County Flood Control and Water Conservation District	Palm Springs Line 43 and 43a	Project proposes to construct a storm drain connecting the proposed Eagle Canyon Dam to West Cathedral Canyon Channel. Project will reduce flood hazard for properties adjacent to this reach of HWY 111. This underground stormdrain will extend from the existing West Cathedral Canyon Channel west to East Palm Canyon Boulevard (HWY 111) then northwest in East Palm Canyon Boulevard to Via Capri Street then southwest approximately 600 feet to the outlet of the future Eagle Canyon Dam.	Water Quality/Stormwater			Uncertain effect	$7,000,000	CVRWMG Project Website
204	7/30/2010	Riverside County Flood Control and Water Conservation District	Palm Springs MDP line 41	Construct flood control facilities from Golf Center Drive westerly in East Palm Canyon Drive to Cherokee Way. Project would construction flood control facilities benefitting the communities of Palm Springs and Cathedral City. Line 41 from Golf Center Drive westerly in East Palm Canyon Drive to Cherokee Way.	Flood Control			Uncertain effect	$15,000,000	CVRWMG Project Website
203	7/29/2010	Riverside County Flood Control and Water Conservation District	Verbena Channel	Verbena Channel is a natural channel located south of Dillon Road and north of Two Bunch Palms Trail, and will be replace by a storm drain and detention basin system from Camino Idilio approximately one mile north Verbena Drive at Park Lane.	Flood Control			Uncertain effect	$11,839,000	CVRWMG Project Website
206	7/29/2010	Riverside County Flood Control and Water Conservation District	Whitewater River Levee Restoration	Whitewater River has levees which are in need of repair or need increasing in size to protect the public from potential flooding issues.	Flood Control			Uncertain effect	$50,420	CVRWMG Project Website

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210	7/30/2010	Riverside County Flood Control and Water Conservation District	Whitewater River Region and Coachella Valley Stormwater Channel Site Specific Objective Evaluation	The proposed project would conduct a monitoring study to determine the contribution of natural background and uncontrollable bacterial indicator sources to water quality conditions in the CVSC. If these sources are found to exceed current Water Quality Objectives, the project will develop the documents necessary to support a Site Specific Objective for the CVSC.	Water Quality/Stormwater			Uncertain effect	$1,400,000	CVRWMG Project Website
244	8/22/2010	Riverside County, Supervisor Benoit	Desert Edge Geothermal Water Conservation and Preservation	Proposed development west of Mountain View Avenue will provide a sewer system to this unincorporated area of the County of Riverside. Extension of the sewer system east of Mountain View, along with proposed 18th Avenue improvements, to Bennett Road (east boundary of Desert Edge) would meet the wastewater removal needs of the community. A sewer system extension from a planned wastewater facility near Mountain View Avenue/Varner Road to Desert Edge east along 18th Avenue would meet the immediate needs for wastewater removal. A sewer system will prevent groundwater contamination from septic systems, leach lines and commercial/industrial runoff into the ground.	Wastewater, Water Quality			Future nutrient load reduction	$3,000,000	CVRWMG Project Website
250	8/5/2010	South Mecca Group	South Mecca Plan	In order to serve the potable water needs for the future residents of Mecca expansion and extension of existing services will need to be designed and constructed. The Project will accommodate future logical development activity in the Mecca area.	Water Supply			Uncertain effect	$2,000,000	CVRWMG Project Website
228	7/29/2010	Torres-Martinez Tribal Government	Desert Cahuilla Wetlands Expansion	The size of the wetlands will be increased by building 100 acre cells. These cells will be shallow (no more than 3 feet deep. Fresh (White Water Storm Channel) and Salt Water (from the Salton Sea) will be used to maintain this project. The project will be built using the natural materials and not importing new materials. It will be built on land that the sea has already receded from. This project is consistent with the State's plan for shallow habitat complexes as described in the planning documents of Salton Sea Restoration.	Natural Resources and Watersheds			Uncertain effect	$500,000	CVRWMG Project Website

Appendix G – Monitoring Wells

Appendix G - Notes

Table 1 Monitored wells with well construction information

Table 2 Monitored wells with no well construction information

Wells considered currently monitored have had data collected from them between 2009 and 2013

Monitoring responsibility may mean collection of data from the agency or owner required to or currently collecting and analyzing groundwater quality and level data.

Abbreviations:
EWR: East Whitewater River
WWR: West Whitewater River
MC: Mission Creek
GH: Garnet Hill
MH: Miracle Hill
SV: Sky Valley
FC: Fargo Canyon
CVWD: Coachella Valley Water District
DWA: Desert Water Agency
CWA: Coachella Water Authority
IWA: Indio Water Authority

Table 1
Currently Monitored Wells with Known Construction Information

Well Identifier	Other Well Name	Owner	Monitoring Resonsibility	Management Zone
WRP07-MW2D		CVWD	CVWD	EWR
WRP07-MW2S		CVWD	CVWD	EWR
WRP07-MW4D		CVWD	CVWD	EWR
WRP07-MW4S		CVWD	CVWD	EWR
05S07E09D01S	5719 // 1	CVWD	CVWD	EWR
WRP07-MW3D		CVWD	CVWD	EWR
WRP07-MW3S		CVWD	CVWD	EWR
05S07E20A02S	5718	CVWD	CVWD	EWR
05S07E20C01S	5709	CVWD	CVWD	EWR
05S07E19A01S	5708	CVWD	CVWD	EWR
05S07E20H01S	5717 // 1	CVWD	CVWD	EWR
05S07E20G01S	5713	CVWD	CVWD	EWR
05S07E20F02S	5714	CVWD	CVWD	EWR
05S07E20P04S	5716	CVWD	CVWD	EWR
05S07E28E03S	5701 // 2	CVWD	CVWD	EWR
05S07E29P02S	5715	CVWD	CVWD	EWR
05S08E28N02S	Well 18	CWA	CWA	EWR
05S08E31C03S	Well 11	CWA	CWA	EWR
05S08E31E01S	Well 17	CWA	CWA	EWR
05S07E36D03S	Well 19	CWA	CWA	EWR
05S07E31A02S	5711 // 2	CVWD	CVWD	EWR
05S07E32B01S	5725 // 1	CVWD	CVWD	EWR
05S07E32H01S	5727 // 1	CVWD	CVWD	EWR
06S07E06B01S	6701	CVWD	CVWD	EWR
06S08E06K02S	Well 12	CWA	CWA	EWR
06S07E04N01S	6707 // 1	CVWD	CVWD	EWR
06S07E10A02S	6734 // 1	CVWD	CVWD	EWR
06S08E09N02S	Well 16	CWA	CWA	EWR
06S07E16A02S	6723	CVWD	CVWD	EWR
06S07E16R02S	6724	CVWD	CVWD	EWR
06S07E22B02S	6726 // 1	CVWD	CVWD	EWR
06S07E22D02S	6725	CVWD	CVWD	EWR
06S08E19C02S	6805	CVWD	CVWD	EWR
06S08E19D04S		LEE & JUNE ESPINOZA	CVWD	EWR
06S08E19D05S	6808 // 1	CVWD	CVWD	EWR
06S07E27A06S		GEORGE MIDDLETON	CVWD	EWR
06S08E25P04S	6807	CVWD	CVWD	EWR
06S08E35A01S	6806	CVWD	CVWD	EWR
06S08E32D01S		HENRY BRIGGS	CVWD	EWR
06S07E34A01S	6728 // 1	CVWD	CVWD	EWR
06S07E34D01S	6729 // 1	CVWD	CVWD	EWR
06S08E35E02S		OTTO L.ZAHLER	CVWD	EWR
06S08E31L02S		ARTURO ARREDONDO	CVWD	EWR
06S08E31L04S		WILLIAM LINFOOT	CVWD	EWR

Currently monitored wells may not be on this list if well construction information is not known or no data was collected from the well in the last 5 years.

Well Identifier	Other Well Name	Owner	Monitoring Resonsibility	Management Zone
06S07E35L02S		CASTRO BROS.	CVWD	EWR
06S08E31P01S		DEERCREEK	CVWD	EWR
06S08E31N02S		KATE WEBER	CVWD	EWR
07S08E01B03S		SILVANO DUARTE	CVWD	EWR
07S08E02A05S		JUAN PABLO GARZA	CVWD	EWR
07S07E01C01S		C.V. FARMERS ASSOC.	CVWD	EWR
07S07E03A01S		KENNEDY	CVWD	EWR
07S07E03C01S	4 W // D4 4W	CVWD	CVWD	EWR
07S07E03C02S	4 E // D4 4E	CVWD	CVWD	EWR
07S07E03D01S	3 E // D4 3E	CVWD	CVWD	EWR
07S07E03D02S	3 W // D4 3W	CVWD	CVWD	EWR
07S07E03D03S	6 // D4 6	CVWD	CVWD	EWR
07S07E03D04S	2 // D4 2	CVWD	CVWD	EWR
07S07E04A01S	1 E // D4 1E	CVWD	CVWD	EWR
07S07E04A02S	1 W // D4 1W	CVWD	CVWD	EWR
07S07E02G02S		WARREN T.WEBER	CVWD	EWR
07S07E03G02S		HOWARD KECK,JR.	CVWD	EWR
07S08E07G01S		KARL LUDVIGSSON	CVWD	EWR
Mecca2-MW4			CVWD	EWR
Mecca2-MW1			CVWD	EWR
07S08E09N01S	7802	CVWD	CVWD	EWR
Mecca2-MW2			CVWD	EWR
Mecca2-MW3			CVWD	EWR
07S08E17A04S	7803 // 1	CVWD	CVWD	EWR
07S09E17K01S	7991 // 1	CVWD	CVWD	EWR
07S08E27A01S		FRANK SCRIVNER	CVWD	EWR
07S08E29D01S	// 1	PRONTO RANCH	CVWD	EWR
07S08E28G01S		LUCKY 1 RANCH	CVWD	EWR
07S08E29K01S	// 7	BOBBY BIANCO	CVWD	EWR
Mecca1-MW1			CVWD	EWR
07S08E29L01S	// 8	BOBBY BIANCO	CVWD	EWR
Mecca1-MW3			CVWD	EWR
Mecca1-MW2			CVWD	EWR
07S09E30R01S	N7901 // 4	CVWD BERNADINE	CVWD	EWR
07S09E30R02S	N7901 // 3	CVWD SHERRIE	CVWD	EWR
07S09E30R03S	N7901 // 2	CVWD PEGGY	CVWD	EWR
07S09E30R04S	N7901 // 1	CVWD RUTH	CVWD	EWR
07S08E28N01S	// 5	HILLSIDE - OASIS	CVWD	EWR
07S08E29Q01S	// #6	BOBBY BIANCO	CVWD	EWR
07S08E29P01S	MC-1	CVWD	CVWD	EWR
07S08E29P02S	MC-2	CVWD	CVWD	EWR
07S08E29P03S	MC-3	CVWD	CVWD	EWR
07S08E29P04S	MC-4	CVWD	CVWD	EWR
07S08E32A01S	MC-5	CVWD	CVWD	EWR
07S08E33E01S	// #3	CY MOORADICK	CVWD	EWR
WRP02-MW1			CVWD	EWR

Currently monitored wells may not be on this list if well construction information is not known or no data was collected from the well in the last 5 years.

Well Identifier	Other Well Name	Owner	Monitoring Resonsibility	Management Zone
WRP02-MW2			CVWD	EWR
WRP02-MW3			CVWD	EWR
07S08E34M01S		POLK RANCH	CVWD	EWR
07S08E34K01S		BLACKBURN	CVWD	EWR
07S08E33N03S	// NEW#7	NORM WALTER	CVWD	EWR
08S09E07N01S	N8901 // 1	CVWD DAVE	CVWD	EWR
08S09E07N02S	N8901 // 2	CVWD ROSIE	CVWD	EWR
08S09E07N03S	N8901 // 3	CVWD GRACIE	CVWD	EWR
08S09E07N04S	N8901 // 62	CVWD RICHARD	CVWD	EWR
Oasis-MW3a			CVWD	EWR
08S09E31Q03S	8993 // 2	CVWD	CVWD	EWR
08S09E31Q04S	8995 // 2	CVWD	CVWD	EWR
08S09E31R01S	8991 // 50	CVWD	CVWD	EWR
08S09E31R03S	8995 // 1	CVWD	CVWD	EWR
Coachella-MW7			CVWD	FC
Coachella-MW2			CVWD	FC
Coachella-MW1			CVWD	FC
Coachella-MW3			CVWD	FC
Coachella-MW6			CVWD	FC
Coachella-MW4			CVWD	FC
Coachella-MW5			CVWD	FC
05S08E28A01S		STEVE MCNAUGTON	CVWD	FC
03S05E04M04S		B DEWELL/A.L. MINTON	CVWD	MC
03S04E12B02S	3408 // 1	CVWD	CVWD	MC
03S04E12C01S	3405	CVWD	CVWD	MC
03S04E12H02S	3409 // 1	CVWD	CVWD	MC
03S04E12H03S	3409 // 2	CVWD	CVWD	MC
03S04E12F01S	3410	CVWD	CVWD	MC
03S06E21G01S		SKY VALLEY MOB. PARK	CVWD	SV
03S06E22M03S		RANDY MEYER	CVWD	SV
03S04E30C01S	DWA17 // 17	DWA	DWA	WWR
03S04E34H01S	DWA30	DWA	DWA	WWR
03S04E34H02S	// DWA35	DWA	DWA	WWR
03S04E36M01S	DWA09 // 9	P.S. WATER CO	DWA	WWR
03S04E34R01S	DWA21 // 21	DWA	DWA	WWR
03S04E35R01S	DWA27 // 27	DWA	DWA	WWR
03S04E35R02S	DWA28	DWA	DWA	WWR
04S04E02B01S	DWA22 // 22	DWA	DWA	WWR
04S05E05A01S	4568 // 1	BURNETT CO. RIO VISTA	CVWD	WWR
04S05E04N01S	4563 // 1	CVWD	CVWD	WWR
04S05E09B02S	4562 // 2	CVWD	CVWD	WWR
04S05E08D01S	4565	CVWD	CVWD	WWR
04S05E08A01S		FALCON LAKE ENT.	CVWD	WWR
04S05E09F03S	4564 // 87	CVWD	CVWD	WWR
04S05E08L01S		DESERT PRINCESS	CVWD	WWR
04S05E09R01S	4567	CVWD	CVWD	WWR

Currently monitored wells may not be on this list if well construction information
is not known or no data was collected from the well in the last 5 years.

Well Identifier	Other Well Name	Owner	Monitoring Resonsibility	Management Zone
04S05E08R01S	4522 // 1	CVWD	CVWD	WWR
04S04E11Q01S	DWA05 // 5	P.S. WATER CO	DWA	WWR
04S04E11Q02S	DWA18 // 18	DWA	DWA	WWR
04S05E15B01S	4526 // 1	CVWD	CVWD	WWR
04S05E15C01S	4524	CVWD	CVWD	WWR
04S04E13C01S	DWA23 // 23	DWA	DWA	WWR
04S05E15G01S	4521	CVWD	CVWD	WWR
04S05E16H01S	4523	CVWD	CVWD	WWR
04S05E16J01S	4525	CVWD	CVWD	WWR
04S06E18Q04S	4630	CVWD	CVWD	WWR
04S06E18Q06S	4631	CVWD	CVWD	WWR
04S05E17P01S	// DWA36	DWA	DWA	WWR
04S04E14R01S	DWA11 // 11	P.S. WATER CO	DWA	WWR
04S04E14Q01S	DWA20 // 20	DWA	DWA	WWR
04S05E22C01S	4566 // 1	CVWD	CVWD	WWR
04S04E24D01S	DWA24 // 24	DWA	DWA	WWR
04S05E19D01S	DWA03 // 3	P.S. WATER CO	DWA	WWR
04S05E23H01S	// 8	MISSION HILLS	DWA	WWR
04S04E24E01S	// # 32	DWA	DWA	WWR
04S04E24H01S	DWA29	DWA	DWA	WWR
PS-MW2			DWA	WWR
04S06E20M02S	4628	CVWD	CVWD	WWR
04S06E19J03S	4610	CVWD	CVWD	WWR
PS-MW3			DWA	WWR
PS-MW1			DWA	WWR
04S05E25A01S	4510	CVWD	CVWD	WWR
04S05E25D02S	4507 // 2	CVWD	CVWD	WWR
04S05E26C01S		MISSION HILLS	CVWD	WWR
04S05E26D01S		MISSION HILLS	CVWD	WWR
04S05E27A01S	4528	CVWD	CVWD	WWR
04S04E26A01S	DWA14 // 14	P.S. WATER CO	DWA	WWR
04S05E28B01S		HILLSBORO PROP.	DWA	WWR
04S05E29A02S	DWA25 // 25	DWA	DWA	WWR
04S05E26H01S	// 5	MISSION HILLS	CVWD	WWR
04S05E27E02S	4520	CVWD	CVWD	WWR
04S05E28F02S	4519 // 1	CVWD	CVWD	WWR
04S05E29H01S	DWA26 // 26	DWA	DWA	WWR
04S06E28K04S	4629	CVWD	CVWD	WWR
04S05E25J01S	4509 // 1	CVWD	CVWD	WWR
04S05E26K01S		MISSION HILLS	CVWD	WWR
04S05E27K01S	4527	CVWD	CVWD	WWR
04S06E32C01S	4613	CVWD	CVWD	WWR
04S06E32C02S	4614	CVWD	CVWD	WWR
04S05E34C01S		P. S. MOBILE CC	DWA	WWR
04S05E33B03S	DWA19 // 19	DWA	DWA	WWR
04S07E31H01S	4722 // 1	CVWD	CVWD	WWR

Currently monitored wells may not be on this list if well construction information
is not known or no data was collected from the well in the last 5 years.

Well Identifier	Other Well Name	Owner	Monitoring Resonsibility	Management Zone
04S05E35G04S	4504	CVWD	CVWD	WWR
04S07E31J01S	4721 // 1	CVWD	CVWD	WWR
04S05E36M01S	4502	CVWD	CVWD	WWR
04S05E34J01S		P. S. MOBILE CC	CVWD	WWR
04S07E31R02S	4720 // 1	CVWD	CVWD	WWR
04S06E32N02S	4611	CVWD	CVWD	WWR
04S06E32N03S	4612	CVWD	CVWD	WWR
04S05E35Q02S		TAMARISK CC	CVWD	WWR
05S06E06B03S	5630 // 1	CVWD	CVWD	WWR
05S07E06B04S	5720	CVWD	CVWD	WWR
05S06E02C01S	5664	CVWD	CVWD	WWR
05S06E03B02S	5658	CVWD	CVWD	WWR
05S06E04A01S	5678	CVWD	CVWD	WWR
05S06E04D03S	5676 // -2	CVWD	CVWD	WWR
05S06E02G03S	5632 // 2	CVWD	CVWD	WWR
05S06E04G01S	5677	CVWD	CVWD	WWR
05S06E02J01S	5679	CVWD	CVWD	WWR
05S07E06J01S	5721	CVWD	CVWD	WWR
05S06E06M02S	5635 // 1	CVWD	CVWD	WWR
05S06E01R01S	5657	CVWD	CVWD	WWR
05S06E03P01S	5629	CVWD	CVWD	WWR
05S06E05Q01S	5613 // 16	CVWD	CVWD	WWR
05S06E11B01S	5669 // 1	CVWD	CVWD	WWR
05S06E09A01S	5682	CVWD	CVWD	WWR
05S06E08F01S	5675	CVWD	CVWD	WWR
05S06E08E01S	5672	CVWD	CVWD	WWR
05S06E09E01S	5656	CVWD	CVWD	WWR
05S06E09M02S	5671 // 1	CVWD	CVWD	WWR
05S06E08K01S	5680	CVWD	CVWD	WWR
05S06E08M03S	5624 // 1	CVWD	CVWD	WWR
05S06E07J04S	5673	CVWD	CVWD	WWR
05S06E09Q01S	5631 // 1	CVWD	CVWD	WWR
05S06E09P01S	5670 // 1	CVWD	CVWD	WWR
05S06E08N02S	5623 // 1	CVWD	CVWD	WWR
05S06E16A02S	5620 // 1	CVWD	CVWD	WWR
05S06E14G01S	5627 // 1	CVWD	CVWD	WWR
05S06E16E01S	5659 // 1	CVWD	CVWD	WWR
05S06E17G03S	5625 // -2	CVWD	CVWD	WWR
05S06E17E01S	5663 // 1	CVWD	CVWD	WWR
WRP10-MW1		CVWD	CVWD	WWR
WRP10-MW2		CVWD	CVWD	WWR
WRP10-MW3		CVWD	CVWD	WWR
05S06E16K03S	5681 // 1	CVWD	CVWD	WWR
05S06E16L01S	5668 // 1	CVWD	CVWD	WWR
05S06E17L01S	5667	CVWD	CVWD	WWR
05S06E13R01S	5633	CVWD	CVWD	WWR

Currently monitored wells may not be on this list if well construction information is not known or no data was collected from the well in the last 5 years.

Well Identifier	Other Well Name	Owner	Monitoring Resonsibility	Management Zone
05S06E14P02S	5603 // 2	CVWD	CVWD	WWR
05S06E22B02S	5639 // 1	CVWD	CVWD	WWR
05S06E20F03S	5662	P. D COMMUNITY SRVCS.	CVWD	WWR
05S06E27C03S	// #1	VINTAGE COUNTRY CLUB	CVWD	WWR

Currently monitored wells may not be on this list if well construction information
is not known or no data was collected from the well in the last 5 years.

Table 2
Currently Monitored Wells with Unknown Construction Information

Well Identifier	Other Well Name	Owner	Monitoring Resonsibilty	Management Zone
3301981-001	WELL #1	Shadow Hills RV Resort	CVWD	EWR
3303026-001	WELL #1	Granite Construction Company	CVWD	EWR
3310051-009	WELL 07	MYOMA DUNES MWC	CVWD	EWR
3310051-011	Well 12	MYOMA DUNES MWC	CVWD	EWR
3301046-001	WELL 01 DATE PALM	Boe Del Heights Mutual Water	CVWD	EWR
3301247-001	WELL 01	Elms Mobile Home Park	CVWD	EWR
3310020-011	WELL 04-A	IWA	IWA	EWR
3310020-016	WELL 04-C	IWA	IWA	EWR
3310020-017	WELL 02-D	IWA	IWA	EWR
3310020-018	WELL 04-B	IWA	IWA	EWR
3310020-019	WELL T	IWA	IWA	EWR
3310020-023	WELL W	IWA	IWA	EWR
3310020-026	WELL Z	IWA	IWA	EWR
3301735-002	Well #2(Jackson)	Waller Tract Water District	CVWD	EWR
3310020-003	WELL 01-B	IWA	IWA	EWR
3310020-004	WELL 01-C	IWA	IWA	EWR
3310020-007	WELL 02-C	IWA	IWA	EWR
05S07E19AO1S			CVWD	EWR
T0606500637-MW-11			CVWD	EWR
T0606500637-MW-12			CVWD	EWR
tepa29-MW-6			CVWD	EWR
tepa29-MW-5			CVWD	EWR
3301040-001	WELL 01 CLUBHOUSE	Bermuda Palms Mobile Est.	CVWD	EWR
3310020-020	WELL S	IWA	IWA	EWR
3310020-022	WELL V	IWA	IWA	EWR
3310020-027	WELL AA	IWA	IWA	EWR
3301107-002	WELL 1	Carver Tract MWC	CVWD	EWR
3310020-008	WELL 03-A	IWA	IWA	EWR
3310020-009	WELL 03-B	IWA	IWA	EWR
3310020-010	WELL 03-C	IWA	IWA	EWR
3310020-021	WELL U	IWA	IWA	EWR
06S08E05F02S		PETER RABBIT FARMS	CVWD	EWR
3301241-001	WELL 01	EL DORADO POLO CLUB	CVWD	EWR
3302027-005	Empire west/ 5 ac	Empire Polo Club	CVWD	EWR
3301148-001	WELL 01	CV Public Cemetery	CVWD	EWR
3301937-001	WELL #1	Mesquite MWC	CVWD	EWR
3301803-001	WELL 01	Castro Trailer Park	CVWD	EWR
06S07E11D04S		-	CVWD	EWR
3301147-001	WELL 01 EAST	CVUSD Facilities/M&O	CVWD	EWR
3301149-001	WELL 01	CVUSD, CV High School	CVWD	EWR
3301153-001	WELL #1	CVUSD, Westside School	CVWD	EWR
3301276-001	WELL 01	Thermal MWC	CVWD	EWR
3301990-001	WELL #1	Amezcua Garcia Water	CVWD	EWR
3301209-001	WELL 01 SOUTH	Desert View Trailer Park	CVWD	EWR
3301305-001	Well#1 - primary use well	California Redi Date, LLC	CVWD	EWR
3301717-001	WELL 01	Valley View Trailer Park	CVWD	EWR
3301935-001	WELL #1	RBI Packing, LLC	CVWD	EWR
3301027-001	WELL 01	Bagdasarian #1&2	CVWD	EWR
06S08E19C03S			CVWD	EWR
06S08E19B02S			CVWD	EWR
3301939-001	WELL #1 MAIN	Jewel Date Co. Inc.	CVWD	EWR
3301373-001	WELL #1	Oasis Date Gardens	CVWD	EWR
06S08E34A02S		O.ARIAS	CVWD	EWR
06S08E33D01S		RUMONDS BROS	CVWD	EWR
06S08E31F01S			CVWD	EWR

Well Identifier	Other Well Name	Owner	Monitoring Resonsibilty	Management Zone
06S08E31M01S		MARY CECKA JOSEPHA MILLER	CVWD	EWR
06S08E31M02S		DEER CREEK	CVWD	EWR
06S08E31N03S		GINA PADILLA	CVWD	EWR
07S08E02B04S		FRANKLIN	CVWD	EWR
07S07E02G02E			CVWD	EWR
3301755-001	WELL 01	Sunbird MHP/Hawkeye Asset	CVWD	EWR
3303035-001	WELL #1	Los Gatos Trailer Park	CVWD	EWR
3303092-001	WELL #1	Mecca Arco Travel Center	CVWD	EWR
07S08E07H02S	// 12"	J.ALVAREZ	CVWD	EWR
L10007086318-MII-4			CVWD	EWR
L10007086318-MII-1			CVWD	EWR
L10007086318-MII-2			CVWD	EWR
L10007086318-MII-3			CVWD	EWR
3301476-001	WELL 01	Ibarra/Spates Families Water	CVWD	EWR
3302079-001	WELL #1	Aida Aguirre/Dimicio Sampaga	CVWD	EWR
3303100-001	WELL #1 MAIN	Oasis Gardens Water Co.	CVWD	EWR
3303100-002	Well #2 Standby well	Oasis Gardens Water Co.	CVWD	EWR
3301380-001	WELL 01	Saint Anthony Trailer Park	CVWD	EWR
3302069-001	WELL #1	La Pena Housing Facility	CVWD	EWR
07S08E29C013			CVWD	EWR
07S08E29C01S	// 2	PRONTO RANCH	CVWD	EWR
07S08E28P02S		ANTHONY VINEYARDS	CVWD	EWR
3301834-001	WELL #1	Musashi Brothers #174	CVWD	EWR
07S08E3301S			CVWD	EWR
3303002-001	WELL #1	Oasis Palms RV Park	CVWD	EWR
3303002-002	well 2 east (back up well)	Oasis Palms RV Park	CVWD	EWR
L10003427428-OMW-1			CVWD	EWR
L10003427428-OMW-3A			CVWD	EWR
08S09E31R04S			CVWD	EWR
L10003659217-MW-7			CVWD	FC
L10003659217-MW-2			CVWD	FC
L10003659217-MW-1			CVWD	FC
L10003659217-MW-3			CVWD	FC
L10003659217-MW-6			CVWD	FC
L10003659217-MW-4			CVWD	FC
L10003659217-MW-5			CVWD	FC
3310008-014	WELL 28	MISSION SPRINGS	MSWD	MC
3301206-001	WELL #1	Desert Hot Springs Spa Hotel	MSWD	MC
3301206-002	WELL 2 EAST	Desert Hot Springs Spa Hotel	MSWD	MC
3303090-001	WELL #1	Mission Creek Preserve	MSWD	MC
3310008-008	WELL 22	MISSION SPRINGS	MSWD	MC
3310008-010	WELL 24	MISSION SPRINGS	MSWD	MC
3310008-015	WELL 29	MISSION SPRINGS	MSWD	MC
3310008-013	WELL 27	MISSION SPRINGS	MSWD	MC
3310008-017	WELL 31	MISSION SPRINGS	MSWD	MC
3301388-001	WELL #1	Desert Dunes Golf Club LLC	MSWD	MC
03S06E21F03S		SKY VALLEY MOBILE PARK	CVWD	SV
03S06E21F04S		SKY VALLEY MOBILE PARK	CVWD	SV
3310078-001	WELL 26A	WEST PALM SPRIN	CVWD	WWR
3310078-002	WELL 26	WEST PALM SPRIN	CVWD	WWR
USGS-335522116415201		USGS	CVWD	WWR
USGS-335348116352701		USGS	CVWD	WWR
USGS-335348116352702		USGS	CVWD	WWR
USGS-335348116352703		USGS	CVWD	WWR
USGS-335339116345301		USGS	CVWD	WWR
USGS-335339116345302		USGS	CVWD	WWR
USGS-335339116345303		USGS	CVWD	WWR

Well Identifier	Other Well Name	Owner	Monitoring Resonsibilty	Management Zone
USGS-335318116363301		USGS	CVWD	WWR
USGS-335304116353001		USGS	CVWD	WWR
USGS-335231116345401		USGS	CVWD	WWR
03S04E35J01S			CVWD	WWR
03S04E35J02S			CVWD	WWR
04S06E08A02S		CHRIS LEHUEDE CDL CONSTRUCTI(	DWA	WWR
04S06E07M01S		J. P. CONSTRUCTION	DWA	WWR
04S06E07R01S		JOSE ESCOBAR MACIAS	DWA	WWR
04S06E15P01S		JOSE ESCOBAR MACIAS	DWA	WWR
04S05E17Q02S		DWA	DWA	WWR
3303012-001	WELL #1	Bel Air Greens	DWA	WWR
04S05E22L01S			DWA	WWR
04S05E23R01S		MISSION HILLS	CVWD	WWR
04S06E27E01S		XAVIER COLLEGE PREP HS	CVWD	WWR
3310001-010	WELL 4503 - INACTIVE	CVWD	CVWD	WWR
04S05E36M012			CVWD	WWR
05S07E05R06S		DESERT RIDGE RANCH LLC	CVWD	WWR
3301238-001	WELL 01	EISENHOWER MEDICAL	CVWD	WWR
3301683-001	WEST WELL	Thousand Trails - PS	CVWD	WWR
3303003-001	WELL #1	Galindo Housing Facility	CVWD	WWR
3310051-007	Well 10	MYOMA DUNES MWC	CVWD	WWR
3310051-008	Well 11	MYOMA DUNES MWC	CVWD	WWR
3310051-010	WELL 04	MYOMA DUNES MWC	CVWD	WWR
05S06E09PO1S			CVWD	WWR
05S06E16F01S			CVWD	WWR
3301155-001	WELL #1 (WELL 3)	COLLEGE OF THE DESERT	CVWD	WWR
3301155-002	Well #2 (well 4)standby	COLLEGE OF THE DESERT	CVWD	WWR
3301155-003	CHLORINATOR (WELL 3)	COLLEGE OF THE DESERT	CVWD	WWR
3301155-004	CHLORINATOR (WELL 4)	COLLEGE OF THE DESERT	CVWD	WWR