Prepared for
Camrosa
Water District

Santa Rosa Basin
Groundwater Management Plan

August 2013

CAMROSA DISTRICT

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BUILDING A BETTER WORLD

Santa Rosa Basin Groundwater Management Plan

Final

August 2013

Project Number 10500990

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Camrosa Water District

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LIST OF ACRONYMS AND ABBREVATIONS

Acronym	Definition
AB	Assembly Bill
Acre-FT	Acre-feet
BGS	Below Ground Surface
BMO	Best Management Objective
CDPH	California Department of Public Health
CIMIS	California Irrigation Management Information System
CSWRB	California State Ware Resources Board
CWC	California Water Code
DBCP	1,2-Dibromo-3-chloropropane
DWR	Department of Water Resources
DWSAP	Drinking Water Source Assessment Program
EPA	Environmental Protection Agency
ET	Evapotranspiration
ETO	Reference Evapotranspiration
FCGMA	Fox Canyon Groundwater Management Authority
FT	Feet
GMP	Groundwater Management Plan
GPM	Gallons per Minute
HC	Hill Canyon
IFMP	Integrated Facilities Management Plan
In	Inch
mg/L	Milligrams per liter
MGD	Million Gallons per Day
MSL	Mean Sea Level
MWH	MWH Americas, Inc.
ND	Non Detect
NO_3	Nitrate
RO	Reverse Osmosis
RWC	Recycled Water Contribution
SB	Senate Bill
SRGMP	Santa Rosa Basin Groundwater Management Plan
SRMWC	Santa Rosa Mutual Water Company
SWP	State Water Project
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WCVC	Watersheds Coalition of Ventura County
WWTP	Wastewater Treatment Plant

Section 1
Introduction

1.1 INTRODUCTION

The Camrosa Water District (District) has developed this Groundwater Management Plan for a portion of the Santa Rosa Groundwater Basin, commonly referred to as the Santa Rosa Groundwater Management Plan (SRGMP).

The SRGMP area, illustrated in **Figure 1-1** and **Figure 1-2**, is located in unincorporated Ventura County between and including parts of the cities of Camarillo and Moorpark. The Basin boundaries coincide with the California Department of Water Resources (DWR) Arroyo Santa Rosa Valley Groundwater Basin, Basin 4-7, boundary as defined in Bulletin 118 (DWR, 2003) and illustrated in **Figure 1-2.** The Arroyo Santa Rosa Valley Groundwater Basin is herein referred to as the Santa Rosa Groundwater Basin. The area to be managed under the SRGMP lies in the eastern portion of the Basin east of the Bailey Fault.

The Santa Rosa Valley covers an area of 12.5 square miles of which the groundwater basin occupies approximately 5.9 square miles (Boyle, 1997). The basin is located in Ventura County, California just north of the City of Thousand Oaks and east of the City of Camarillo.

Santa Rosa Valley is an elliptical, broad, and flat-bottomed valley and is separated from the Tierra Rejada Basin to the east by the narrow Rejada Canyon of Arroyo Santa Rosa and the Conejo Volcanics east of the Basin. Similarly the groundwater basin terminates at the Conejo Volcanics. The Santa Rosa Valley is separated from the larger Pleasant Valley to west by a constriction caused by a low, north-trending ridge of volcanic rocks southwest of the District offices on Santa Rosa Road. This surface constriction extends downward into the subsurface aquifer materials, thins out locally at the western constriction and forms a partial underground barrier that separates the Santa Rosa Groundwater Basin from the larger Pleasant Valley Groundwater Basin (Bailey, 1969).

1.2 REPORT ORGANIZATION

The SRGMP is organized as follows:

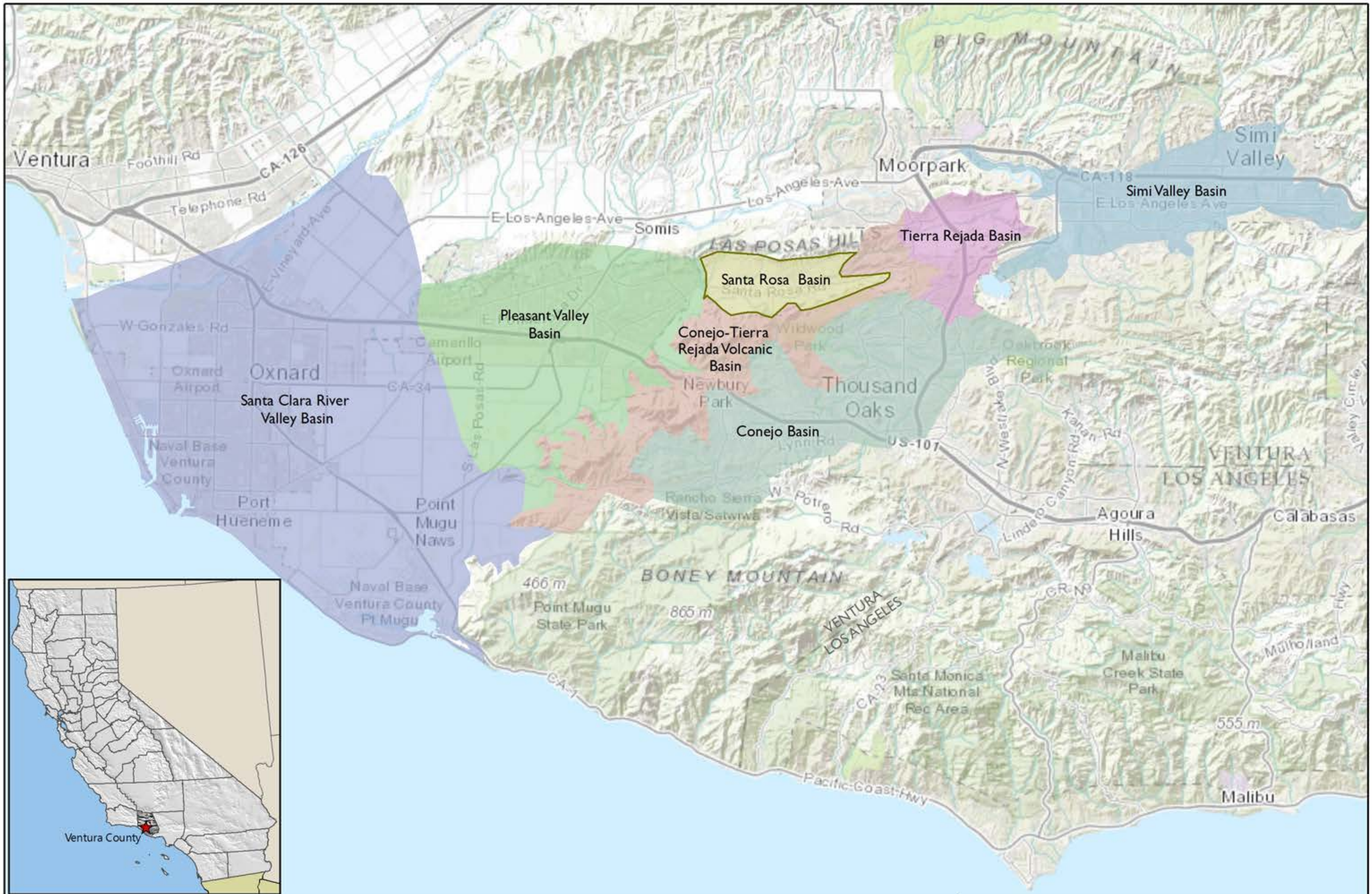
Section 1 – Introduction: Provides information regarding the SRGMP goals, basin background, roles of various agencies, existing groundwater management plans, SRGMP authority, and essential SRGMP components.

Section 2 - Water Resources Setting: In this section information is presented to assist the reader in understanding the availability of different water supplies within the SRGMP area. This section also provides a description of the groundwater basin, highlighting the hydrogeology within the SRGMP area. It also provides information on surface water and groundwater quality.

Section 3 - Basin Yield: A review of previous basin yield evaluations is presented followed by an updated evaluation of the basin yield. The updated evaluation is based on data collected over the last 25 years. This section also defines operational yield and presents methods to increase the yield of the basin by adjusting operations of the basin.

Section 4 - Management Plan Goal and Objectives: This section describes the purpose of the goal statement, Basin Management Objectives (BMOs), and management actions, and how they were prepared, reviewed and finalized. Together the BMOs will result in improving the water quality and supply reliability within the Santa Rosa Valley.

Section 5 - Plan Components: This section identifies the components that constitute a groundwater management plan in accordance with State guidelines. This section also provides categories of plan components and actions as well as potential groundwater projects that meet the BMOs.



Key to Features

Groundwater Basins

- Conejo
- Tierra Rejada
- Conejo-Tierra Rejada Volcanic
- Santa Clara River Valley
- Pleasant Valley
- Santa Rosa
- Simi Valley

Topographic Imagery Source: ESRI, et al. Groundwater Basin Source: California Groundwater Bulletin 118

0 2.5 5 Miles

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Groundwater Basins Adjacent to the Santa Rosa Valley

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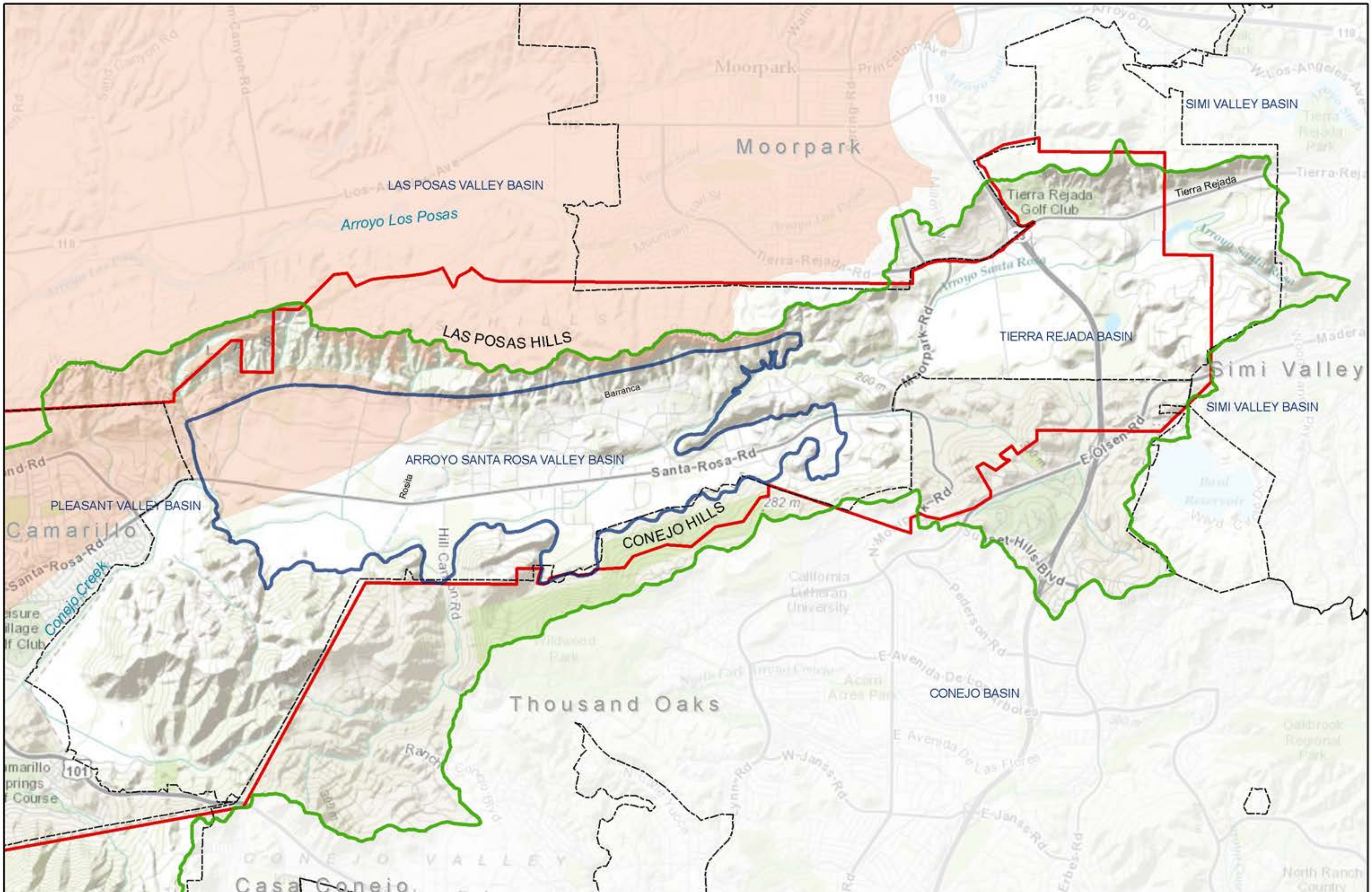
Figure 1-1



Key to Features

- Santa Rosa Groundwater Basin
- Watershed
- Camrosa District Boundary
- City Boundaries
- Fox Canyon Groundwater Management Association

Topo Map Source: ESRI

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Adjacent City and Water Agency Service Areas

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Figure 1-2

1.3 PURPOSE AND GOALS OF THE SRGMP

The purpose of the SRGMP is to serve as the initial framework for coordinating the management activities into a cohesive set of BMOs and related actions to improve management of the groundwater resources in the Santa Rosa Basin.

The management goals for the Santa Rosa Basin are to optimize the beneficial uses of groundwater, preserve and enhance water quality, understand and operate within the yield of the basin, and assure preservation of groundwater and environmental resources for future generations. The California Water Code (CWC) states that BMOs and specific actions taken to achieve these objectives, with sufficient specificity, must be developed within a groundwater management plan. The objectives and actions should be quantitative such that they are measurable in implementation through monitoring and management programs. At the same time, the BMOs are intended to be flexible so as to be adaptive to increase knowledge of how the groundwater basin behaves over time as additional monitoring data is collected. To meet these co-equal objectives, general BMO statements have been prepared and are accompanied by specific and measurable methods for implementation. Based on these guidelines, four BMOs have been developed from the Basin management goals and District Strategic Plan (District, 2008). These objectives and their associated actions are detailed in Section 4 and Section 5:

- Protect and enhance groundwater quality
- Sustain a safe, reliable local groundwater supply
- Maximize the beneficial use of groundwater (which is the most cost-effective water supply to stakeholders)
- Maintain public awareness and confidence, and honor the public trust

1.4 BACKGROUND

The following subsection provides background information on the District, other relevant adjacent cities and water agencies surrounding the SRGMP area, and other stakeholders in the region.

1.4.1 Camrosa Water District

The District was organized under the CWC and established on July 24, 1962. The original district boundary, encompassing approximately 8,000 acres, has expanded gradually via annexations to encompass more than 30 square miles within Ventura County. The initial customers in 1965 were typically agricultural interests and took delivery of imported water. After construction of the Camrosa distribution system in 1965, the District has expanded to approximately 10,600 municipal water connections serving a population of approximately 30,000 (District, 2011a).

In 2010, approximately 18,720 acre-feet of water was delivered to District customers for both potable and non-potable use (District, 2011b). Approximately 45 percent of the total water supply (about 8,800 acre-feet) was diverted from Conejo Creek for use as non-potable irrigation supply; 8 percent of the water supply (about 1,565 acre-feet) was produced from the Camrosa Wastewater Treatment Plant and delivered for non-potable use; 29 percent (about 5,670 acre-feet) was imported through the Metropolitan Water District and its wholesale agency, Calleguas Municipal Water District; and the remainder of the water, about 18 percent or 3,520 acre-feet, was pumped from local groundwater basins (District, 2011a). Two basins, the Tierra Rejada Groundwater Basin and the Santa Rosa Groundwater Basin, lie within the District's boundaries (District, 2011a) and are an important supply source for the District.

1.4.2 Fox Canyon Groundwater Management Agency

The Fox Canyon Groundwater Management Agency (FCGMA) is located in Ventura County and manages several coastal basins that underlie Port Hueneme, Camarillo, Moorpark, Ventura, and Oxnard. The agency overlies about 185 square miles. The FCGMA was initially created to manage the groundwater in both over-drafted and seawater-intruded areas within Ventura County. The current objectives of the FCGMA are to preserve groundwater resources for agricultural, municipal, and industrial uses (FCGMA Groundwater Management Plan, 2007). The FCGMA has management jurisdiction over the western portion of the Santa Rosa Groundwater Basin west of the Bailey Fault.

1.4.3 Adjacent Cities

Of the approximately 30 square miles within the District's boundaries, about 7 square miles lie within the City of Camarillo city limits, approximately 1.5 square miles lie within the boundaries of the City of Thousand Oaks and 21.5 square miles lie within the unincorporated area of Ventura County.

The City of Thousand Oaks plays a significant role in groundwater management in the Basin because they supply approximately 50 percent of the annual discharge in Conejo Creek from wastewater treatment facilities. Conejo Creek is a key source of groundwater recharge for the Basin. Related to this discharge, since 1995 the District has a 25-year agreement with the City of Thousand Oaks for primary access to Hill Canyon Wastewater Treatment Plant (WWTP) discharge in Conejo Creek.

1.4.4 County of Ventura

The Santa Rosa Basin is entirely within the County of Ventura. The County of Ventura has many administrative arms that are relevant to groundwater management in the Santa Rosa Groundwater Basin.

The Ventura County Water and Environmental Resources Division, Groundwater Section, oversees the administration of Ventura County Ordinance No. 4184. The purpose of this ordinance is to provide for the construction, maintenance, operation, use, repair, modification, and destruction of wells.

The Ventura County Watershed Protection District collects groundwater data throughout Ventura County, including Santa Rosa Basin, and reports these data to DWR. The

Ventura County Watershed Protection District is the only entity in the County with the jurisdiction to monitor groundwater elevation levels in all the groundwater basins within the County. They currently measure almost 200 wells every six weeks. The District has a database of groundwater level data dating back to the early 1970's.

1.4.5 Watersheds Coalition of Ventura County

The Watersheds Coalition of Ventura County (WCVC) was formed in April 2006 as the water resource management group required by the passage of Propositions 50 and 84, and is managed by County staff. The WCVC is a collaborative entity with interests in improving water quality, water supply reliability, water recycling, water conservation, flood control, recreation and access, wetlands enhancement and creation, and environmental and habitat protection (Ventura County, 2013). The WCVC, and its three watershed committees, are engaged in a variety of local planning efforts designed to address the objectives developed by the watershed committees; the District is a member of the Calleguas Creek committee. These committees form the Integrated Regional Water Resources Plan (IRWMP) development team for the area.

1.5 ROLES OF THE STATE AND FEDERAL AGENCIES IN CALIFORNIA GROUNDWATER MANAGEMENT

This section describes the roles that state and federal agencies have in California groundwater management. Although the groundwater management plans are the local responsibility, State and federal agencies still have goals related to groundwater management that are focused on maintaining a reliable groundwater supply.

1.5.1 Department of Water Resources

DWR's role in groundwater management involves programs that directly benefit local groundwater management efforts. DWR's programs include assisting local agencies to assess basin characteristics and identify opportunities to develop additional water supply, monitoring groundwater levels and quality, and providing standards for well construction and destruction.

1.5.2 State Water Resources Control Board and Regional Water Quality Control Board

The goals of the State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Board (RWQCB) are to ensure water quality in the State and to enforce water quality objectives and implement plans to protect beneficial uses of the State's waters. The SWRCB and RWQCB are involved in developing basin plans to identify beneficial uses of marine water, groundwater, and surface waters. The Los Angeles RWQCB has jurisdiction of the Santa Rosa Basin.

The Clean Water Act (§303) requires states to develop water quality standards for all waters and to submit them to the United States Environmental Protection Agency for approval. CWC §13241 specifies that each RWQCB establish water quality objectives for their region. These water quality objectives are defined as "the allowable limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." (RWQCB, 1994). These water quality objectives are intended to protect the public health, and maintain or enhance water quality in relation to existing and potential beneficial uses of the water.

The surface water and groundwater quality objectives prepared by Los Angeles RWQCB for the Santa Rosa Basin are published in the Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (RWQCB, 1994); these are commonly referred to as the Basin Plan objectives.

1.5.3 United States Geological Survey

The United States Geological Survey (USGS) has an active role in California groundwater basin studies and maintains an extensive database consisting of groundwater level and groundwater quality monitoring data. The USGS also maintains an extensive surface water flow data.

1.6 AUTHORITY TO PREPARE AND IMPLEMENT THE SRGMP

The authority for the District to prepare the SRGMP is outlined in the Groundwater Management Act, CWC §10750, originally enacted as Assembly Bill (AB) 3030 in 1992 to encourage voluntary groundwater management at the local level and provide local public agencies increased management authority over their groundwater resources. AB 3030 applies to all groundwater basins identified by the California Department of Water Resources.

In September 2002, new legislation, Senate Bill 1938 (SB 1938) expanded AB 3030 by requiring groundwater management plans to include certain specific components in order to be eligible for grant funding for various types of groundwater related projects.

The District selected the SRGMP as one of the tools to effectively protect and manage the Santa Rosa Basin. Protecting and effectively managing the Basin is consistent with the Camrosa Water District Urban Water Management Plan (District, 2011b), Integrated Facilities Master Plan (District, 2011a), as well as the CWC.

On December 14, 2011, the District Board set a Public Hearing date of January 11, 2012, to accept public comments, and at the conclusion of the Public Hearing make a decision to adopt a Resolution of Intention to prepare a Groundwater Management Plan Update. On January 11, 2012 the District Board of Directors adopted the Resolution of Intention to prepare a Groundwater Management Plan Update (included in **Appendix A**). The GMP is a required element of the policy.

Recently, there has been an emphasis by the State for agencies to develop integrated regional solutions for water management solutions (SB 1672), and coordinate the conjunctive management of surface and groundwater to improve regional water supply reliability and water quality.

1.7 SRGMP COMPONENTS

The California Department of Water Resources and the CWC provide a summary of Groundwater Management Plan components. The SRGMP includes required and voluntary components as listed in the CWC §10750 and DWR §10775.2 recommended components. Each of these components is addressed within the SRGMP.

Table 1-1 lists these components and indicates the section(s) in which each is addressed.

Table 1-1
Location of SRGMP Components

Description	Section(s)
A. CWC §10750 et seq., Required Components[1]	
1. Documentation of public involvement statement.	I
2. Basin Management Objectives (BMOs).	4
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping.	2
4. Plan to involve other agencies located within groundwater basin.	5
5. Adoption of monitoring protocols by basin stakeholders.	5
6. Map of groundwater basin showing area of agency subject to GMP, other local agency boundaries, and groundwater basin boundary as defined in CDWR Bulletin 118.	1.1
7. For agencies not overlying groundwater basins, prepare GMP using appropriate geologic and hydrogeologic principles.	Not Applicable
B. CDWR's Recommended Components	
1. Manage with guidance of advisory committee.	Not Applicable
2. Describe area to be managed under GMP.	1.1
3. Create link between BMOs and goals and actions of GMP.	4
4. Describe GMP monitoring program.	2.2, 2.3, 5.2
5. Describe integrated water management planning efforts.	5.5
6. Report on implementation of GMP.	5.6
7. Evaluate GMP periodically.	5.6
C. CWC §10750 et seq., Voluntary Components[2]	
1. Control of saline water intrusion.	5.3
2. Identification and management of wellhead protection areas and recharge areas.	5.3
3. Regulation of the migration of contaminated groundwater.	Not Applicable
4. Administration of well abandonment and well destruction program.	5.3
5. Mitigation of conditions of overdraft.	Not Applicable
6. Replenishment of groundwater extracted by water producers.	Not Applicable
7. Monitoring of groundwater levels and storage.	5.3
8. Facilitating conjunctive use operations.	5
9. Identification of well construction policies.	5.3
10. Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	5.7
11. Development of relationships with state and federal regulatory agencies.	5.1
12. Review of land use plans and coordination with land use planning agencies to assess activities that create reasonable risk of groundwater contamination.	5.1, 5.5

1. CWC §10750 *et seq.* (seven required components). Amendments to the CWC §10750 *et seq.* require GMPs to include several components to be eligible for the award of funds administered by DWR for the construction of groundwater projects or groundwater quality projects. These amendments to the CWC were included in Senate Bill 1938, effective January 1, 2003.

2. CWC §10750 *et seq.* (12 voluntary components). CWC §10750 *et seq.* includes 12 specific technical issues that could be addressed in GMPs to manage the basin optimally and protect against adverse conditions

Addressing each of these components in the SRGMP demonstrates that the local groundwater basin management authority (the District) has a plan to protect the groundwater resource in a sustainable method for the benefit of current and future interests in the Basin.

Section 2
Water Resources Setting

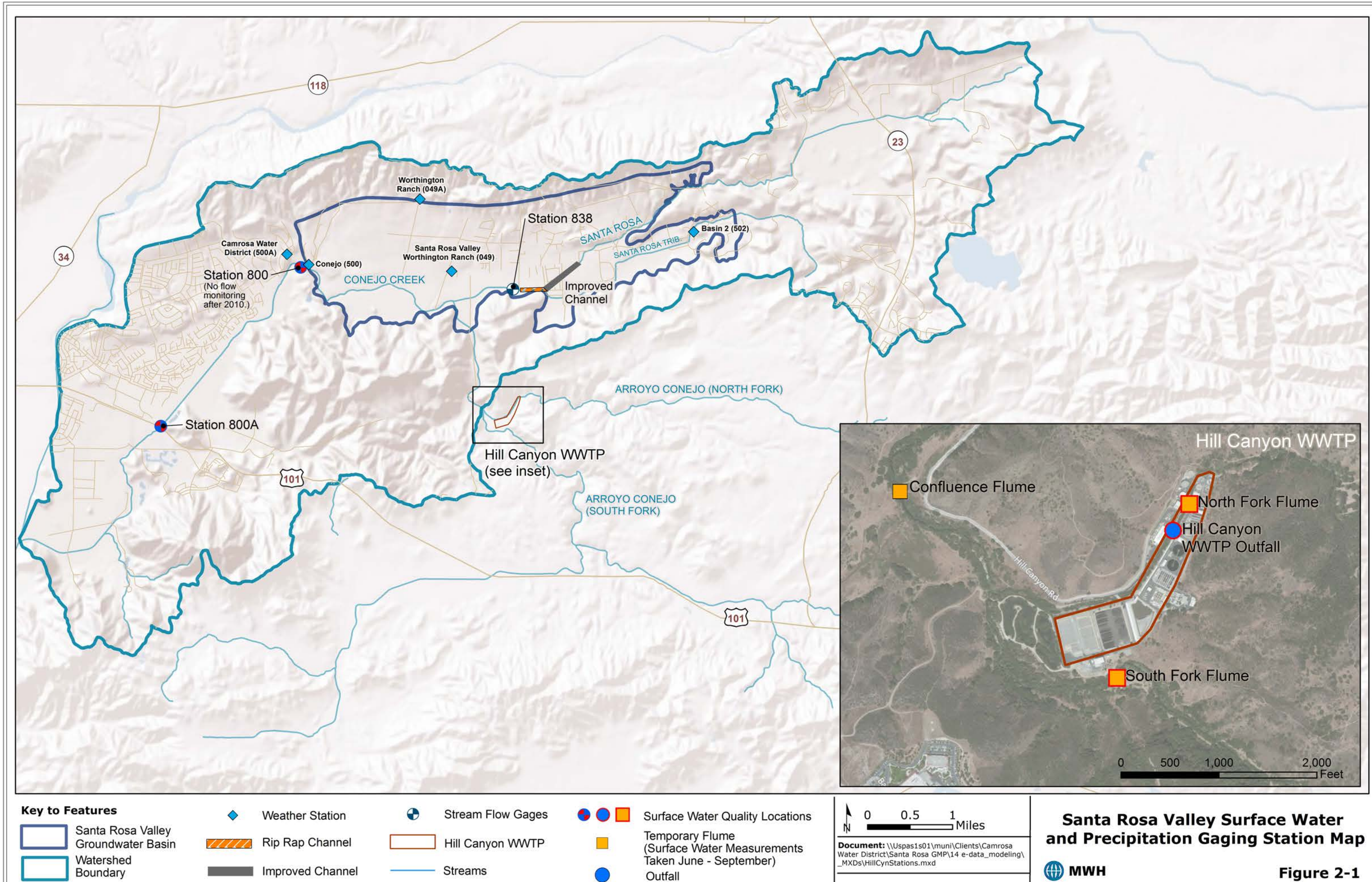
This section describes the water resource setting including the current understanding of the surface and subsurface features of the Santa Rosa Groundwater Basin. This section also includes a description of the groundwater and surface water features in the Basin. Information for this section was obtained from ongoing monitoring efforts and results of previous studies, and represents the best available information. The charts and figures included in this section illustrate the type of information and period of record for understanding the groundwater conditions within the Basin. Instances where the data record appears incomplete, inconsistent, or missing altogether are also noted.

2.1 ENVIRONMENTAL SETTING

The climate of the Basin is classified as Mediterranean. On average, more than 90 percent of the annual rainfall occurs during the six-month period extending from November through April, typical of the Southern California coastal area. Based on precipitation stations maintained by Ventura County Flood Control District, the Santa Rosa Valley surface drainage area receives an average of almost 15 inches of rainfall per year, varying from less than six inches in the driest years to more than 30 inches in the wettest years (District, 2010). **Figure 2-1** shows the watershed and Santa Rosa Groundwater Basin, as well as major surface water and precipitation monitoring stations.

The average temperature fluctuates between an average low of about 44 degrees (January) and an average high of about 75 degrees (August). **Table 2-1**, based on the period of record May 1998 through January 2010 for the Oxnard California WFSO 045672 station, lists the monthly average climatic data for the District service area.

The evapotranspiration (ET) averages for the service area are also contained in **Table 2-1**. These monthly averages are based on historical data obtained from California Irrigation Management Information System (CIMIS) Station 156 – Camarillo, California for the period October 2001 through January 2010.



Santa Rosa Valley Surface Water and Precipitation Gaging Station Map

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Figure 2-1

Table 2-1
Santa Rosa Basin Climate Averages

Month	Standard Monthly Average ETo[1] (inches/year)	Monthly Average Maximum Temperature (°F)	Monthly Average Minimum Temperature (°F)	Monthly Average Total Precipitation (inches)
January	1.83	66.8	45.6	2.91
February	2.20	65.9	45.7	3.76
March	3.42	66.9	47.0	1.75
April	4.49	67.6	48.1	1.24
May	5.25	70.0	52.8	0.44
June	5.67	72.5	56.4	0.03
July	5.86	75.8	59.5	0.00
August	5.61	76.0	59.2	0.00
September	4.49	74.8	57.7	0.10
October	3.42	73.7	53.7	0.63
November	2.36	70.3	48.8	1.19
December	1.83	66.4	44.8	1.60
Annual Total/Average	**46.43**	**70.6**	**51.6**	**13.65**

1. ETo is the evapotranspiration from a standardized grass surface
2. Source: District, 2011b Urban Water Management Plan, Table 2.

2.1.1 Precipitation

Precipitation is often a key element of a water budget and therefore characterization of trends in precipitation is of great importance in evaluating long-term hydrologic relationships. Precipitation and related runoff is a major source of groundwater recharge. Cumulative departures from the mean are used to identify long-term trends in both precipitation and stream flow. Cumulative departures of the annual precipitation from the long-term mean are accumulated through the period of record and plotted against time. The resulting plot illustrates dry periods and wet periods, as well as the severity and frequency of each. This plot can also be used to determine if there is a temporal correlation between groundwater and precipitation. The cumulative departure plot of precipitation for Worthington Ranch (Ventura County Watershed Protection District station 049) was used to identify wet and dry periods (**Figure 2-2**). The wet and dry climatic periods were determined using the rising and falling limbs of the cumulative departure curve, respectively.

Four alternating climate cycles that resulted in four wet and five dry periods between 1929 and 2012 were identified on the basis of the cumulative departure curve for precipitation measured at Worthington **Table 2-2**. The climate cycles were separated into wet-year and dry-year periods as follows:

Table 2-2
Santa Rosa Basin Climate Cycles

Cycle	Dry Period	Wet Period
1	1929–1934	1934–1944
2	1944–1964	1964–1969
3	1969–1977	1977–1986
4	1986–1991	1991–2006

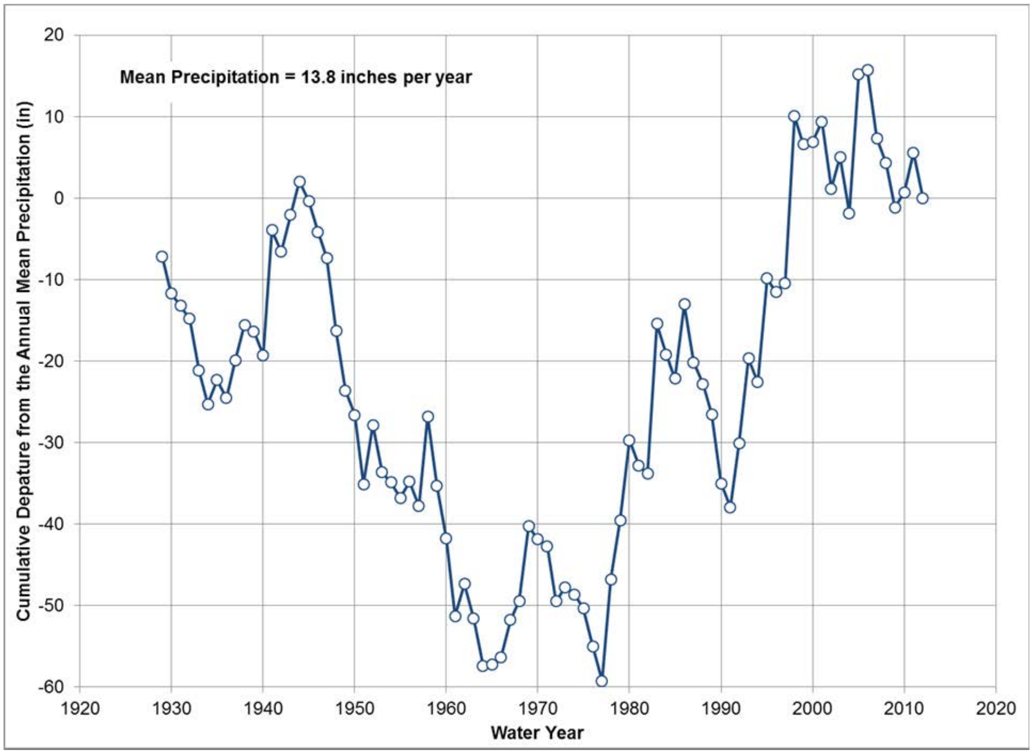


Figure 2-2
Precipitiation Cumulative Departure From the Mean – Station 049 Worthington Ranch

2.1.2 Land Use

Land use is important for groundwater management because it affects the quality of local surface water and groundwater as well as the ability to recharge groundwater. The land use within the contributing drainage area to the Santa Rosa Groundwater Basin is illustrated on **Figure 2-3** and listed on **Table 2-3**. The majority of the land within the Santa Rosa Valley and the contributing drainage area to the Santa Rosa Groundwater Basin is unincorporated and planning efforts are coordinated by the County of Ventura. Local cities within the contributing drainage area conduct their own planning activities.

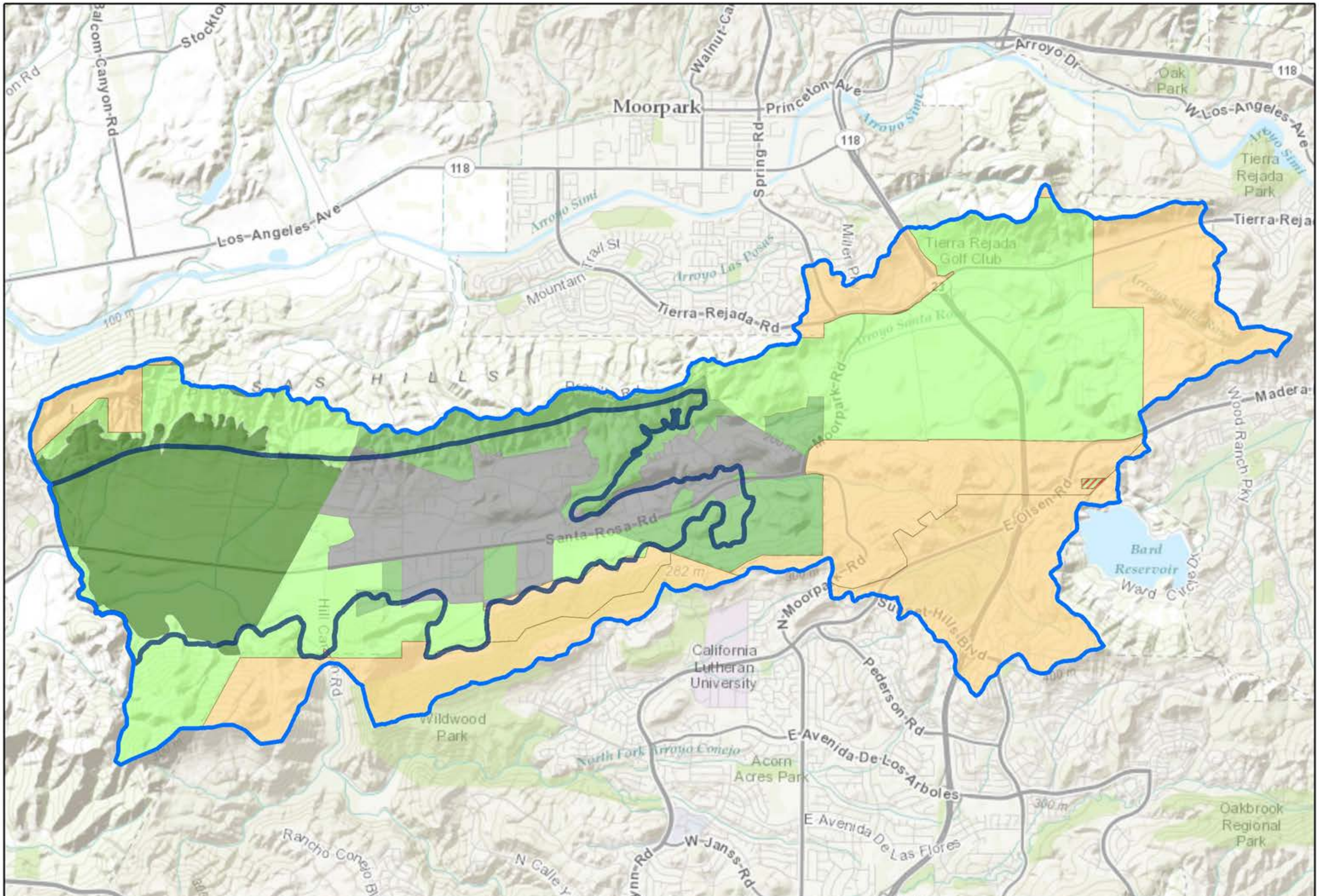
Prior to the 1960's, the Santa Rosa Valley was dedicated to agriculture, primarily citrus crops. By the late 1980's, residential development had risen to 40 percent of the basin area (Boyle, 1987). By 2011, residential lots, ranging in size from two to 40 acres, accounted for 30 percent of the basin area (District, 2011). The Santa Rosa Valley has an annual population growth rate of 0.75 percent. Agricultural use currently accounts for approximately 13 percent of the land within the contributing drainage area. Crop types consist of orchards, berries/nursery, and row crops. Approximately 37 percent of agricultural zoned acreage is irrigated, 26 percent is non-irrigated, and 37 percent is planned to be converted to municipal and industrial use (District, 2011). The remaining land use consists of rural space, open space, and a small fraction of urban development. The entire basin is dependent on permitted septic systems for wastewater disposal. A significant portion of the contributing drainage area does not have a land use classification.

The Tierra Rejada Valley is located on the eastern boarder of the Santa Rosa Valley. The Tierra Rejada Valley is primarily open space and agriculture, with sparse rural-residential developments (District, 2011). A golf course is located in the northeastern portion of the watershed. This area also relies on septic systems for wastewater disposal.

Table 2-3
Land Use Distribution in the Santa Rosa Groundwater Basin Contributing Drainage Area

Land Use Type[1]	Area (acres)	Percent of Total Areal
Agricultural	1,650	13%
Urban	1,150	9%
Open Space	3,808	31%
Rural	1,335	11%
Open Space Urban Reserve	7	<1%
Existing Community	1,429	12%
Non-Classified	2,895	24%
Total Area (acres)	**12,274**	**100**

1. County of Ventura, 2010



Key to Features

Santa Rosa Valley Groundwater Basin	Agricultural
Contributing Drainage Area	Community
Open Space	Rural
Open Space Urban Reserve	Urban

Land Use Source: Ventura County Geographical Information System

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Santa Rosa Groundwater Basin Contributing Drainage Area Land Use

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Figure 2-3

2.2 SURFACE WATER CONDITIONS

The primary surface water bodies in the Santa Rosa Valley are the Arroyo Conejo, Conejo Creek, and Arroyo Santa Rosa (**Figure 2-1**). Arroyo Conejo enters the basin from the south and is the primary drainage of Thousand Oaks, draining through the Conejo Hills into Hill Canyon and then into the Santa Rosa Valley. At the mouth of Hill Canyon, the creek joins Arroyo Santa Rosa and becomes Conejo Creek which turns west and drains into the Pleasant Valley Basin and eventually Calleguas Creek. Arroyo Santa Rosa trends east-west, bisecting the Santa Rosa Valley, draining the Tierra Rejada Basin before joining Arroyo Conejo. The drainage area compromises 64 square miles (Boyle, 1987).

2.2.1 Arroyo Santa Rosa

Arroyo Santa Rosa bisects the Santa Rosa Valley and is an ephemeral creek. In 2006 a stream gage was established about one mile upstream of where the Arroyo Santa Rosa discharges into Conejo Creek (**Figure 2-1**). Stream flow measurement at Station 838 on Arroyo Santa Rosa began in 2006. Station 838 was installed for the purpose of recording peak flows during high precipitation events. The data provided by the stream gage is not reliable for typical flows and therefore was not used.

From Santa Rosa Road to Honey Hill Road (approximately 3,000 feet), Arroyo Santa Rosa is composed of a rectangular reinforced concrete channel and a trapezoidal rip rap channel. Downstream of Honey Hill Road to Blanchard Road (approximately 2,750 feet) the channel is still an improved trapezoidal channel, however, this segment is not concrete lined.

2.2.2 Arroyo Conejo

Arroyo Conejo enters the basin from the south where it becomes Conejo Creek draining through the Conejo Hills into Hill Canyon and the into the Santa Rosa Valley. There are two forks of the Arroyo Conejo, a north fork and a south fork. These creeks have no USGS gaging stations, although the Hill Canyon WWTP records flow information on both forks during the summer months. As shown in **Figure 2-1**, the Hill Canyon WWTP discharges effluent into the north fork of Arroyo Conejo. Immediately downstream of the Hill Canyon WWTP, the south fork of Arroyo Conejo merges with the north fork.

The largest contribution to flow to Conejo Creek is the effluent flow from the Hill Canyon WWTP and it is also the most consistent over the recorded period. The Hill Canyon WWTP effluent began discharging into the creek in 1961, although the data presented in **Table 2-4** are all that are available from the facility.

2.2.3 Conejo Creek

At the mouth of Hill Canyon is the confluence of Arroyo Conejo and Arroyo Santa Rosa known as Conejo Creek. From the confluence it turns west and drains into the Pleasant Valley Basin and eventually Calleguas Creek. Discharge in Conejo Creek is predominantly from Arroyo Conejo. Since the addition of the Hill Canyon WWTP effluent in 1961, Conejo Creek was a perennial stream with continuous flow at the County's gauging station (Station 800). In 1968 this gaging station was established by the Ventura County Watershed Protection District and has recorded year-round flows since October 1972. From 1972 through 2010 this gaging station was located just outside of the groundwater basin near the District headquarters on Santa Rosa Road. In 2011 the gage was renamed as Station 800A and was relocated to Ridge View Street south of Highway 101. **Table 2-4** lists the Station 800 flow data from 2003 to 2010. **Table 2-4** also lists the percentage of creek flow that consists of WWTP effluent.

Data presented in **Table 2-4** suggest that the composition of flow in Conejo Creek varies depending on precipitation. Effluent from Hill Canyon WWTP makes up between 23 percent to 71 percent of the total annual flow of Conejo Creek on an annual basis. Using only dry months (June through September where the long-term precipitation averages 0.10 inches or less), Hill Canyon WWTP effluent contributes an average of 79 percent of the total flow in Conejo Creek. For the majority of the year, Hill Canyon WWTP effluent is the predominant contributor to the flow in Conejo Creek.

Table 2-4
Summary of Average Annual Flow at Conejo Creek and Hill Canyon WWTP Effluent

	Annual Discharge			Dry Month Discharge[3]		
Year	HC WWTP Effluent[1] (MGD)	Conejo Creek[2] (MGD)	Percent HC WWTP Effluent	HC WWTP Effluent[1] (MGD)	Conejo Creek[2] (MGD)	Percent HC WWTP Effluent
1997	9.4	20.4	46	9.2	11.1	82
1998	10.2	44.4	23	9.8	16.3	60
1999	9.8	14.7	66	9.8	10.9	90
2000	10.3	16.1	64	10.2	10.8	94
2001	11.1	25.1	44	10.8	12.3	88
2002	10.6	14.9	71	10.3	11.4	90
2003	11.2	19.3	58	10.8	12.9	84
2004	11.1	21.5	52	10.7	13.5	80
2005	12.0	41.4	29	10.9	16.9	64
2006	10.6	20.8	51	10.4	15.0	70
2007	10.3	15.2	68	10.3	13.4	77
2008	10.6	22.5	47	10.2	13.9	74
2009	10.0	16.3	61	9.8	10.4	94
Average	**10.6**	**22.6**	**47**	**10.2**	**13.0**	**79**

1. Conejo Creek discharge measurement at Station 800
2. Hill Canyon WWTP (HC WWTP) discharge measurement at HC WWTP Effluent Outfall
3. Dry months are defined as the period from April through December.

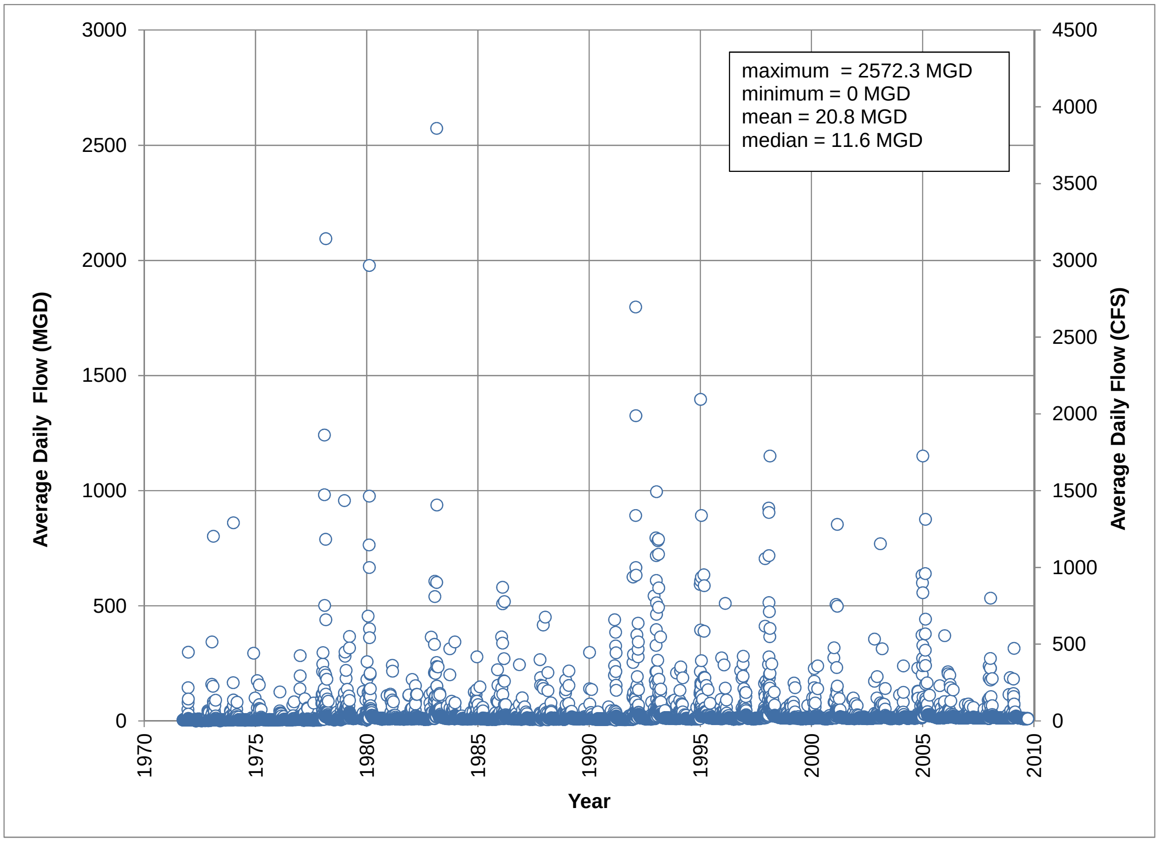


Figure 2-4
Conejo Creek (1971-2010) Hydrograph at Station 800

Figure 2-4 illustrates the average daily flow at Station 800 on Conejo Creek from 1971 to 2009, a different time period than **Table 2-4**. The variability in discharge rate can be attributed to precipitation events which dramatically increase flow in the creek.

Figure 2-5 illustrates the average monthly flow in Conejo Creek, from 1971 to 2010. The wet months of January, February, and March have a significantly higher flow than the summer months.

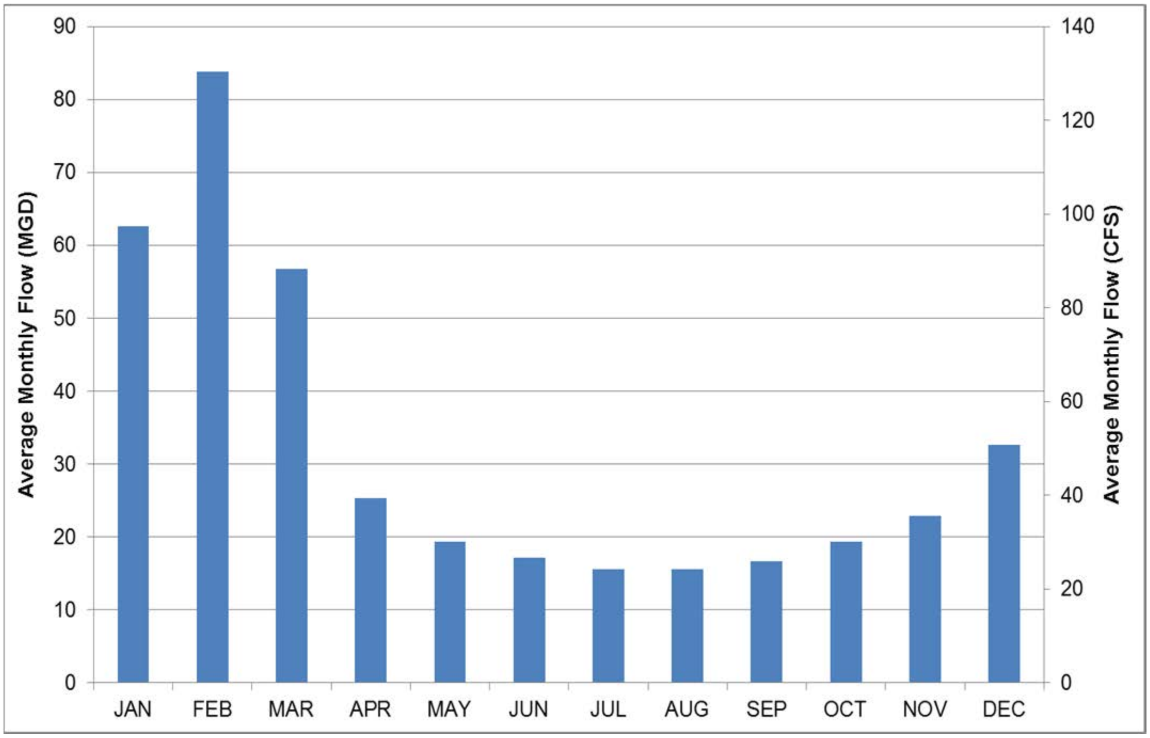


Figure 2-5
Average Monthly Flow in Conejo Creek (1971-2010) at Station 800

2.2.4 Surface Water Quality

Water quality data within the Santa Rosa Basin has been collected and reported for the period from 1990 to the present by the District. Water quality samples are collected from approximately 45 locations within the basin including groundwater wells, creeks, Hill Canyon WWTP effluent, recycled water system, drinking water system, and reservoirs. Monthly samples are collected from the following locations: Hill Canyon WWTP Effluent Outfall, Station 800A, Arroyo Conejo North Fork (North Fork Flume), Arroyo Conejo South Fork (South Fork Flume), and Conejo Creek (Station 800) (as shown on **Table 2-5**). Samples are analyzed for chloride, fluoride, hardness, nitrate, nitrite, pH, phosphate, sulfate, TDS, and turbidity. Additional sampling and analysis for other constituents is conducted periodically, approximately every one to three years. This section provides a summary of the surface water quality results and brief descriptions of trends for constituents in relation to regulatory objectives.

Figure 2-1 presents the flow and water quality measurement locations within the basin. Water quality data for Arroyo Santa Rosa is not available.

Surface water quality from monitoring locations throughout the basin (**Figure 2-1**) has been tabulated on **Table 2-5**; the table also presents the inland surface water quality objectives of the Los Angeles RWQCB within the Arroyo Santa Rosa Hydrologic Unit. These are published in the Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (RWQCB, 1994) and commonly referred to as Basin Plan objectives.

The Clean Water Act (§303) requires states to develop water quality standards for all waters and to submit them to the United States Environmental Protection Agency for approval. CWC §13241 specifies that each RWQCB establish water quality objectives for their region. These water quality objectives are defined as "the allowable limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." (RWQCB, 1994). These Basin Plan objectives are intended to protect the public health, and maintain or enhance water quality in relation to existing and potential beneficial uses of the water.

Table 2-5 also lists a comparison of surface water quality data with applicable California drinking water quality standards, both primary and secondary (aesthetic) maximum contaminant levels (MCLs). Primary MCLs are derived from health-based criteria which include technologic and economic considerations. Primary MCLs are legally enforceable standards that apply to public water systems designed to protect the public health by limiting the levels of contaminants in drinking water. Secondary MCLs are designed to regulate contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. In California, public water systems are required to comply with both primary and secondary MCLs as per §116555 of the California Safe Drinking Water Act.

Water quality sampling results from Hill Canyon WWTP Effluent Outfall, Station 800A, Arroyo Conejo North Fork (North Fork Flume), Arroyo Conejo South Fork (South Fork Flume), and Conejo Creek (Station 800) (as shown on **Figure 2-1**) indicate that one or more of the regulatory limits are exceeded for the following constituents:

- Chloride
- Nitrate
- Sulfate
- Total Dissolved Solids

Table 2-5
Surface Water Quality Summary from 1990 to 2010[1]

Constituent	Primary MCL	Secondary MCL	RWQCB Basin Plan Objectives[2]	Units	Arroyo Conejo (North Fork)				Arroyo Conejo (South Fork)				Hill Canyon WWTP Effluent Outfall				Conejo Creek (Station 800)				Diversion Flume (Station 800A)			
					Count	Max	Min	Ave	Count	Max	Min	Ave	Count	Max	Min	Ave	Count	Max	Min	Ave	Count	Max	Min	Ave
Chloride	--	250	150	mg/L	213	357	22	219	206	259	54	173	75	188	52	136	217	350	37	154	83	227	39	155
Fluoride	2	--	1.4-2.4[3]	mg/L	31	0.8	0.049	0.37	23	0.74	0.25	0.35	28	1.00	0.07	0.53	29	0.75	0.19	0.47	30	0.8	0.07	0.48
Hardness (as CaCo3)	--	--	--	mg/L	228	899	120	665	215	860	200	665	86	475	150	211	229	600	200	389	93	612	171	371
Nitrate (as NO3)	45	--	45	mg/L	216	28	0.6	8	205	36	0.6	8	75	63	8.2	39	216	102	7	31	82	50	0.3	29
Sulfate	--	250	250	mg/L	211	1040	46.6	311	200	922	68	308	74	173	36	122	216	306	78	200	81	312	42	199
Total Dissolved Solids	--	500	850	mg/L	213	1,660	22	1221	206	1,584	54	1,116	75	820	52	572	217	1,372	37	799	83	1,222	39	790

1. Number of samples per location and constituent vary. Averages are calculated using the total number of samples, as provided by the count.
2. Values provided from the Los Angeles Regional Water Quality Control Board (RWQCB) Basin Plan, dated June 13, 1994, for inland surface waters of the “Calleguas Creek Watershed Above Potrero Road”.
3. MCL for fluoride by annual average of maximum daily air temperature.
MCL = Maximum Contaminant Level
mg/L = Milligrams per Liter
-- = (Not Applicable)

Chloride: The surface water Basin Plan objective for chloride is 150 milligrams per liter (mg/L). As shown in **Table 2-5**, chloride concentrations range from 22 to 357 mg/L. Increased concentration of chloride may be attributed to high chloride levels in Conejo creek, cyclical increases of chloride in imported water, natural sources in geologic formations, and agricultural activities (District, 2011).

Nitrate: The surface water Basin Plan objective for nitrate (as NO_3) is 45 mg/L. As shown in **Table 2-5**, nitrate (as NO_3) concentrations range from 0.6 to 102 mg/L. Concentrations of nitrate have historically exceeded RWQCB Basin Plan objectives. The District currently blends groundwater with State Water Project (SWP) water to adjust high levels of nitrate.

Sulfate: The surface water Basin Plan objective for sulfate is 250 mg/L. As shown in **Table 2-5**, sulfate concentrations range from 36 to 1,040 mg/L.

Total Dissolved Solids (TDS): The surface water Basin Plan objective for TDS is 850 mg/L. As shown in **Table 2-5**, TDS concentrations range from 22 to 1,660 mg/L. Concentration of TDS has remained consistently high since the mid-1980's (Boyle, 1996).

2.3 GROUNDWATER CONDITIONS

This subsection provides a description of general groundwater conditions including the groundwater basin, the geology/hydrogeology, groundwater elevation, and groundwater quality within the SRGMP area.

2.3.1 Groundwater Basin

The Santa Rosa Groundwater Basin underlies Santa Rosa Valley in southern Ventura County. The valley is bounded on the north by the Las Posas Hills and Simi Fault, on the south by the Conejo Volcanic rocks, on the east by the Mountcliff Ridge, and the west by the Pleasant Valley Summit. Ground surface elevations range from about 200 feet in the west to about 400 feet above sea level in the east. The Conejo Hills reach elevations of over 1,000 feet above mean sea level (about 700-800 feet higher than the valley floor). The western boundary of the basin consists of a low, north-trending ridge of volcanic rocks. The narrow Arroyo Santa Rosa Valley separates the Santa Rosa Basin from the Tierra Rejada Basin to the east (District, 1997). The groundwater basin is illustrated on **Figure 2-1**.

2.3.2 Geology and Hydrogeology

The Santa Rosa Basin is located in the tectonically active Transverse Ranges physiographic province. The surrounding mountains are composed of a variety of consolidated marine and terrestrial sedimentary and volcanic rocks of Late Cretaceous through Quaternary age. The basin is filled with a mixture of consolidated and unconsolidated marine and terrestrial coastal deposits of Tertiary and Quaternary age. These basin-fill sediments and consolidated rocks form a complex set of aquifer systems that have been the primary source of water supplies since the early 1900s.

Agriculture has been the main user of groundwater, and in recent years public supply and industry have become significant users of groundwater.

Hydrostratigraphy

According to Hanson et al. (USGS, 2003), lithology in the Santa Rosa Basin and surrounding area can be grouped into two general categories:

- Upper Cretaceous and Tertiary consolidated bedrock and
- Quaternary unconsolidated deposits

The local surficial geology is shown on **Figure 2-6**.

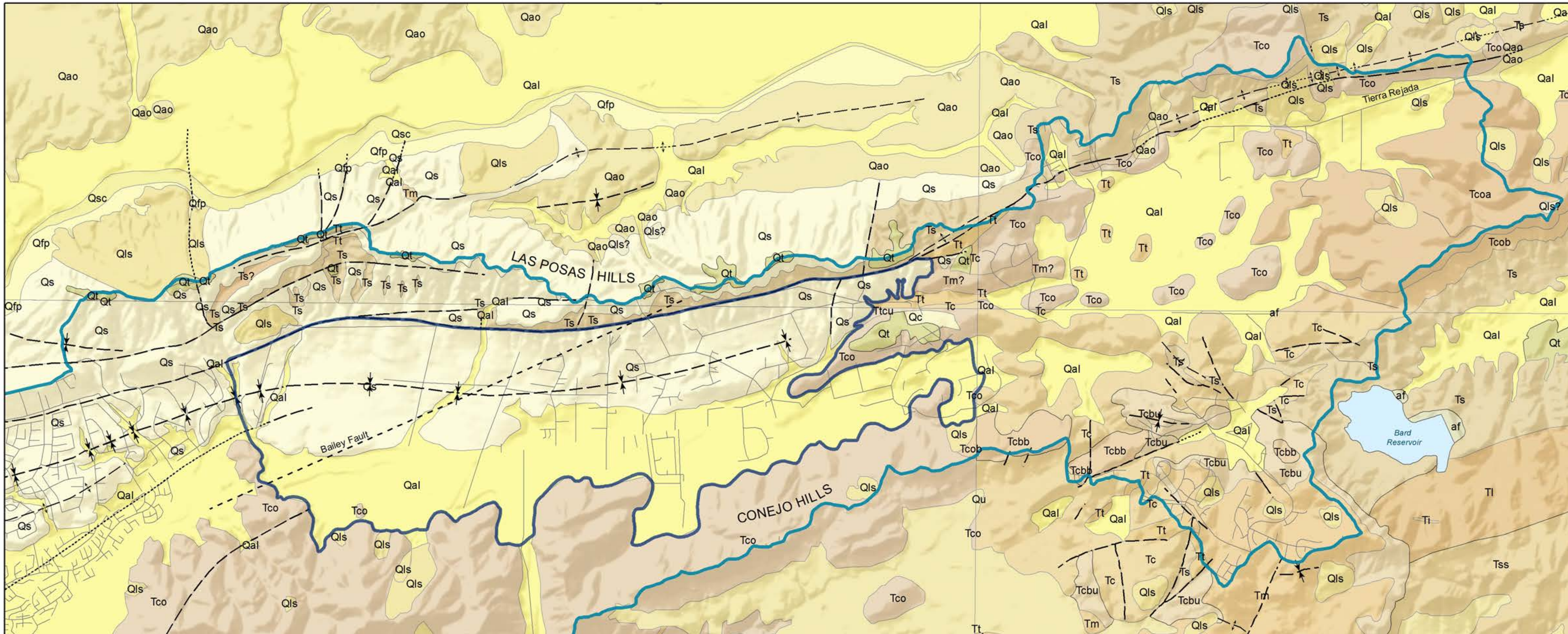
The upper Cretaceous and Tertiary consolidated rocks include sedimentary, volcanic, igneous, and metamorphic rocks. These rocks are virtually non-water bearing and form the base of the basin.

Volcanic rocks and related intrusive rocks of Miocene age underlie parts of Santa Rosa Basin that have been developed for water supply where alluvial deposits are absent. The Conejo Volcanics comprise more than 1,000 feet of basalt breccias and lava flows of Miocene age (Boyle, 1987).

The Santa Margarita Formation in the Santa Rosa Valley subbasin is grouped with the unconsolidated sediments of the lower system. Layers within the Santa Rosa Valley can be 300 to 100 feet thick (Boyle, 1987). During the Pleistocene epoch, major changes in sea level resulted in cycles of erosion and deposition. The sequence of deposits above the erosional unconformities typically starts with a basal conglomerate that is laterally extensive, relatively more permeable than the underlying deposits, and a potential major source of water to wells perforated in these deposits. These coarse-grained layers of fluvial and beach deposits are interbedded with extensive fine-grained layers.

The Quaternary unconsolidated deposits consist of the Santa Barbara Formation, the San Pedro Formation, and the Saugus Formation, all of the Pleistocene epoch, and unconsolidated alluvial and fluvial deposits of the Pleistocene to Holocene epoch. Hanson et al. (USGS, 2003) grouped the unconsolidated deposits together into the upper-aquifer system and the lower-aquifer system.

The Santa Barbara Formation overlies consolidated Tertiary rocks and consists of marine sandstone, siltstone, mudstone, and shale. The formation is of low permeability and generally contains water of poor quality (USGS, 2003). This formation consists of an estimated 20 to 30 feet of blue-gray sandy silt; it only occurs at the extreme western end of the basin and appears to pinch out to the east (Boyle, 1987).



Geologic Units

Quaternary Sedimentary Deposits

Unit	Description
af	Artificial Fill
Qal	Old alluvium-unconsolidated to moderately indurated clay, silt, sand, gravel
Qao	Old alluvium-unconsolidated to moderately indurated clay, silt, sand, gravel
Qc	Colluvium
Qf	Alluvial-fan deposits
Qfp	Floodplain deposits
Qls	Landslide debris
Qs	Saugus Formation - sandstone and pebble conglomerate
Qsc	Stream depostis - unconsolidated gravel, sand and silt in active streambeds
Qsp	San Pedro Formation - unconsolidated sandy unit
Qt	Terrace Deposits - gravel, sand, silt, clay
Qu	Undifferentiated surficial deposits

Tertiary

Unit	Description
Tc	Conejo Volcanics - basalt flows, breccia
Tcbb	Tcbb - Conejo Volcanics - basaltic lower zone, basalt and andesitic basalt, basaltic breccia
Tcbu	Tcbu - Calabasas Formation - undivided interbedded clayey to silty sandstone and silty shale
Tco	Tco - Conejo Volcanics - undivided
Tcoa	Tcoa - Conejo Volcanics - andesitic central zone
Tcob	Conejo Volcanics - basalt and andesitic basalt
Ti	Intrusive rocks, undivided
Tl	Llajas Formation - sandstone, conglomerate
Tm	Modelo Formation - mudstone, diatomaceous clay shale, or siltstone
Ts	Sespe Formation - pebbly to conglomerate sandstone
Tss	Santa Susana Formation sandstone, siltstone
Tt	Topanga Group - fine to medium grained sandstone
Ttcu	Topanga Canyon Formation - undivided, marine sandstone
Tv	Vaqueros Formation - Sandstone and interbedded siltstone

Santa Rosa Valley Groundwater Basin

Watershed

Fault, Approximately Located

Fault, Concealed

Syncline, Concealed

Syncline, Approximately Located

Road

Geology Map Source: USGS, 1975

N 0 0.5 1 Miles

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Santa Rosa Basin Local Geology Map

MWH

Figure 2-6

The lower portion of the San Pedro Formation consists of marine sand and gravel beds. The upper part of San Pedro Formation consists of lenticular layers of sand, gravel, silt, and clay of marine and continental origin (USGS, 2003). The silt, sand, and gravel fluvial deposits within the upper part of the San Pedro Formation are mapped to as the Saugus Formation. The sand and gravel layers range from 10 to 105 feet thick and are separated by silt and clay layers that generally are 10 to 20 feet thick (Boyle, 1997). The Santa Barbara and San Pedro Formations are absent east of the Santa Rosa Valley. In the eastern part of the basin, recent alluvial and terrace deposits were deposited unconformably on the marine shale and sandstone beds of the Santa Margarita Formation (Late Miocene) or rest unconformably on the Conejo Volcanics (Middle Miocene).

The Late Pleistocene and Holocene deposits are unnamed, consist of relatively flat-lying unconsolidated alluvial deposits. The alluvium deposits include gravels, sands, and silts deposited within and adjacent to the channels of Santa Rosa, and Conejo Creeks. These deposits are generally less than 100 feet thick (Boyle, 1987), and are regionally grouped into the upper system of water-bearing deposits. These deposits were deposited unconformably on the older unconsolidated deposits. The basal deposits of the Holocene epoch consist of gravel and sand, which are overlain by fine-grained deposits. These basal deposits are relatively more permeable than underlying deposits, and are potential major sources of water to wells completed in the saturated parts of these deposits.

Aquifer Systems

Hansen et al. (USGS, 2003) divided the water-bearing deposits in the Santa Clara-Calleguas Basin into six aquifers. In the Santa Rosa Basin, however, five aquifers are identified. The unconsolidated deposits of the late Pleistocene and Holocene epochs are grouped into the regional upper-aquifer system, which includes the Shallow, Oxnard, and Mugu Aquifers. The lower-aquifer system is composed of complexly faulted and folded unconsolidated deposits of the Pliocene and Pleistocene epochs and includes the Upper and Lower Hueneme Aquifers. This representation is regional, but consistent with Bailey (1969, and Boyle, 1987) for the Santa Rosa Basin. East of the Bailey Fault, the shallow aquifer, Santa Margarita, and Conejo Volcanics are the primary water bearing units (Boyle, 1987).

The Shallow Aquifer extends from land surface to a depth of up to 600 feet (Boyle, 1987). The Shallow Aquifer consists of fine-to-medium sand with interbedded clay layers. Clay layers separate the Shallow Aquifer from the underlying Santa Margarita Aquifer.

East of the Bailey Fault, underlying the Shallow Aquifer is the Santa Margarita Aquifer. The thickness of this aquifer is 700 feet in the center of the basin and pinches out against the Conejo Volcanics to the south (Boyle, 1987).

Structure and Groundwater Subbasins

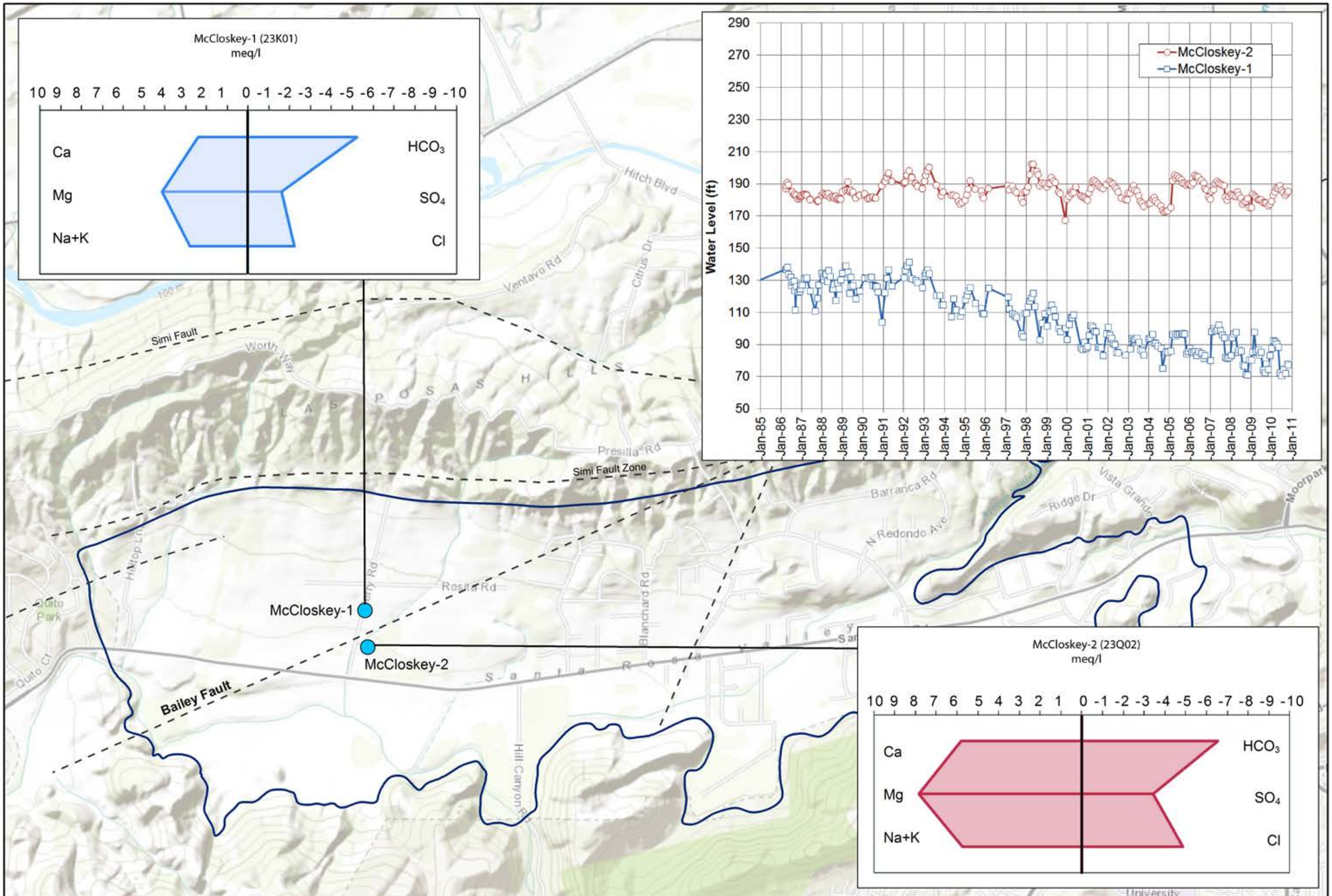
The dominant structural feature of the Santa Rosa Groundwater Basin is the Santa Rosa Syncline, which is a roughly east-west trending downward folding that extends from the east end of the Tierra Rejada Valley dipping westward into Pleasant Valley. Two northeast-southwest trending faults cut the Santa Rosa Groundwater Basin into three subbasins. The western fault is termed Bailey Fault and the eastern fault is unnamed. The western subbasin (west of the Bailey fault) is managed by the FCGMA. The SRGMP study focuses on the eastern two subbasins. There is little evidence of hydraulic subdivision of the two eastern subbasins; they are considered the same basin in this document. The westernmost subbasin divided by the Bailey Fault from the others, shows hydraulic separation from the eastern two thirds of the basin and is discussed below.

Bailey Fault

Boyle Engineering (1997) reported water level differences of 60 to 80 feet across the fault. McCloskey Well-1 (screened 350-800 feet bgs) and McCloskey Well-2 (no screen data is available) are located on west and east side of the Bailey Fault separated by a distance of 900 feet. **Figure 2-7** shows the location of the two wells, hydrographs, and water quality diagrams for each. Water levels at McCloskey Well-2 were generally around 180 feet mean sea level (msl) with low magnitude of fluctuation from March 1986 to July 2010. The average water elevation at McCloskey Well-1 was 108 feet msl and the water level fluctuated from a low of 66 feet msl on May 4, 1964 to a high of 142 feet msl on April 1, 1992.

Water quality data are illustrated with water quality or Stiff diagrams on **Figure 2-7**. A Stiff diagram is a graphical representation of chemical analyses developed by H.A. Stiff (Stiff, 1951). Stiff diagrams are created by plotting the equivalent concentration of the cations left of the center axis and anions on the right. The points are connected to form the figure. These diagrams are useful for quickly identifying water from different sources. A sample taken from McCloskey Well-1(23K01) on May 25, 2000 has a magnesium-sodium-bicarbonate (Mg-Na-HCO3) character, a TDS concentration of 560 mg/L and a nitrate concentration of 10 mg/L. A sample from McCloskey Well-2(23Q02) was taken on May 25, 2000 and analyzed to have magnesium-calcium-bicarbonate (Mg-Ca-HCO3) character, a TDS concentration of 1170 mg/L, and a nitrate concentration of 292 mg/L.

The water level and water quality differences (i.e. Stiff diagram differences) suggest that the Bailey fault is a groundwater flow barrier.



Key to Features

Well

Santa Rosa Valley Groundwater Basin

N

0 0.25 0.5 Miles

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Bailey Fault as a Barrier to Groundwater Flow

MWH

Figure 2-7

2.3.3 Groundwater Production

The District has been the major producer of groundwater within the Santa Rosa Basin. Major pumping wells are SRMWC-3, SRMWC-8, SRMWC-9, SRMWC-10, Penney, Conejo-1, Conejo-2, Conejo-3, and Conejo-4. Annual total production provided by the District is summarized on **Figure 2-8.** Groundwater production had been reduced sharply from the late 1950s and early 1960s until 1991, when pumping began to increase until 2008. Annual total production over the last 50 years is approximately 3,040 acre-feet/year. **Figure 2-9** indicates production well location and **Table 2-6** lists all the wells in the Santa Rosa Basin along with summary information for each well.

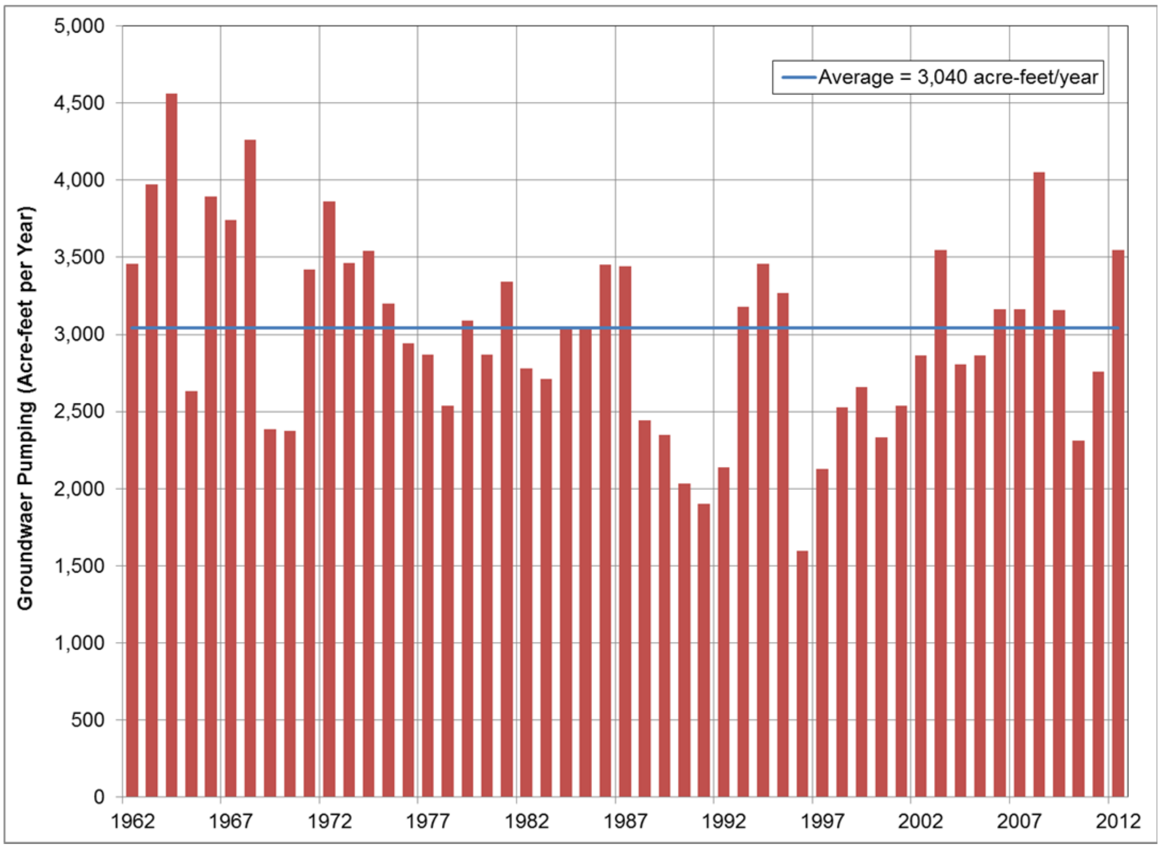
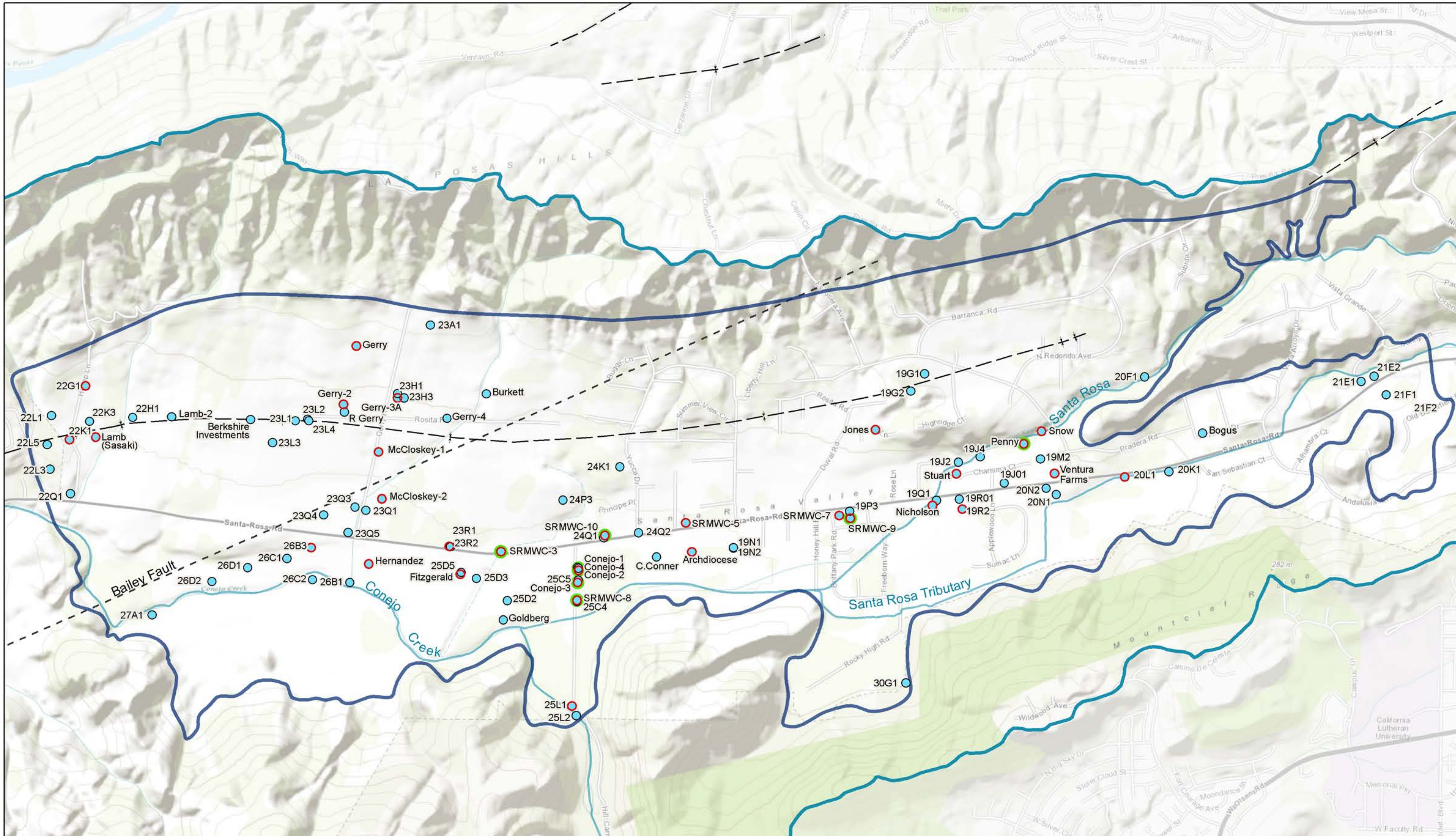


Figure 2-8
Known Santa Rosa Basin 50-Year Groundwater Pumping Summary (no data for 1984 and 1985, assumed mean value)

Groundwater remains an important water supply for the area and the Santa Rosa Basin groundwater represents roughly 12 percent of the total supply for the District, or about 16 percent of the total potable supply (District, 2011a). **Table 2-7** lists the projected pumping in the Santa Rosa Basin through 2035 and the percent of the total water supply the Santa Rosa groundwater comprises (District, 2011a). The planned pumping amounts are approximately 16 percent higher than the 50-year pumping average.



Key to Features

Santa Rosa Valley Groundwater Basin
Watershed
Well
Well with Water Quality Data
Stream
Syncline, Approximately Located
Well with Water Levels
Well with Water Levels and Water Quality Data

Topo Map Source: ESRI

0 0.25 0.5 Miles

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Santa Rosa Basin Well Map

MWH

Figure 2-9

Table 2-6
Santa Rosa Basin Summary of Well Information

State Well No.	Local Well or Map Name	Well Elevation (ft MSL)	Lithology Record (Y/N)	Water Level Period	Status (if known)
02N/19W-19G01	19G1				
02N/19W-19G02	19G2				
02N/19W-19J01	19J1	301	Y	1989	
02N/19W-19J02	19J2				
02N/19W-19J03	Stuart	315	N	1986-2003	
02N/19W-19J04	19J4		Y	1951	
02N/19W-19L01	Jones	347	N	1972-88	Destroyed
02N/19W-19N01	19N1	237.9	N	None	
02N/19W-19N02	19N2	240	Y	None	In-use
02N/19W-19M02	19M2				
02N/19W-19P01	SRMWC-7	276.6	N	1986-89	
02N/19W-19P02	SRMWC-9	280	Y	1986-Present	In-use
02N/19W-19P03	19P3				
02N/19W-19Q01	19Q1	265	Y	None	
02N/19W-19Q02	Nicholson	290	N	1986-2010	
02N/19W-19R01	19R1	295.26	N	None	
02N/19W-19R02	19R2	291.4	Y	1972-1986	
02N/19W-20F01	20F1				
02N/19W-20K01	20K1	318.3	Y	None	
02N/19W-20K02	Bogus		N	None	
02N/19W-20L01	20L1	302.5	Y	1972-Present	Inactive
02N/19W-20M01	Snow	320.6	Y	1986-94	Destroyed
02N/19W-20M03	Ventura Farms	322	Y	1986-2000	In-use
02N/19W-20M04	Penny	325	Y	1986-2010	Inactive
02N/19W-20N01	20N1	305.55	N	None	
02N/19W-20N02	20N2	316.22	Y	None	In-use
02N/19W-21E01	21E1	420	Y	None	
02N/19W-21E02	21E2	438	Y	None	
02N/19W-21F01	21F1		Y	None	
02N/19W-30G01	30G1				
02N/20W-22G01	22G1			1969-2008	
02N/20W-22H01	22H1				
02N/20W-22J01	Lamb-2		Y	None	In-use
02N/20W-22K01	22K1				
02N/20W-22K02	Lamb (Sasaki)	282	Y	1986-93	In-use
02N/20W-22K03	22K3				
02N/20W-22L01	22L1				
02N/20W-22L03	22L3				
02N/20W-22Q01	22Q1				
02N/20W-23A01	23A1				
02N/20W-23G01	Gerry	378	Y	1986-93, 2012	
02N/20W-23G02	Gerry-2	310	Y	1987-2010	Abandoned
02N/20W-23G03	R Gerry		Y	None	In-use
02N/20W-23H01	23H1				
02N/20W-23H02	Gerry-3A	320	Y	1986-93	In-use
02N/20W-23H03	23H3				
02N/20W-23J01	Gerry-4		Y	None	In-use

State Well No.	Local Well or Map Name	Well Elevation (ft MSL)	Lithology Record (Y/N)	Water Level Period	Status (if known)
02N/20W-23K01	McCloskey-1	274	Y	1955-Present	In-use
02N/20W-23L02	23L2				
02N/20W-23L03	23L3		Y	None	In-use
02N/20W-23L04	23L4				
02N/20W-22L05	22L5				
02N/20W-23L01	23L1				
02N/20W-23M01	Berkshire Investments		Y	None	In-use
02N/20W-23Q01	23Q1	230	Y	None	
02N/20W-23Q02	McCloskey-2	235	Y	1986-2010	In-use
02N/20W-23Q03	23Q3	226.3	Y	None	
02N/20W-23Q04	23Q4		Y	None	
02N/20W-23Q05	23Q5		Y	None	
02N/20W-23R01	23R1	234.6	Y	1928-Present	In-use
02N/20W-23R02	23R2				
02N/20W-24E01	Burkett	330	Y	None	In-use
02N/20W-24K01	24K1	300	Y	None	
02N/20W-24P03	24P3		Y	None	
02N/20W-24Q01	24Q1	225.97	Y	None	
02N/20W-24Q02	24Q2	225.5	Y	None	
02N/20W-24Q03	SRMWC-10	235	Y	1986-95	In-use
02N/20W-24R02	Archdiocese	240	Y	1986-2002	
02N/20W-24R03	SRMWC-5	245	Y	1986-96	Destroyed
02N/20W-25B01	C.Conner	800	Y	None	In-use
02N/20W-25C01	Conejo-1	235	Y	None	In-use
02N/20W-25C02	Conejo-2	226	Y	1986-Present	In-use
02N/20W-25C03	25C3	227.16	Y	None	
02N/20W-25C04	25C4	228	Y	1986-93	
02N/20W-25C05	Conejo-3	220	Y	1993-2010	In-use
02N/20W-25C07	Conejo-4				
02N/20W-25C06	SRMWC-8	260	Y	1986-2008	In-use
02N/20W-25D01	SRMWC-3	235	Y	1986-2010	In-use
02N/20W-25D02	25D2		Y	None	
02N/20W-25D03	25D3	222.87	Y	None	
02N/20W-25D04	Fitzgerald	219.1	Y	1986-95	In-use
02N/20W-25D05	25D5	234	Y	None	In-use
02N/20W-25D06	Goldberg	230	Y	None	In-use
02N/20W-25L01	25L1	235.2	Y	1972-2004	
02N/20W-25L02	25L2	234.91	Y	None	
02N/20W-26B01	26B1	204.7	Y	None	
02N/20W-26B02	Hernandez	200	Y	1986-2000	In-use
02N/20W-26B03	26B3	218	Y	1972-Present	
02N/20W-26C01	26C1				
02N/20W-26C02	26C2	201.63	Y	None	
02N/20W-26D01	26D1		Y	None	
02N/20W-26D02	26D2				
02N/20W-27A01	27A1		Y	None	

Table 2-7
Projected Santa Rosa Basin Groundwater Pumping

	2015	2020	2025	2030	2035
Projected Groundwater Pumping[1] (acre-feet/year)	3,530	3,530	3,530	3,530	4,650
Percent of Total District Water Supply[1]	13	13	12	12	11

1. Camrosa Water District Urban Water Management Plan (District, 2011b).

For purposes of groundwater management, if the District acts as a replenishment agency, pursuant to Part 4 (commencing with Section 60220) of Division 18, may fix and collect fees and assessments for groundwater management. These fees must be equitable annual fees and assessments for groundwater management based on the amount of groundwater extracted from the basin for costs incurred for groundwater management. These costs might include the acquisition of replenishment water, administrative and operating costs, and costs of construction of capital facilities necessary to implement the groundwater management plan. This practice is not currently employed by the District.

2.3.4 Groundwater Monitoring, Levels, and Movement

This section describes the current conceptual understanding of groundwater levels, trends, and recharge and discharge of groundwater flow in the Santa Rosa Basin. Historically, the District monitored water level data at 19 production wells. Among these wells, Chamberlain 5, SRMWC-5, Snow, and Ventura Farms have been abandoned, destroyed, or no longer produce water. The Ventura County Watershed Protection District has maintained a record of water level measurements at eight wells in the Basin. The water level monitoring information is summarized in **Table 2-6**. In total, 11 continuous water level measurement records up to 2010 or later have been maintained. The District has also recorded its production at 11 production wells: Penny, SRMWC-3, SRMWC-8, SRMWC-9, SRMWC-10, Conejo-1, Conejo-2, Conejo-3 and Conejo-4. Water levels and groundwater production are reported on a monthly basis. Non-District groundwater pumping is not reported. (When no local well name is available, the last four characters of the state well number are used, e.g., 2N19W20L1 = 20L1.)

Groundwater levels experienced a steady decline at an average of approximately five feet per year from the early 1950's to the early 1960's. This water level decline was due to groundwater pumping in combination with lower than average recharge. Coincident with the commencement of discharges from the Hill Canyon WWTP effluent into the Arroyo Conejo Creek by the City of Thousand Oaks since 1964, water levels in the Basin have been rising rapidly (Boyle, 1987). While water levels in the central portion of the Basin rose at an average rate of 10 feet per year from 1964 to 1972, water levels rose in the eastern portion of the basin at a rate of 5 feet per year from 1964 to 1980 (Boyle, 1987). Through the early 1980s water levels remained flat with a decreasing trend in groundwater pumping and then in the mid-1980s to early 1990s water levels began to decline during a period of lower than average precipitation. In the late 1990s groundwater levels experienced a steady increase of up to 10 feet per year due a period of higher than average precipitation.

Based on existing water level data, three typical hydrographs have been identified. These hydrographs are representative of the eastern, central and western (east of the Bailey Fault) portions of the Basin. The magnitude of water level fluctuation reduces from east to west. **Figure 2-10 Figure 2-11**, and **Figure 2-12** are hydrographs for wells 20L1, SRMWC-9, and 26B3, respectively. These wells represent the eastern, central, and western portions of the Basin respectively; their locations are shown on **Figure 2-9**.

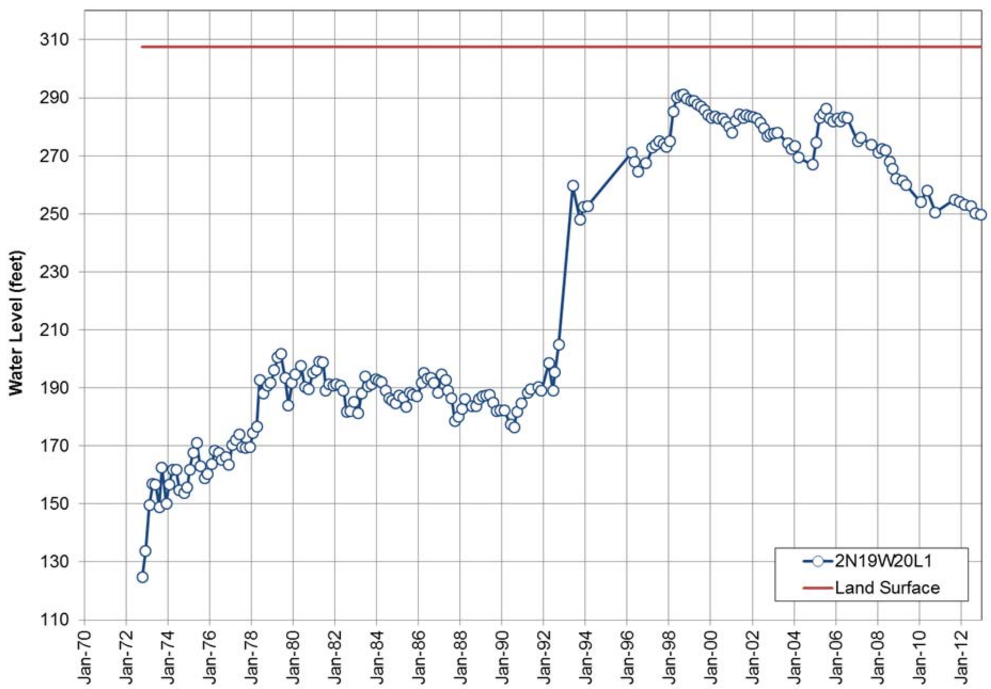


Figure 2-10
Eastern Santa Rosa Basin Long Term Hydrograph for Well 20L1

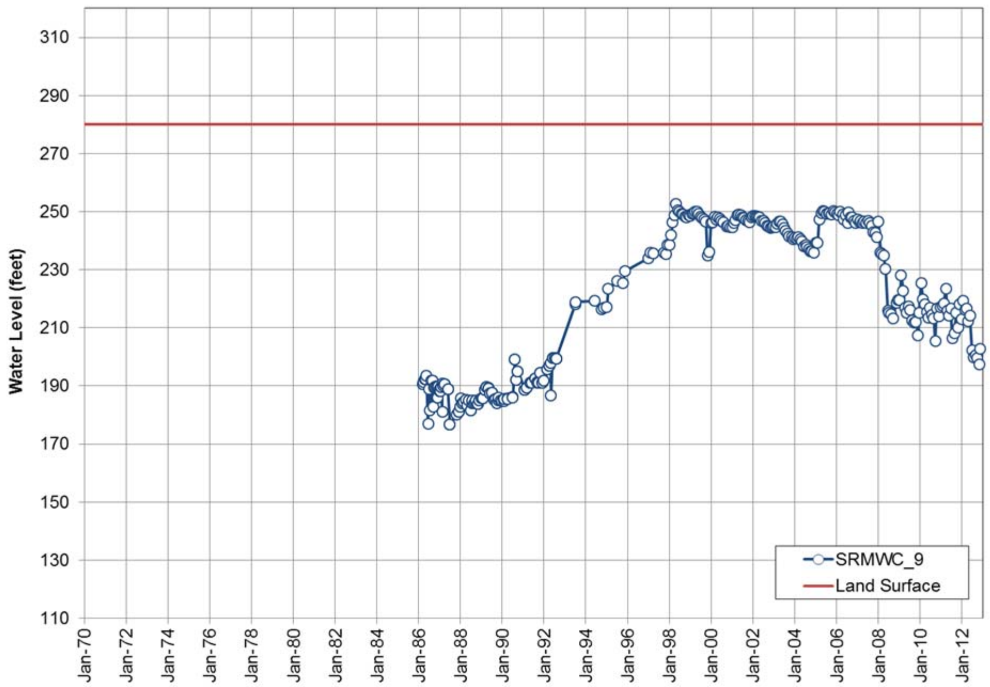


Figure 2-11
Central Santa Rosa Basin Long Term Hydrograph for SRMWC-9

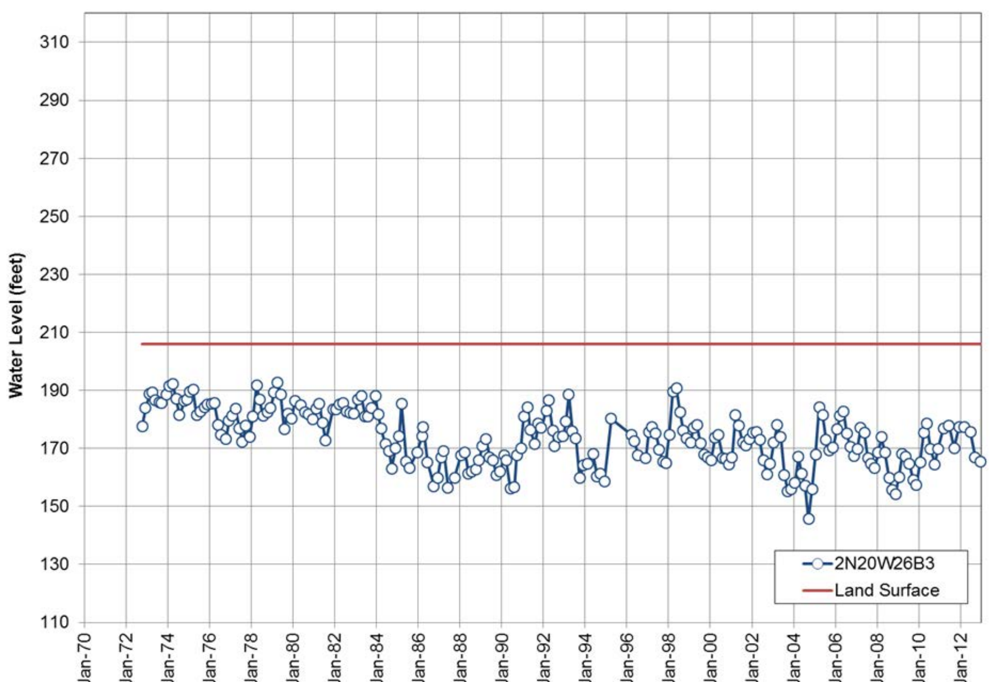


Figure 2-12
Western Santa Rosa Basin Long-Term Hydrograph for 26B3

Approximately to 110 feet of water level rise was observed in Well 20L1 from August 1990 to August 1998. Over this same period, the water level rose approximately 50 feet in Well SRMWC-9. A water level rise of 25 feet was observed in Well 26B3. The water level changes during this period correlate to the reduction in groundwater pumping and wet weather conditions.

Figure 2-13 shows the hydrograph for Well 20L1 with annual precipitation and a five-year moving average of annual precipitation. There is a strong correlation between precipitation and water levels in the eastern portion of the basin. Western wells, e.g., Well 26B3 exhibit much less variably.

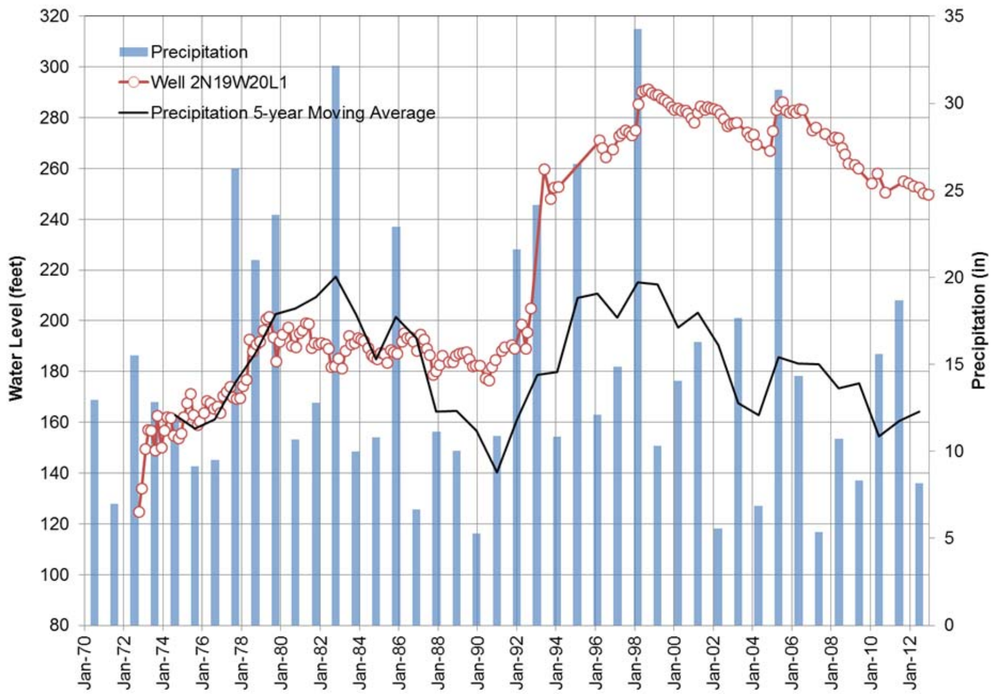
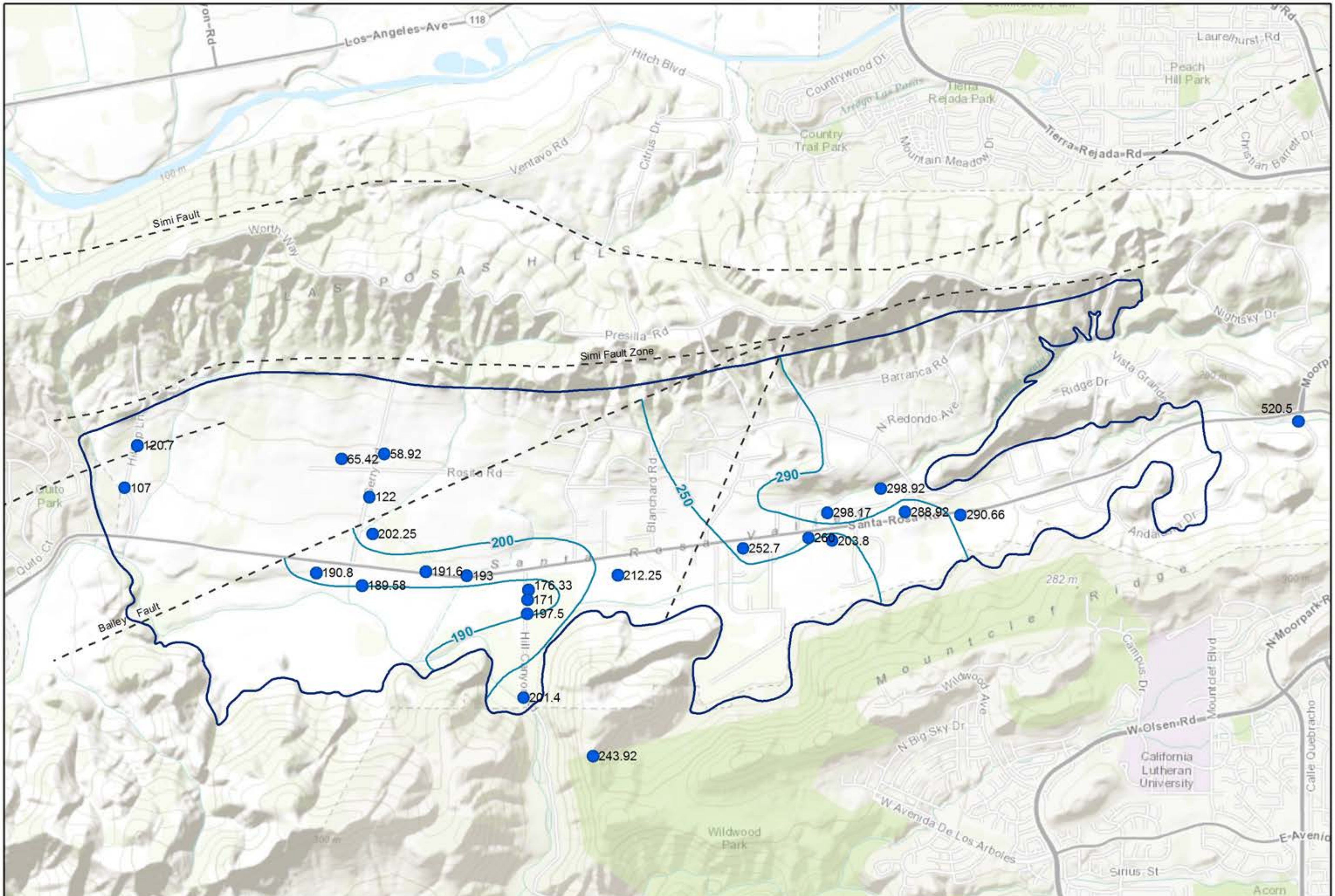


Figure 2-13
Annual Precipitation and Hydrograph for Well 20L1

Figure 2-14 and **Figure 2-15** represent high water (2006) and lower water (1990) conditions for the Santa Rosa Groundwater Basin. These contour maps illustrate the lines of equal hydraulic, or piezometric, head in the aquifer. Groundwater flow is from east to west, regardless of the high or low condition. These figures also indicate the primary recharge sources in the Santa Rosa Basin are from the east and north. Hydrographs for all wells within the data where data is available are in **Appendix B**.



Key to Features

- Well
- Wet Year Contours of Equal Groundwater Elevation (10 foot intervals)
- Santa Rosa Valley Groundwater Basin

N

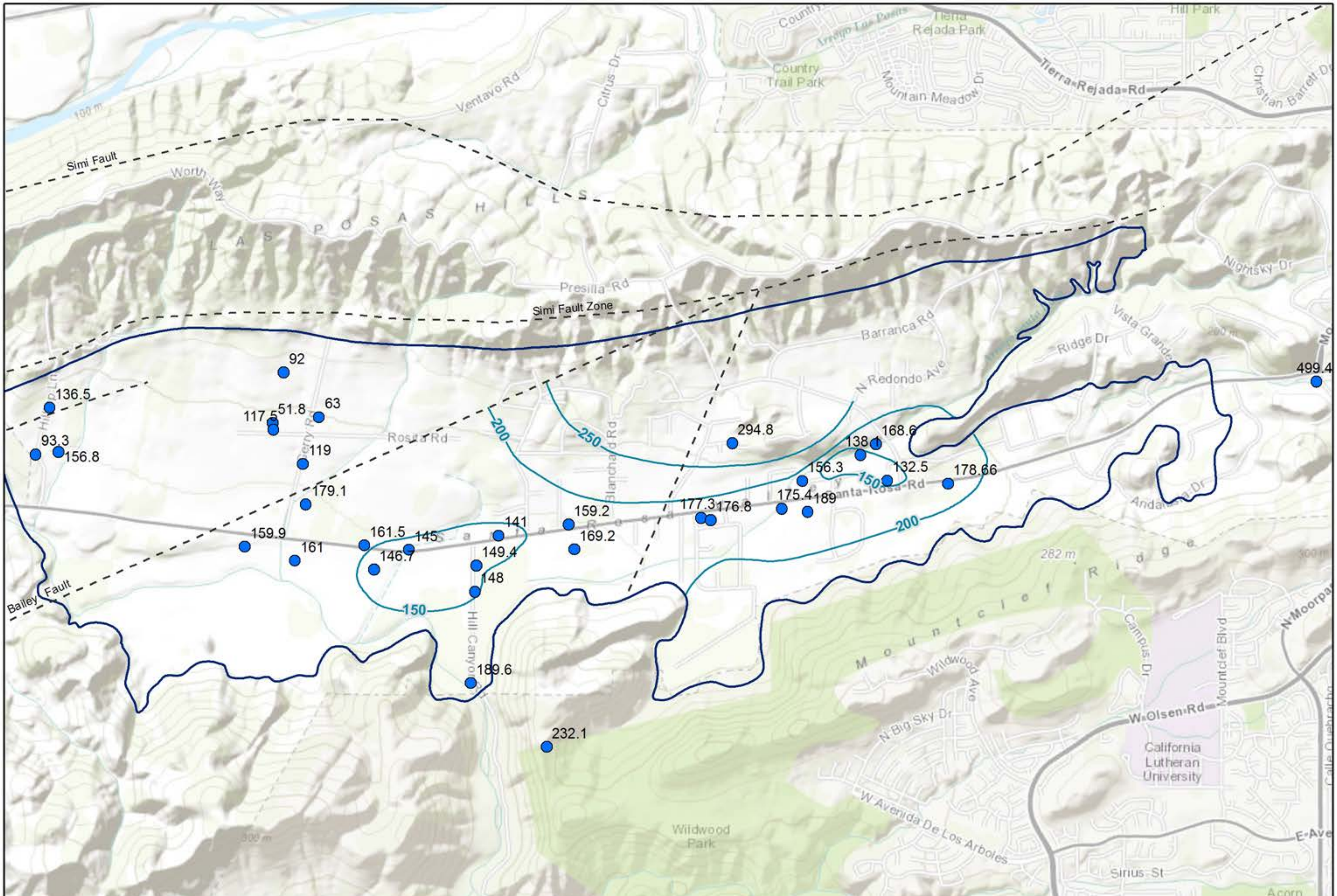
0 0.25 0.5 Miles

Document: \\Uspas1s01\muni\Clients\Camrosa Water District\Santa Rosa GMP\14 e-data_modeling_MXDs\HighGWElev.mxd

High Water Groundwater Elevations (2006)

MWH

Figure 2-14



Key to Features

- Well
- Santa Rosa Valley Groundwater Basin
- Dry Year Contours of Equal Groundwater Elevation (50 foot intervals)

N

0 0.25 0.5 Miles

Document: \\Uspas1s01\muni\Clients\Camrosa Water District\Santa Rosa GMP\14 e-data_modeling_MXDs\LowGWElev.mxd

Low Water Groundwater Elevations (1990)

MWH

Figure 2-15

2.3.5 California Statewide Groundwater Elevation Monitoring

In 2009 the California State Legislature amended the Water Code with SBx7-6. This Bill mandates a groundwater level monitoring to track trends in groundwater elevation in the Bulletin 118 defined groundwater basins. With local monitoring and State reporting, collaboration is required between local monitoring agencies and DWR. In accordance with this amendment to the Water Code, DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program. The purpose of CASGEM is to establish a program of regular and systematic monitoring of groundwater elevations and to track seasonal and long-term trends in groundwater elevations statewide (DWR, 2012). Local agencies conduct the monitoring and DWR's role is to coordinate the statewide CASGEM program for statewide reporting. The law anticipates that the monitoring of groundwater elevations required by the enacted legislation will be done by local entities. The law required local entities to notify DWR in writing by January 1, 2011 if the local agency or party seeks to assume groundwater monitoring functions in accordance with the law (DWR, 2012).

One of the major benefits of the CASGEM system is that groundwater levels are coordinated statewide and made available for public access. The Santa Rosa Basin has four wells in the CASGEM system. Dr. Timothy Ross, the Southern Region contact for DWR and CASGEM, ensures that the groundwater level for all CASGEM wells in Ventura County are being collected and submitted by the Ventura County Watershed Protection District. As long as there exists a reporting entity in charge of the groundwater basin, overlapping agencies become eligible for all state loans and grants that require CASGEM compliance. Because the Ventura County Watershed Protection District is reporting groundwater level data, the District (Camrosa Water District) has attributed to it all the benefits of compliance. In a document written to the Ventura County Board of Supervisors on December 14, 2010, the Ventura County Watershed Protection District documented the plan and background for assuming monitoring duties for the entire county. The following is an excerpt from that document:

"*The District (Ventura County Watershed Protection District) is the only entity in the County with the jurisdiction to monitor groundwater elevation levels in all the groundwater basins within the County. The District has decades of experience in groundwater level monitoring throughout the County and currently measures almost 200 wells every six weeks. The District has a database of groundwater level data dating back to the early 1970's and beyond. All other groundwater entities within the County have been contacted, are willing to provide data, and have no objection to the District becoming the Umbrella Monitoring Entity for Ventura County. By volunteering to be the Monitoring Entity for all groundwater basins within Ventura County, the District continues to be a regional provider of services to all County residents with up to date groundwater resource data and information, while providing an additional benefit to many local agencies to avoid risking their eligibility to apply for future state loans and grants.*" (Ventura County Watershed Protection District, 2010)

The District need take no action to comply with Water Code/SBx7-6.

2.3.6 Groundwater Quality

Water quality in the Santa Rosa Groundwater Basin has been studied by several authors, including Perliter and Ingalsbe Consulting Engineers for the Camrosa County Water District in 1977 and in 1980, the U.S. ·Bureau of Reclamation in 1978, and Boyle Engineering in 1987 and 1997. Historically, a common conclusion drawn from these investigations is that total TDS and Nitrate (nitrate-nitrogen) concentrations have been rising since the mid-1950's. The rise in TDS concentrations reflect a basin wide trend, while high nitrate values appeared more localized.

Historically, nitrate concentrations occasionally exceed State standards for certain wells within the basin. Speculation attributes these localized occurrences of elevated concentrations of nitrate to percolation of residues of nitrogen-based fertilizers, wells with inadequate sanitary seals, excessive application of fertilizers, effluent from septic tanks, and effluent from the Thousand Oaks Hill Canyon Treatment Plant. TDS concentrations have remained fairly consistent since the mid-1980's. TDS concentrations have ranged between 600 and 1,500 mg/L.

For this GMP, groundwater quality data within the Santa Rosa Basin has been collected and reported for the period from 1990 to the present. Monthly samples are collected from the following wells Conejo-2, Conejo-3, Conejo-4, Penny, SRMWC-10, SRMWC-3, SRMWC-8, and SRMWC-9 and analyzed for chloride, fluoride, hardness, nitrate, nitrite, pH, phosphate, sulfate, TDS, and turbidity. Weekly samples are collected from Conejo-2, Conejo-3, Conejo-4 and analyzed for nitrate. Additional sampling and analysis for other constituents is conducted periodically, approximately every one to three years. This section provides a summary of the groundwater quality results and brief descriptions of trends for constituents in relation to regulatory objectives.

Concentrations of various minerals in groundwater have increased since 1987 (Boyle, 1996). The primary influences over groundwater quality within the basin are agricultural operations, residential use with septic systems, and Hill Canyon WWTP effluent.

Table 2-8 presents a basin-wide water quality summary for the period of 1997 to 2011 provided by the District. **Table 2-8** also lists applicable groundwater quality objectives for groundwater within the Arroyo Santa Rosa Hydrologic Unit. These are published in the Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (RWQCB, 1994) and commonly referred to as Basin Plan objectives. The Basin Plan objectives are intended to protect the public health, and maintain or enhance water quality in relation to existing and potential beneficial uses of the water. **Table 2-8** also lists California drinking water quality standards (both primary and secondary MCLs for comparison purposes).

Table 2-8 indicates that chloride, nitrate, sulfate, and TDS exceed Basin Plan objectives. Water quality results from Conejo-2, Conejo-3, Conejo-4, Penny, SRMWC-10, SRMWC-3, SRMWC-8 and SRMWC-9 were analyzed in further detail for these constituents of concern. **Table 2-9** summarizes data for these wells and constituents. These constituents of concern are discussed in further detail below.

Table 2-8
Santa Rosa Groundwater Basin Groundwater Quality Summary from 1997 to 2011[1]

Constituent	Primary MCL	Secondary MCL	RWQCB Groundwater Basin Plan Objectives[2]	Units	Results		Exceeds Primary or Secondary MCL	Maximum Exceeds RWQCB Groundwater Basin Plan Objective
General Mineral					Maximum	Minimum		
Calcium	--	--	--	mg/L	102	72	--	--
Chloride	--	250	150	mg/L	249	100	Yes	Yes
Fluoride	2	--	1.0	mg/L	0.94	0.18	No	No
Hardness (as CaCo3)	--	--	--	mg/L	802	360	--	--
Magnesium	--	--	--	mg/L	92	58	--	--
Nitrate (as NO3)	45	--	45	mg/L	179	6.7	Yes	Yes
Potassium	--	--	--	mg/L	2	1	--	--
Sodium	--	--	--	mg/L	108	89	--	--
Sodium Percent	--	--	60	%			--	No
Sulfate	250	250	300	mg/L	489	104	Yes	Yes
Alkalinity (total)	--	--	--	mg/L	360	230	--	--
General Physical								
Total Dissolved Solids	500	500	900	mg/L	1492	670	Yes	Yes
Inorganics								
Aluminum	1	0.2	1	mg/L	ND	ND	No	No
Antimony	0.006	--	0.006	mg/L	ND	ND	No	No
Arsenic	0.01	--	0.05	mg/L	0.006	0.003	No	No
Barium	2	--	1	mg/L	0.021	0.005	No	No
Beryllium	0.004	--	0.004	mg/L	ND	ND	No	No
Boron	--	--	1	mg/L	0.300	ND	--	No
Cadmium	0.005	--	0.005	mg/L	ND	ND	No	No
Chromium	0.05	--	0.05	mg/L	0.0150	0.002	No	No
Copper	--	1	--	mg/L	0.01	ND	No	--
Iron	--	0.3	0.3	mg/L	ND	ND	No	No
Lead	0.015	--	--	mg/L	0.0054	ND	No	--
Manganese	--	0.05	0.05	mg/L	ND	ND	No	No
Mercury	0.002	--	0.002	mg/L	ND	ND	No	No
Nickel	0.1	--	0.1	mg/L	0.005	ND	No	No
Perchlorate	--	--	--	mg/L	ND	ND	--	--
Selenium	0.05	--	0.05	mg/L	0.005	0.003	No	No
Silver	--	0.1	--	mg/L	ND	ND	No	--
Thallium	0.002	--	0.002	mg/L	ND	ND	No	No
Vanadium	--	--	--	mg/L	0.061	0.059	--	--
Zinc	--	5.0	--	mg/L	ND	ND	No	--

1. Table was provided by Camrosa Water District and amended using recent data provided by Camrosa Water District.
2. Values provided from the Los Angeles Regional Water Quality Control Board (RWQCB) Basin Plan, dated June 13, 1994, for the Arroyo Santa Rosa basin.
mg/L = Milligrams per Liter
-- = (Not Applicable)

Table 2-9
Santa Rosa Groundwater Basin Well Water Quality Summary from 1990 to 2010[1]

Constituent	Primary MCL	Secondary MCL	RWQCB Basin Plan Objectives[2]	Units	Conejo-2				Conejo-3				Conejo-4				Penny			
					Count	Max	Min	Ave	Count	Max	Min	Ave	Count	Max	Min	Ave	Count	Max	Min	Ave
Chloride	--	250	150	mg/L	181	189	97	145	190	241	112	144	165	195	88	137	153	249	47	107
Nitrate (as NO3)	45	--	45	mg/L	194	179	5	104	201	140	4.6	78	169	152	6.8	103	155	43	0.88	15
Sulfate	--	250	300	mg/L	181	280	52	186	190	347	120	193	165	263	68	174	153	200	7.2	99
TDS	--	500	900	mg/L	180	1,490	308	973	188	1,350	724	962	161	1,308	412	955	153	834	348	643

Constituent	Primary MCL	Secondary MCL	RWQCB Basin Plan Objectives[2]	Units	SRMWC-10				SRMWC-3				SRMWC-9				SRMWC-8			
					Count	Max	Min	Ave	Count	Max	Min	Ave	Count	Max	Min	Ave	Count	Max	Min	Ave
Chloride	--	250	150	mg/L	68	173	99	129	94	195	109	148	18	139	65	98	209	180	40	148
Nitrate (as NO3)	45	--	45	mg/L	84	137	80	109	93	112	27	57	26	175	81	101	221	91	7	35
Sulfate	--	250	300	mg/L	68	262	118	171	94	262	120	195	18	145	100	116	209	489	24	195
TDS	--	500	900	mg/L	66	1,492	682	941	94	1,156	746	950	17	828	558	739	207	1118	528	874

1. Number of samples per location and constituent vary. Averages are calculated using the total number of samples, as provided by the count.
2. Values provided from the Los Angeles Regional Water Quality Control Board (RWQCB) Basin Plan, dated June 13, 1994, for the Arroyo Santa Rosa basin.
MCL = Maximum Contaminant Level
mg/L = Milligrams per Liter
-- = (Not Applicable)
No = Number of samples collected from 1990 to 2010

Chloride, nitrate, sulfate, and TDS were further analyzed for trends in space and time. **Figure 2-16**, **Figure 2-17**, **Figure 2-18**, and **Figure 2-19** display data for these constituents for Penny Well, Conejo 3, and SRMWC 3 from the period of 1990 to 2010. These wells represent the eastern, central, and western portions of the Basin, respectively. Water quality in the eastern portion of the Basin, represented by Penny Well, is typically of lower concentration for all four constituents. Chloride, sulfate, and TDS are shown to increase over time for Conejo 3. Nitrate increases over time for Conejo 3 from 1990 to 2002, then decreases from 2002-2010. The four constituents are discussed in further detail below.

Chloride: The secondary MCL for Chloride is 250 mg/L and the Basin Plan objective is 150 mg/L. As shown in **Figure 2-16** and illustrated on **Figure 2-16**, chloride concentrations range from 98 to 249 mg/L. Note that Chloride concentrations are lower in the eastern portion of the Basin.

Nitrate: As shown in **Figure 2-17** and illustrated on **Figure 2-17**, nitrate (as NO_3) concentrations range from 15 to 179 mg/L. Concentrations of nitrate have historically exceeded Basin Plan objectives. The District blends groundwater from the Conejo wells with State Water Project (SWP) water to adjust high levels of nitrate. Nitrate concentrations are higher in the central and western portions of the Basin. It should be noted that nitrate levels have decreased since 2002.

Sulfate: The secondary MCL for sulfate is 45 mg/L and the Basin Plan objective is 300 mg/L. As shown in **Figure 2-18** and illustrated on **Figure 2-18**, sulfate concentrations range from 99 to 489 mg/L. Sulfate is typically less than the Basin Plan objective.

Total Dissolved Solids (TDS): The secondary MCL for TDS is 500 mg/L and the Basin Plan objective is 900 mg/L. As shown in **Figure 2-19** and illustrated on **Figure 2-19**, TDS concentrations range from 572 to 1,492 mg/L. TDS concentrations are higher in the central and western portions of the basin.

Pesticides: Agricultural operations within the basin have led to a single detectable concentrations of ethylene dibromide (EDB), dibromochloropropoane (DBCP), and other pesticides. The EPA Primary MCLs for EDB and DBCP are 0.00005 mg/L and 0.0002 mg/L, respectively. A 1999 investigation of Penny Well’s water quality showed a significant decrease in pesticide concentration (IMFP, 2011).

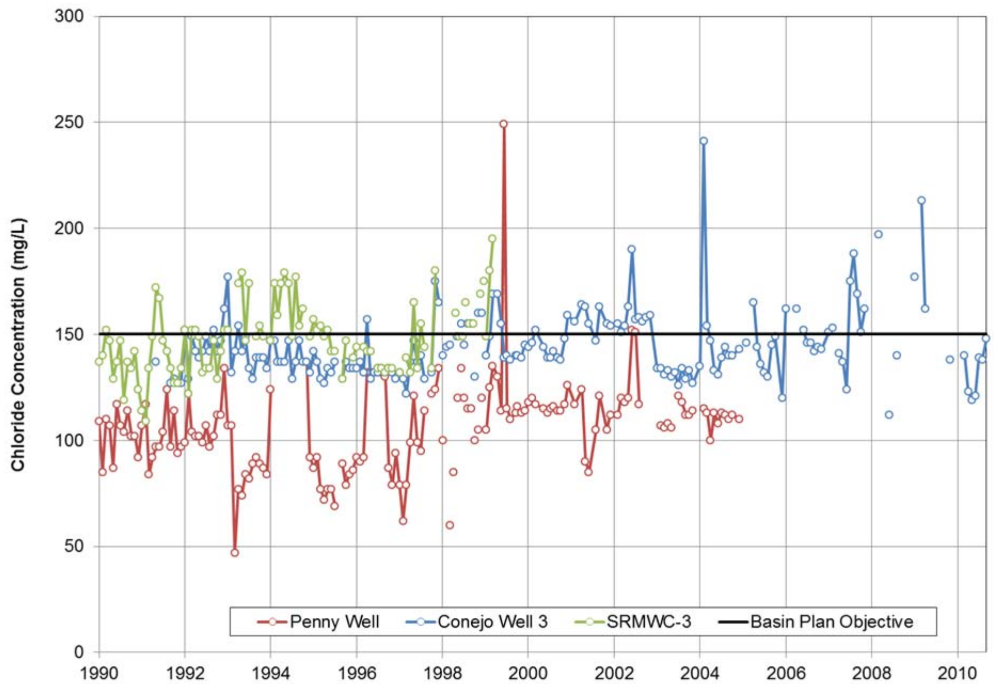


Figure 2-16
1990 to 2010 Chloride Concentration at Penny Well, Conejo 3, and SRMWC-3

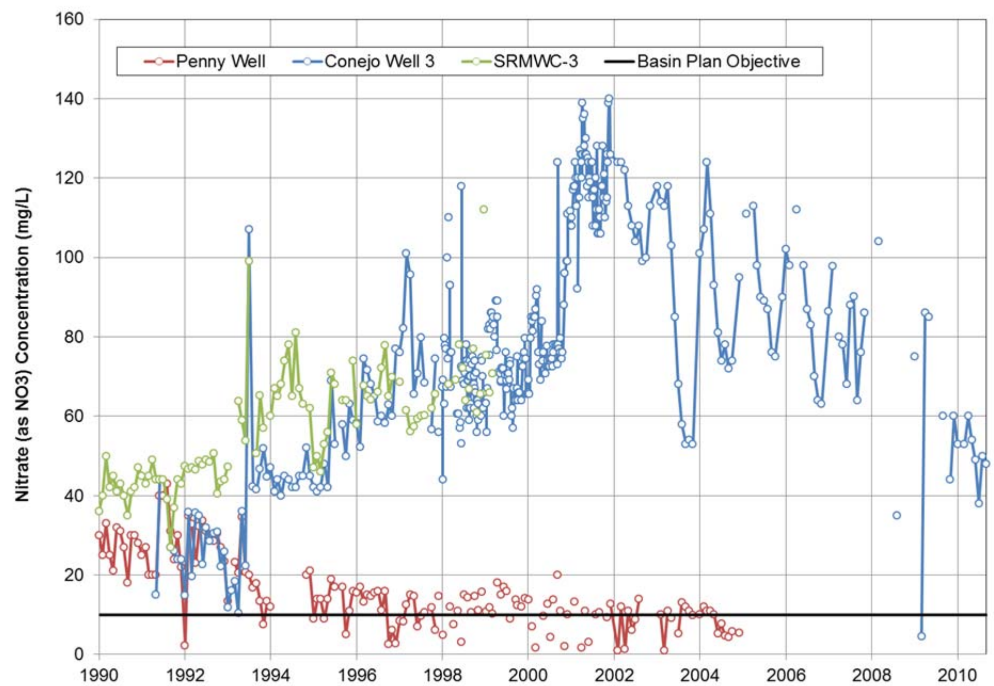


Figure 2-17
1990 to 2010 Nitrate (as NO_3) Concentration
at Penny Well, Conejo 3, and SRMWC-3

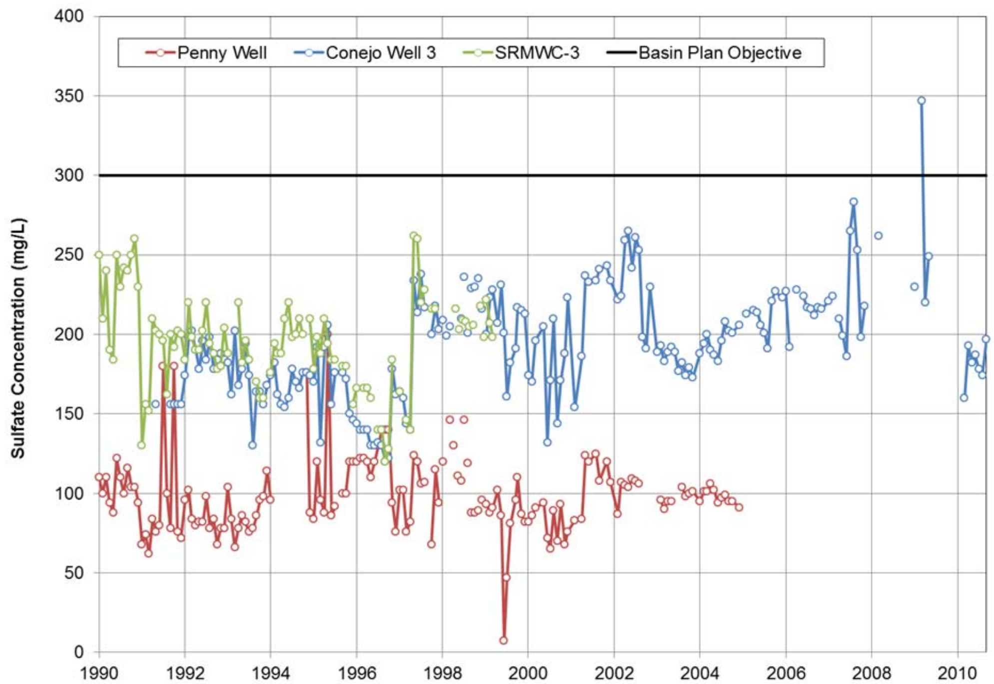


Figure 2-18
1990 to 2010 Sulfate Concentration
at Penny Well, Conejo 3, and SRMWC-3

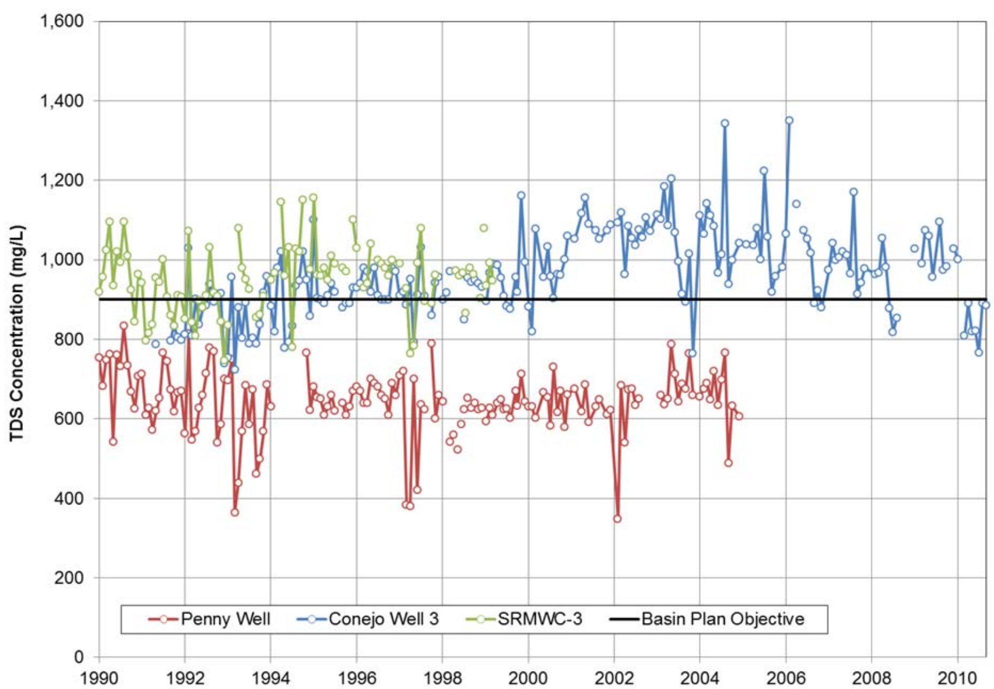


Figure 2-19
1990 to 2010 TDS Concentration
at Penny Well, Conejo 3, and SRMWC-3

2.4 SURFACE WATER AND GROUNDWATER INTERACTION

To evaluate the interaction between surface water and groundwater, Conejo Creek discharges at various locations were compared. Staff at Hill Canyon WWTP place temporary flumes in the locations shown in **Figure 2-1** to measure flow rates in the Arroyo Conejo from June through September every year, although data was only available for the period from 2003 to 2009. A summary of these data is listed in **Table 2-10**. The data provided by Hill Canyon WWTP is useful to evaluate the contribution of each source that comprises the flow in Arroyo Conejo, and eventually Conejo Creek. The measured discharge at the Confluence Flume represents the surface flow measured prior to entrance in to the Santa Rosa Basin.

The Confluence Flume and Station 800 represent the entrance and exit of the reach of the creek, respectively, that traverses the groundwater basin, as shown on **Figure 2-1**. By subtracting the creek discharge at Station 800 from the creek discharge at the Confluence Flume, the net losses to groundwater within the Santa Rosa Basin can be estimated. On average, the value of this calculation is positive, suggesting the groundwater basin is recharged by Conejo Creek. The negative value in 2004 suggests the opposite scenario: flow from groundwater to Conejo Creek. These data indicate that the groundwater basin typically has a net recharge from the creek, but when water levels are high, as in 2003 through 2008, there is little storage capacity in the groundwater basin and groundwater can discharge to Conejo Creek. In 2004 there was a net gain by the Creek.

Table 2-10
Estimated Conejo Creek Losses (June-September) 2003-2009

Year	Confluence Flume Discharge (acre-feet)	Average Station 800 Discharge (acre-feet)	Conejo Creek Losses to Groundwater (acre-feet)
2003	5,406	4,782	624
2004	4,479	5,040	(561)
2005	6,414	6,325	89
2006	6,114	5,604	510
2007	5,545	5,012	533
2008	5,391	5,187	204
2009	5,089	3,907	1,182
Average	**5,491**	**5,122**	**369**

The evaluation of gains or losses from Conejo Creek indicates that for the period evaluated the average four-month loss rate to groundwater is about 370 acre-feet, or about 1,100 acre-feet per year. This is consistent with previous work. Boyle (1997) estimated Conejo Creek losses of about 1,480 to acre-feet per year and Boyle (1987) estimated 1,370 acre-feet per year from 1973 to 1983.

2.5 WATER BUDGET

Table 2-11 provides a summary of the water budget components which are further described in this section. The water budget was prepared to evaluate recharge and discharge of the groundwater system and to develop a groundwater model. The water budget could be considered the average condition for the Basin and individual years will vary. Documentation of the groundwater model can be found in **Appendix C**. Estimates found in this section represent the best available information at the time the SRGMP was published. It is important to note that water budget analyses are intended to provide baseline estimates for flows into and out of the system; the values are not known with high certainty, but are used to offer guidance and reasonable limits to the groundwater modeling effort.

Table 2-11
Estimated Water Budget Components

Component	Annual Volume (AF/yr)
Inflow into Basin (Recharge)	
Precipitation (Valley Floor)	450
Precipitation (Watershed)	360
Subsurface Inflow (from Tierra Rejada Basin)	240
River Leakage (Conejo Creek)	1,030
River Leakage (Arroyo Santa Rosa)	600
Agricultural Return	200
Residential Wastewater Return (Indoor)	715
Residential Wastewater Return (Outdoor)	765
Residential Wastewater Return (Public and Others)	30
Total Inflows	**4,390**
Outflow from Basin (Discharge)	
Pumping	3,320
Evapotranspiration / Consumptive Use	775
Outflow to Adjacent Subbasin (Bailey Fault)	290
Total Outflows	**4,390**

2.5.1 Recharge

Precipitation

A study completed by Blaney (California Department of Public Works, 1934) suggested that annual fractions of rainfall penetration range from 0.01 to 0.17 for dry years and from 0.06 to 0.34 for wet years. The available data shows that water year 1987 to 1988 is a dry year with 11.12 inches of precipitation, 1997 to 1998 is a wet year with 34.25 inches and 1999 to 2000 a normal year with 14.05 inches. For this study, a recharge coefficient of 0.09 for dry year, 0.34 for wet year and 0.2 for normal year was used. This results in an estimate of about 450 acre-feet per year, this is consistent with other work.

Subsurface Inflow

Schaaf (1998) estimated a subsurface inflow of 225 acre-feet/year. Boyle (1997) reported a similar estimate of 301 acre-feet/year. Based on these values and the model results, a value of 240 acre-feet per year was used for this water budget.

River Leakage

Boyle (1997) estimated a total river leakage of 1,113 acre-feet/year from the Hill Canyon WWTP effluent to the Gage Station 800. Boyle (1997) reported an estimate of 1,370 acre-feet/year. Using the latest data for a much shorter period and the groundwater model, MWH estimated a value of 1,030 acre-feet/year for Conejo Creek and 600 acre-feet//year for Arroyo Santa Rosa.

Agricultural Return

Using data from the District efficiency report (District, 2009), the estimated maximum, minimum and average agricultural return is 462, 154 and 407 acre-feet/year, respectively. Based on these values and model calibration, a value of 200 acre-feet/year is estimated.

Residential Returns

According to the District IFMP (District, 2011) the population in Santa Rosa Valley area in 2005 was 6,580. For indoor use, assuming no sewer connection and a consumption rate of 100 gallons/person/day and 97 percent return rate, a total of 715 acre-feet/year is estimated.

The District IFMP (District, 2011) also reported that the total potable residential sale in 2005 was 6,750 acre-feet/year. Subtracting personal daily consumption, a total of 3,630 acre-feet/year was used for landscaping. Assuming 79 percent of efficiency in 2005 (District, 2009), the estimated landscaping return is approximately 765 acre-feet/year.

Within a total of 1,660 acres of open space and parks area, 155 acres were in Santa Rosa Valley in 2005. Total water sale for public and others was 1,320 acre-feet. Thus public and others water use in Santa Rosa Valley was 122 acre-feet. Assuming 25 percent return of this water, the estimated return is 30 acre-feet/year.

2.5.2 Discharge

Stream Outflow

During years with high precipitation when groundwater elevations are high, discharge occurs from the groundwater basin to Conejo Creek. This event occurs rarely and is not considered an average condition.

Pumping

Groundwater production had been reduced sharply from 1959 until 1991, when pumping began to increase up to 2008. On average, annual total production was approximately 3,190 acre-feet/year. For this study considering the time period ranging from 1984 to 2012, the annual output is 2,874 acre-feet/year.

Evapotranspiration / Consumptive Use

Evapotranspiration and consumptive use values were estimated based on the IFMP Plan (District, 2011), and the District efficiency report (District, 2009). This value is estimated to be 1,380 acre-feet/year.

Outflow to Adjacent Subbasin

Boyle (1997) reported water level differences of 60 to 80 feet across the fault. In addition to a large difference in water level, MWH has analyzed water quality using Stiff diagrams showing that there is a clear difference in water quality across the Bailey Fault. Although the calibrated groundwater model indicated that there is flow out of the Basin across the majority of the fault, there is likely flow in the southwest corner, where the historical Conejo Creek channel has likely cut across the fault. The estimation of 290 acre-feet/year (Boyle, 1997) is used in this study as a reasonable flow out of the Basin.

Comments on the draft report were received regarding flow across the Bailey Fault, these comments are listed in **Appendix D**. As such, further discussion on the issue is provided. The Bailey Fault was simulated as a no flow boundary with exception to the portion of the fault immediately adjacent to the Conejo Creek. This portion of the fault is assumed to have been cut or eroded by the historical Conejo Creek. In this area adjacent to the creek, the calibrated groundwater model assumes discharge from the eastern portion of the Santa Rosa Basin to the western portion (FCGMA) of the basin west of the Bailey Fault. Additional work could be completed to decrease the uncertainty of this value, although it is not within the scope of this project. This work could include the construction of monitoring wells on each side of the fault, pumping testing, and the development of new cross-sections with the new lithologic data.

2.6 DATA GAPS

This section summarizes data gaps that were observed in preparing the water resources setting summary.

Surface Water:

- No stream flow data in North and South forks Arroyo Conejo in the winter. These data would assist in characterizing gains or losses for Conejo Creek.
- Gage station 828 (Arroyo Santa Rosa) has some data, but it is variable and the quality is suspect. Arroyo Santa Rosa flow data would assist in accurately characterizing the surface water system.
- Flow for 2010 to present was excluded on Conejo Creek because Station 800 moved to 800A. Because the distance from Hill Canyon to 800A is twice the distance from Hill Canyon to 800 it was not possible to correlate the data. Maintaining data collection at the original location of Station 800 is very important for characterizing groundwater and surface water relationships.

Groundwater:

- There is little water level or water quality data west of the Conejo Well field. These data would assist in understanding the groundwater flow relative to Conejo Creek and assist in characterizing groundwater quality.

Section 3
Basin Yield

The concept of a safe yield is based on a balance between groundwater development for economic demands and environmental needs and providing adequate resources for the future. This section defines terms used in basin yield management, summarizes previous estimates, summarizes the current basin yield estimate, and provides recommendations for developing an operational yield for the Santa Rosa Basin.

3.1 SAFE YIELD

Safe yield has been defined by technicians and the courts since the early 1900's. Within the California legal system, the issue of safe yield has been defined by decisions typically pertaining to basin overdraft. Overdraft is a condition that occurs when the extraction from a groundwater basin exceeds the safe yield and groundwater levels decline. The legal cases that have defined safe yield are usually brought to the court to resolve water rights issues in a groundwater basin where the current extraction rate, or yield, cannot be maintained and overdraft is occurring. Within California, safe yield is a method to clarify an availability and allocation of supply. There have been numerous cases within the state of California to refine the definition of safe yield, although *Los Angeles v. San Fernando (1975 14 Cal. 2d 199, 278)* provides a succinct and often referenced definition:

> "By definition, the safe yield of the ground water reservoir of the Upper Los Angeles River area is the maximum average annual pumping draft which can be continually withdrawn for useful purposes under a given set of conditions without causing an undesired result."

The safe yield is an average amount which may vary based on variable water budget conditions, such as precipitation in a given year, but the yield is the average annual extraction. The set of conditions that effect the estimation of safe yield include the base period for assessing the values of the hydrologic components of safe yield and the geographic distribution of extraction from the basin. Other conditions could include the concept of using basin management techniques to optimize yield. The undesirable results vary by location; these results are typically gradual lowering of the groundwater levels resulting eventually in depletion of the supply, land subsidence, and/or impacts to water quality.

3.2 PREVIOUS ESTIMATES

The previous yield analyses and estimates conducted within the Santa Rosa Groundwater Basin included portions of the basin that are both east and west of the Bailey Fault.

Safe yield estimates have been completed for the Santa Rosa Basin since 1953. Bulletin 12 prepared by the California State Water Resources Board (CSWRB, 1953) estimated a yield of 3,100 acre-feet on average years. The data used to prepare these estimates was from 1951, prior to wastewater discharge into Conejo Creek.

In 1969, the District retained Thomas Bailey, a professional geologist, to report on the geology and groundwater supplies of the District. The Bailey report included a statement of safe yield for the entire Basin. Bailey indicated that effluent discharge from the Hill Canyon facility increased the safe yield of the Basin to approximately 3,600 acre-feet per year, but decreased the expected long-term water quality as a result of the facility.

Prior to 1964, water levels in the Santa Rosa Basin had been rapidly declining under an average annual extraction of approximately 3,500 acre-feet. This extraction rate was believed to be over drafting the Basin by about 600 acre-feet per year (Boyle, 1987). With the discharge of treated wastewater to Arroyo Conejo in 1964 from the Hill Canyon WWTP, water levels within the Basin began to recover. Recovery of overdraft conditions was established by 1970 and water levels have remained relatively stable. The 1987 Boyle study found the annual yield of the Basin to be approximately 4,200 acre-feet per year.

In 1997, Boyle prepared an updated groundwater management plan and again evaluated the yield of the Basin. This study concluded that western portion of the Basin (west of the Bailey fault) had a yield of 1,380 acre-feet per year, the middle portion of the Basin has a yield of 2,335 acre-feet per year (lower area between the Bailey Fault and unnamed fault just west of SRMWC-7), and the upper portion of the Basin had a yield of 385 acre-feet per year for a total of 4,100 acre-feet per year.

3.3 ESTIMATE OF BASIN YIELD

Maimone (2004) articulates that the idea that there exists a single, correct number representing sustainable safe yield must be abandoned. There is no single value but a working definition, coupled with an adaptive management approach, based on the following considerations: understanding the local, sub-regional, and regional effects, a comprehensive conceptual water budget, temporal aspects of yield (including droughts and floods), stakeholders input to understand tradeoffs and develop consensus, and determination of the interdisciplinary nature of the impacts of groundwater utilization. What is provided herein is a range of estimates that should be revised based on adaptive management of the basin and updated understanding of the above considerations.

Methods of determining safe yield are generally based on mass conservation considerations expressed in the hydrologic balance equation. The Hill Method and the Zero Water Level Change Method were used to evaluate the yield on the Basin and are further described below. The Hill Method defines safe yield as annual pumping amount when average annual water level change equals zero. The Zero Water Level Change Method defines safe yield as the average amount of pumping over a period of time, provided that the groundwater storage elevation is the same at the beginning and end of this long period of pumping.

As previously noted, previous yield analyses and estimates conducted included portions of the Basin that are east and west of the Bailey Fault. This study only considers the yield within the Santa Rosa Basin east of the Bailey Fault.

3.3.1 Hill Method

The Hill Method is a plot of pumping versus water-level change, this relationship allows for identification of the pumping amount associated with zero water level change (Sophocleous, 1998). The Hill Method does not consider all potential undesirable effects of pumping, only the prevention of overdraft. The evaluation was completed on a monthly time scale at two different wells within the Basin over two different time periods. This method has several assumptions and simplifications. It assumes the Basin is a single aquifer, one well represents the entire aquifer, the well configuration (location and magnitude) does not and will not change, and the climatic conditions during the evaluation period are representative. It also assumes that there were no undesirable effects during the periods used.

Figure 3-1 illustrates the Hill Method applied to the Nicholson Well for the periods of 1987 to 1990 and 1994 to 2009. Monthly groundwater pumping is represented on the x-axis and change in groundwater level is presented on the y-axis. A linear trend line is used to determine at what monthly pumping rate there is zero change in head. When these data are plotted there is a weak relationship. The coefficient of determination for these two plots relationships is 0.10 and 0.14 for 1987 to 1990 and 1994 to 2009 periods, respectively. The coefficient of determination, or R^2, is used to describe how well a regression line fits a set of data, the closer to 1.0 the better the fit. Using the equation for the trend line the monthly acre-feet for the basin at zero change in water level is 215 acre-feet and 210 acre-feet for 1987 to 1990 and 1994 to 2009 periods, respectively. This is equivalent to 2,580 for the period of 1987 to 1990 and 2,520 acre-feet per year for the period of 1994 to 2009.

Figure 3-2 illustrates the Hill Method applied to the SRMWC-5 well for the periods of 1986 to 1994 and 1990 to 1995. Again, monthly groundwater pumping is represented on the x-axis and change in groundwater level is presented on the y-axis and a linear trend line is used to determine at the pumping rate there is zero change in head. A relationship is apparent, but not a strong one. The coefficient of determination for these two plots relationships is 0.19 and 0.14 for 1986 to 1994 and 1990 to 1995 periods, respectively. Using the equation for the trend line the monthly acre-feet for the basin at zero change in water level is 167 acre-feet and 229 acre-feet for 1986 to 1994 and 1990 to 1995 periods, respectively. This is equivalent to 1,980 for the period of 1987 to 1990 and 2,760 acre-feet per year for the period of 1990 to 1995. These results present a larger range than the Nicholson Well; the 1990 to 1995 period is 37 percent larger than the 1986 to 1994 period.

The results of the Hill Method safe yield estimates are summarized in **Table 3-1**. The estimates range from 1,980 to 2,760 acre-feet per year. The average of the estimates is 2,460 acre-feet per year.

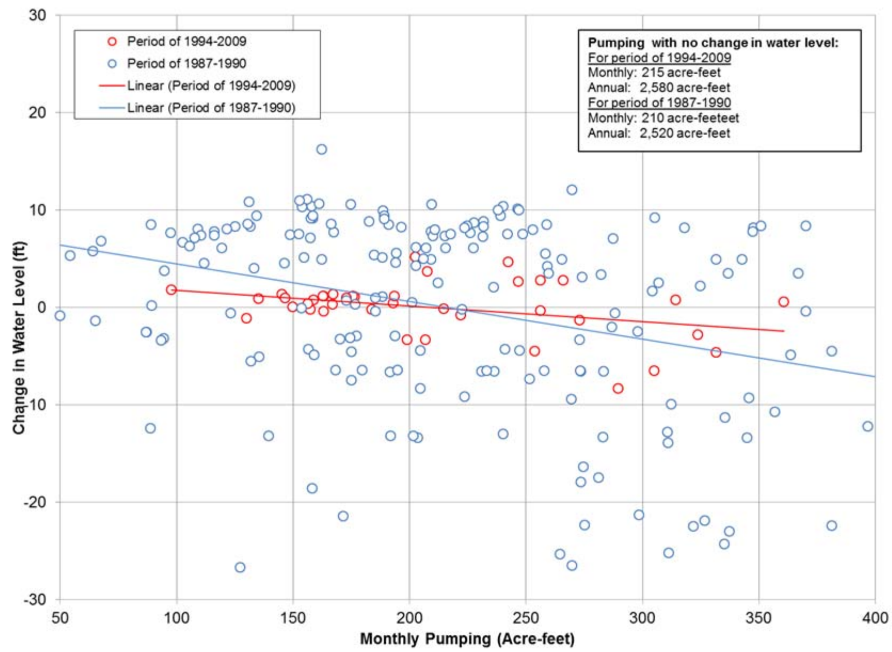


Figure 3-1
Monthly Change in Head at Nicholson Well and Total Santa Rosa Basin Pumping

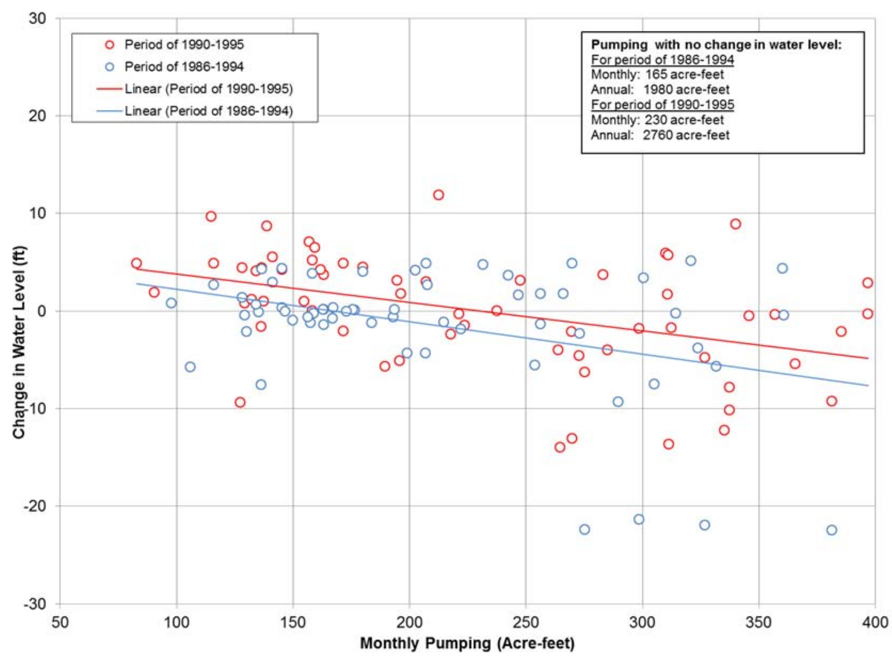


Figure 3-2
Monthly Change in Head at SRMWC-5 Well and Total Santa Rosa Basin Pumping

Table 3-1
Hill Method Results Summary

Well	Period	Calculated Monthly Yield (acre-feet/mo)	Estimated Annual Yield (acre-feet/yr)
Nicholson	1987-1991	215	2,580
Nicholson	1994-2009	210	2,520
SRMWC-5	1986-1994	167	1,980
SRMWC-5	1990-1995	229	2,760
Average			**2,460**

3.3.2 Zero Water Level Change Method

The Zero Water Level Change Method defines safe yield as the average amount of pumping over a period of time, provided the groundwater storage elevation is the same at the beginning and end of this long period of pumping. The groundwater storage is determined by the water level elevation in a well. When the elevation at the well is at the same water level the assumption is made that the storage is the same, hence the zero water level change method. This method also has its assumptions and simplifications. It assumes the basin is a single aquifer, one well represents the entire aquifer, the well configuration (location and magnitude) does not and will not change, and the climatic conditions during the evaluation period are representative. It also assumes that there were no undesirable effects during the periods used.

Listed in **Table 3-2** are the selected periods from representative wells used for the yield estimate. Listed next to each well is the starting and ending period when the net groundwater storage change was zero, as represented by the same water level. These periods are shown as hydrographs on **Figure 3-3** and **Figure 3-4.** To determine the yield estimate for each of these periods the total groundwater production for the period is divided by the length of the period. The four periods ranged from 55 to 184 months and spanned both wet and dry climatic periods.

Table 3-2
Zero Water Level Change Yield Estimate Summary

Well	Period Starting Month	Water Level (ft)	Period Ending Month	Water Level (ft)	Total Period Production (acre-feet)	Average Annual Production (acre-feet)
Nicholson	Feb-87	189.6	Sep-91	189.7	11,366	2,480
Nicholson	Apr-94	228.2	Aug-09	228.1	39,766	2,590
SRMWC-5	Aug-86	169.5	Sep-94	168.6	21,603	2,670
SRMWC-5	Nov-90	179.2	Dec-95	179.3	14,209	2,790
Average	**-**	**-**	**-**	**-**	**21,736**	**2,630**

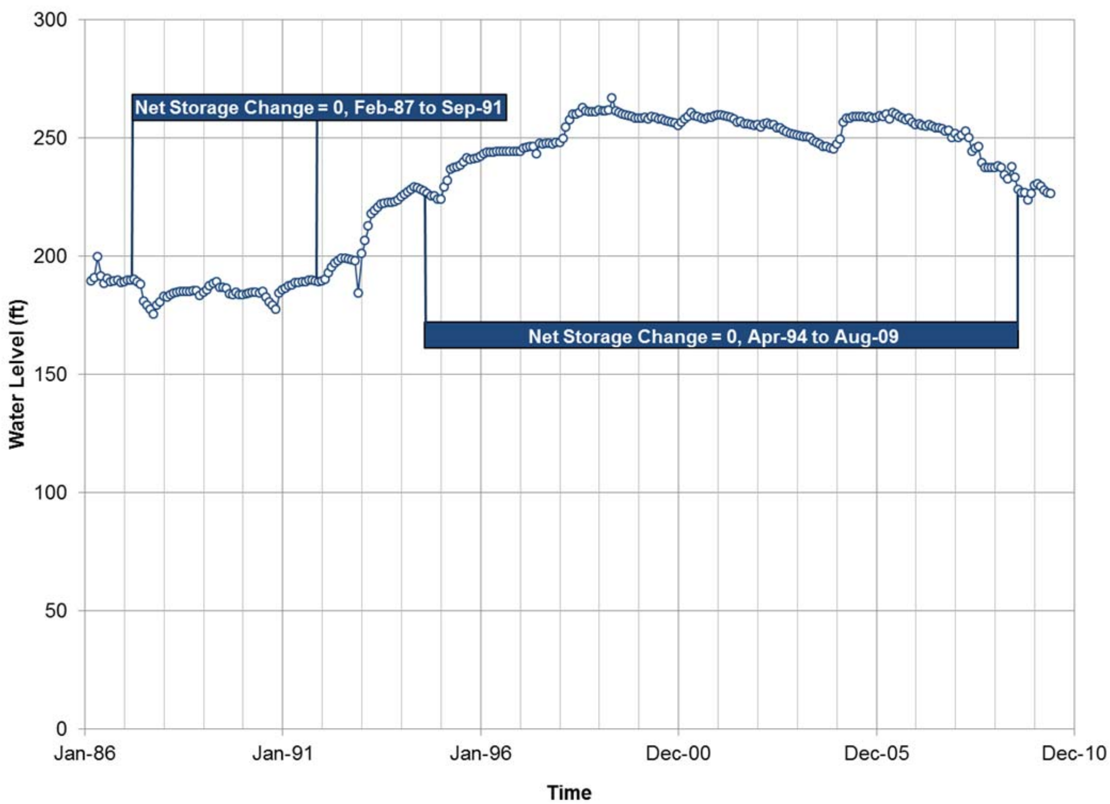


Figure 3-3
Hydrograph and Basin Change in Storage at Nicholson Well

The results of the Zero Water Level Change Method safe yield estimates are summarized in

Table 3-2. The estimates range from 2,480 to 2,790 acre-feet per year. The average of the estimates is 2,630 acre-feet per year.

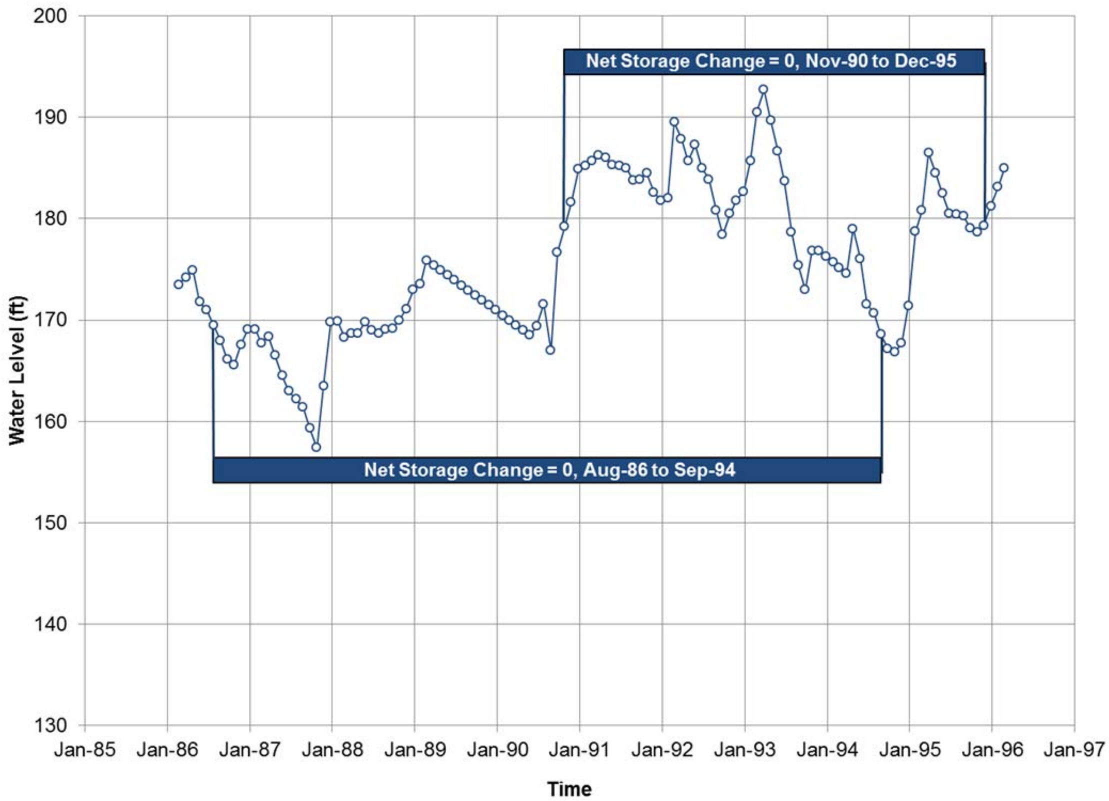


Figure 3-4
Hydrograph and Basin Change in Storage at Well SRMWC-5

Table 3-3
Zero Water-Level Change Yield Estimate Summary

Well	Period	Total Period Production (acre-feet)	Average Production per Month (acre-feet)	Estimated Annual Yield (acre-feet)
Nicholson	Feb-87 to Sep-91	11,366	207	2,480
Nicholson	Apr-94 to Aug-09	39,766	216	2,590
SRMWC-5	Aug-86 to Sep-94	21,603	222	2,670
SRMWC-5	Nov-90 to Dec-95	14,209	233	2,790
Average		**21,736**	**220**	**2,630**

3.3.3 Numerical Groundwater Model

A groundwater model was prepared and calibrated for the Santa Rosa Groundwater Basin to assist in the development of the GMP and evaluate future projects. The model was also used to evaluate the effects of long-term pumping and estimate basin yield.

The model code used for this effort was MODFLOW 2000 (Harbaugh et al., 2000). The model is simulated as a single-layer system. A uniform cell dimension of 100 feet is used for the model. There are a total of 10,469 active cells. The two sets of grid lines are orientated east-west and north-south. Complete model documentation is provided in **Appendix C**.

During development and calibration of the groundwater model, a number of unique characteristics of the groundwater system became apparent. The most significant characteristics related to basin yield are summarized below.

- A pumping rate of approximately 3,320 acre-feet per year was sustainable for long-term pumping (east of the Bailey Fault) without overdraft.
- The model is very sensitive to the elevation of the Conejo Creek surface (stage) and ability of the river bottom to allow groundwater flow (conductance). The groundwater relationship with Conejo Creek is significant. The groundwater system has a net discharge of approximately 775 acre-feet per year to the creek, meaning water level elevations were higher in the groundwater basin than in the creek.
- Water level observation and water quality data have shown that the Bailey Fault is a groundwater flow barrier, at least in the central part. It is unclear to what extent the other part of the fault acts as a groundwater barrier.

3.3.4 Basin Yield Estimate Summary

As previously discussed, the values estimated herein and summarized below represent a best estimate for a long-term average annual pumping rate. These are all estimates, each with limitations as there is no perfect solutions. All Basin yield estimates were completed for the portion of the Basin that is east of the Bailey Fault. There is no single, correct number representing sustainable safe yield, but a value that can be used with an adaptive management approach that changes based on performance of the basin and several other considerations. Listed in **Table 3-4** is a summary of the estimated yield for the basin and the method used to obtain the estimate.

Table 3-4
Basin Yield Estimate Summary[1]

Method	Basin Yield Estimate (acre-feet/yr)
Hill	1,980 - 2760
Zero Water Level Change	2,480 - 2790
Numerical Model	3,320

1. These estimates represent the yield for the Santa Rosa Basin east of the Bailey Fault. Boyle (1997) estimated the yield for portion of the Basin west of the Bailey Fault at 1,380 acre-feet per year and the portion east of the Bailey Fault at 2,720 acre-feet per year.

Based on the various estimates, the basin yield is approximately 2,800 acre-feet per year. For clarification, the values listed **Table 3-3** are related to the historical pumping rates. The pumping that has occurred during the yield evaluation periods has established a new equilibrium in the Basin. The consistent yield estimates reflect this equilibrium that has been established with relatively consistent recharge and discharge. What is not known is if greater groundwater production yield could occur without undesirable results. This can only be determined with monitoring and adaptive management. Monitoring would include any sensitive habitat, subsidence, and groundwater levels. Adaptive management would entail making modifications to operations based on analysis of the monitoring data.

3.4 PROJECT PUMPING AND APPROXIMATE SAFE YIELD

Table 3-5 summarizes estimated Basin yield, actual recent pumping and planned basin pumping by the District. Care must be taken to not over draft the basin, the basin water levels should be monitored for water regularly to prevent overdraft. As previously stated, there is significant uncertainty with the estimated yield; pumping greater than the estimated yield may be feasible. Monitoring and adaptive management are recommended to determine if pumping above the estimated yield causes undesirable results.

Table 3-5
Basin Yield, Recent Actual Pumping and Projected Pumping[1]

Year	Estimated Basin Yield (acre-feet/yr)	Actual/Projected District Pumping[1] (acre-feet/yr)	Balance (acre-feet/yr)
2010	2,800	2,310	490
2011	2,800	2,760	40
2012	2,800	3,250	(450)
2013	2,800	3,250[2]	(450)
2014	2,800	3,250[2]	(450)
2015	2,800	3,530	(730)
2020	2,800	3,530	(730)
2025	2,800	3,530	(730)
2030	2,800	3,530	(730)
2035	2,800	4,650	(1,850)

1. Camrosa Water District Urban Water Management Plan (District, 2011b).
2. No published projected pumping, value assumed based on 2012 pumping.

Adaptive management focuses on monitoring, learning and adapting operations to create and maintain sustainable systems. A common problem in resource management involves the linear processes of decision making, by which the best action depends on the state of the managed system. Different management decisions at a given time can influence the state of the system from that time forward. A key issue is how best to choose management actions, recognizing that the most appropriate management strategy is obscured by limited understanding. This can only be done by closely monitoring the system and making operational adjustments based on what is observed.

3.5 OPERATIONAL YIELD

The operational yield of a groundwater basin is the optimal amount of annual pumping which can be annually withdrawn for useful purposes under a given set of conditions without causing an undesired result. This is a dynamic quantity that varies with management goals, objectives, and constraints.

Balleau et al (1988) described the transition of groundwater development from storage depletion to induced recharge. Every groundwater development operation, whether from a local river bed or a large regional scale flow system, begins with 100 percent withdrawal from groundwater in storage. The timing of the change from storage depletion to induced recharge from surface water bodies is fundamental to developing protective long-term water use policy. If the change from storage to induced recharge is a short period of time there will be less groundwater storage depletion. If the change takes a long period of time, the storage depletion can be great.

When evaluating basin yield for water policy a distinction is necessary between developed and non-developed groundwater basins, with three groundwater basin scenarios possible:

1. *A non-developed system* which has no human interaction and is in equilibrium or steady state in the absence of pumping;
2. *A developed system* with pumping, that is in equilibrium or steady state, with moderate pumping at a fixed depth; and
3. *A depleted system*, in non-equilibrium or unsteady state, with heavy pumping at an ever increasing depth.

In the non-developed system, the average recharge is equal to average discharge, net storage change is zero, with no pumping. In the developed system the captured recharge is the increase in recharge induced by pumping. Similarly, the captured discharge is the decrease in discharge induced by pumping. The “residual discharge” is equal to natural recharge minus captured discharge. Net recharge is equal to the sum of captured recharge plus captured discharge. Net recharge varies with the intensity of pumping; the greater the intensity of pumping, the greater the net recharge, permitting there is a source. Pumping in the developed groundwater system is equal to net recharge, or captured recharge and discharge (Ponce, 2007). The depleted system pumps the captured recharge, captured discharge, as well as water from storage. Pumping in the depleted groundwater system is equal to net recharge plus captured storage. This has the long-term effect of lower water levels and overdraft.

3.5.1 Santa Rosa Basin and Operational Yield

The Santa Rosa Basin is a developed system with pumping that is in near equilibrium or steady state. The long-term operations in the Basin have passed the transition from storage depletion to induced recharge. The system is currently capturing recharge induced by pumping. Similarly, the system is capturing discharge, with the decrease in discharge induced by pumping. **Table 2-10** indicates that during periods of wet conditions there can be a net discharge to the Conejo Creek; therefore, there is still discharge to be captured. Operational yield within the Santa Rosa Basin would mean finding a balance between lower water levels in the western portion of the basin, specifically near Conejo Creek, to ensure there is no discharge to the creek and storage capacity for wet periods.

Section 4
Management Plan Goals and Objectives

This section of the SRGMP provides a description of management plan elements developed for the Basin. Within this section, goals for four supporting basin management objectives (BMOs) are documented.

4.1 GROUNDWATER MANAGEMENT GOAL

The management goal for the Santa Rosa Basin is to optimize the beneficial uses of groundwater, preserve and enhance water quality, understand and operate within the yield of the Basin, and assure preservation of groundwater and environmental resources for future generations.

4.2 BASIN MANAGEMENT OBJECTIVES (BMO)

The California State Water Code §10753.7 (a) (1) states that the required components of a GMP include the following relative to basin management objectives:

> "Prepare and implement a groundwater management plan that includes basin management objectives for the groundwater basin that is subject to the plan. The plan shall include components relating to the monitoring and management of groundwater levels within the groundwater basin, groundwater quality degradation, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin."

This portion of the Water Code implies that BMOs and actions taken to achieve these objectives need to have sufficient specificity in numerical objectives so as to be measurable in implementation through monitoring and management programs. At the same time, the BMOs are intended to be flexible so as to be adaptive to increase knowledge of how the groundwater basin behaves over time as better monitoring data is collected. To meet these co-equal objectives, general BMO statements have been prepared and are accompanied by specific and measurable methods for implementing. Additional specificity is provided with the actions listed under each component category in Section 5.

Based on these guidelines, four (4) BMOs have been developed from the Basin management goal and Camrosa Water District Strategic Plan (District, 2008) and are listed below:

1) Protect and enhance groundwater quality

2) Sustain a safe, reliable local groundwater supply

3) Improve understanding of groundwater elevations, Basin yield and hydrogeology

4) Maintain public awareness and confidence, and honor the public trust

4.2.1 BMO No.1 - Protect and Enhance Groundwater Quality

BMO No. 1 is intended to protect and enhance the groundwater quality in the basin by locating and reducing groundwater contamination, protecting recharge areas, and improving recharge water quality.

Background

As documented in Section 2, groundwater quality within the Basin varies by location. In general, the average reported concentrations of TDS and nitrates are well above the Basin Plan objectives in the western portion of the Basin. Water quality is a significant problem in the Basin.

Recharge of groundwater occurs primarily from percolation of irrigation water, infiltration along creeks and drainages, percolation of precipitation, and subsurface inflow. Protection of natural recharge is an important element of protecting and enhancing groundwater quality.

Methods/Approach

In order to meet this BMO, The District will work toward accomplishing multiple activities including:

- The District will collect and analyze additional monitoring data to better understand the sources and relative volumes of constituents in groundwater. These data include groundwater water level, surface flow data, as well as groundwater and surface water quality data. The analysis will be the basis of developing source control strategies.
    - Collecting groundwater water level and quality data will indicate recharge sources and the recharge source impact on basin water quality.
    - Collecting surface water flow data and quality will assist in the impact of surface water on the groundwater quality.
- Groundwater remediation techniques may be implemented where contamination is identified.

- Investigate the feasibility of implementing conjunctive use and groundwater desalination in the Basin. Implementation priority will be given to feasible projects that improve groundwater quality in addition to water supply reliability.

Desired Outcome

As described in District's Strategic Plan (District, 2008): maintaining affordable, independent supplies with a uniform quality is the District's ultimate goal. The District will work toward protecting and enhancing groundwater quality for the benefit of basin groundwater uses. This BMO will be met when groundwater quality constituent concentrations in the Basin are brought to concentrations lower than those defined by their respective Basin Plan objectives.

4.2.2 BMO No.2 - Sustain a Safe, Reliable Local Groundwater Supply

The intent of BMO No.2 is to sustain a safe and reliable local groundwater supply for existing and future groundwater uses by adaptive management of groundwater production.

Background

Groundwater supply was approximately 18 percent of the total water supplied to customers in 2010 and 38 percent of the total potable water supplied in 2010. As described in the District Urban Water Management Plan, having multiple water sources gives the District considerable flexibility and improved reliability. Local groundwater helps maintain that reliability at the lowest cost. Reduced dependence on imported water is part of the District's Strategic Plan (District, 2008). The costs of imported water is a substantial expenditure incurred by the District (District, 2008). Minimizing the use of imported water and purchased power will provide independence in providing service to the District's customers.

Moving in the future, groundwater is planned to remain an important water supply, representing roughly 25 percent of the total supply used within the District 2015 through 2035.

Methods/Approach

In order to meet this BMO, the District can operate under their current conditions, which have not created overdraft or undesirable hydraulic conditions. Alternatively, the District could manage groundwater storage more aggressively to 1) induce additional recharge from Conejo Creek, 2) reduce or eliminate discharge of groundwater to Conejo Creek, and 3) allow for additional storage of groundwater during wet periods. The management of storage, or development of an operational yield program, must be conducted in a controlled and calculated manner as not to present undo risk to users by land subsidence, dewatering of existing wells, degrading groundwater quality, and adding cost to pumping groundwater from lower elevations. Increases in pumping for supply could also be offset by artificial recharge of the Basin.

Desired Outcome

Developing an operational yield program and or conjunctive use program would increase the reliability of the groundwater supply for future uses. The program would include incremental increases in groundwater pumping with monitoring for undesirable impacts, such as harm to vegetation, low water levels, and subsidence.

4.2.3 BMO No.3 - Improve Understanding of Groundwater Elevations, Basin Yield and Hydrogeology

The intent of this BMO is to improve the general understanding of the Basin specifically related to groundwater elevations, yield and hydrogeology.

Background

Understanding the groundwater system will improve the planning and management of the groundwater basin. This SRGMP has documented the current basin understanding by reporting on previously-collected data related to well construction, groundwater elevation and quality, surface water quantity and quality, and borehole lithology.

Methods/Approach

In order to meet this objective, some additional monitoring and reporting is to be implemented through the adoption of this SRGMP. Similar to BMO No.1, the data collected would include: groundwater water level, surface flow data, as well as groundwater and surface water quality data. The analysis will be the basis of developing source control strategies.

- Collecting groundwater water level and quality data.
- Collecting daily surface water flow data and quality data.

These data are to be reviewed annually and formally reported biennially. The review and analysis would consist of the preparation of wet year water budgets and dry year water budgets. Daily surface water and groundwater data will allow for more accurate estimates of groundwater and surface water interaction.

Desired Outcome

This BMO will be met when the District has analyzed groundwater elevation fluctuations, responses to pumping, and has quantified hydrogeologic connections between groundwater and surface water and the potential for increasing storage capacity.

4.2.4 BMO No.4 – Maintain Public Awareness and Confidence and Honor the Public Trust

The intent of this BMO is to improve the awareness of stakeholders, ensure the stakeholders are heard in the management process, and instill confidence in the public that the District is maintaining the Basin for future beneficial uses.

Background

The management actions taken by the District in implementing the SRGMP will impact a range of individuals and agencies that have a stake in the successful management of the Basin; which include well owners, state and federal water resource agencies. To address the needs of all the stakeholders, this SRGMP pursues several means of achieving broader involvement in the management of the Basin. These means include: (1) involving members of the public; 2) involving other agencies within and adjacent to the basin; (3) developing relationships with state and federal water agencies; and, (4) pursuing a variety of partnerships to achieve the BMOs.

Methods/Approach

The approach to this BMO is to develop effective public outreach tools and media to educate the District's stakeholders about water resources. This includes incorporation of the public into the process and regular reporting of groundwater conditions to the public.

Desired Outcome

As described in the District's Strategic Plan, the objective of this BMO is to clearly communicate the challenges faced by Camrosa related to water reliability and water quality with the public.

Section 5
Plan Components

This section of the SRGMP provides a description of management plan elements developed for the Basin. Section 4 presented the management goal and the four objectives to reach the goal. This section documents the five component categories established with specific measurable management actions to be implemented by the District.

Table 1-1 lists a variety of components that are required, recommended and voluntary per CWC §10750, and DWR Bulletin 118 (DWR, 2003). For the purpose of the SRGMP, the individual components listed on **Table 1-1** have been grouped into five broad component categories as listed below:

1) Coordination and stakeholder involvement

2) Monitoring program

3) Groundwater resource protection

4) Groundwater sustainability

5) Planning integration

Each of the five component categories listed above are presented in detail in the following sections. For each component category, a set of management actions is developed to implement the BMOs. The following sections provide a listing of management actions within each component category.

5.1 COORDINATION AND STAKEHOLDER INVOLVEMENT

The management actions taken by the District in implementing the SRGMP has the potential to impact numerous stakeholders in the successful management of the basin. Stakeholders include: agricultural, or agricultural-residential private well owners, residential customers, residential well owners, land owners with septic systems, and local municipalities. To address the needs of all the stakeholders, this SRGMP pursues several means of achieving broader involvement in the management of the basin. These consist of: (1) involving members of the public; 2) involving other agencies within and adjacent to the Basin; (3) developing relationships with state and federal water agencies; and, (4) pursuing a variety of partnerships to achieve the BMOs. Each of these is discussed further below.

5.1.1 Involving the Public

Keeping the public informed of groundwater conditions and management is important to maintain the public trust.

Actions:

- Conduct annual public groundwater management update meetings for stakeholders. At these meetings the District will present a summary of current water quality monitoring, water level monitoring, groundwater pumping, projected groundwater pumping, current project status, planned project status, and current issues and concerns.
- Develop an outreach program for agricultural pumpers to educate basin water users on irrigation efficiency options.

5.1.2 Involving Other Agencies Within and Adjacent to the Santa Rosa Basin

Working relationships between the District and local, state, and federal regulatory agencies are important in developing and implementing various groundwater management strategies and actions detailed in this SRGMP. This District will work toward further establishing points of contact with those responsible for resource management within these agencies.

Actions:

- Establish a point of contact within local, state, and federal regulatory agencies that have responsibility for resource management within Santa Rosa Basin. Publish this list in future updates to the SRGMP. Maintain relationships with these contacts to assist in the completion of other action items.
- Coordinate with FCGMA regarding the data transmitted to DWR for CASGEM reporting.
- Monitor and review new development proposals and projects within the watershed to ensure that these proposals incorporate appropriate measures to protect water quality and water quantity within the Santa Rosa drainage area.
- Collaboration with the Ventura County Water & Environmental Resources Division, Groundwater Section, for the permitting of wells in accordance with the objectives of the SRGMP.
- Provide copies of the adopted SRGMP and subsequent bi-annual state of the basin assessments to representatives from the City of Thousand Oaks, Moorpark, FCGMA, Camarillo, and other interested parties.

5.2 MONITORING PROGRAM

At the heart of a groundwater management plan is a monitoring program. Data collected under this program allows the District to better assess the current condition of the Basin and document future management actions water level responses. The program includes monitoring groundwater elevations and stream flows, groundwater and surface water quality, assessing the potential for land surface subsidence resulting from groundwater pumping, and developing a better understanding of the interaction between surface water and groundwater. The monitoring related actions are described below.

5.2.1 Groundwater Elevation Monitoring

The accurate and continuous measurement of water levels in existing wells is an important data collection activity that provides information about changing groundwater conditions.

Actions:

- Continue water level monitoring at a monthly frequency.
- Identify an additional monitoring well west of SRMWC-3. This well will be used to monitor water levels relative to Conejo Creek surface elevation.
- Complete a well survey to determine if there is a need for well abandonment or location for possible new monitoring wells in areas lacking groundwater data.

A well survey is an inventory of wells within the basin. A well survey is important because it will indicate any wells that provide an conduit for aquifer contamination, assist in determining non-District pumping, potential locations for groundwater monitoring. It is in the best interest of the District that a survey is completed. The County of Ventura is not responsible for well surveys. The well survey will record the following:

- Photo
- Diameter
- Water level
- Location (coordinates)
- Total depth (if feasible)
- Video survey (if feasible)
- If a pump is present
- Potential pumping rate (pump size)
- Level of surface protection (potential for aquifer contamination)

5.2.2 Groundwater Production Monitoring

The accurate and continuous measurement of groundwater production is also an important data collection activity that provides information about changing groundwater conditions.

Actions:

- Continue to track groundwater production on a monthly basis at all production wells within the Basin.
- Prepare estimates of non-District groundwater pumping and return flows based on water service connection data and crop information. This would entail reviewing water service connections, land use, and checking land use water demands with the amount of water served. For example, if there is no connection to an acre of alfalfa, alfalfa requires 5 feet per acre of water to grow, then it can be assumed that there must be 5 acre-feet of water pumped on site. This information can be cross-checked with well survey data.
- Complete a well survey to determine if there are additional unknown groundwater production wells.

5.2.3 Groundwater Quality Monitoring

Groundwater quality data within the Basin has been collected and reported for the period from 1990 to the present by the District. Monthly samples are collected from wells Conejo-2, Conejo-3, Conejo-4, Penny, SRMWC-10, SRMWC-3, SRMWC-8, and SRMWC-9 and analyzed for chloride, fluoride, hardness, nitrate, nitrite, pH, phosphate, sulfate, TDS, and turbidity. Weekly samples are collected from Conejo-2, Conejo-3, Conejo-4 and analyzed for nitrate.

Several constituents, specifically chloride, nitrate, sulfate, and TDS exceed Basin Plan objectives. Water quality at production wells requires high-cost imported water for blending.

Agricultural operations within the area have led to detectable concentrations of ethylene dibromide (EDB), dibromochloropropoane (DBCP), and other pesticides. A 1999 investigation of Penny Well's water quality showed a significant decrease in pesticide concentration (District, 2011).

Actions:

- Continue to complete required water quality analyses on each water supply well.
- Annually evaluate groundwater at key wells for pesticides and herbicides. These key wells must be established. The wells should vary in location and depth within the Basin.
- The District will prepare a Salt and Nutrient Management Plan consistent with the DWR Bulletin 160. It is the intent of this plan to identify salt and nutrient sources in the basin and develop management protocols on a basin-wide basis for the attainment of water quality objectives and protection of beneficial uses.

5.2.4 Surface Water Flow Monitoring

Surface water monitoring is an integral part of determining the amount of water recharged to the groundwater basin.

Actions:

- Coordinate with Hill Canyon WWTP staff to document Arroyo Conejo flow data.
- Install permanent gaging station at Confluence Flume location. These data would help define surface water entering the Basin. This location is currently monitored four months per year by Hill Canyon WWTP staff.
- Re-install Station 800 near the District offices on Conejo Creek. This station would help define the surface water exiting the basin and help define surface water-groundwater interaction.

5.2.5 Surface Water Quality Monitoring

Monthly samples are collected from the following locations: Hill Canyon WWTP Effluent Outfall, Station 800A, Arroyo Conejo North Fork (North Fork Flume), Arroyo Conejo South Fork (South Fork Flume), and Conejo Creek (Station 800) (as shown on **Figure 2-1**). Samples are analyzed for chloride, fluoride, hardness, nitrate, nitrite, pH, phosphate, sulfate, TDS, and turbidity.

Actions:

- Continue monthly water quality sampling and analysis.
- Annually evaluate surface water for pesticides and herbicides. Ideally this would be conducted on surface water prior to entering the Basin, e.g., Confluence Flume, and leaving the Basin, e.g., Station 800.

5.2.6 Land Surface Elevation Monitoring

Land surface elevation monitoring is conducted to track inelastic land subsidence. Inelastic land subsidence is the permanent compaction of the subsurface. Activities that have the most potential to cause inelastic land subsidence are withdrawals of groundwater or petroleum from the subsurface. Adverse impacts related to inelastic land subsidence include permanent loss in aquifer storage and damage to foundations, roads, bridges, and/or other infrastructure. Inelastic land subsidence has not been historically reported or documented within the Santa Rosa Basin. Because of the lack of a large thickness of compressible clay, the Basin does not appear to be at high risk of inelastic subsidence. Nevertheless action will be taken to document the presence or absence of subsidence.

Actions:

- Establish a surveyed benchmark that can be used to evaluate subsidence trends over time. One benchmark should be located near the Conejo Wellfield.
- Conduct an annual subsidence monitoring at the identified benchmark and report in the biennial report (described in Section 5.2.8).

5.2.7 Protocols for the Collection of Groundwater and Surface Water Data

In order for the District to ensure quality data is being used to make management decisions Standard Operation Procedures (SOPs) for the collection of future data are provided in **Appendix E** and **Appendix F**. These SOPs will be reviewed periodically and modified to reflect new data collection techniques and procedures as necessary. To improve the comparability, reliability and accuracy of groundwater data, the District will take the following actions:

Actions:

- Determine monitoring network adequacy and periodically review and expand as appropriate to meet the needs of the SRGMP on a 5-year frequency or on a special project need basis.
- Establish protocols for methods and frequency of collection, and storing of data. These protocols will be documented in **Appendix E** and **Appendix F** and may be updated in the bi-annual state of the basin assessments.

5.2.8 Groundwater Reporting

The District, basin stakeholders, and the public will benefit from preparing a biennial State of the Basin Report on the conditions of the Santa Rosa Basin. This SRGMP prepared by the District is not intended to be a static document. As conditions change, such as population, land uses, water quality, surface water flows, it may be warranted to revisit the District's goals and BMOs to ensure that the overall goal of sustaining its groundwater resources to meet current and future demands for the District is being satisfied. As conditions and usage change in the future, it will be necessary to update and revise or expand this SRGMP.

Actions:

- The District will report on implementation progress in a biennial State of the Basin Report that summarizes the groundwater conditions in the Santa Rosa Basin. This report will include the following information:
    - Activities and progress made in implementing the SRGMP
    - Groundwater conditions and monitoring results and trends of groundwater levels and quality
    - Information on the improved characterization of the Santa Rosa Valley through continued data collection and analysis
    - A discussion, supported by monitoring results, of whether management actions are meeting BMOs
    - Any plan component changes, including modification of BMOs during the period covered by the report
    - Declaration of additional management actions
    - The state of the basin report will be completed within two years after SRGMP adoption, and every two years thereafter. It will report on conditions and activities completed through the preceding year. The District will provide

summaries to interested stakeholders, and made available on the District website for stakeholder access.

5.2.9 Surface Water Groundwater Interaction Monitoring

The interaction between groundwater and surface water has not been extensively evaluated within the basin. The primary occurrence of surface water and groundwater interaction exists at along Conejo Creek. This occurs as a result of losses from the Creek to the Basin and underflow from the basin to the Creek. The potential losses of groundwater supplies to the Creek necessitates the need for active monitoring of this interaction.

Actions:

- Regularly summarize groundwater and Conejo Creek water quality in the biennial report.
- Actions as described in Sections 5.2.1 and 5.2.4 are fundamental to evaluating the interaction of surface water and groundwater:
  - Identify an additional monitoring well west of SRMWC-3. This well will be used to monitor water levels relative to Conejo Creek surface elevation.
  - Coordinate with Hill Canyon WWTP staff to document Arroyo Conejo flow data.
  - Install permanent gaging station at Confluence Flume location. These data would help define surface water entering the Basin. This location is currently monitored four months per year by Hill Canyon WWTP staff.
  - Re-install Station 800 near the District offices on Conejo Creek. This station would help define the surface water exiting the basin and help define surface water-groundwater interaction.

5.3 GROUNDWATER PROTECTION

Groundwater protection is one of the most critical components of ensuring a sustainable groundwater resource. Prevention measures include proper well construction and destruction practices, development of wellhead protection measures, and protection of recharge areas. Prevention also includes measures to prevent contamination from human activities as well as contamination from natural substances such as saline water bodies from entering the potable portion of the groundwater system.

5.3.1 Well Policies

The County of Ventura administers well construction policies through a well permitting program for the entire County. The Ventura County Water and Environmental Resources Division, Groundwater Section, oversees the administration of Ventura County Ordinance No. 4184. This purpose of this ordinance is to “provide for the construction, maintenance, operation, use, repair, modification, and destruction of wells in such a manner that the groundwater of the County will not be contaminated or polluted, and that water obtained from wells will be suitable for beneficial use and will not jeopardize the health, safety or welfare of the people of this (Ventura) County."

5.3.2 Well Abandonment Policies

Ventura County Water and Environmental Resources Division, Groundwater Section, oversees the administration of these policies. There are no planned actions addressing well abandonment policies.

5.3.3 Well Destruction Policies

Ventura County Water and Environmental Resources Division, Groundwater Section, oversees the administration of these policies. There are no planned actions addressing well destruction policies.

5.3.4 Protection of Recharge Areas

Protection of the recharge area will maintain and or improve water quality within the groundwater basin. The contributing drainage area and its associated land use, illustrated on **Figure 2-3,** as well as the contributing drainage area to the Arroyo Conejo, all have a direct impact on the water quality of the Basin. Protecting these recharge and runoff area protects the water quality of the Basin.

Actions:

- Coordinate with City of Thousand Oaks on a source water protection program. For the Hill Canyon WWTP. This source water protection program will assist in the protection groundwater quality within the Santa Rosa Basin.
- Coordinate with County of Ventura to ensure planned land density requirements are maintained to protect groundwater quality. This will limit the density of septic systems and protect water quality.
- Develop outreach an program for agricultural stakeholders to educate them on pesticides and herbicides use, handling disposal, and the relationship to groundwater quality.

5.3.5 Wellhead Protection Measures

A drinking water source assessment is the first step in the development of a complete drinking water source protection program. The assessment includes: A delineation of the area around a drinking water source through which contaminants might move and reach that drinking water supply; an inventory of possible contaminating activities (PCAs) that might lead to the release of microbiological or chemical contaminants within the delineated area; and a determination of the PCAs to which the drinking water source is most vulnerable. Identification of wellhead protection is the objective of the Drinking Water Source Assessment and Protection (DWSAP) Program administered by the California Department of Public Health (DHS). As a first step to a complete source protection program, DHS requires water systems to conduct a preliminary assessment. The District has completed source assessment for current Basin production wells.

Another aspect of wellhead protection is the proper destruction of abandoned wells and or adequate well head protection to prevent contamination from the ground surface.

Actions:

- The District will continue to complete drinking water source assessments for any new production wells.
- The District conduct an inventory and survey of active and inactive wells in the Basin to identify potential abandoned wells, and develop an approach for possible grant funding to provide incentives to properly destroy abandoned wells.
- The District prepare and distribute a “Guide for Well Owners” that includes consumer information about the SRGMP, the County’s well construction, abandonment and destruction requirements, well head protection information, and recommendations for ensuring that wells are properly maintained and protected.

There remains the potential for localized contamination of groundwater by industrial point sources such as diesel fuel tanks, street runoff and agricultural runoff .

While the District does not have authority or the responsibility for the oversight or remediation of contamination, it will coordinate with responsible parties and regulatory agencies to keep Basin stakeholders informed on the status of potential contamination in the Santa Rosa Valley.

5.4 GROUNDWATER SUSTAINABILITY

To ensure a long-term sustainable supply of groundwater reduce dependence on imported water, the District must consider ways to increase or maintain groundwater recharge, improve groundwater quality, increase recycled (or non-potable) water use, and increase conservation.

5.4.1 Hill Canyon WWTP

Recharge from Conejo Creek is a primary portion of the groundwater recharge to the Basin. Approximately 50 percent of the annual flow in Conejo Creek is discharge from Hill Canyon WWTP.

The agreement regarding the District’s primary access to Hill Canyon WWTP discharge in Conejo Creek was executed in 1994. This 25-year contract will expire in 2019. The District is currently in the process of renegotiating the agreement to retain rights to Hill Canyon WWTP water. This agreement is important to the sustainability of groundwater as a water supply in the Basin.

Actions:

- Complete negotiations and extend the agreement with City of Thousand Oaks for primary access to Hill Canyon WWTP discharge in Conejo Creek.

5.4.2 Brackish Groundwater Desalination Component

As described in the Section 2, the groundwater quality fails to meet drinking water standards and several Basin Objective standards. If groundwater pumping is increased the quality of the water requires that the groundwater be blended with imported water at a significant price. Due to the Conejo Wellfield location, introducing greater quantities of imported water to the produced groundwater is not currently feasible (District, 2011a). An alternative to imported water that would increase reliability and decrease reliance on outside sources, is to treat a portion of the groundwater to meet drinking water standards. A proposed desalination facility considered by the District would divert up to 1 MGD from the total groundwater pumped prior to it being blended, treat that stream to the appropriate quality, and blend with untreated groundwater for potable distribution (District, 2011a).

Actions:

- The District will report on the technical, economical, and environmental feasiblity of Santa Rosa Basin desalination within the biennial report within two years from the release of this report.

5.5 PLANNING INTEGRATION

Planning integration involves making decisions with regional consideration of viewpoints, and considering multiple viewpoints from inside and outside the Basin regarding how groundwater should be managed. Such integration also promotes resource enhancements and reliability, operational efficiency, cost savings, and possibly environmental benefits.

As the District continues to seek out alternative supplies to imported water, and as awareness of the cost and dependence on others grows, it has become increasingly beneficial for the District to cooperate with neighboring districts and agencies to find practical, regional solutions to regional problems. Several interagency efforts are already in place, such as the Hill Canyon WWTP agreement that provides the District with non-potable surface water from Conejo Creek, and District plans to pursue cooperative projects that take a regional perspective in addressing water supply problems, the removal of salts from the watershed, and maintain the overall health and sustainability of regional resources (District, 2011).

5.5.1 Integrated Regional Water Management Plan

The Watersheds Coalition of Ventura County (WCVC) was formed in April 2006 as the water resource management group required by the passage of Propositions 50 and 84, and is managed by County of Ventura staff. The WCVC is a collaborative entity with interests in improving water quality, water supply reliability, water recycling, water conservation, flood control, recreation and access, wetlands enhancement and creation, and environmental and habitat protection (Ventura County, 2013). The WCVC, and its three watershed committees, are engaged in a variety of local planning efforts designed to address the objectives developed by the watershed committees; the District is a member of the Calleguas Creek committee.

The District developed the IRWMP in coordination with the Cities of Thousand Oaks, Camarillo, and Simi Valley; Calleguas Municipal Water District, Ventura County Water Works Districts 1 and 19, Ventura County Resource Conservation District; and Santa Monica Mountains Recreation and Conservation Agency. The broader Watershed Plan seeks to reduce reliance on imported water and over drafted, confined groundwater aquifers by reclaiming poor quality, unconfined groundwater supplies and otherwise expanding water recycling projects. The District adopted the IWRMP for the Calleguas Creek Watershed.

The IRWMP provides an umbrella under which the Urban Water Management Plan (UWMP) was developed. The facilities envisioned in the plan reduce reliance on imported water supplies while improving water quality through the managed transport of salts out of the watershed. The goals and objectives of the IRWMP are reflected in the projections and projects incorporated in this UWMP.

5.5.2 Urban Water Management Plan (UWMP)

The District prepared a 2010 UWMP, which was then adopted by the Board of Directors on June 8, 2011. The purpose of the plan was to update information in the previous plan, extend the water supply planning horizon to 2030, provide comprehensive assessment of the District's water resource needs for a 20-year planning period, develop a plan to meet the 20 percent water conservation requirements in 2015 and 2020, and document present and future water sources and demands. The UWMP was coordinated with a number of agencies to ensure that data and issues were accurate. The results of the UWMP were incorporated in the District's Integrated Facilities Master Plan (IFMP). Copies of the Draft 2010 Urban Water Management Plan were circulated and coordinated with the following agencies: Calleguas Municipal Water District, City of Camarillo, City of Thousand Oaks, California State University - Channel Islands, County of Ventura, and Pleasant Valley County Water District.

5.5.3 Integrated Facilities Master Plan (IFMP)

In September 2011, the District published the District's IFMP. The purpose of this plan was to evaluate the District's ability to meet its demand through 2035 and properly plan for the capital requirements to do so. The evaluation conducted within the document was based on the current population projections, land development trends, and water and wastewater demand forecasts. The resulting recommendations were developed to serve as the guide for capital improvements to meet 2035 potable and non-potable water service demands and sanitary service demands. Several of these capital improvements are groundwater-related projects.

Firm projects include the construction of additional wells. Other projects identified that require further study include: a Santa Rosa Desalination Facility, denitrification of the Conejo Creek Wellfield, and groundwater recharge in the Santa Rosa Basin with non-potable water (District, 2011b).

5.6 IMPLEMENTATION

Many of these actions involve coordination by the District with other local, and or state agencies and most of these will begin within 6 months, following adoption of this SRGMP. A few activities involve assessing trends in basin monitoring data for the purpose of determining the adequacy of the monitoring network. These assessments will be made as new monitoring data become available for review by the District, and results will be documented in an annual Biennial State of the Basin assessment.

5.6.1 Biennial GMP Implementation Report

The District will report on progress made implementing the SRGMP in a Biennial State of the Basin assessment, which will summarize groundwater conditions in the Santa Rosa Basin and document groundwater management activities from the previous two years. This report will include:

- Summary of hydrologic conditions and monitoring results, including a discussion of historical trends.
- Changes in well status – constructed destroyed etc.
- Summary of management actions during the period covered by the report.
- A discussion, supported by monitoring results, of whether management actions are achieving progress in meeting BMOs.
- Summary of status of BMO component category implementation.

The State of the Basin assessment will be completed by April 1st every other year and will report on conditions and activities completed through December 31st of the preceding two years.

5.6.2 Future Review of the SRGMP and Related Programs

This SRGMP is intended to be a framework for the management efforts in the Santa Rosa Basin area. Many of the identified actions will likely evolve as the District continues to actively manage and learn more about the Basin. Many additional actions will also be identified in the biennial report. The SRGMP is therefore intended to be a living document, and it will be important to evaluate all of the actions and objectives over time to determine how well they are meeting the overall goal of the plan. The District plans to evaluate this entire plan within five years of adoption.

5.6.3 Financing

It is envisioned that implementation of the SRGMP, as well as many other groundwater management-related activities will be funded from a variety of sources including the District, state or federal grant programs, and local, state, and federal partnerships. Some of the items that may qualify for funding include:

Preparation of SRGMP biennial reports.

- Updates of the overall SRGMP
- Update of data sets and recalibration/improvement of existing groundwater model
- Collection of additional subsidence data
- Construction of monitoring wells where critical data gaps exist
- Stream-aquifer interaction studies

Implementation of the SRGMP including:

- Monitoring for groundwater quality or elevations in wells
- Reactivation of surface water gauging

5.6.4 Implementation Summary

This subsection summarizes the plan components, their actions, and which BMO they are associated with. Is ongoing

Table 5-1
Summary of Implementation Actions

Action	Timing/ Frequency	BMO[A]
Coordination and Stakeholder Involvement		
Conduct annual public groundwater management update meetings for stakeholders. At these meetings the District will present a summary of current water quality monitoring, water level monitoring, groundwater pumping, projected groundwater pumping, current project status, planned project status, and current issues and concerns.	2014 - ongoing	4
Develop an outreach program for agricultural pumpers to educate basin water users on irrigation efficiency options.	2014 - ongoing	1,2,4
Establish a point of contact within local, state, and federal regulatory agencies that have responsibility for resource management within Santa Rosa Basin. Publish this list in future updates to the SRGMP. Maintain relationships with these contacts to assist in the completion of other action items.	2014	4
Coordinate with FCGMA regarding the data transmitted to DWR for CASGEM reporting.	2014 - ongoing	4
Monitor and review new development proposals and projects within the watershed to ensure that these proposals incorporate appropriate measures to protect water quality and water quantity within the Santa Rosa drainage area.	2013 - ongoing	1,2
Collaboration with the Ventura County Water & Environmental Resources Division, Groundwater Section, for the permitting of wells in accordance with the objectives of the SRGMP.	2014 - ongoing	1,2,4
Provide copies of the adopted SRGMP and subsequent bi-annual state of the basin assessments to representatives from the City of Thousand Oaks, Moorpark, FCGMA, Camarillo, and other interested parties.	2013	4
Monitoring Program		
Action		
Continue water level monitoring at a monthly frequency.	2013 - ongoing	3
Identify an additional monitoring well west of SRMWC-3. This well will be used to monitor water levels relative to Conejo Creek surface elevation.	2014	3
Complete a well survey to determine if there is a need for well abandonment or location for possible new monitoring wells in areas lacking groundwater data.	2014 - ongoing	1,3
Continue to track groundwater production on a monthly basis at all production wells within the Basin.	ongoing	2,3
Prepare estimates of non-District groundwater pumping and return flows based on water service connection data and crop information.	2014	2,3
Continue to complete required water quality analyses on each water supply well.	2013 - ongoing	1,2
Annually evaluate groundwater at key wells for pesticides and herbicides. These key wells must be established. The wells should vary in location and depth within the Basin.	Annually	1,2
Prepare a Salt and Nutrient Management Plan consistent with the DWR Bulletin 160. It is the intent of this plan to identify salt and nutrient sources in the basin and develop management protocols on a basin-wide basis for the attainment of water quality objectives and protection of beneficial uses.	2014	1,2,3
Coordinate with Hill Canyon WWTP staff to document Arroyo Conejo flow data.	2014	3
Install permanent gaging station at Confluence Flume location. These data would help define surface water entering the Basin. This location is currently monitored four months per year by Hill Canyon WWTP staff.	2014/2015	3
Re-install Station 800 near the District offices on Conejo Creek. This station would help define the surface water exiting the basin and help define surface water-groundwater interaction.	2014/2015	3
Annually evaluate surface water for pesticides and herbicides. Ideally this would be conducted on surface water prior to entering the Basin, e.g., Confluence Flume, and leaving the Basin, e.g., Station 800.	Annually	1,2
Establish a surveyed benchmark that can be used to evaluate subsidence trends over time. One benchmark should be located near the Conejo Wellfield.	2014	2,3
Conduct an annual subsidence monitoring at the identified benchmark and report in the biennial report	Annually	2,3
Determine monitoring network adequacy and periodically review and expand as appropriate to meet the needs of the SRGMP on a 5-year	Ongoing	3
Establish protocols for methods and frequency of collection, and storing of data. These protocols will be documented in Appendix D and Appendix E and may be updated in the bi-annual state of the basin assessments.	2014 - ongoing	3
Report on implementation progress in a biennial State of the Basin Report that summarizes the groundwater conditions in the Santa Rosa Basin.	Biennially	4
Identify an additional monitoring well west of SRMWC-3. This well will be used to monitor water levels relative to Conejo Creek surface elevation.	2014	3
Groundwater Protection		
Action		
Coordinate with City of Thousand Oaks on a source water protection program. For the Hill Canyon WWTP. This source water protection program will assist in the protection groundwater quality within the Santa Rosa Basin.	2014	1
Coordinate with County of Ventura to ensure planned land density requirements are maintained to protect groundwater quality. This will limit the density of septic systems and protect water quality.	2014	1
Develop outreach an program for agricultural stakeholders to educate them on pesticides and herbicides use, handling disposal, and the relationship to groundwater quality.	2014 - ongoing	1
Conduct an inventory and survey of active and inactive wells in the Basin to identify potential abandoned wells, and develop an approach for possible grant funding to provide incentives to properly destroy abandoned wells.	2014 - ongoing	1
Prepare and distribute a "Guide for Well Owners" that includes consumer information about the SRGMP, the County's well construction, abandonment and destruction requirements, well head protection information, and recommendations for ensuring that wells are properly maintained and protected.	2014	1
Groundwater Sustainability		
Action		
Complete negotiations and extend the agreement with City of Thousand Oaks for primary access to Hill Canyon WWTP discharge in Conejo Creek.	2013	2
The District will report on the technical, economical, and environmental feasibility of Santa Rosa Basin desalination within the biennial report within two years from the release of this report.	Biennially	2,4
Planning Integration		
Action		
Preparation of Biennial GMP Implementation Report - The State of the Basin assessment will be completed by April 1st every other year and will report on conditions and activities completed through December 31st of the preceding two years.	Biennially	2,4

A. BMO = Best Management Objective, definitions: 1. Protect and enhance groundwater quality, 2. Sustain a safe, reliable local groundwater supply, 3. Improve understanding of goundwater elevations, Basin yield and hydrogeology and, 4. Maintain public awareness and confidence, and honor the public trust

5.7 GROUNDWATER RELATED PROJECTS

As described in 5.5.3, firm projects described in the IFMP included the construction of additional wells. Other projects identified that require further study included a Santa Rosa Desalination Facility, denitrification of the Conejo Creek Wellfield, and groundwater recharge in the Santa Rosa Basin with non-potable water (District, 2011b). Projects were recommended by the District for evaluation in this management plan relative to increased yield. These projects included:

- Recharge Basin East of Conejo Wellfield
  - With non-potable water
  - With recycled water
- Recharge within Arroyo Santa Rosa
- Direct injection wells

Other projects were also considered that improve water quality and may increase yield of the Basin, these included:

- Western Extension of the Conejo Wellfield
- Desalination of Groundwater (and possibly denitrification)
  - At the District office site
  - At Conejo Wellfield

The location of each of these projects is shown on **Figure 5-1**. Listed below is a brief description of each project, summary of any analysis completed, project benefits, and project issues.

5.7.1 Recharge Basin East of Conejo Wellfield

Recharge basins have been considered by the District and were defined in the IFMP. The project would construct recharge ponds east of the Conejo Wellfield on a vacant parcel owned by the City of Thousand Oaks, as shown on **Figure 5-1**.

Recharge water would be delivered to the basin(s) from either the current non-potable distribution system, a new pipeline from Hill Canyon WWTP for recycled water, and or a diversion from Arroyo Santa Rosa for stormwater.

This project was modeled with the numerical groundwater model developed as part of this SRGMP to evaluate the potential additional yield and affects to groundwater from the project. Hydraulic modeling is independent of the type of water recharged. The total recharge area assumed is 3.3 acres. The initial recharge basin area was larger, nearly 10 acres, and had to be reduced due to high groundwater conditions, or mounding. Initial simulations were reduced until high groundwater and discharge to Arroyo Santa Rosa was eliminated. This issue is related to the current depth to groundwater, site hydraulic properties, and the assumed recharge rate. A feasibility analysis that includes field testing should be conducted to validate and or measure these properties.

It was assumed that the facilities would be in operation for 10 months a year, 2 months down time is assumed for cleaning. A recharge rate of one foot per day was assumed based on local soil types. Given these assumptions, a total of 990 acre-feet of either non-potable, recycled, or stormwater water can be recharged annually. If pumping remains constant, this additional recharge increases the Basin outflow to Conejo Creek by the same amount, this can be assumed to be the approximate increased yield. If possible, this additional yield could be captured with new wells.

Issues that require further assessment:

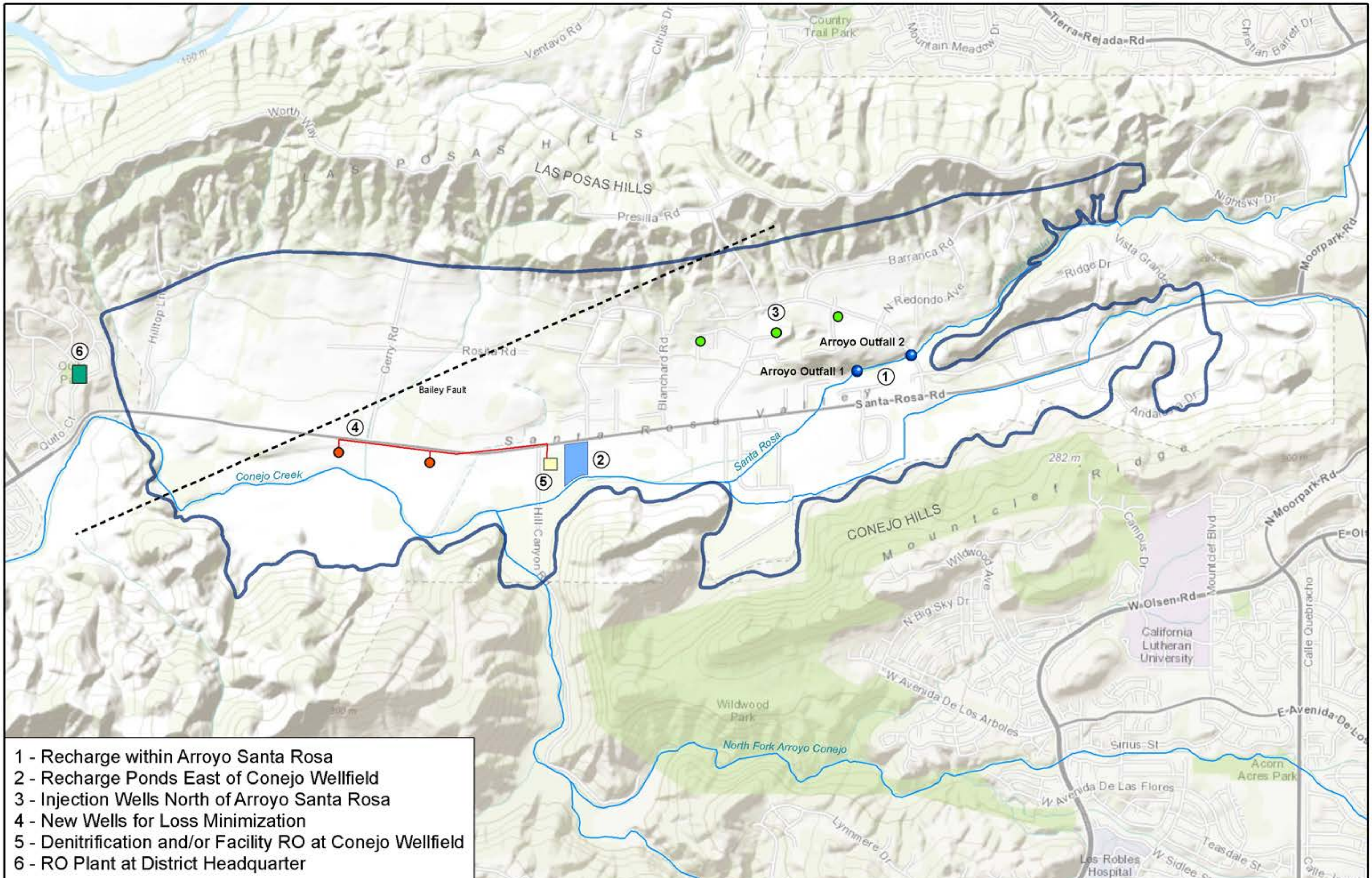
Hydraulic Properties: modeling assumptions related to recharge rate, conductivity, and current depth to water were made and directly affect the model results. A feasibility analysis that includes field testing should be conducted to validate and or measure these properties.

Land Acquisition: The land on which the basins would be constructed must be obtained, further evaluation must be conducted to determine the value of the land and the potential to obtain the required land for recharge operations.

Project Permitting: An issue with a recharge project of this type will be the recharge water quality. Water quality must meet the RWQCB Basin Plan objective for groundwater, regardless of water type (non-potable from Conejo Creek, recycled water from Hill Canyon WWTP, or stormwater) because there is limited assimilative capacity in the Basin for chloride, nitrate, sulfate, or TDS. This may be one of the largest impediments to a potential project. Currently, the non-potable water does not meet the chloride Basin Plan requirement for groundwater, and therefore, could not be recharged alone. A recharge project using only non-potable water is not feasible. Recycled water or stormwater would meet all Basin Plan objectives.

The use of recycled water will require a permit from the RWQCB and the recharge of another supply as dilution, or diluent water. Diluent water is defined as water, other than treated wastewater, that actively or passively is used to dilute treated wastewater in a recharge project. Diluent water requirements (CWC §60320) may be satisfied by using surface water, stormwater, or groundwater. The amount of diluent water required is a function of the water quality of the recycled water and diluent water. The Recycled Water Contribution (RWC) is defined by the following equation in CWC §60320:

$$RWC = \frac{Recycled\ Water\ Volume}{Recycled\ Water\ Volume + Diluent\ Volume}$$



1 - Recharge within Arroyo Santa Rosa
2 - Recharge Ponds East of Conejo Wellfield
3 - Injection Wells North of Arroyo Santa Rosa
4 - New Wells for Loss Minimization
5 - Denitrification and/or Facility RO at Conejo Wellfield
6 - RO Plant at District Headquarter

Key to Features

- Recharge within Arroyo Santa Rosa
- New Wells for Loss Minimization
- Potential Injection Wells
- City Boundaries
- Santa Rosa Valley Groundwater Basin
- Watershed
- Recharge Ponds East of Conejo Wellfield
- New Pipeline for Loss Minimization
- Injection Well Area
- Denitrification and/or RO Facility at Conejo Wellfield
- RO Plant at District Headquarter

N
0 0.3 0.6 Miles

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Santa Rosa Basin
Potential Groundwater Projects

MWH

Figure 5-1

For example, if 1,000 acre-ft of recycled water is combined with 4,000 acre-ft of diluent water,

$$RWC = \frac{1000}{1000 + 4000} = 0.2 = 20\%.$$

The initial RWC is based on CDPH's review of a project engineering report. The RWC can range from 0.2 for surface spreading (i.e. 20% recycled water), to ≤ 0.5 for subsurface injection (i.e. 50% recycled water), to 1.0 (100% recycled water) for advanced treated water surface recharge or injection. The RWC calculation is typically made on a 60-month rolling average. Increasing the allowable RWC is dependent on the Total Organic Carbon (TOC) in the recycled water (CWC §60320) and would require approval by CDPH and the RWQCB modified in the project permit. Also the maximum allowable TOC as defined under CWC §60320 is,

$$TOC_{\max} = \frac{0.5\ mg/L}{RWC}.$$

For example, for a 20% RWC,

$$TOC_{max} = \frac{0.5\ mg/L}{0.2} = 2.5\ mg/L.$$

So, recycled water with TOC greater than 2.5 mg/L may require reverse osmosis to comply with CWC §60320.

Using recycled water may require the purchase of imported water if stormwater does not provide sufficient diluent water. District non-potable water may be considered diluent water. This will require RWQCB and CDPH approval, but it fits the current definition provided in the draft permit – although, this water does NOT currently meet the basin plan objective. A feasibility analysis must be completed to the determine the amount of non-potable water that could be reached to meet potential permit requirements. With the lack of reliable monitoring data on Arroyo Santa Rosa, it is not known if there is a reliable diluent supply or if imported water must be purchased.

There are no regulatory requirements for the use of stormwater for surface spreading. The RWQCB has determined that it is not feasible to develop numeric limits for stormwater permits. Stormwater quality is protected by NPDES permits (including Municipal Separate Storm Sewer Systems [MS4] permits) issued by the Los Angeles RWQCB. Each regulated MS4 is required to develop and implement a stormwater management program to reduce the contamination of stormwater runoff and prohibit illicit discharges. These individual permits, if issued upstream of the recharge facility, protect stormwater recharge water quality.

A recycled water recharge project would have a net benefit on groundwater quality due the current quality of recycled water and the ambient water quality within the basin.

Capital and Operating Expenses: Capital construction costs were not evaluated for this project and require further study. Annual operation and maintenance will be required for the recharge basins, which typically range from $10 to $30 per acre-foot of recharge volume.

5.7.2 Recharge within on Arroyo Santa Rosa

Recharge within the Arroyo Santa Rosa can be increased if the residence time and wetted area are increased. This project is described in the IFMP and would be constructed near two non-potable system turnouts, above Charisma Court, upstream of Santa Rosa Road and downstream of East Las Posas Road. Although the project could also be completed with recycled water, imported water or stormwater could also be used.

This reach of the Arroyo Santa Rosa has sections of both improved and natural channels. The improved areas generally have riprap bank protection and a natural bottom with medium to heavy vegetation. Recharge within the stream channel can be achieved with the construction of inflatable rubber dams. Inflatable rubber dams are used throughout California to retain water for recharge and or divert water to off channel recharge facilities. A typical rubber dam installation consists of a reinforced concrete foundation constructed across a riverbed with a rubber bladder anchored to the foundation. The bladder is inflated and deflated through connected air piping. Most contemporary rubber dams use air for inflation, but water may be suitable where hydraulic conditions are more demanding.

For project evaluation, two rubber dams were assumed to be constructed within the Arroyo Santa Rosa. It is assumed that the facilities will be in operation during the dry season only, that is, from April to November, with a recharge rate is one foot per day. The channel width was assumed to be 40 feet. Given these assumptions, a total of 435 acre-feet of either non-potable, recycled, or stormwater water can be recharged annually. If pumping remains constant, this additional recharge increases the Basin outflow to Conejo Creek by the same amount. Again, this can be assumed to be the approximate increased yield and this amount could be captured with new wells. .

Issues that require further assessment:

Construction within a stream channel can be a greater effort than the development of recharge basins or wells due to habitat protection measures, potential additional permitting, and flood management considerations.

Hydraulic Properties: modeling assumptions related to recharge rate, conductivity, and current depth to water were made and directly affect the model results. A feasibility analysis that includes field testing should be conducted to validate and or measure these properties. Monitoring data should be collected on the Arroyo Santa Rosa to determine potential for stormwater recharge with the project.

Access: The land on which the rubber dams would be constructed and access to the site for operations requires additional evaluation and was not considered assessment.

Project Permitting: The same water quality requirements and blending requirements listed in Section 5.7.1 also apply for this project. Again, there are no regulatory requirements for the use of stormwater for surface spreading.

Capital construction costs for this project will require further feasibility analysis.

5.7.3 Injection Wells

This project would consist of three injection wells that would directly inject water into the underlying aquifer. This project would create injection facilities that recharge water throughout the year in the eastern portion of the Basin. The injection wells would be constructed to an anticipated depth of 400 feet below ground surface. Each well is assumed to have an injection capacity of 300 gpm, and each would be in operation for 11 months annually.

Recharge water would be delivered to the wells most likely via the imported water system. Typically in California, permitted injection projects require from either fully treated water that meets California drinking water standards or advanced treated recycled water. There are exceptions, but they are rare. Injection of tertiary treated recycled water, stormwater, or non-potable water is not recommended due to substantial permitting requirements and additional well maintenance requirements. Recharge of imported water would have a positive effect on groundwater quality in the Basin.

This project was modeled with the numerical groundwater model developed as part of this SRGMP to evaluate the potential additional yield and affects to groundwater from the project. The initial location of the wells described by District Staff was farther east than those modeled, due to a lack of thickness in the aquifer the wells were moved west to reduce high groundwater conditions, or mounding. Given the model assumptions, a total of 1,000 acre-feet of water can be recharged annually. If Basin pumping remains constant, this additional recharge increases the Basin outflow to Conejo Creek by the same amount. Again, this can be assumed to be the approximate increased yield and this amount could be captured with new wells.

Issues that require further assessment:

Land Acquisition: The land on which the wells would be constructed must be obtained, and right-of-ways must be obtained for any connecting piping. Further evaluation must be conducted to determine the value of the land and the potential to obtain the required land for recharge operations.

Hydraulic Properties: Modeling assumptions related to recharge rate, conductivity, and current depth to water were made and directly affect the model results. A feasibility analysis that includes field testing (and pilot well program) should be conducted to validate and or measure these properties. Monitoring wells may also be required to evaluate the impact of the injection program.

Project Permitting: The same water quality requirements and blending requirements listed in Section 5.7.1 also apply for this project.

The injection wells associated with this project would be classified as Environmental Protection Agency (EPA) Class V wells. To meet EPA requirements for Class V wells, injection well owners and operators are required to submit basic inventory information to the primacy enforcement agency. In California the primacy authority is the RWQCB and oversees all permitting. The RWQCB is more restrictive than the EPA and requires local permitting for a Class V injection well. . The RWQCB issues permits, but also works with DPH which will require monitoring and reporting of the injection well program. The permits are typically in the form of waste discharge permits and have requirements for water quality, monitoring, reporting, and compliance determination.

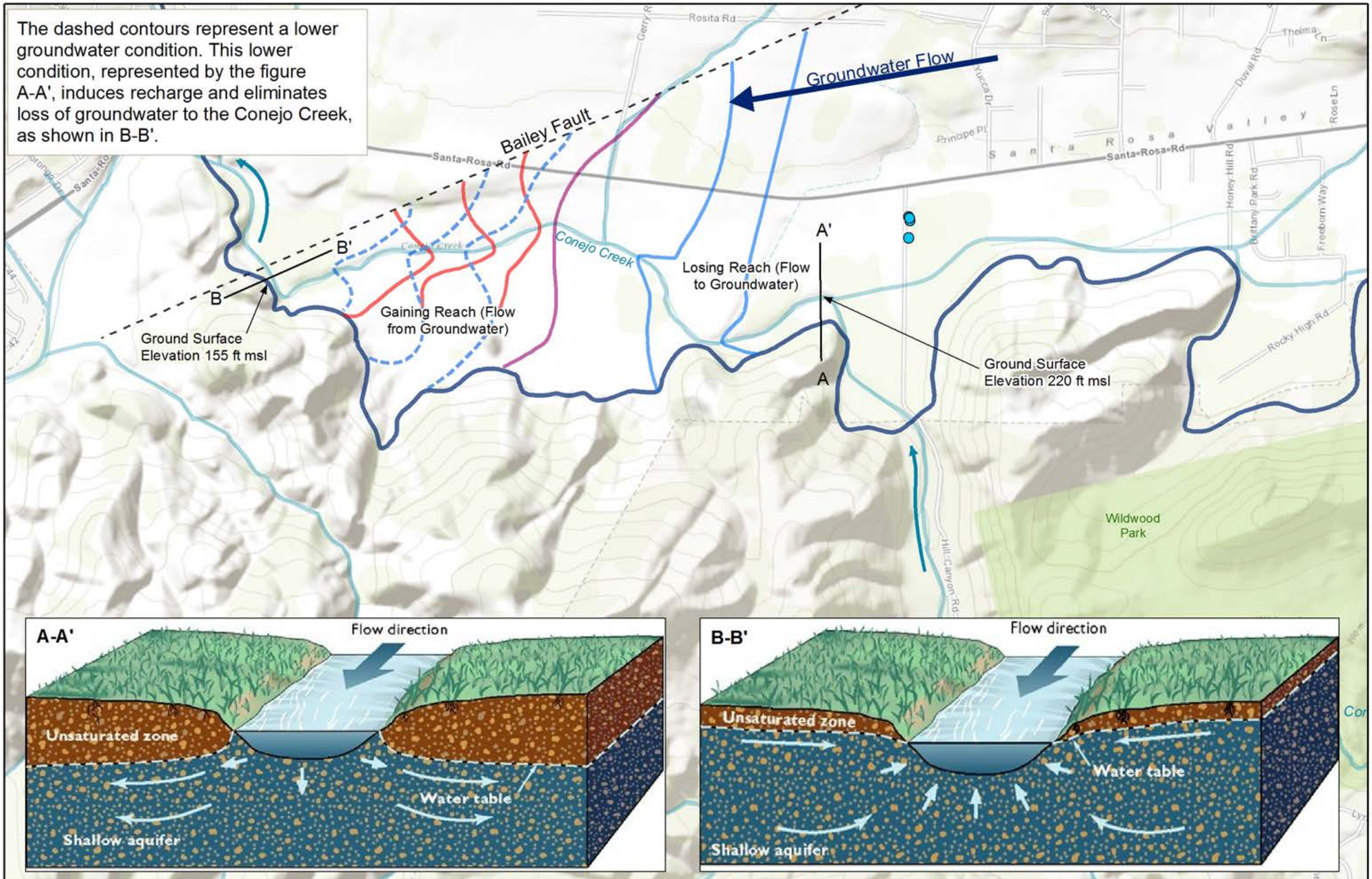
Capital and Operating Expenses: Capital construction costs were not evaluated for this project and require further study.

Cost of Imported Water: The cost to buy imported water could present significant constraints to the project.

5.7.4 Western Extension of the Conejo Wellfield

This project would consist of two additional extraction wells located west of the Conejo Creek Wellfield and parallel to Conejo Creek. The conceptual project would include a pipeline to the Conejo Creek Wellfield for distribution. The purpose of this project draw water levels down to 1) provide storage capacity for wet periods and 2) maintain a lower water level in the Basin than the water level in Conejo Creek whereby recharge from the creek always occurs.

A review of surface water flow and groundwater levels indicate that the groundwater basin typically has a net recharge from the creek, but when water levels are high, as in 2003 through 2008, there is little storage capacity in the groundwater basin and groundwater can discharge to Conejo Creek. Keeping groundwater levels lower will ensure no losses of groundwater to the Creek. This the lowering of groundwater levels is conceptually illustrated on **Figure 5-2**. As summarized in Section 2, over 1,000 acre-feet of groundwater was lost to the Creek in 2004 during a wet period.



Key to Features

- Conejo Production Wells
- Stream
- Fault

Conceptual Groundwater Contours

- Equilibrium
- Gaining Reach
- Losing Reach
- Lower Water Level

- Santa Rosa Valley Groundwater Basin Boundary
- Surface Water Flow Direction

Stream Cross Section Source: Winter and others, 1999

N — 0 0.25 0.5 Miles

Document: \\Uspas1s01\Camrosa Water District\Santa Rosa GMP (10500900)\14 e-data_modeling_MXDs\ConceptualContours.mxd

Conceptual Surface Water / Groundwater Relationship

MWH

Figure 5-2

Issues that require further assessment:

Land Acquisition: The land on which the wells would be constructed must be obtained, and right-of-ways must be obtained for any connecting piping. Further evaluation must be conducted to determine the value of the land and the potential to obtain the required land.

Environmental Analysis: An environmental impact analysis must be completed to determine any potential impact to the Conejo Creek based from lowering groundwater levels. This project requires modeling and additional technical evaluation.

Capital and Operating Expenses: Capital construction costs were not evaluated for this project and require further study.

5.7.5 Desalination of Groundwater (and possibly Denitrification)

Desalination and denitrificaiton of Conejo Wellfield water for use in the potable distribution system is a project that is summarized in the IFMP. The construction of a reverse osmosis (RO) desalination facility, would either be located at at the Conejo Wellfield or at Camrosa Headquarters.

If the facility is located at the District site, water produced at the Conejo Wellfield would be treated with a 3 MGD RO treatment plant constructed in the back lot at District Headquarters, 2.3 miles away. The water would be treated to remove salts and the finished water would be blended back potable distribution system.

The proposed treatment facility at Conejo Wellfield would be located between Well Conejo-3 and Well SRMWC-8 and consist of a 1 MGD treatment facility. Feed water piping into the treatment facility would allow water to be taken separately from Wells Conejo-2 and/or 4 or the onsite tank that is filled by the wells. The highest nitrate concentrations would be supplied to the treatment facility and allow the treated product water to be blended back into the poor quality well water. This project would have a significant impact on the reliability of groundwater supply for the District and improve long-term Basin water quality.

The brine waste stream from the treatment plant would be discharged through a brine line that would interconnect with the Calleguas MWD Regional Brine Line. Depending on the location of the facility, 3.0 to 5.3 mile-long pipeline would run along Santa Rosa Road from the treatment plant to Upland Road, and then along Upland Road to connect to the Salt Management Pipeline in Lewis Road. The pipeline along Upland Road would be attached to the Upland Road Bridge to avoid a trenched crossing of Calleguas Creek (District, 2011).

Issues that require further assessment:

Brine Discharge: The Calleguas Regional Salinity Management Pipeline (SMP) is being constructed by the Calleguas Municipal Water District. The pipeline will extend from the city of Simi Valley, at the most easterly point, through the cities of Moorpark, Camarillo, Oxnard, and areas of unincorporated Ventura County. The westerly endpoint of the pipeline is located in Port Hueneme. The alignment of the SMP near the District has not been determined and may impact the cost of using the SMP. Connection fees for the SMP were not evaluated as part of this project.

Capital and Operating Expenses: Capital construction costs were not evaluated for this project and require further study. A financial evaluation should be conducted to determine the size of the treatment facility, the cost of treated water relative to imported costs for blending, and the value of an independent reliable water supply.

Section 6
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Appendix A

Public Notices

Client:

CAMROSA WATER/WC LEGAL

Account #	19833	Ad #	296175
Phone:	(805) 987-4797 Ext: 0		
Fax:			
Address:	7385 SANTA ROSA ROAD		
	CAMARILLO, CA 93012		
Sales Rep.:			
Phone:	(805) 437-0352		
Fax:	(805) 437-0065		
Email:	legals@vcstar.com		
Entry date:	12/19/2011	11:23 AM	
Class.:	1299	Other Public Notices	

Requested By:

DONNIE ALEXANDER

PO #:	UMWP
Entered By:	147412
Printed By:	147412
Start Date:	12/21/2011
End Date:	01/04/2012
Nb. of	4
Publications:	Ventura County Star Web
Total Price:	$143.00
Paid Amount:	$0.00

Page 1 of 1

NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that a Public Hearing with the Camrosa Water District Board of Directors will be held:

---Wednesday, January 11, 2012 at 5:00pm---
CAMROSA WATER DISTRICT
7385 Santa Rosa Rd. Camarillo, CA. 93012
(805) 482-4677

The purpose of this Public Hearing is to accept public testimony regarding the preparation of a groundwater management plan for the Santa Rosa Basin.

Tony L. Stafford
Secretary / Interim General Manager
CAMROSA WATER DISTRICT BOARD OF DIRECTORS
Publish: Dec. 21, 2011, Jan. 4, 2012 Ad No.296175

CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

December 21, 2011

THIS IS TO CERTIFY THAT THREE COPIES OF THE CAMROSA WATER DISTRICT'S PUBLIC HEARING NOTICE FOR:

- ***Preparation of the Santa Rosa Groundwater Management Plan***

WERE PLACED WITHIN DISTRICT BOUNDARIES FOR CAMROSA CUSTOMERS AND ITS CONSTITUENTS TO VIEW.

THE PUBLIC HEARING NOTICE POSTING LOCATIONS ARE:

SANTA ROSA ELEMENTARY SCHOOL
13282 Santa Rosa Rd. Camarillo, CA. 93012

CAMROSA WATER DISTRICT
7385 Santa Rosa Rd. Camarillo, CA. 93012

CAMROSA WATER RECLAMATION FACILITY
1900 Lewis Rd. Camarillo, CA. 93010

Donnie Alexander
Communications Coordinator

Certificate of Publication

Ad #296175

In Matter of Publication of:

NOTICE OF PUBLIC HEARING

State of California)
))§
County of Ventura)

I, **Ossie Knowlton**, hereby certify that the **Ventura County Star Newspaper** has been adjudged a newspaper of general circulation by the Superior Court of California, County of Ventura within the provisions of the Government Code of the State of California, printed and published in the City of Camarillo, County of Ventura, State of California; that I am a clerk of the printer of said paper; that the annexed clipping is a true printed copy and publishing in said newspaper on the following dates to wit:

December 21, 2011, January 4, 2012

I, Ossie Knowlton certify under penalty of perjury, that the foregoing is true and correct.

Dated this January 4, 2012, in Camarillo, California, County of Ventura.

Ossie Knowlton

NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that a Public Hearing with the Camrosa Water District Board of Directors will be held:

—Wednesday, January 11, 2012 at 5:00pm—
CAMROSA WATER DISTRICT
7385 Santa Rosa Rd. Camarillo, CA. 93012
(805) 482-4677

The purpose of this Public Hearing is to accept public testimony regarding the preparation of a groundwater management plan for the Santa Rosa Basin.

Tony L. Stafford
Secretary / Interim General Manager
CAMROSA WATER DISTRICT BOARD OF DIRECTORS
Publish: Dec. 21, 2011, Jan. 4, 2012 Ad No.296175

CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

January 5, 2012

Dear Camrosa Customer:

The Camrosa Water District (District) is in the early planning phase of updating its existing groundwater management plan (Plan) for the Santa Rosa Groundwater Basin. The original groundwater management plan was first prepared in 1987 and subsequently updated in 1997 under the authority of the Groundwater Management Act of the California Water Code. Nearly 15-years have passed and a Plan update is needed to assist the District in optimizing the beneficial uses of the groundwater basin, preserve and enhance water quality, and assure preservation of the resource for future generations.

All agricultural interests and private pumpers overlying the groundwater basin have the opportunity to participate and comment in the development of the Plan.

On December 14, 2011, the District Board set a Public Hearing date of January 11, 2012, to accept public comments, and at the conclusion of the Public Hearing make a decision to adopt a Resolution of Intention to prepare a Plan update.

If you have any comments, you may attend the meeting held on January 11, 2012, beginning at 5:00 PM, or submit your comments in writing to:

Camrosa Water District
C/O Mr. Terry Curson
7385 Santa Rosa Road
Camarillo, CA 93012

or email at tcurson@camrosa.com

Sincerely,

Tony Stafford,
Interim General Manager

7385 Santa Rosa Road • Camarillo, CA 93012

CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

Resolution No: 12-01

A Resolution of the Board of Directors of Camrosa Water District

To Draft A Groundwater Management Plan For The Santa Rosa Valley Basin Pursuant To The Groundwater Management Act Of The California Water Code

Whereas, California's Legislatures has declared that groundwater is a valuable natural resource and should be managed to ensure both its safe production and quality; and

Whereas, the Groundwater Management Act, commonly referred to as AB3030 was signed into law on September 26, 1992, and became effective on January 1, 1993, and is incorporated into the California Water Code under Section 10750 et seq., authorizing local agencies whose service area includes a groundwater basin that is not subject to groundwater management pursuant to other provisions of the law or court decisions, to adopt and implement a groundwater management plan; and

Whereas, the Santa Rosa Valley Groundwater Basin lies within Camrosa's boundaries and the greatest portion of this basin, east of what is known as the Bailey Fault, is not subject to groundwater management pursuant to other provisions of the law; and

Whereas, the Camrosa Water District was organized under Division 12, Section 3000 of the State Water Code and is authorized to prepare and adopt groundwater management plans pursuant to the California Water Section 10750 et seq.,; and,

Whereas, agricultural interests and private pumpers overlying the groundwater basin will be given opportunity to participate and comment in the development of the groundwater management plan; and

Whereas, following publication of notice as required by law, the Camrosa Water District held a Public Hearing on January 11, 2012, to receive public comment on the merits of whether or not to adopt a Resolution of Intent to draft a groundwater management plan; and,

Whereas, after considering the public comments and other information presented at the Hearing, Camrosa's Board of Directors determines that it is in the best interest of the District's constituents to draft a groundwater management plan for the Santa Rosa Valley Basin.

Now, Therefore, Be It Resolved by the Camrosa Water District Board of Directors as follows:

1. *Camrosa hereby declares its intention to draft a Groundwater Management Plan, pursuant to the Groundwater Management Act of 1993, for the Santa Rosa Valley Basin, in the portion not subject to groundwater management pursuant to other provisions of the law, and in cooperation with local agricultural and private well owners interest.*

2. *Camrosa hereby declares its intention in developing the Groundwater Management Plan is to assure that adequate water supplies of the highest possible quality are maintained for all current and future users of the Groundwater Basin.*

3. *Camrosa hereby declares its intended objectives as follows:*

   A. *Evaluate historical and projected groundwater pumping and estimated groundwater balance/overdraft; and,*

   B. *Characterize and estimate quantities of flows in and out of the Basin and Sub-basins; and,*

   C. *Evaluate groundwater quality characteristics and water quality improvements and degradation trends; and,*

   D. *Identify points of natural and/or intentional basin recharge.*

Adopted, Signed and Approved this 11th day of January 2012.

Al E. Fox, President
Board of Directors
Camrosa Water District

ATTEST:

Tony L. Stafford, Secretary
Board of Directors
Camrosa Water District

CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

December 3, 2012

Dear Camrosa Customer:

The Camrosa Water District (District) is preparing an update to the Santa Rosa Basin Groundwater Management Plan. The original groundwater management plan was first prepared in 1987 and subsequently updated in 1997 under the authority of the Groundwater Management Act of the California Water Code. Nearly 15-years have passed and a Plan update is needed to assist the District in optimizing the beneficial uses of the groundwater basin, preserve and enhance water quality, and assure preservation of the resource for future generations.

The District is convening a stakeholder meeting on December 13, 2012 at 4:00 PM to conduct an overview of the Groundwater Management Plan and provide interested stakeholders an opportunity to discuss the Plan's development. The meeting will take place at the following location:

Camrosa Water District
7385 Santa Rosa Road
Camarillo, CA 93012

Additional information may be obtained by contacting Mr. Terry Curson, Project Engineer by email terryc@camrosa.com or by telephone at (805) 482-8063.

Sincerely,

Tony Stafford
General Manager

7385 Santa Rosa Road ▪ Camarillo, CA 93012-9284
Phone: (805) 482-4677 ▪ FAX: (805) 987-4797
Website: www.camrosa.com

CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

STAKEHOLDER MEETING

NOTICE IS HEREBY GIVEN that a Stakeholder Meeting with the Camrosa Water District Staff will be held:

---Thursday, December 13, 2012 at 4:00pm---

CAMROSA WATER DISTRICT
7385 Santa Rosa Rd. Camarillo, CA. 93012
(805) 482-4677

The purpose of the Stakeholder Meeting is to conduct an overview of the preparation of the Santa Rosa Basin Groundwater Management Plan Update and provide interested stakeholders an opportunity for discussion.

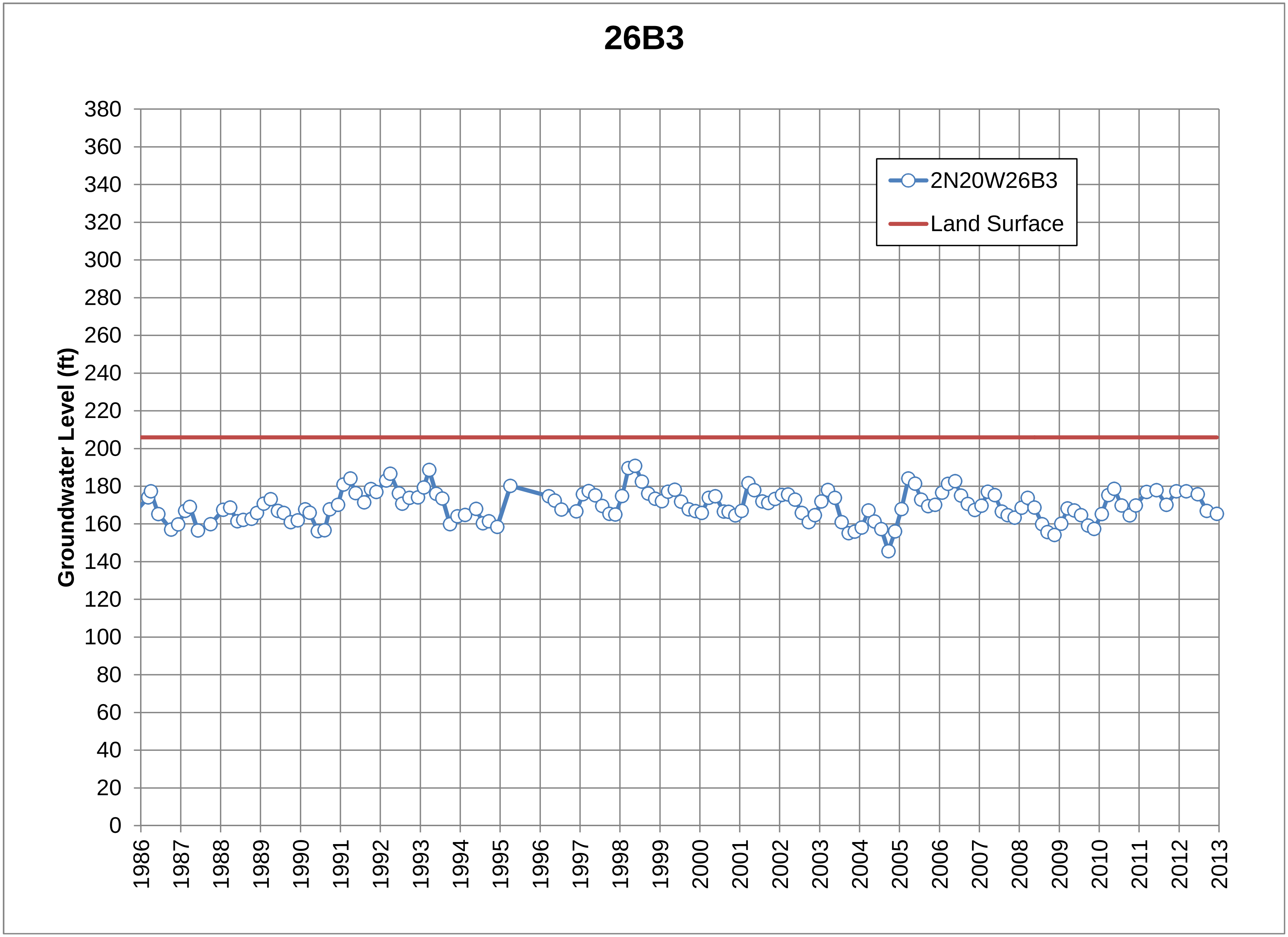
Tony Stafford

Tony L. Stafford
Secretary / General Manager

7385 Santa Rosa Road ▪ Camarillo, CA 93012-9284
Phone: (805) 482-4677 ▪ FAX: (805) 987-4797
Website: www.camrosa.com

Appendix B

Santa Rosa Basin Hydrographs



26B3
Groundwater Level (ft)
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
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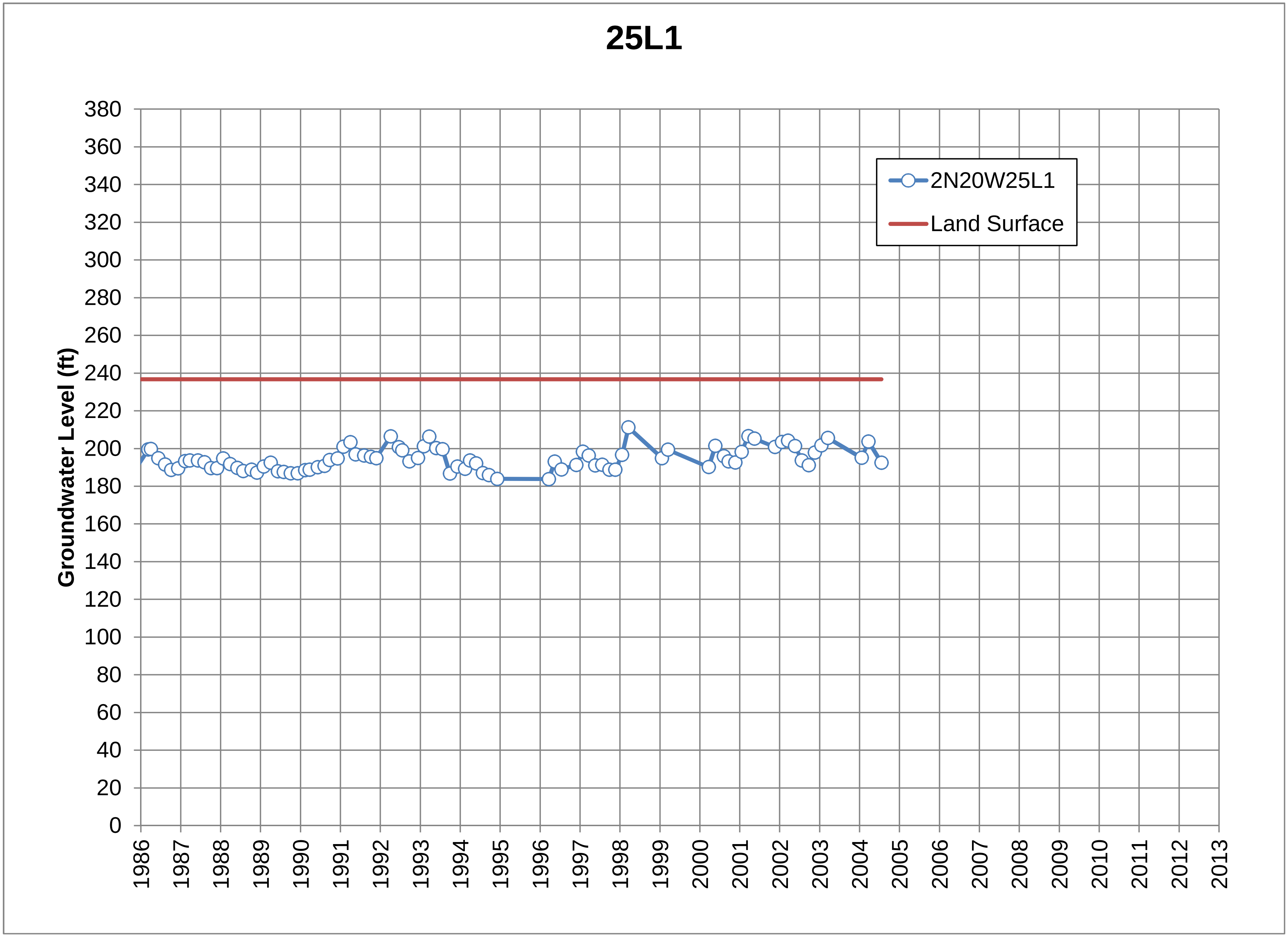
2013
2N20W26B3
Land Surface


25L1
Groundwater Level (ft)
2N20W25L1
Land Surface
0
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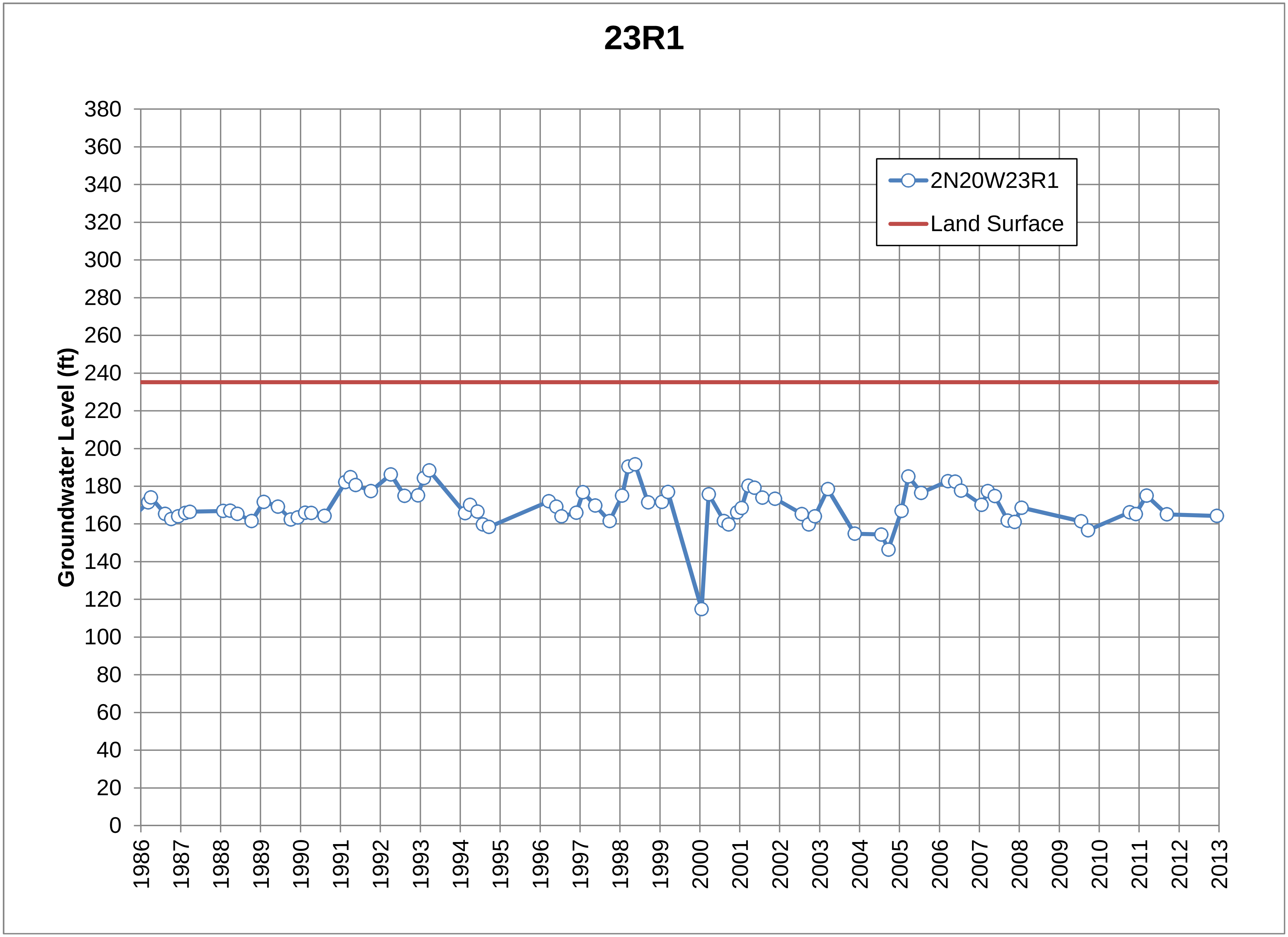

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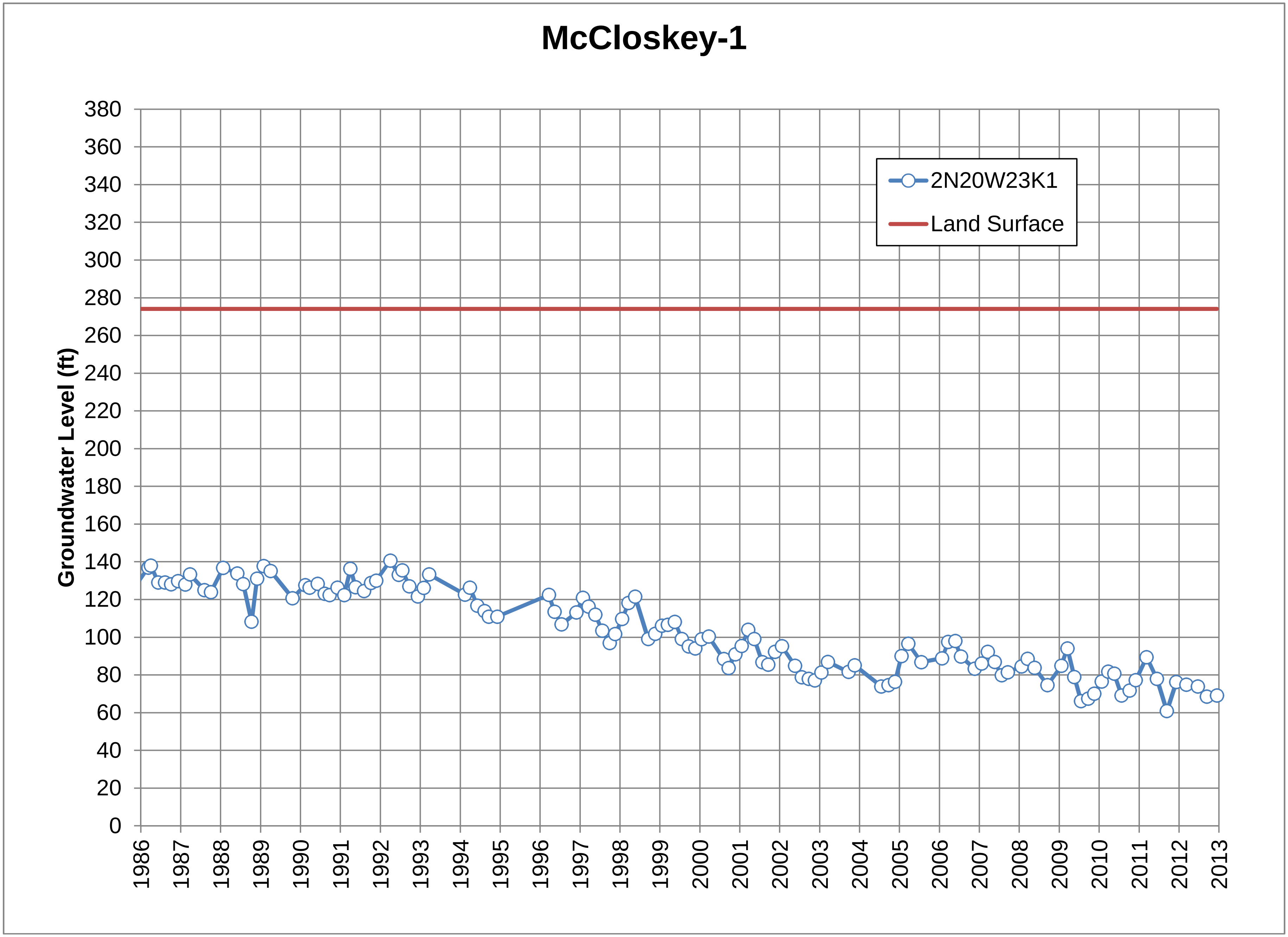

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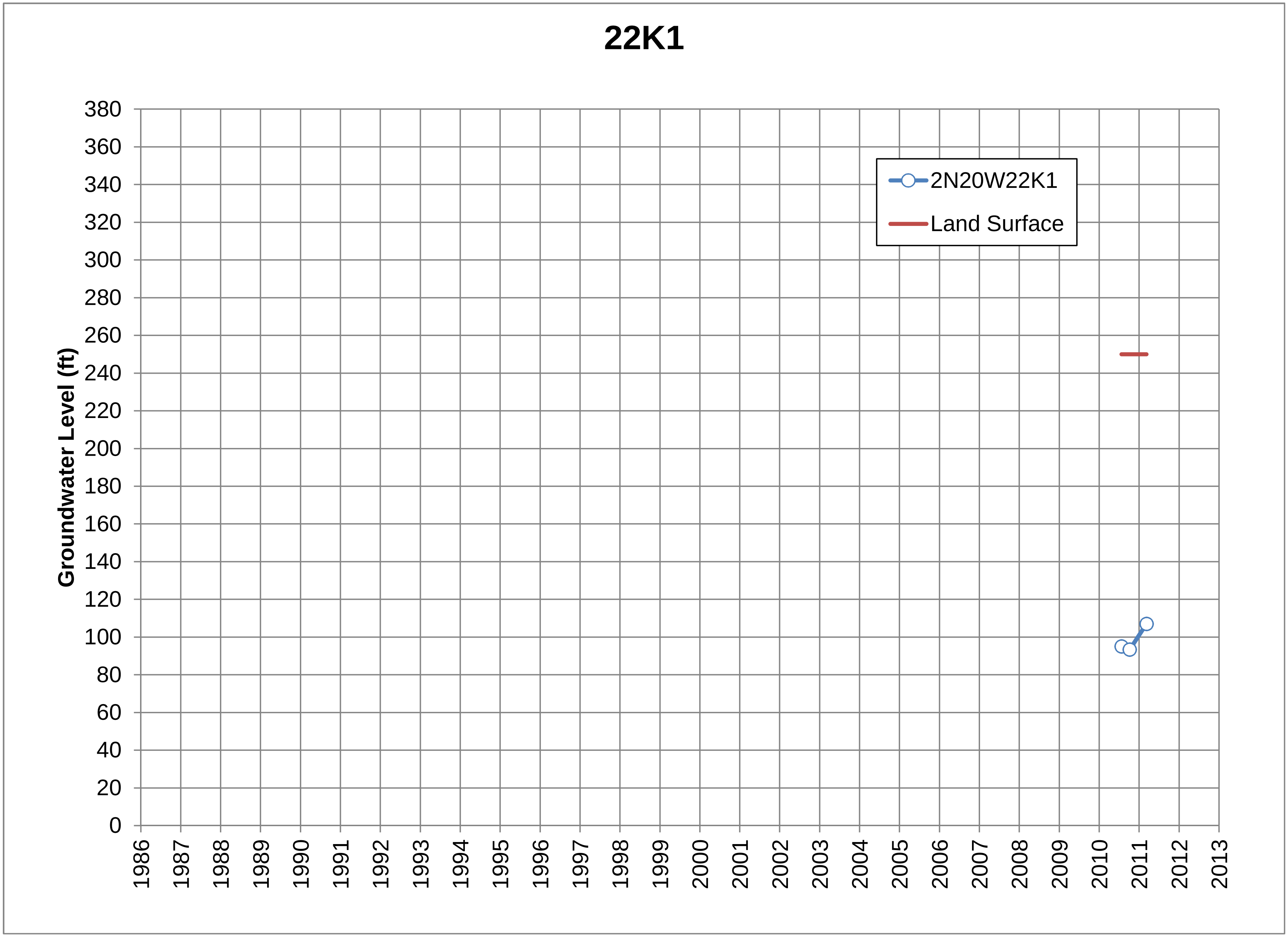

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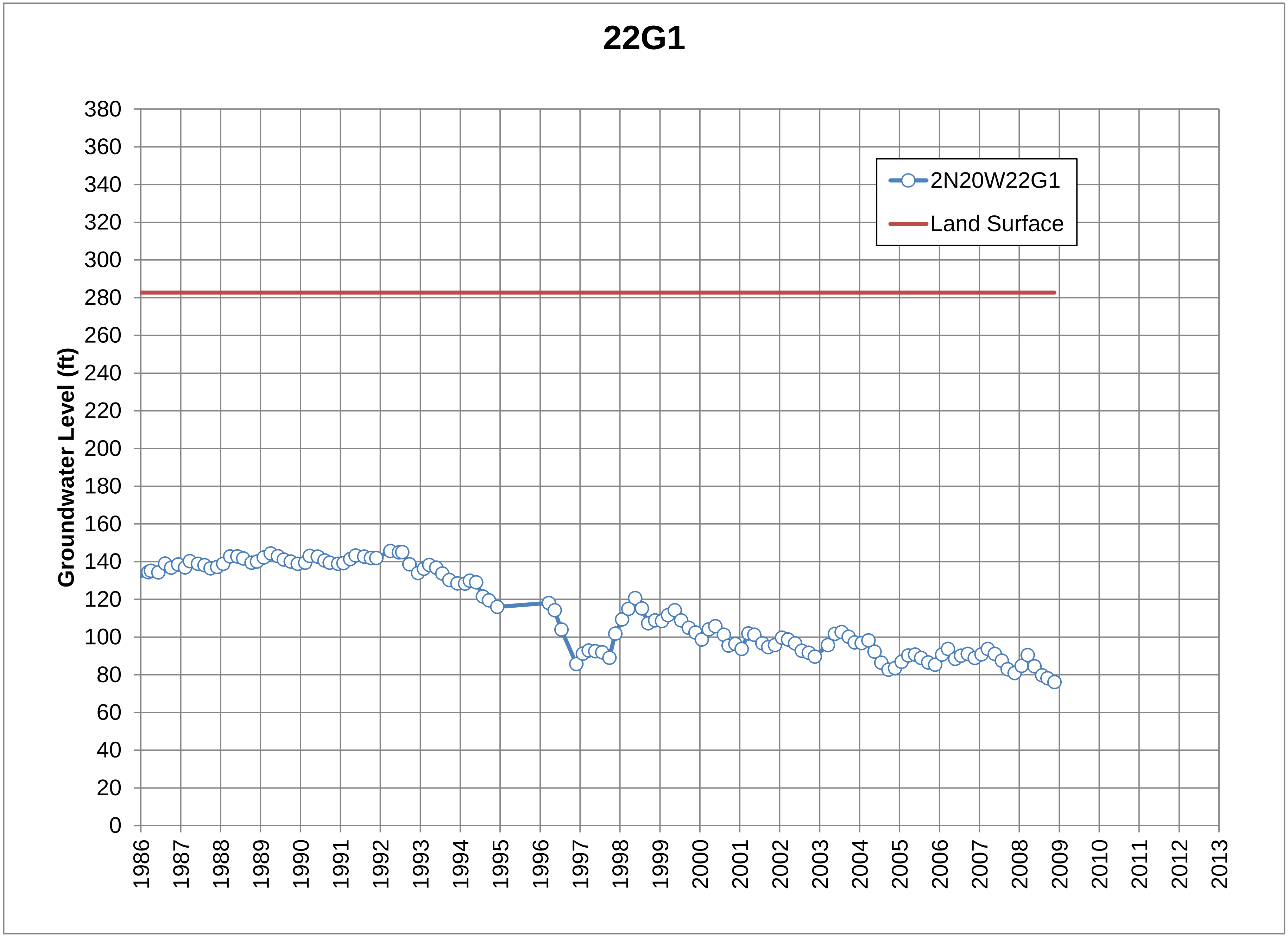
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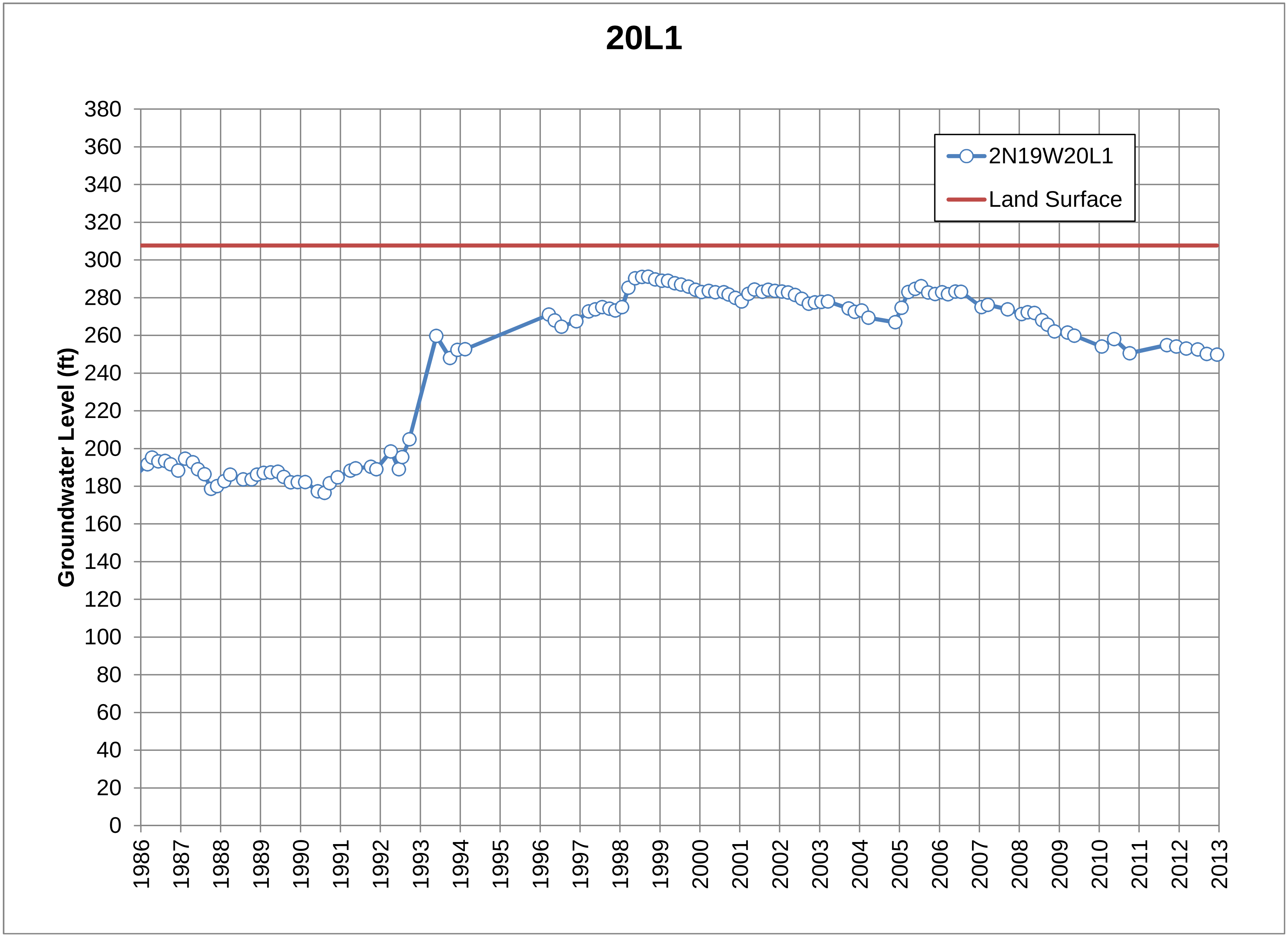

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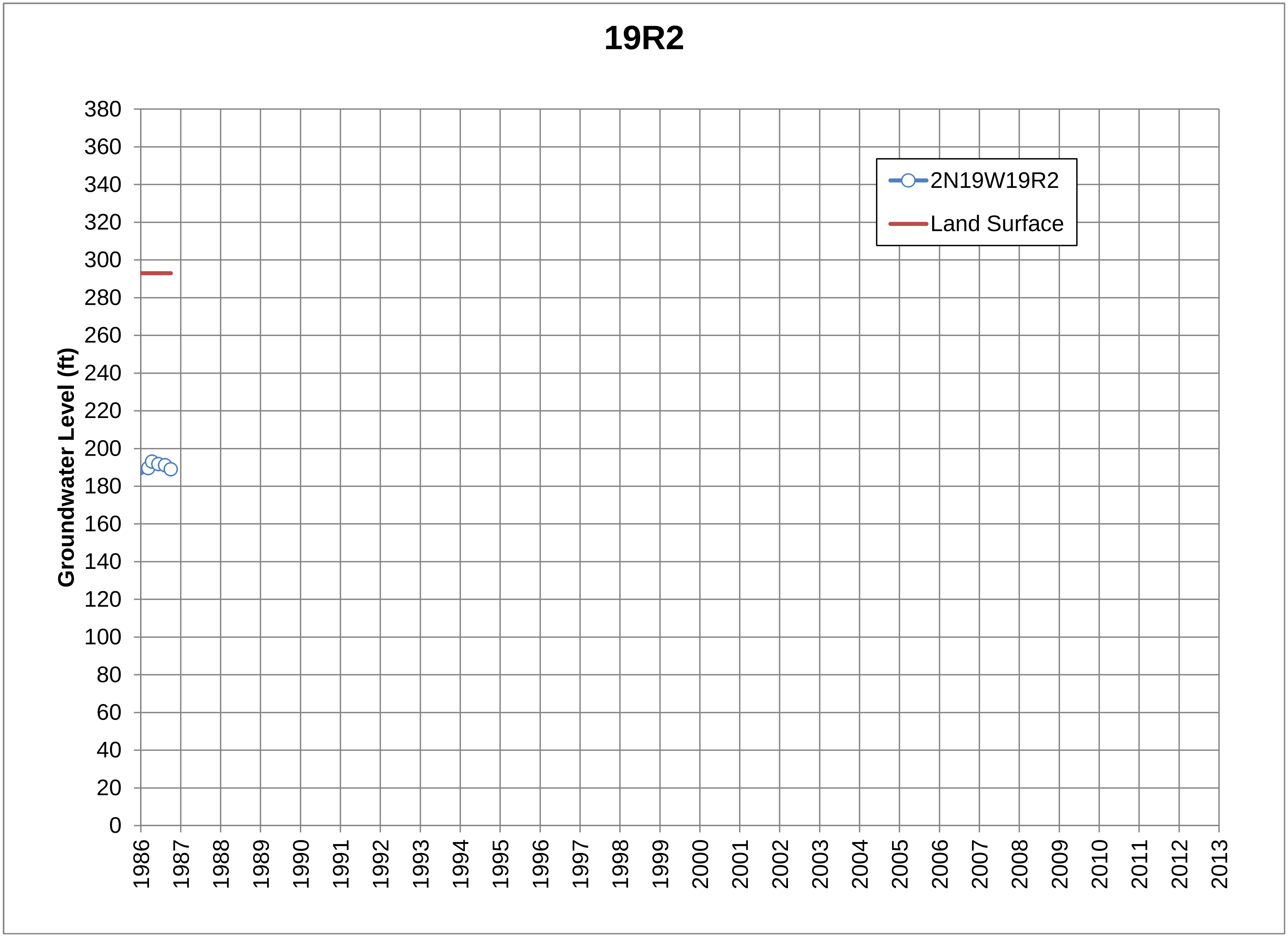
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340
360
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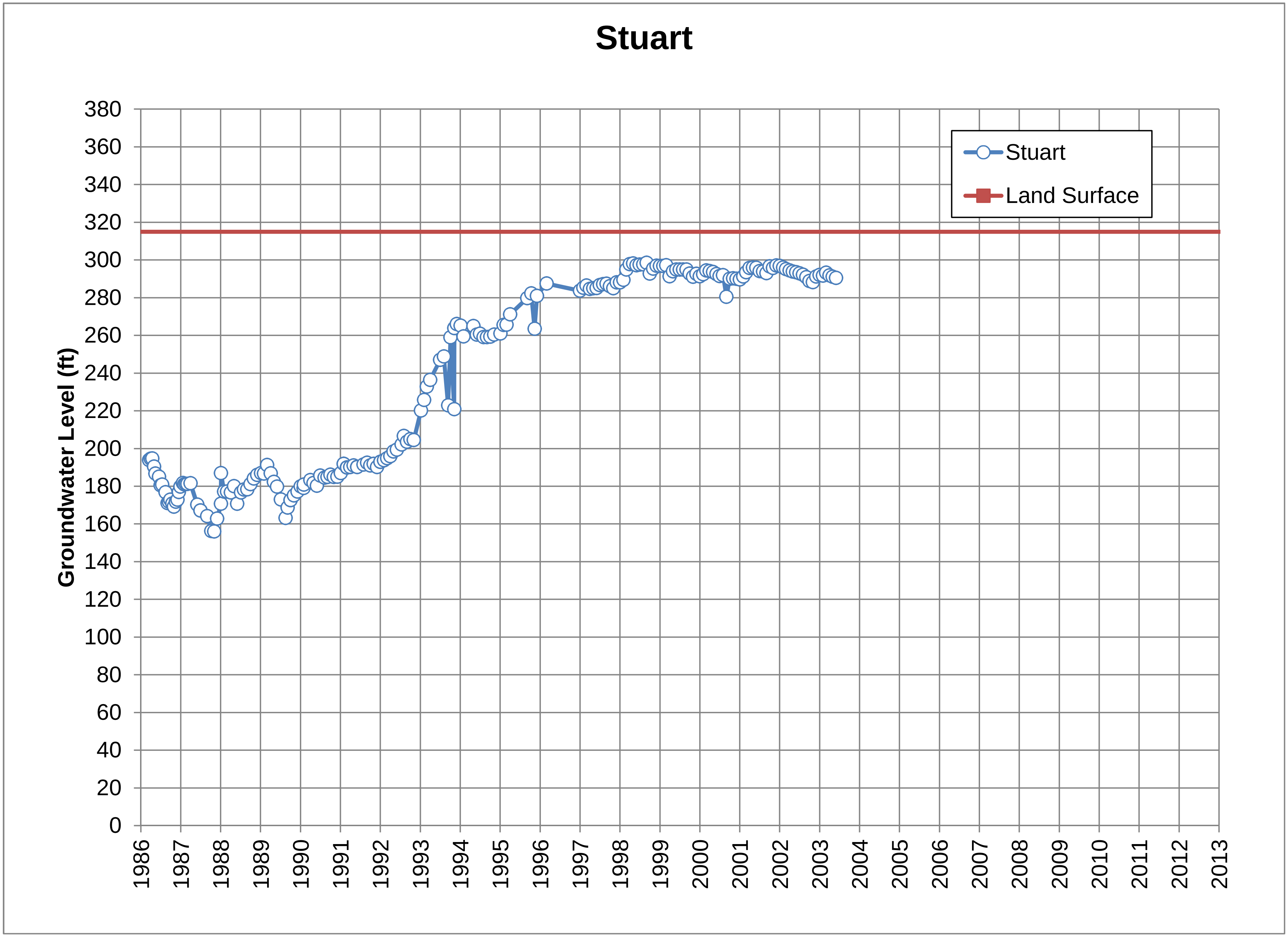

Stuart
Groundwater Level (ft)
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360
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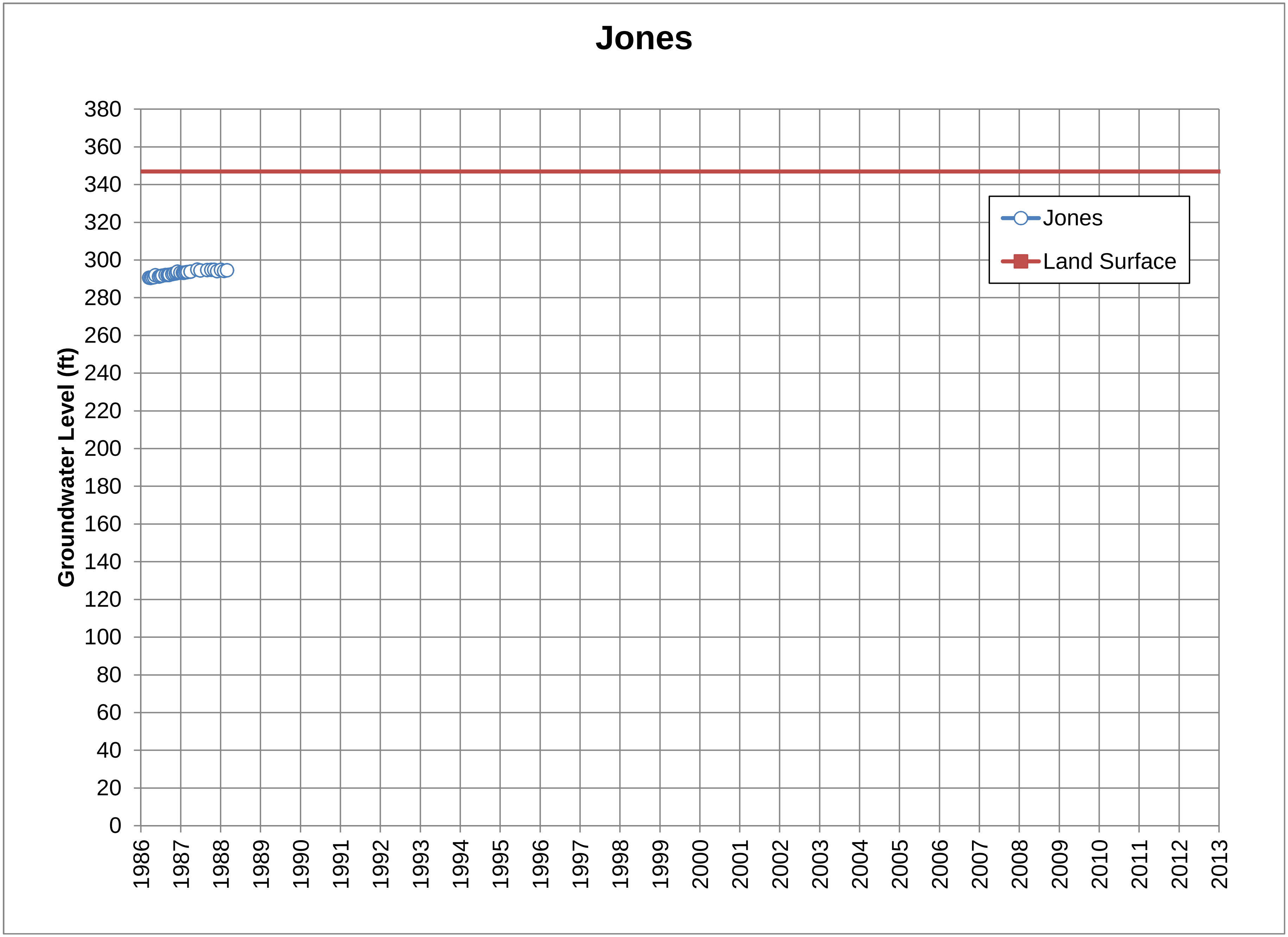
Stuart
Land Surface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Groundwater Level (ft)
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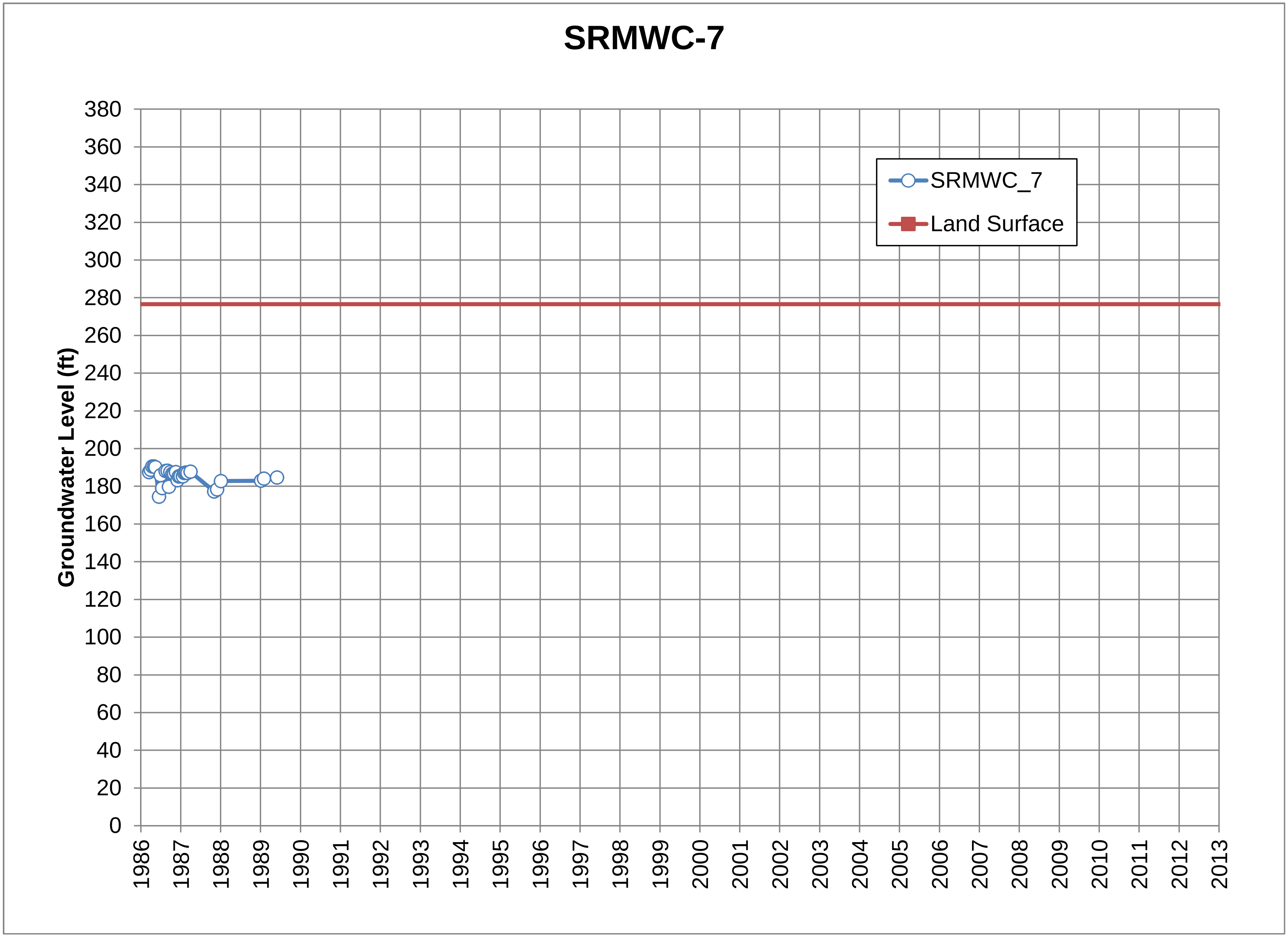
Jones
Land Surface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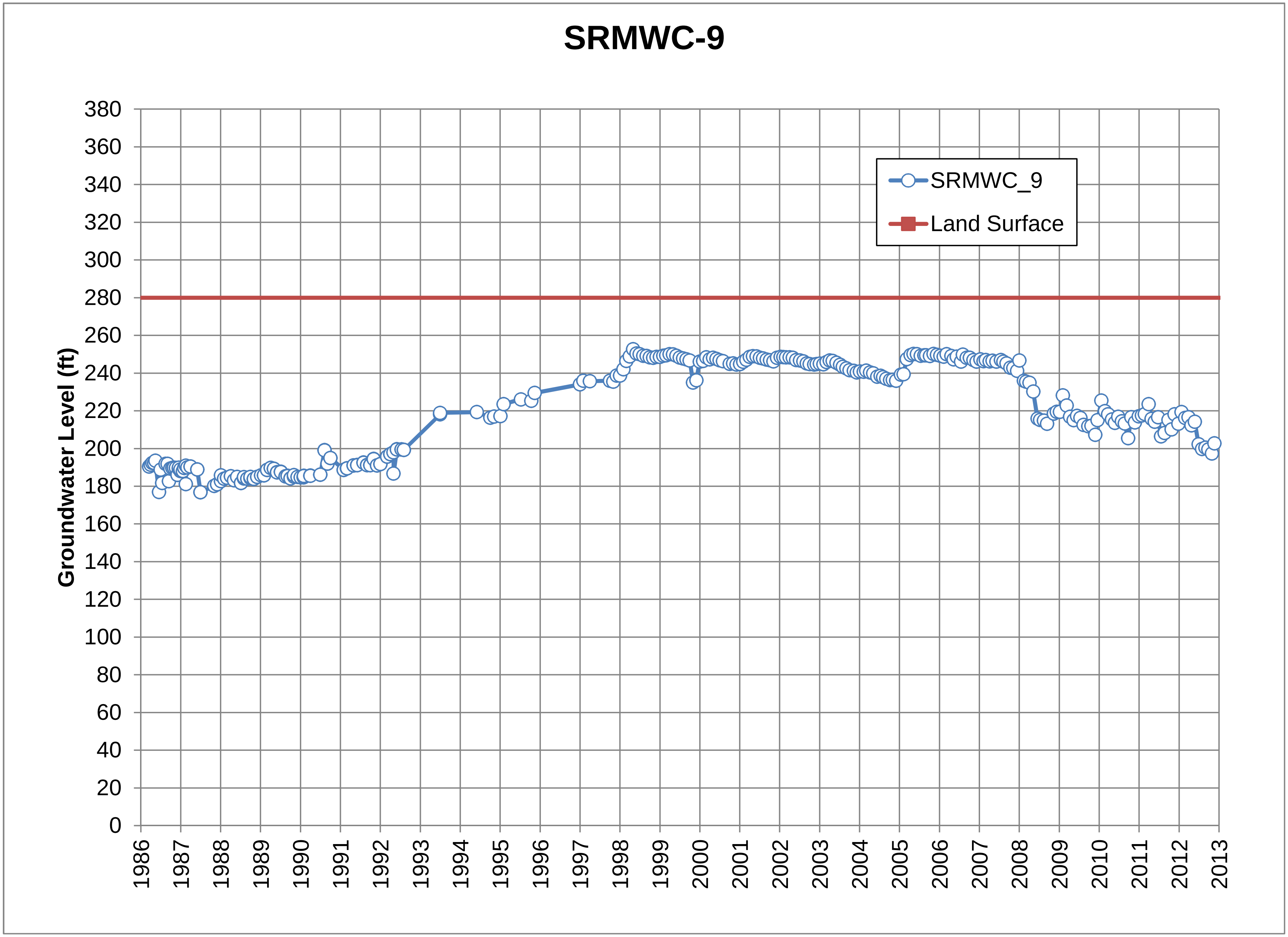
SRMWC_7
Land Surface



SRMWC-9
Groundwater Level (ft)
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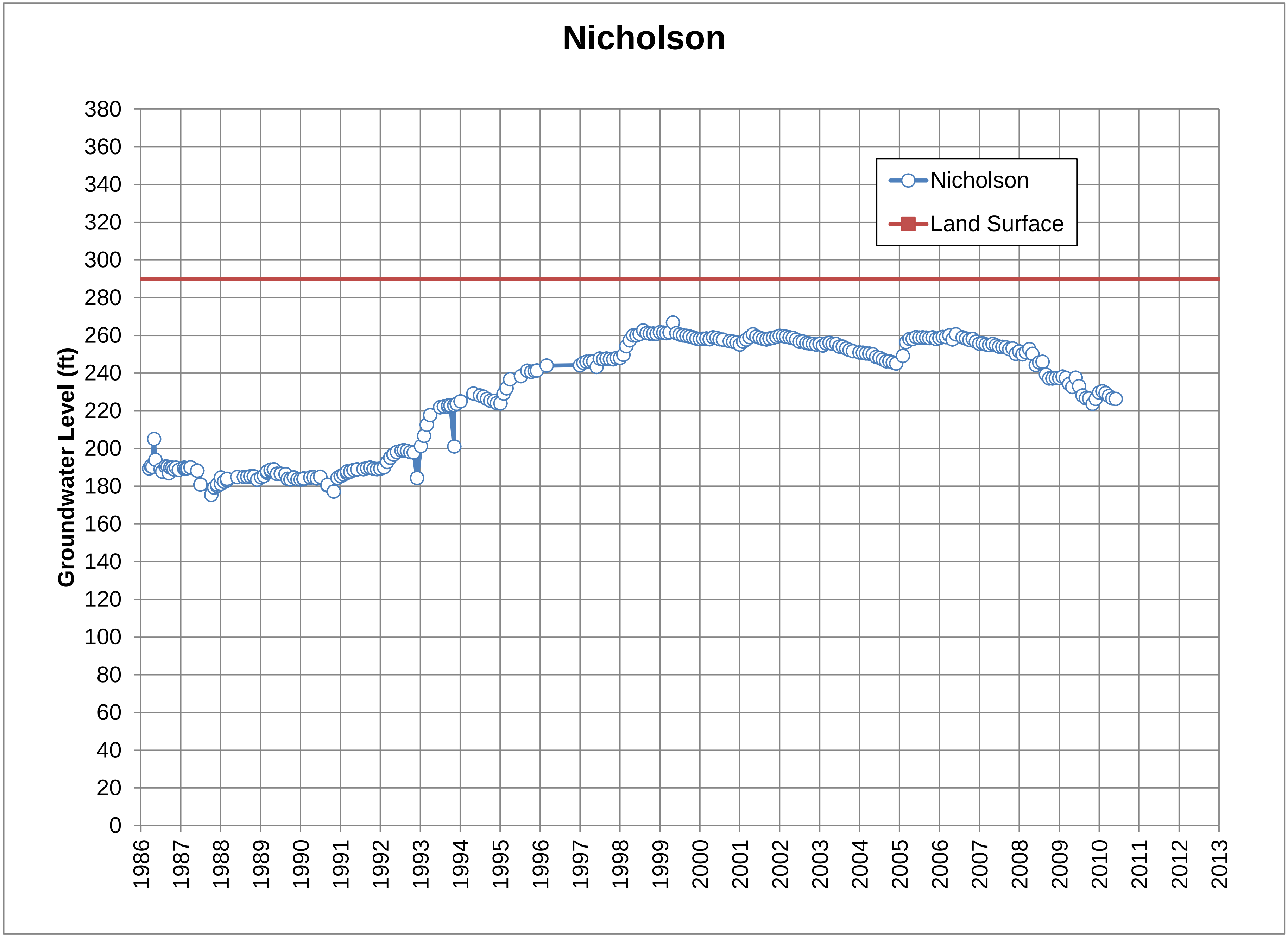
SRMWC_9
Land Surface



Nicholson
Groundwater Level (ft)
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360
340
320
300
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140
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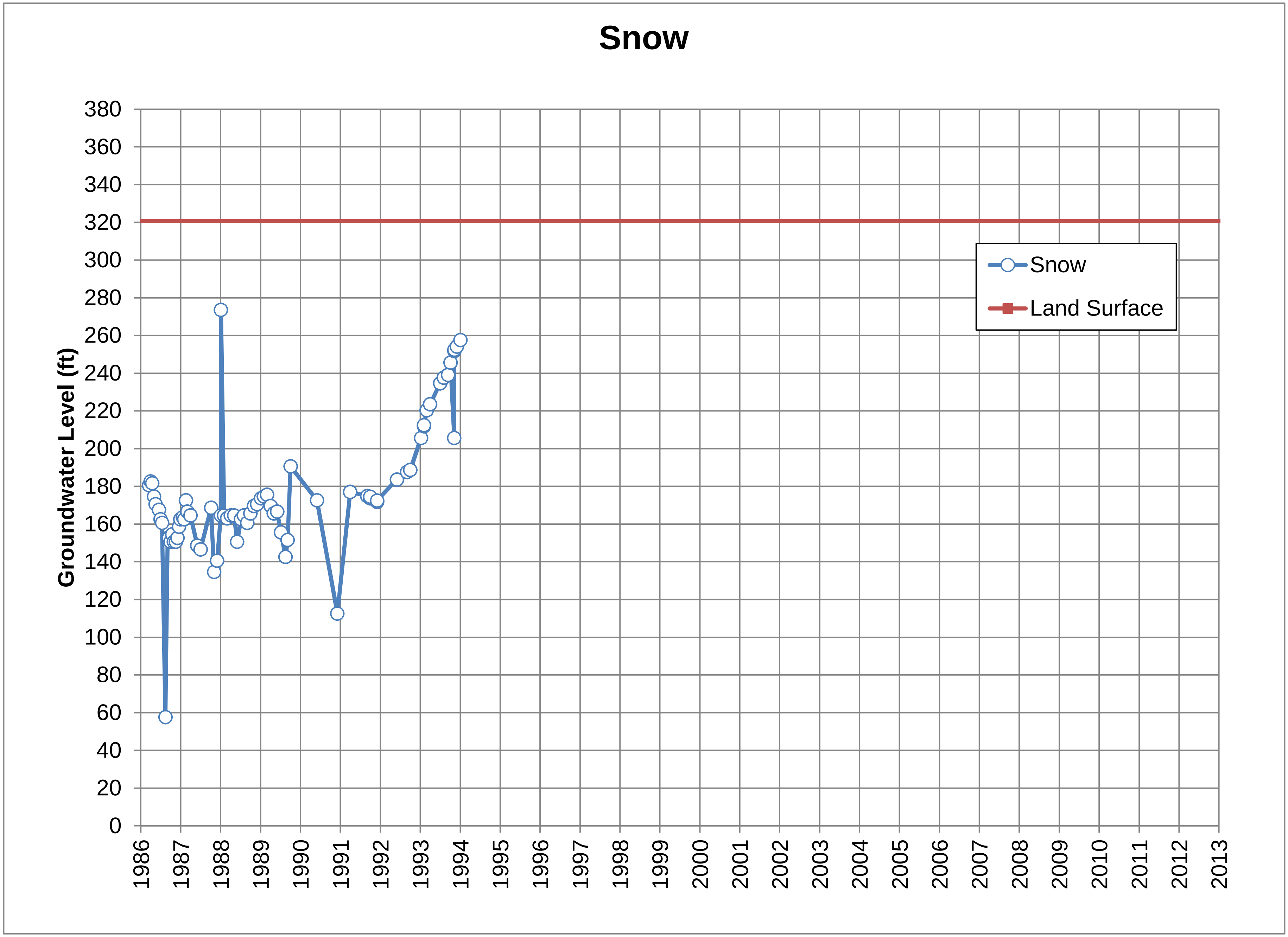
2013
Nicholson
Land Surface



Snow
Groundwater Level (ft)
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360
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320
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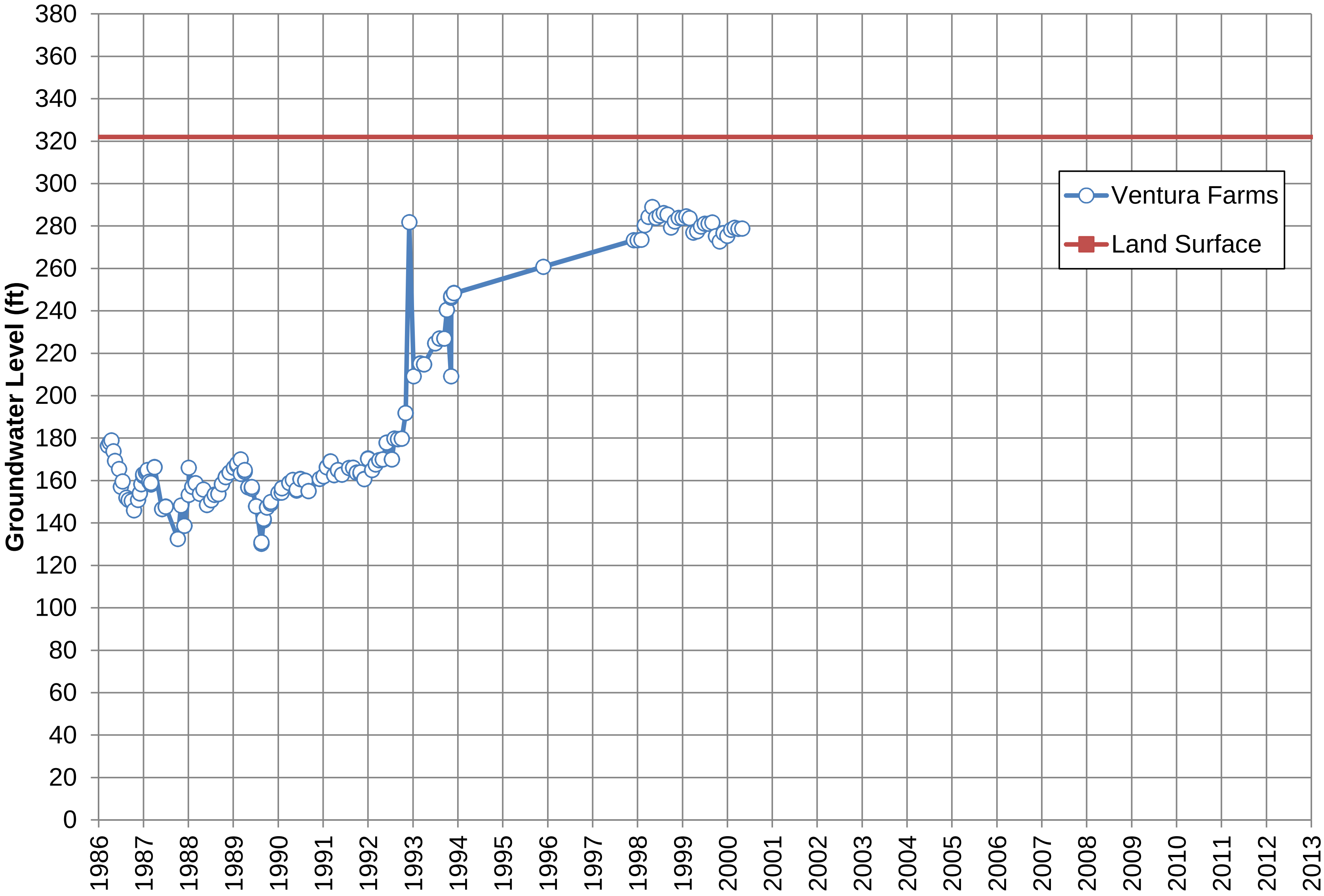
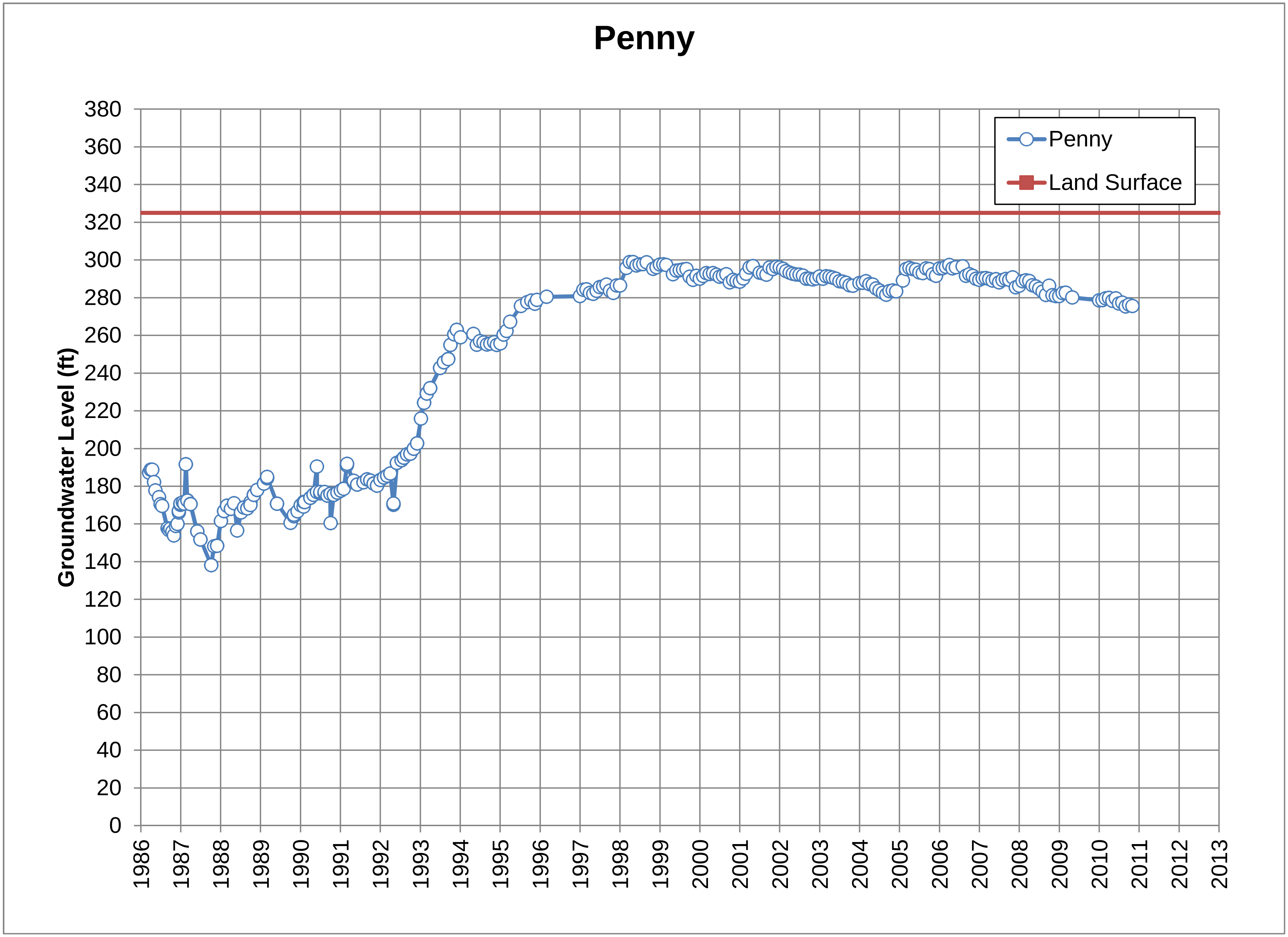
Snow
Land Surface

Ventura Farms





Penny
Groundwater Level (ft)
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360
340
320
300
280
260
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140
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40
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2012
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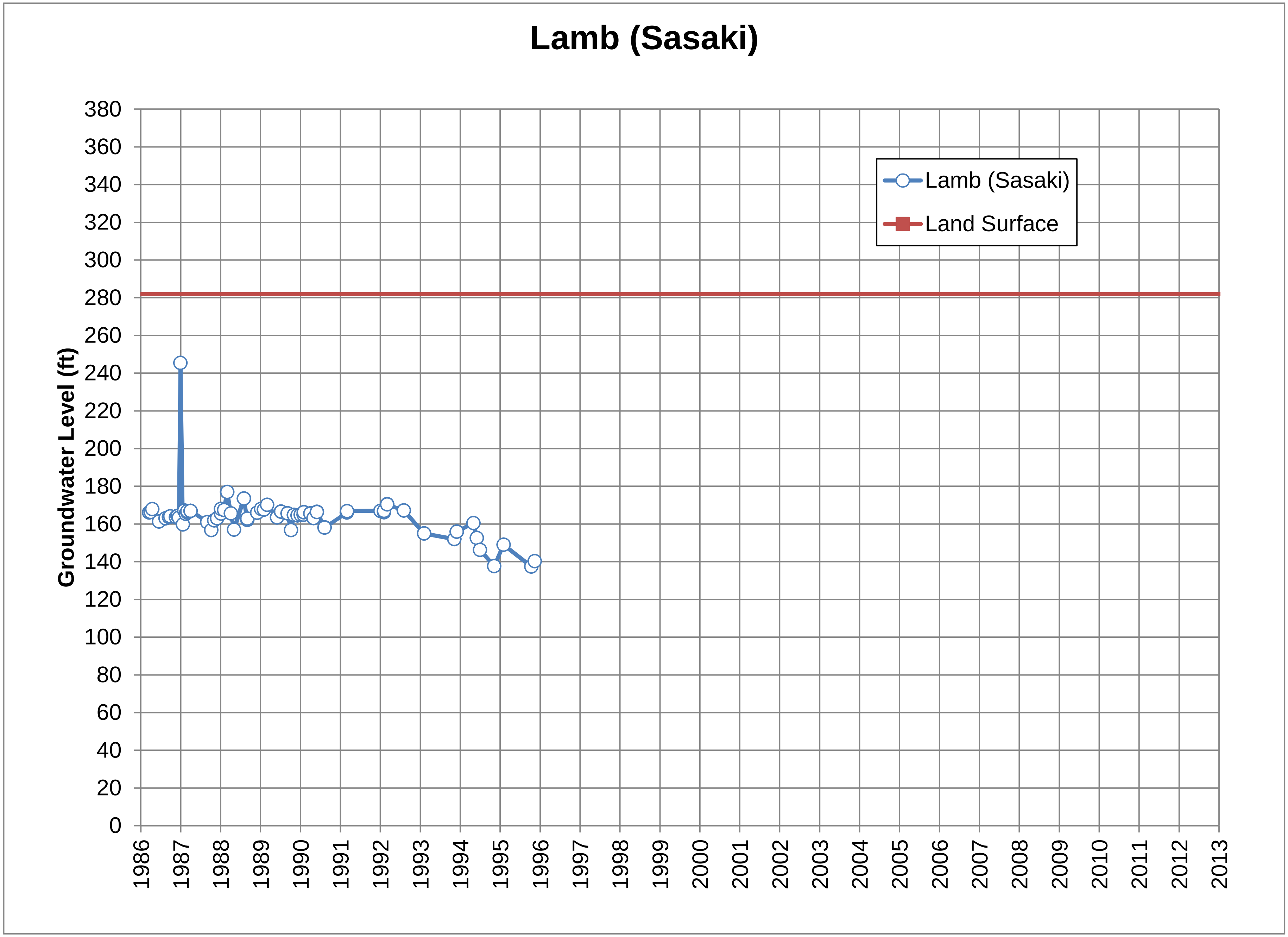
Penny
Land Surface



Lamb (Sasaki)
Groundwater Level (ft)
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360
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300
280
260
240
220
200
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140
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80
60
40
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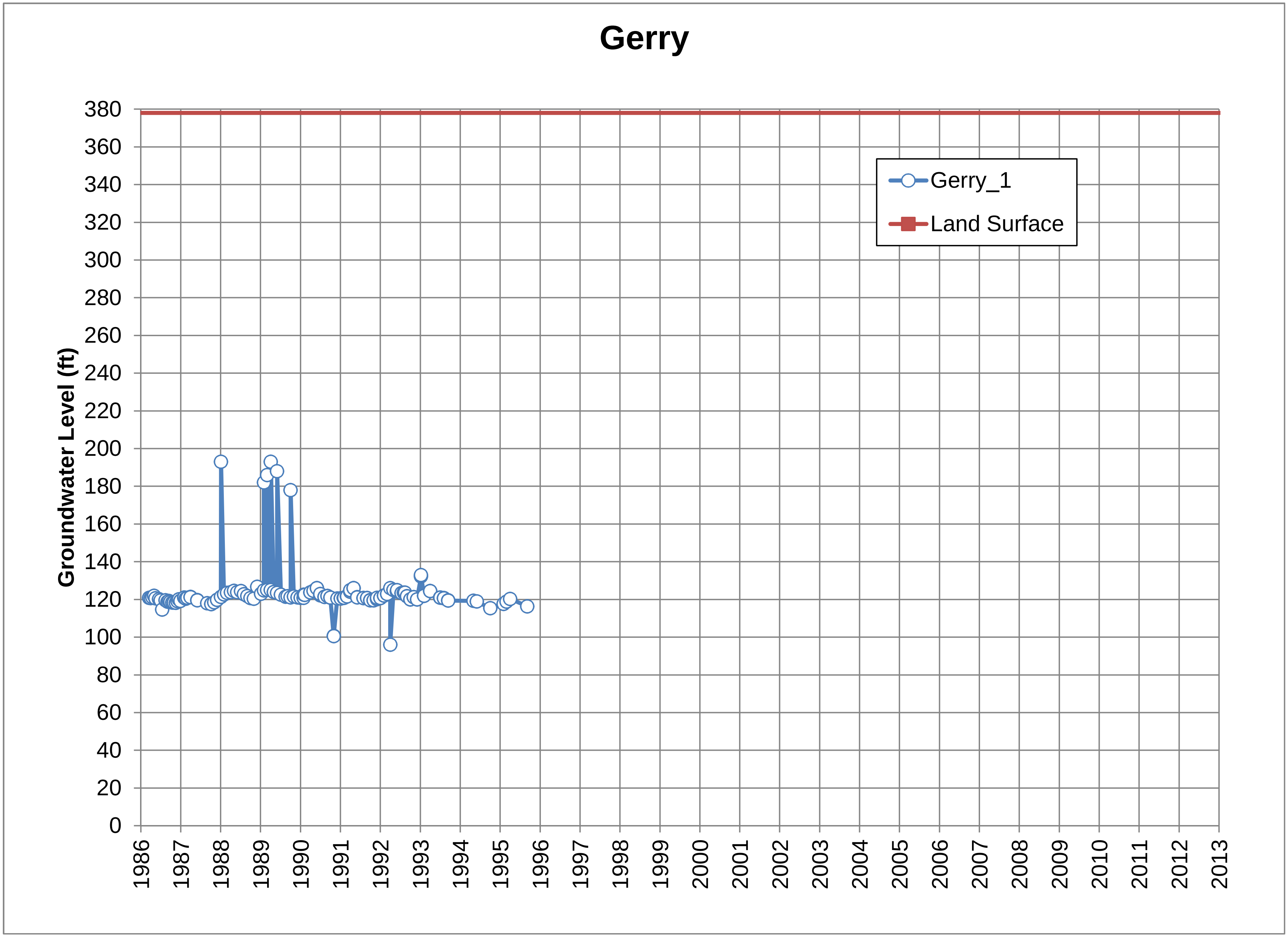
Lamb (Sasaki)
Land Surface



Gerry
Groundwater Level (ft)
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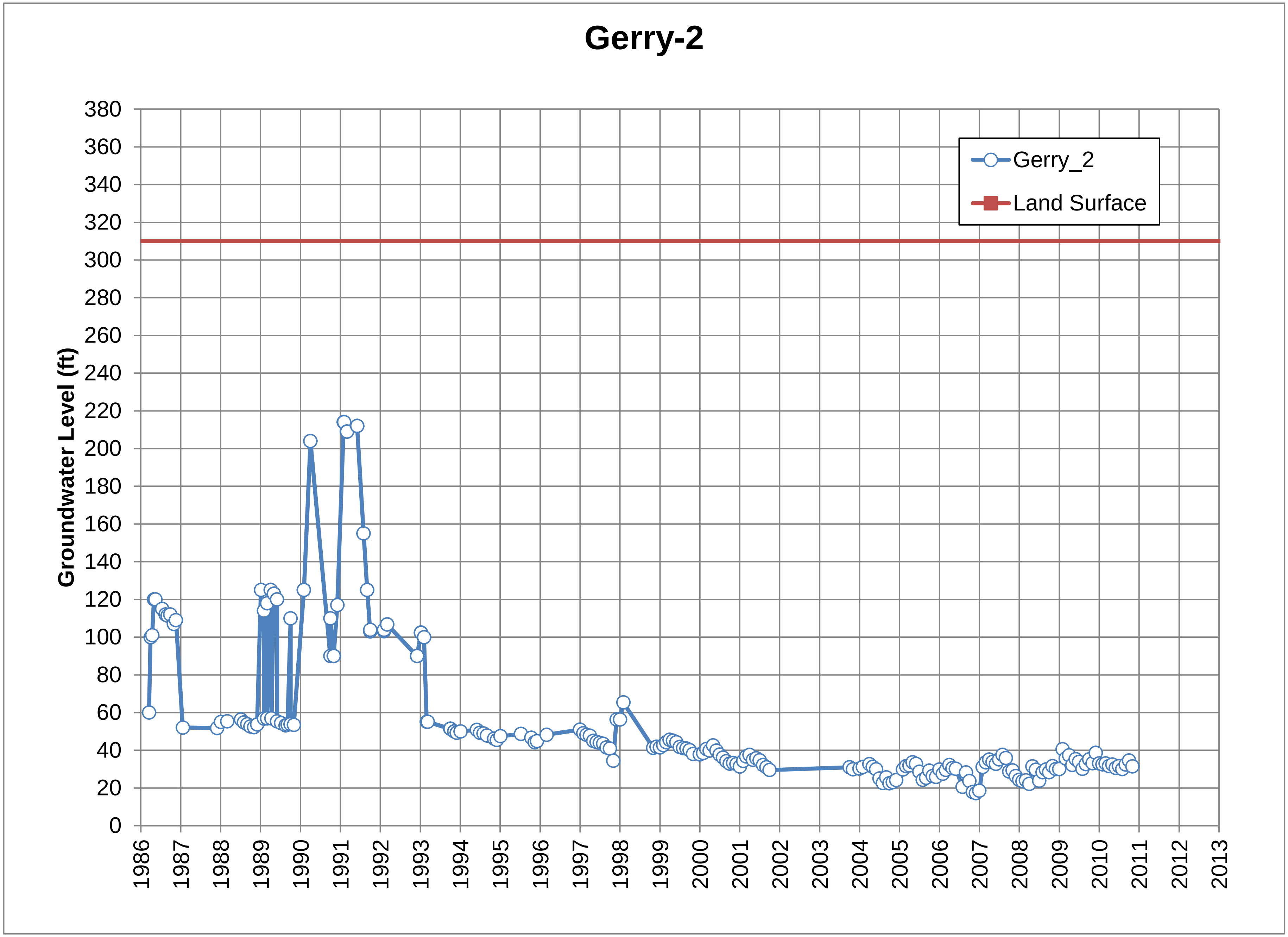
Land Surface



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Gerry_2
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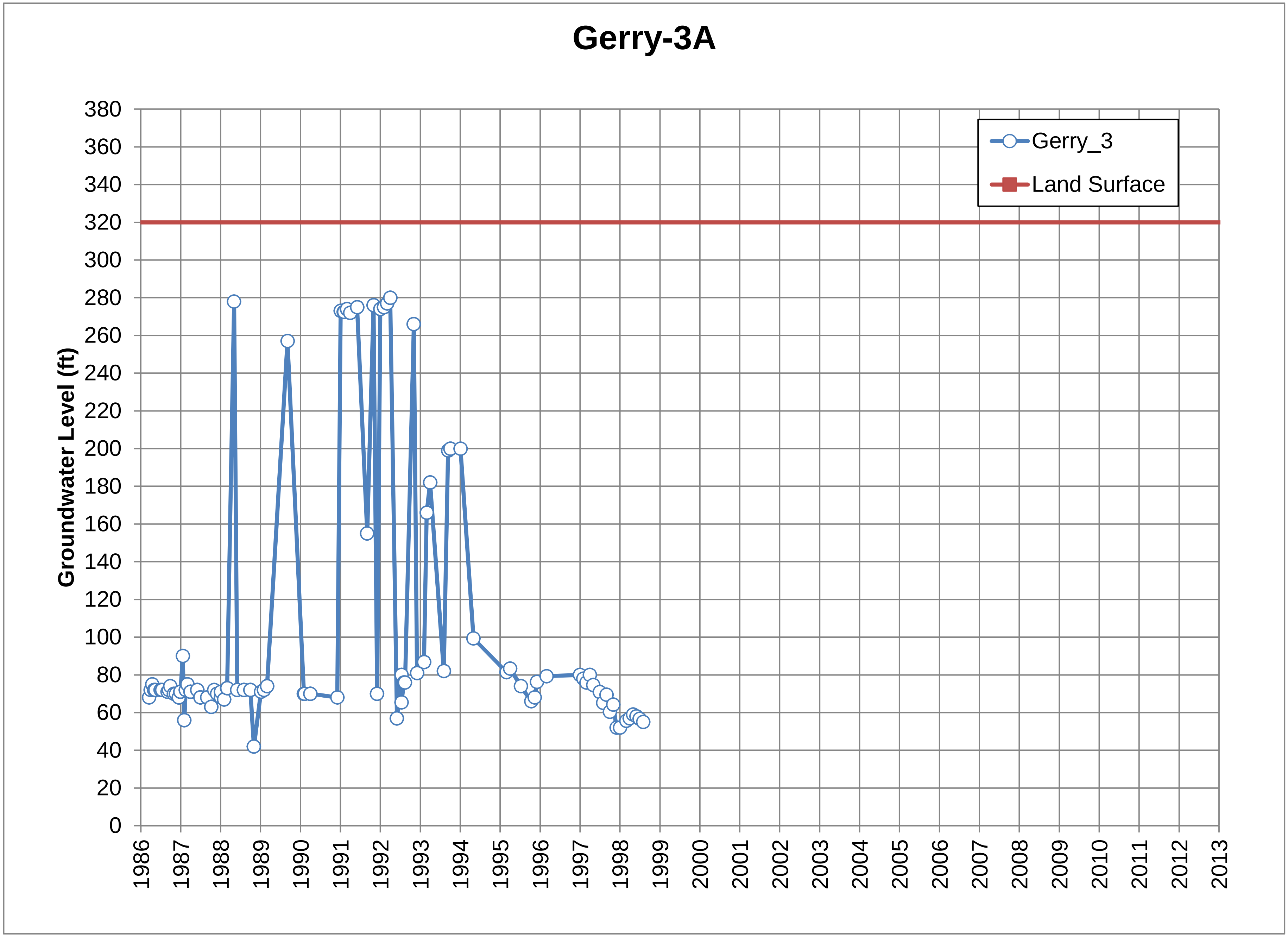
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Gerry_3
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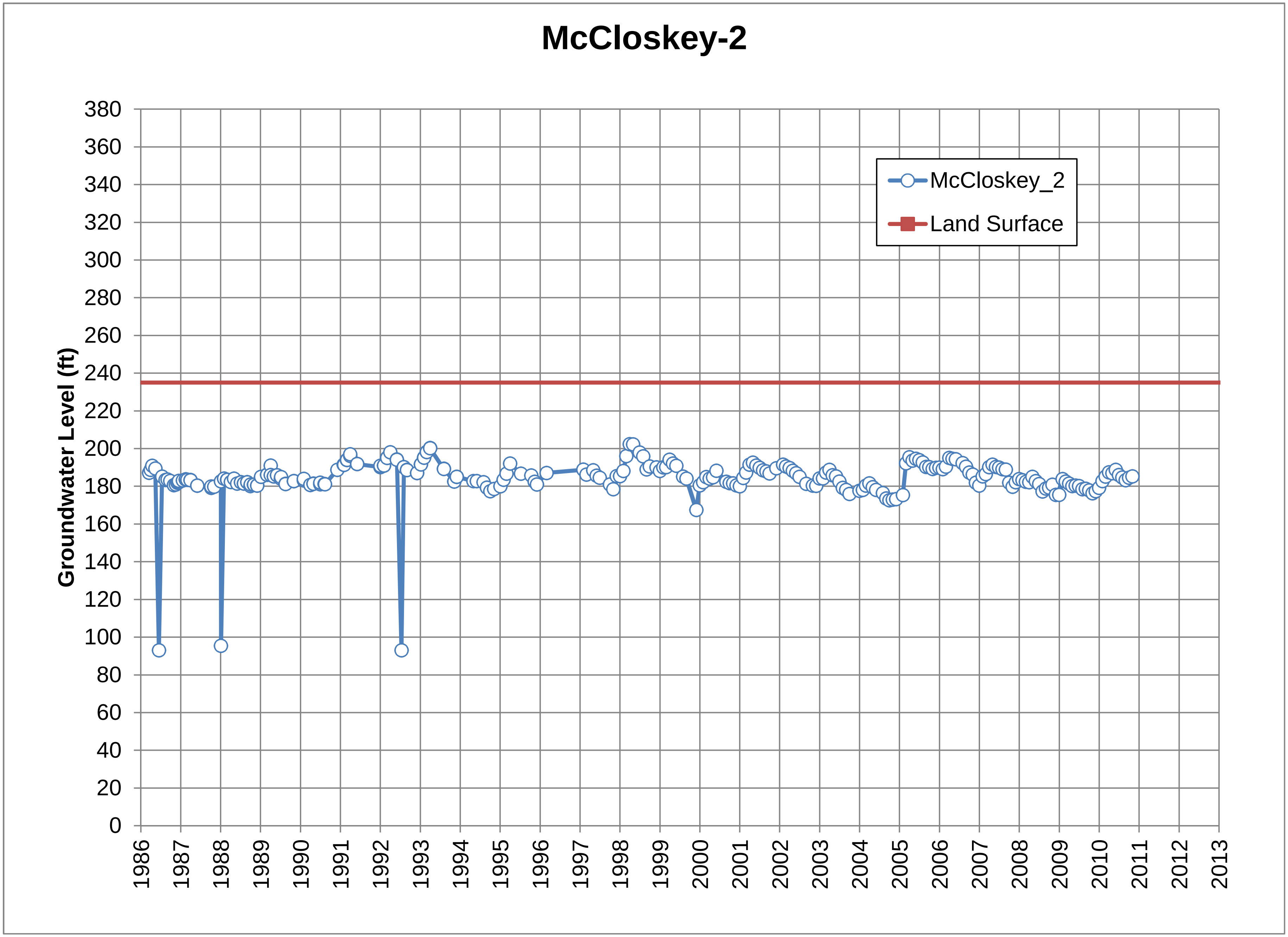

McCloskey-2
McCloskey_2
Land Surface
Groundwater Level (ft)
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200
220
240
260
280
300
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360
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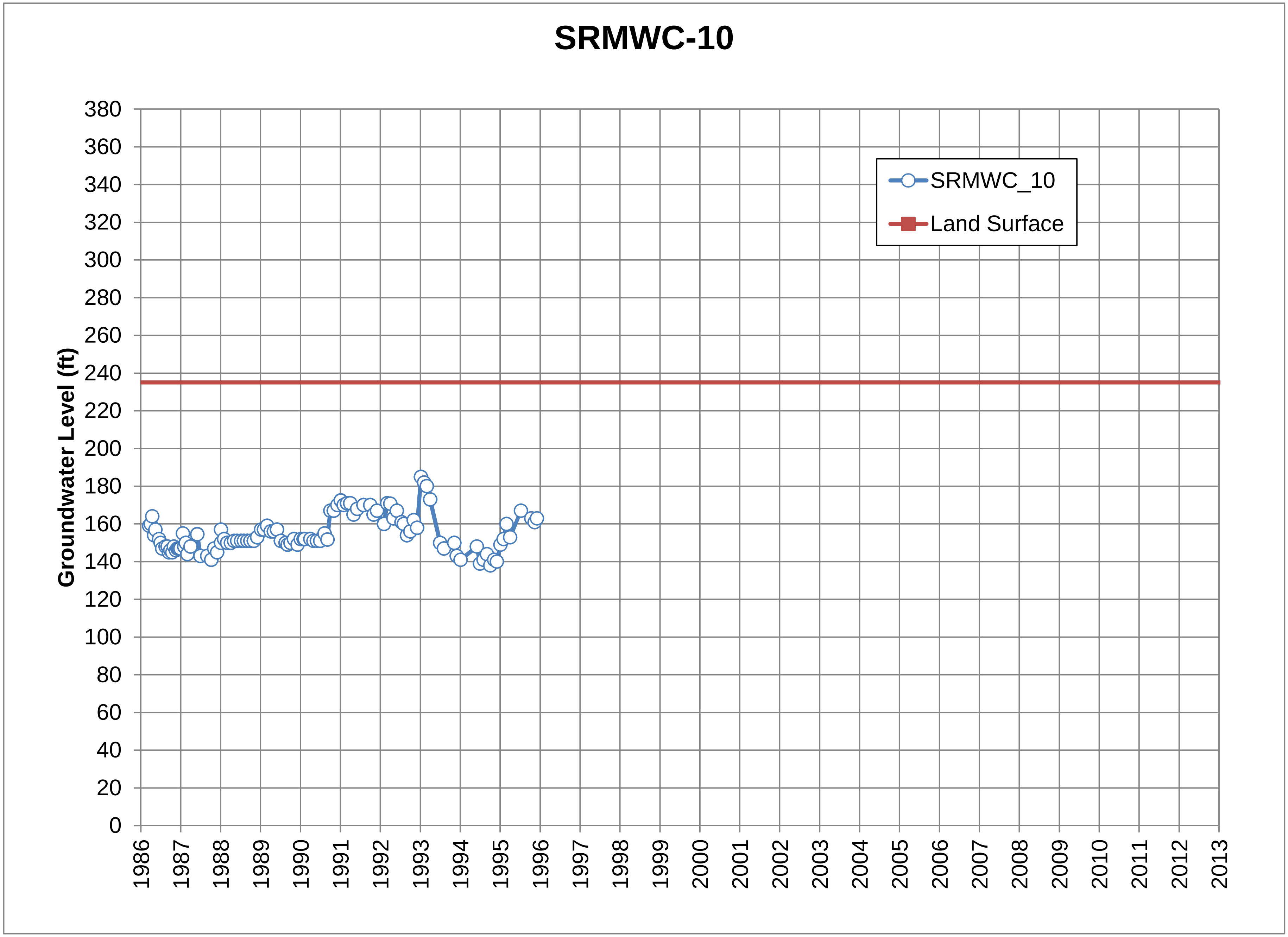

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SRMWC_10
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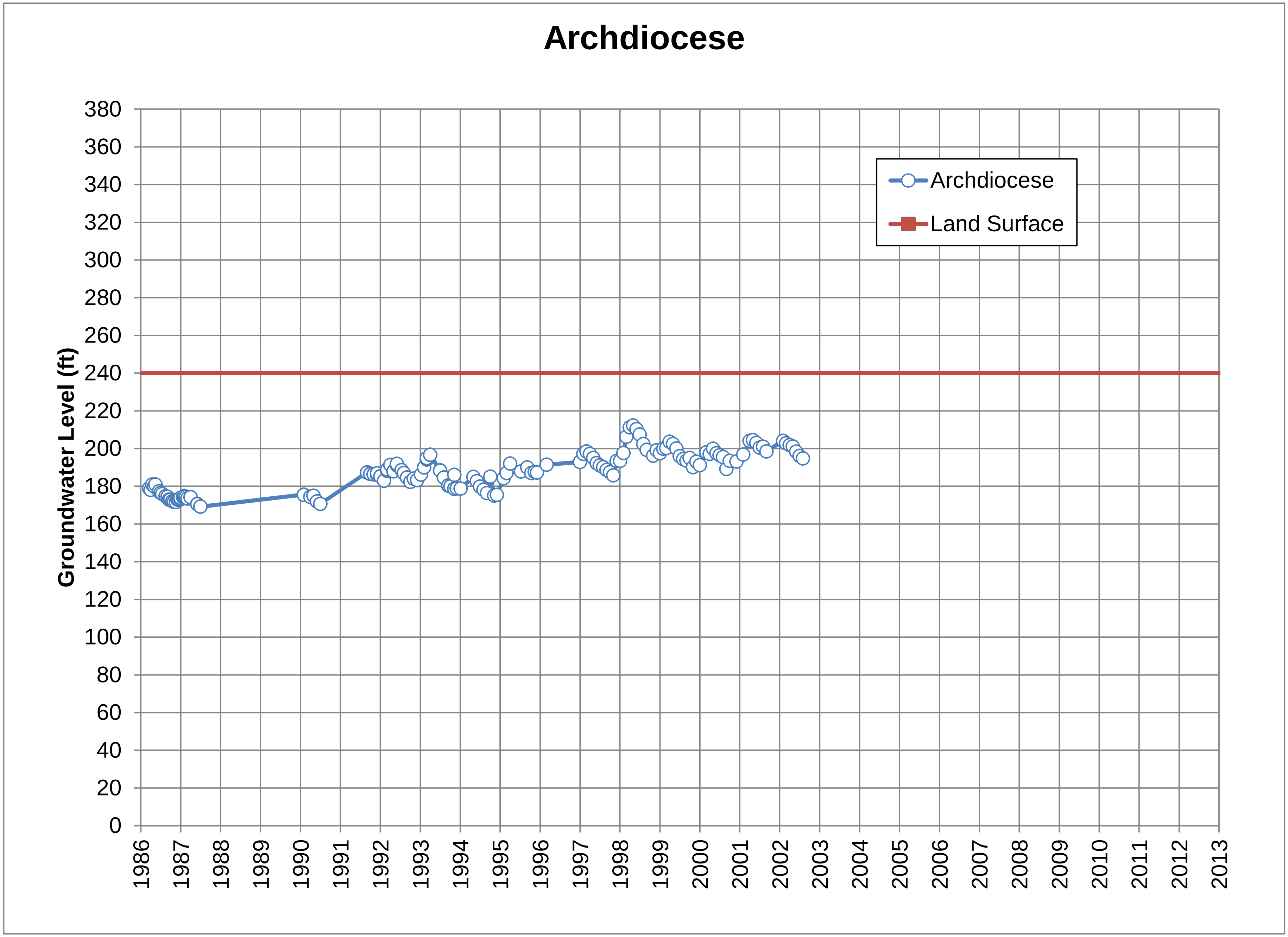

Archdiocese
Groundwater Level (ft)
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100
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340
360
380
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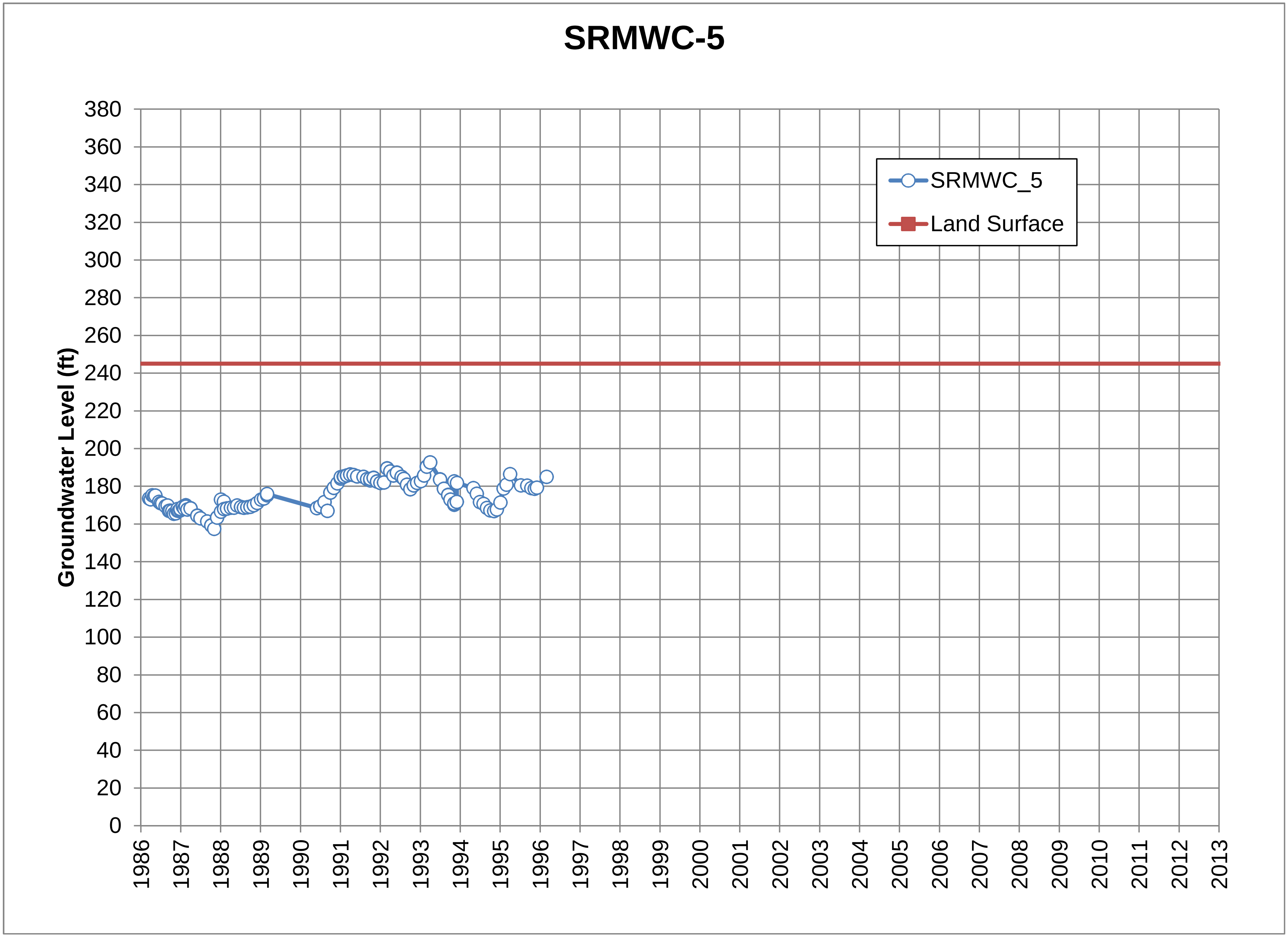
Archdiocese
Land Surface



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Groundwater Level (ft)
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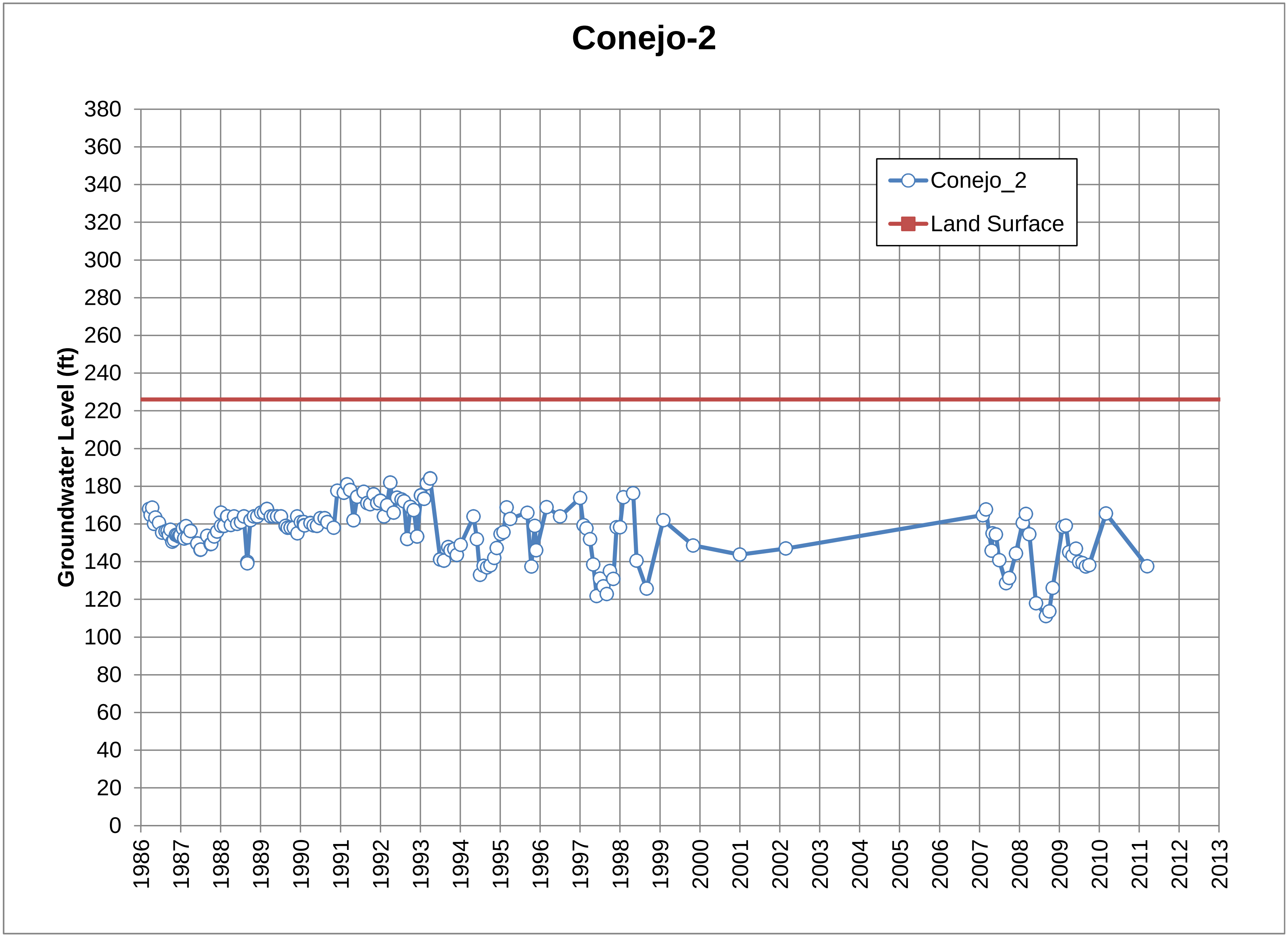
SRMWC_5
Land Surface



Conejo-2
Groundwater Level (ft)
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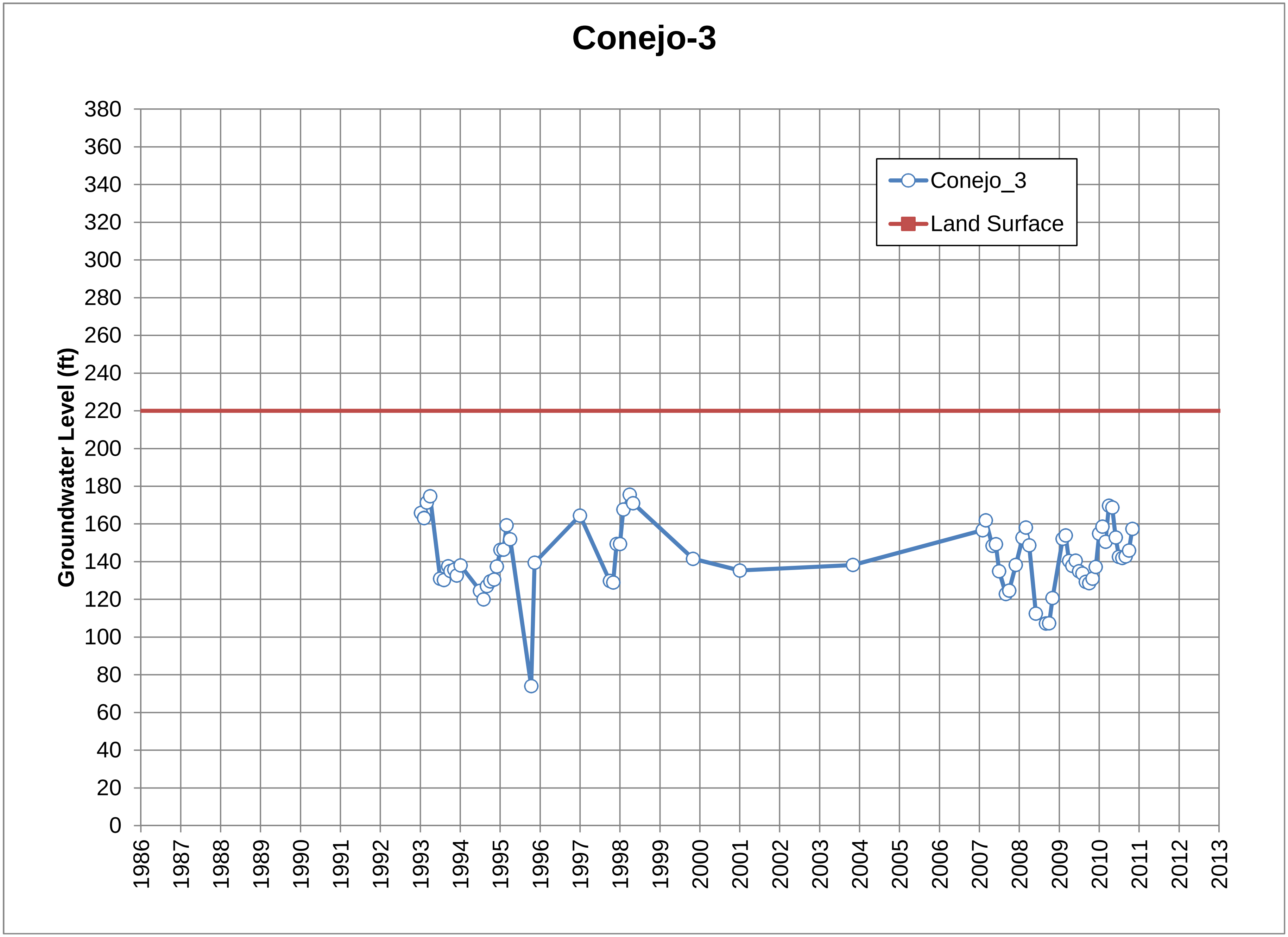
Conejo_2
Land Surface



Conejo-3
Groundwater Level (ft)
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180
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20
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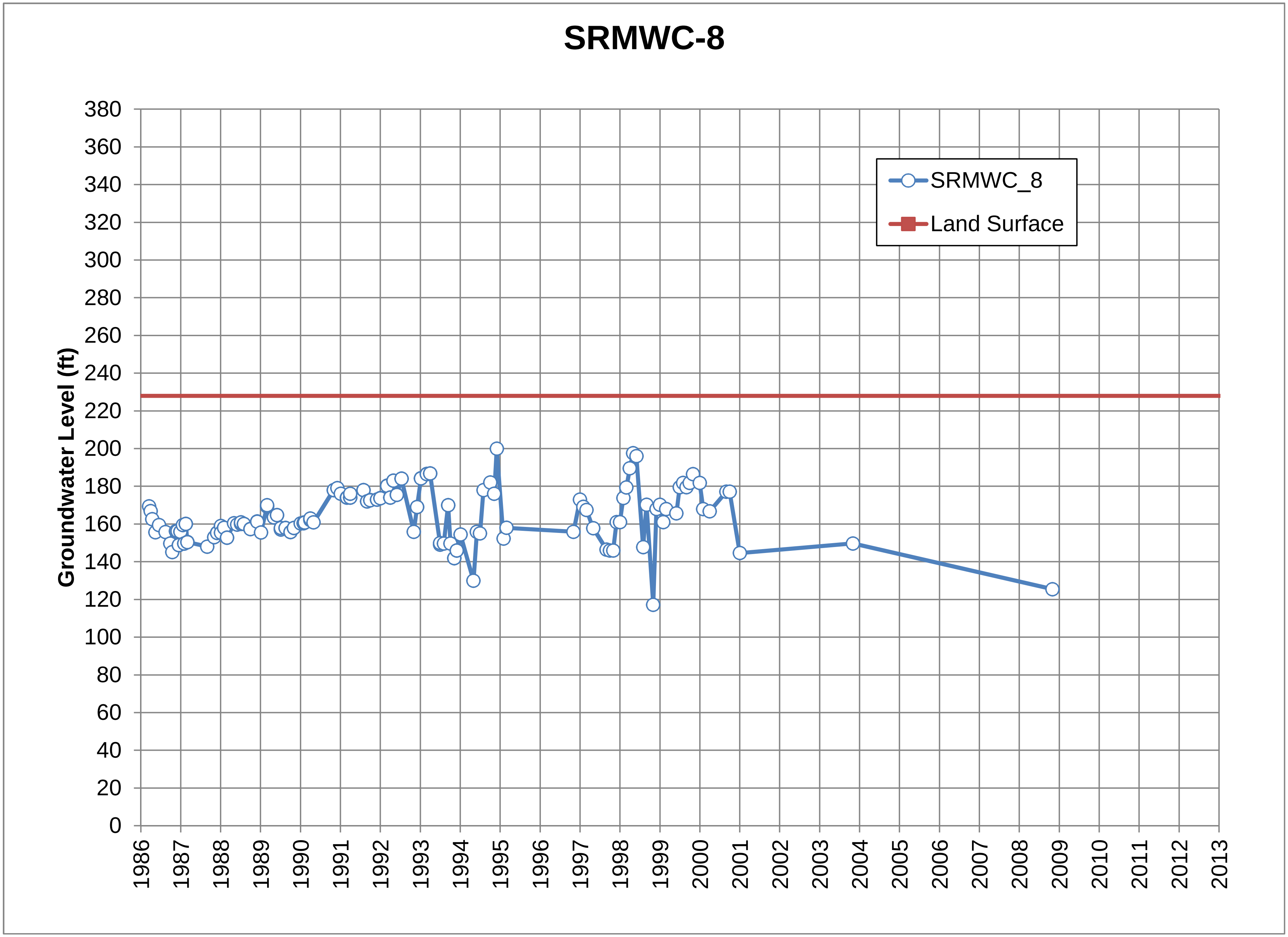
Conejo_3
Land Surface


SRMWC-8
Groundwater Level (ft)
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340
360
380
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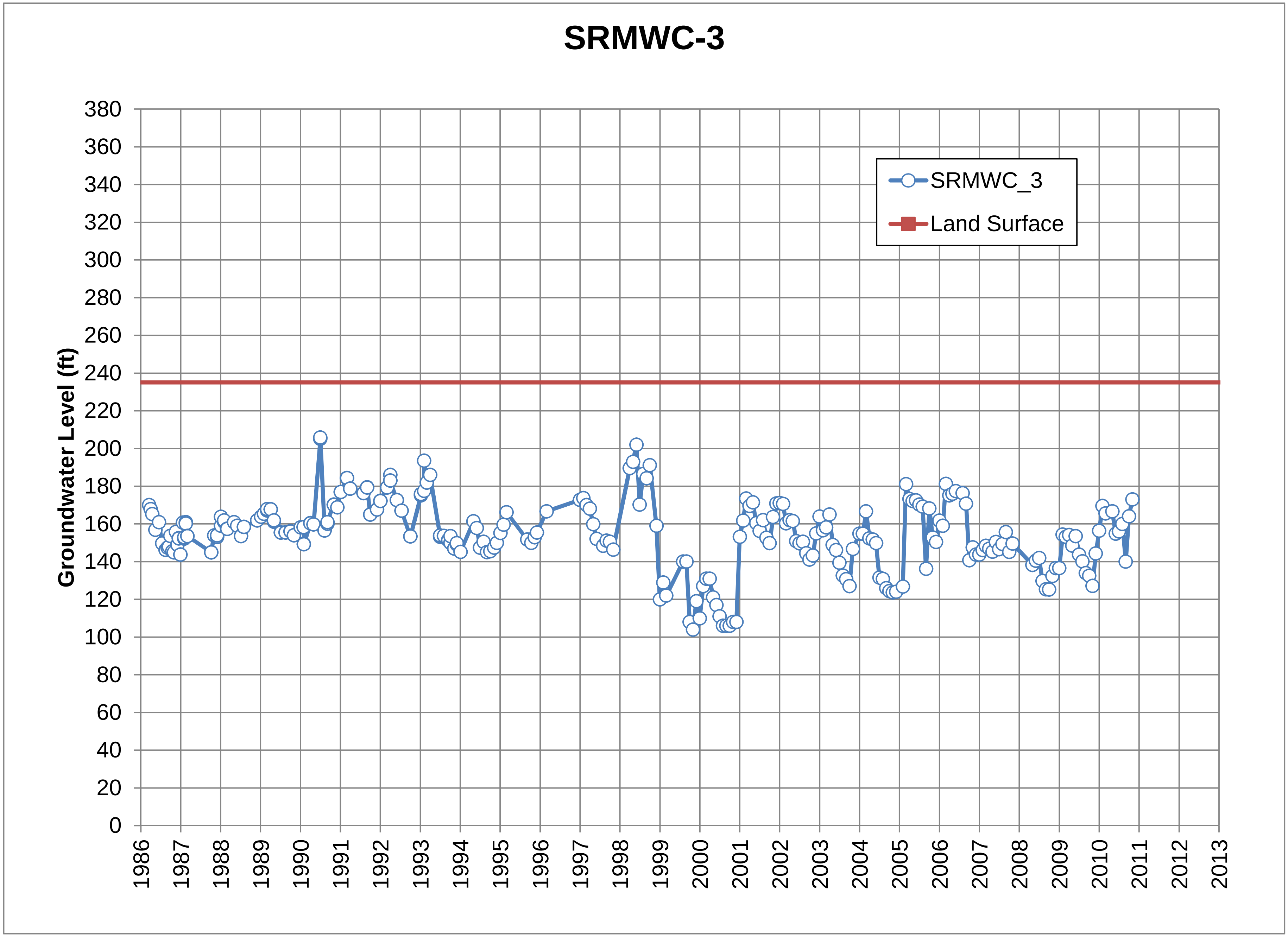
SRMWC_8
Land Surface


SRMWC-3
Groundwater Level (ft)
SRMWC_3
Land Surface
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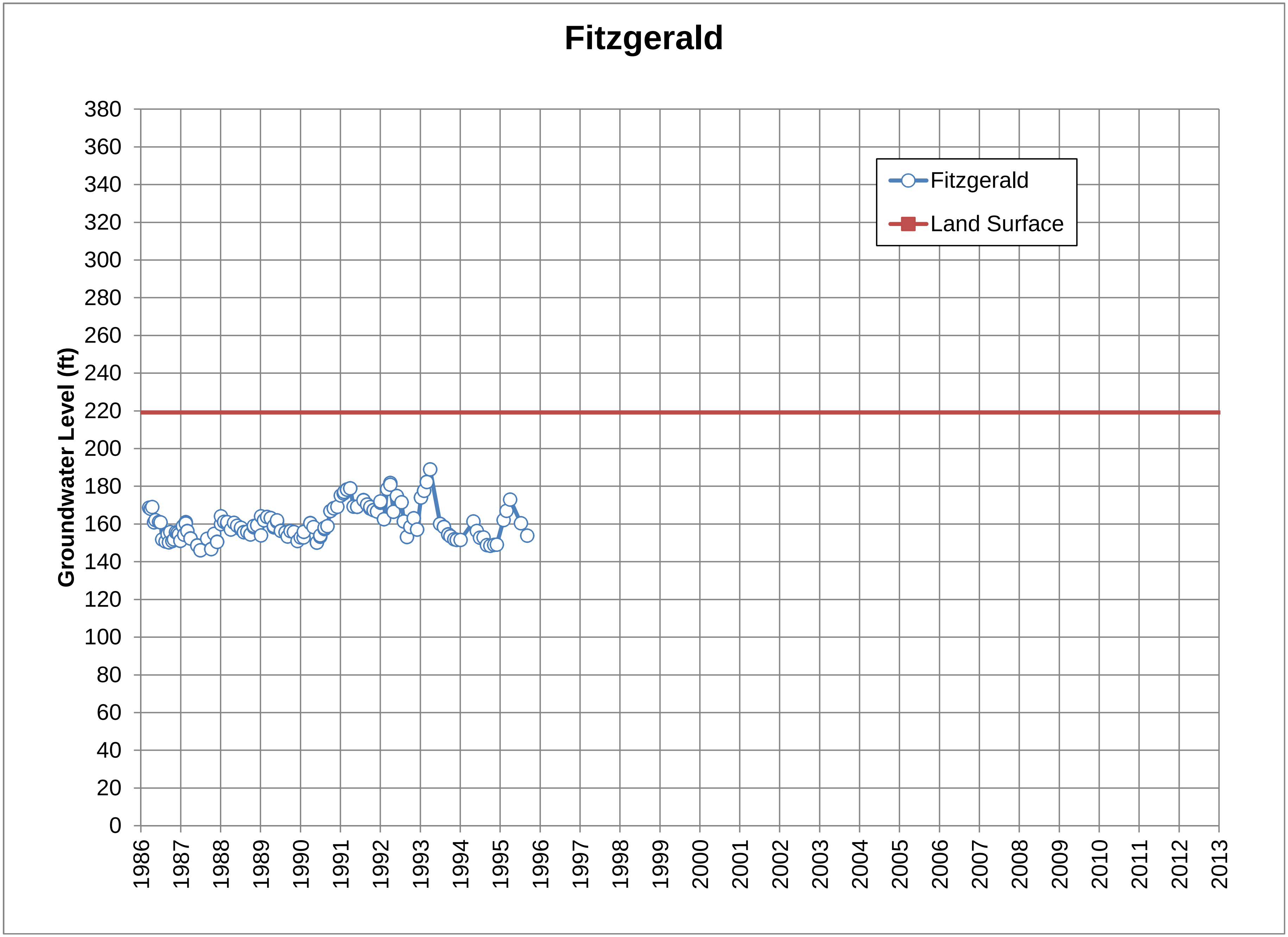

Fitzgerald
Groundwater Level (ft)
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360
340
320
300
280
260
240
220
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180
160
140
120
100
80
60
40
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1986
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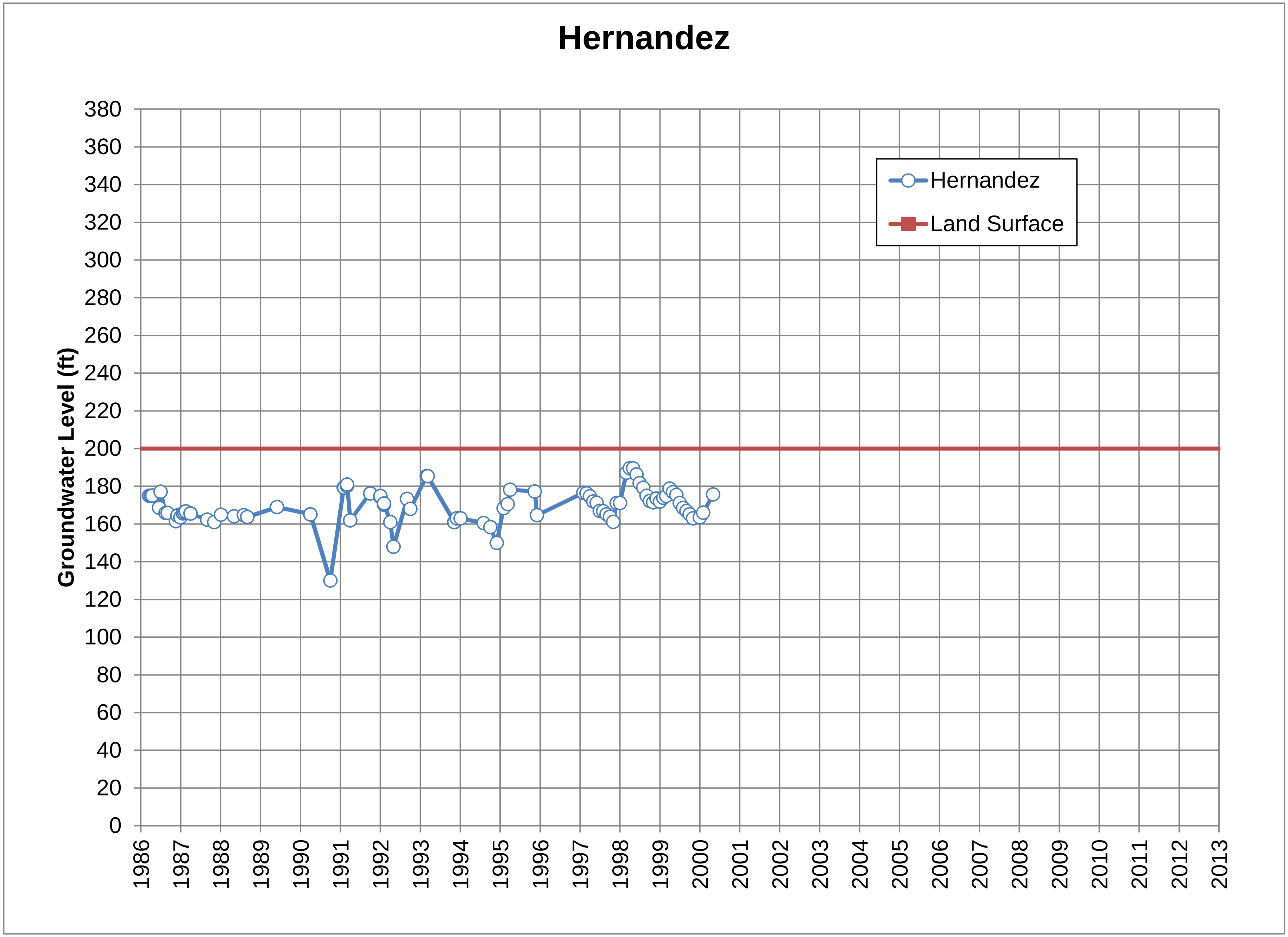
2013
Fitzgerald
Land Surface


Hernandez
Groundwater Level (ft)
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40
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Hernandez
Land Surface

Appendix C

Groundwater Model Documentation and Evaluation of Recharge Projects

MWH
BUILDING A BETTER WORLD

Technical Memorandum

TO: *Camrosa Water District*

DATE: *March 2013*

FROM: *MWH*

REFERENCE: 10500990

SUBJECT: *Santa Rosa Basin Groundwater Model Documentation*

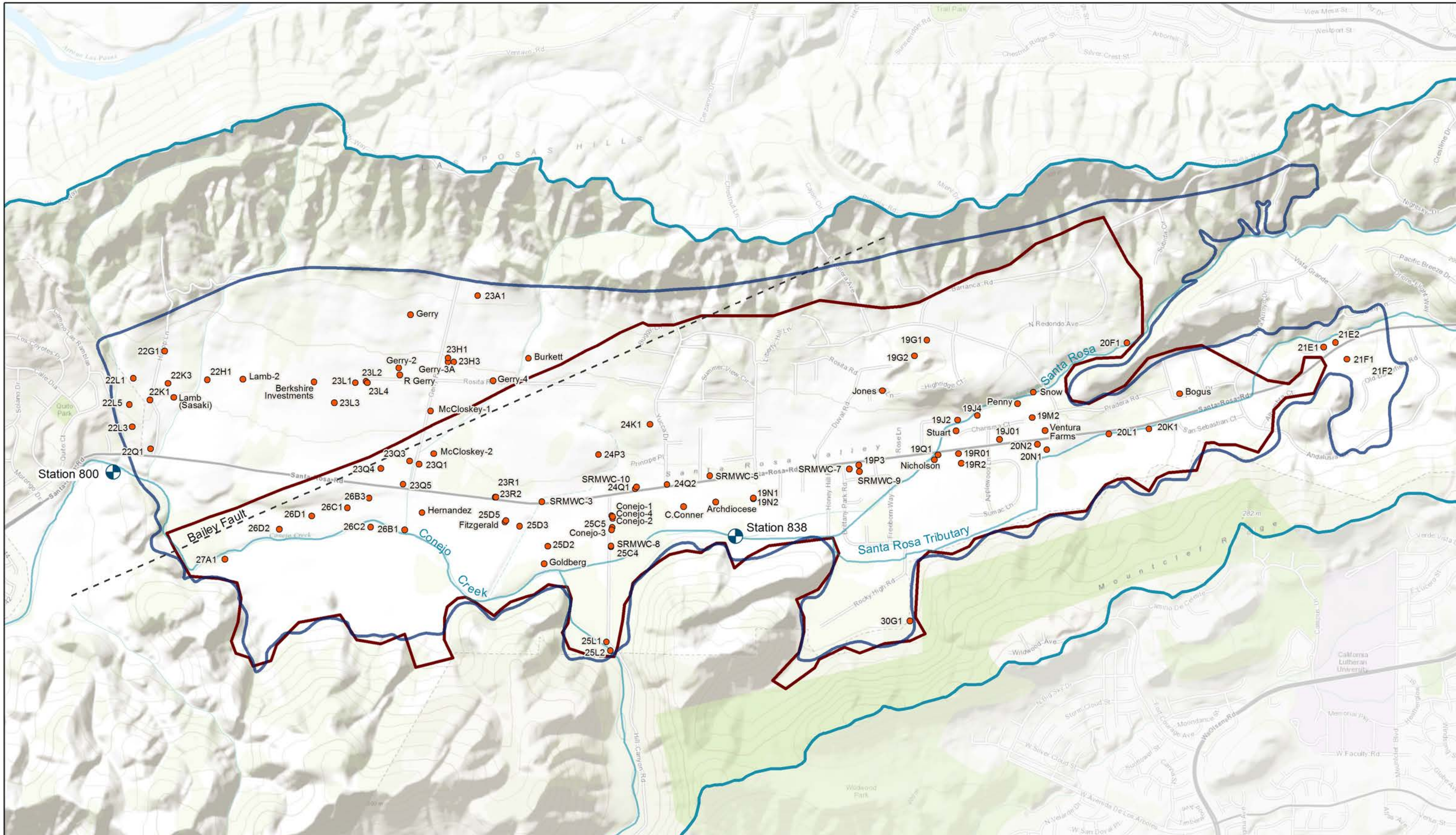
1.0 Introduction

MWH prepared and calibrated the Santa Rosa Basin (SRB) groundwater model to assist evaluate and develop the updated groundwater basin management plan. This Technical Memorandum (TM) is intended to document the SRB groundwater model development and calibration for future reference.

The SRB model boundaries (or "domain") are shown in **Figure 1.** The model domain is coincident with the groundwater basin boundaries at the northern, eastern and southern portions of the basin. The western boundary is the Bailey Fault, which acts as a groundwater barrier (Bailey, 1969; Johnson et al., 1987).

The TM is organized as follows:

- Section 1: Introduction
- Section 2: Groundwater Model Attributes
- Section 3: Steady-State Calibration Results
- Section 4: Conclusions and Recommendations
- Section 5: References



Study Area

Figure 1

2.0 Groundwater Model Attributes

The modeling software used for this effort was MODFLOW 2000 (Harbaugh et al., 2000).The MODFLOW code was developed the the U.S. Geological Survey, and was selected because it is a standard in the industry, is public domain software, and is very well documented (Harbaugh, et al, 2000). This section describes the model attributes assigned during the model development and calibration effort. Head dependent flux (River Package) was used to simulate the Conejo Creek.

Boundary Conditions

The northern, southern, and eastern boundaries of the model were assigned no-flow boundaries, which mimic hydrogeologic conditions in the basin. The Bailey Fault was also modeled as a no-flow boundary. A variable, or head dependent flux termed the River Package was used to simulate the Conejo Creek. Recharge package was used to simulate precipitation recharge, leakage from septic tanks and irrigation return flow. The recharge amounts used in the model are based on the groundwater budget described in the updated Groundwater Management Plan.

The SRB study area is delineated by hydraulic boundaries (either bedrock boundaries or a flow barrier). To the north, east and south, the study area is bounded by undulating hills. Minimal groundwater flows across these boundaries. The northeast-southwest trending Bailey Fault acts as a flow barrier.

Model Layering

Interpretation of lithologic logs and evaluation of well construction and water level observation data suggest that the Santa Rosa Groundwater Basin is composed of a single unconfined aquifer. Accordingly, the model utilizes one layer to represent the groundwater system.

MODFLOW is designed to calculate flow and groundwater elevations in a rectangular grid system. The rectangular area within the grid is called a cell. For the SRB groundwater model, a uniform cell dimension of 100 feet by 100 feet was used. There are a total of 10,469 active cells in the groundwater model. The grid is orientated due east-west and north-south direction.

Model Zonation within Layers

Each cell within the MODFLOW grid is assigned hydraulic properties. The hydraulic properties used in the model include horizontal hydraulic conductivity, vertical anisotropy of hydraulic conductivity and specific yield.

The model domain is subdivided into a number of zones of assumed similar parameter values. The model zonation is primarily based on geological and hydrogeologic data consisting of:

- Correlation of data from drilling logs.
- Various reports and publications on wells pump tests, and monitoring reports performed in the Santa Rosa Groundwater Basin study area obtained from Camrosa Water District.

The MODFLOW model is calibrated by a trial and error process whereby aquifer parameters, or zones of aquifer parameters are changed to make the model simulation approximate observed field conditions. The difference between the model-simulated head and field-measured head at a particular location is called a *residual*. The preliminary zone maps were revised by parameter value, spatial extent, and number (added or removed) during the calibration process until the final zonation was achieved following calibration of the steady-state model. **Table 1** lists the zone properties by parameter. **Figure 2** presents the model parameter zonation map.

The calibrated parameter values listed in **Table 1** fall within the range of published hydraulic conductivity and storage coefficients for the types of sediments found in the basin (Freeze and Cherry, 1979). The hydraulic conductivity values range from a high of 50 feet/day (representing sands and gravelly silty sands), to a low of 3 feet/ day (representing low-conductivity clayey silt). The specific yield values range from a high of 0.15 to a low of 0.06. These values fall within the typical range for modeling applications (Anderson and Woessner, 1992), and were estimated during the calibration process.

Table 1
Aquifer Parameter Values Estimated During Calibration

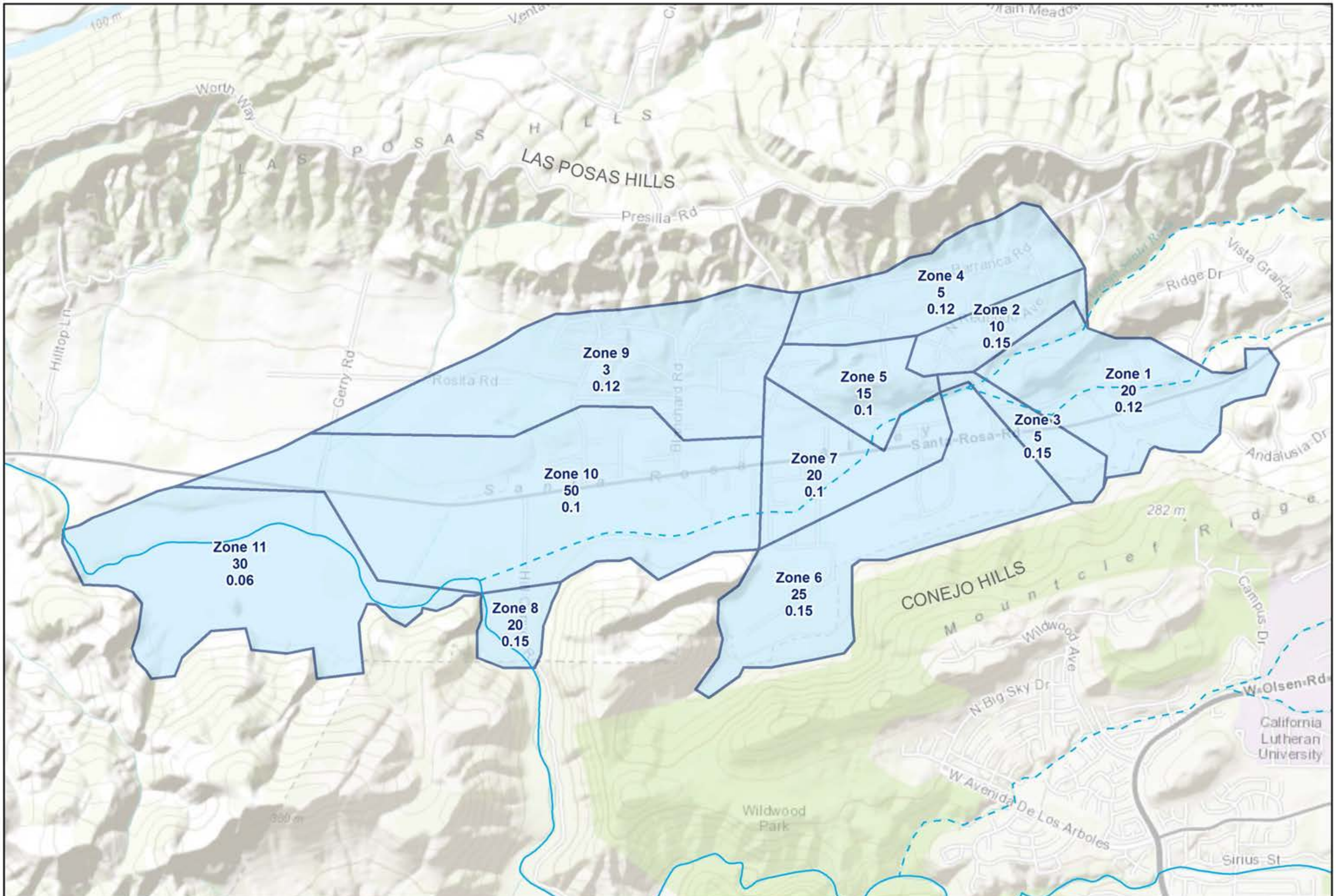
Zone ID	Horizontal K (ft/d)	Specific yield (-)	Vertical Anisotropy of Hydraulic Conductivity (-)
1	20	0.12	10
2	10	0.15	10
3	5	0.15	10
4	5	0.12	10
5	15	0.1	20
6	25	0.15	10
7	20	0.1	20
8	20	0.15	10
9	3	0.12	10
10	50	0.1	10
11	30	0.06	10

3.0 Steady-State Calibration Results

Steady-state calibration was completed for the SRB groundwater model. The term “steady-state” means that boundary conditions such as pumping are unchanged during the simulation period. The calibration process was competed in an iterative or trial-and-error process.

The steady-state model represents the groundwater conditions in the period in mid-1993. In some cases water level information prior to or after the mid-1993 were used for calibration if it is the only available data. Steady-state calibration targets can be categorized in three areas:

- Simulated water levels match field-measured water level data from Camrosa Water District and Ventura County Watershed Protection District;
- The overall or areal groundwater flow pattern matches the general pattern based on field observations; and,
- A realistic water budget is achieved.



Key to Features

Zone 1 20 0.12	Layer 1 Zone Horizontal Hydraulic Conductivity (ft/day) Specific Yield (-)

Perennial Stream

Intermittent Stream

N 0 0.25 0.5 Miles

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Date: January 29, 2013

Parameter Zonation Map

Figure 2

MWH

A brief description of each calibration target area and how the calibrated model performed relative to the observed, or estimated, data is provided below.

Water Level Data

Wells used for steady-state calibration to calibrate water levels for specific locations are shown on **Figure 1** and listed in **Table 2**. **Table 2** also lists the calibration residual at each calibration well.

Table 2
Calibration Wells and Steady-State Calibration Head Residual

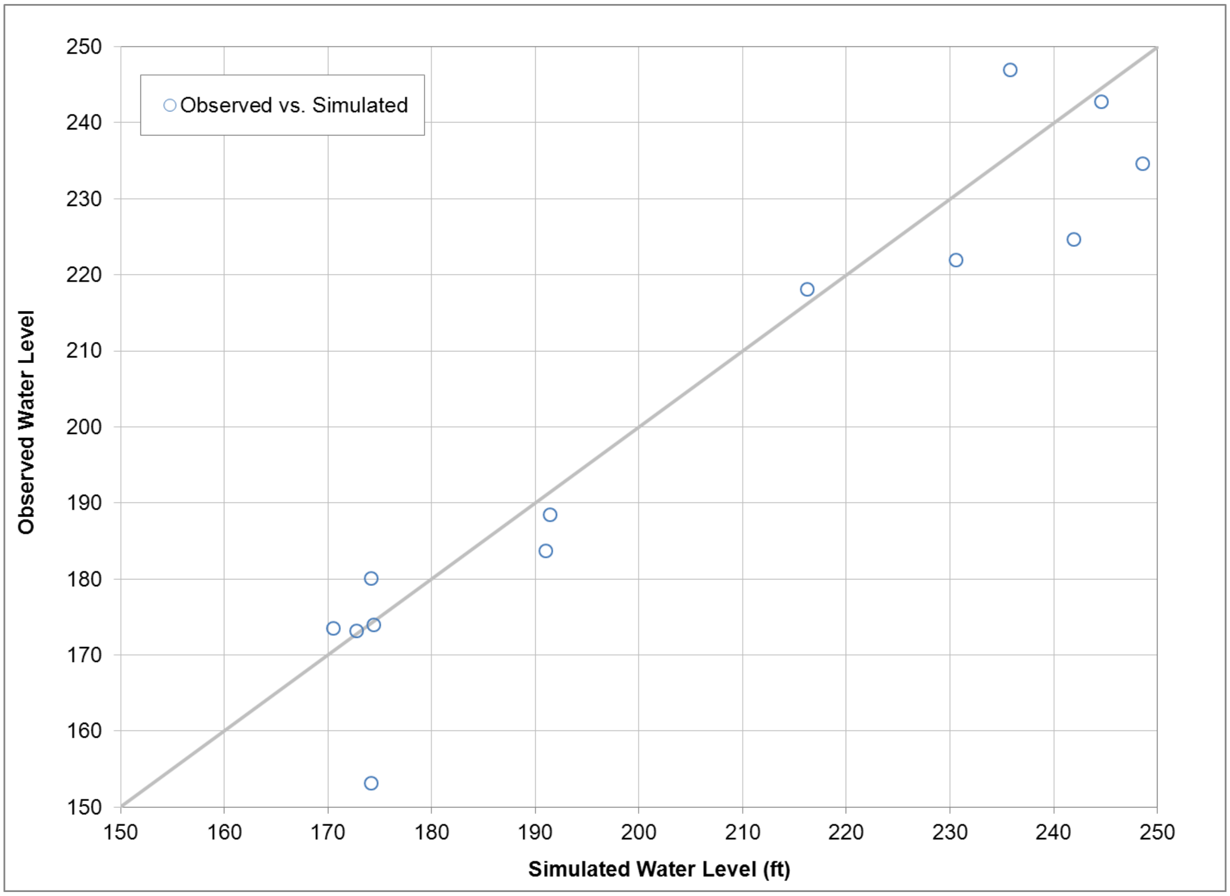
Well Name	State Well No.	X (ft)	Y (ft)	Ground Surface Elevation (ft amsl)	Well Depth (ft)	Observed Water Level (ft amsl)	Simulated Water Level (ft amsl)	Residual (ft)
Ventura Farms	2N19W-20M3	1728155	270312	322	300	224.7	241.9	-17.2
Penny	2N19W-20M4	1727571	270883	325	464	242.8	244.6	-1.8
SRMWC 3	2N20W-25D1	1717522	268804	235	460	153.2	174.2	-21.0
Fitzgerald	2N20W-25D4	1716741	268371	219.1	190	174	174.4	-0.4
SRMWC 8	2N20W-25C4	1718982	267871	260	240	149.1	169.3	-20.2
Conejo 2	2N20W-25C2	1719014	268451	226	399	141.3	165.8	-24.5
Stuart	2N19W-19J3	1726273	270306	315	N/A	247	235.8	11.2
SRMWC 5	2N20W-24R3	1721071	269357	245	287	183.7	191.0	-7.3
26B3	2N20W-26B3	1713872	268885	218	300	173.5	170.5	3.0
Hernandez	2N20W-26B2	1714986	268573	200	392	173.2	172.7	0.5
23R1	2N20W-23R1	1716529	268905	234.6	555	180.1	174.2	5.9
Snow	2N19W-20M1	1727909	271123	320.6	500	234.6	248.6	-14.0
Archdiocese	2N20W-24R2	1721191	268802	240	N/A	188.5	191.4	-2.9
Nicholson	2N19W-19Q2	1725814	269694	290	N/A	221.9	230.5	-8.6
SRMWC 9	2N19W-19P2	1724229	269444	280	393	218.1	216.2	1.9

Table 3 is a statistical residual summary for the steady-state SRB Groundwater model.

- The **mean residual** is the average difference between observed and simulated head in feet. If this value is close to zero, then it indicates that the positive residuals are balanced by the negative residuals. The mean residual for this model is -13.23 feet. The negative value indicates that, overall, the model tends to under predict water levels.
- The **mean absolute error** is the mean error after taking the absolute value of the errors. The mean absolute residual for the model is 15.18 feet, which means that the average simulated head is about ± 15 feet from an observed head. This value indicates the average elevation residual of the calibrated model.
- The **root mean square error** (RMSE) is a measure of precision, or the repeatability of the model results. This statistic is calculated by summing the square of the residuals, dividing by the number of observations, and taking the square root. The lower the RMSE the better the model fit. The SRB model has a RMSE of 22.96 feet.

Figure 3 is a plot of all observed and corresponding model simulated heads for the steady-state calibration. Perfect simulation would result in a straight line where the simulated head would equal the observed head. All of the points are distributed closely around the diagonal line. The points that do deviate from the diagonal line are randomly distributed, indicating no significant trend in residuals with varying elevation.

Figure 3
Comparison of Observed and Simulated Water Levels



Causes of residuals include the following:

- **Groundwater Flow not in a Steady State.** Most of the water level observations started in March 1986. Hydrographs show that water level fluctuated at low level between March 1986 and January 1991, and then increased steadily until mid-1998.
- **Water Level Observed in Pumping Wells.** Most water level measurements were taken from pumping wells and there may be drawdown interference from nearby pumping wells.
- **Known Non-Contemporaneous Data Points**. Water level measurements for the steady-state calibration were taken at different times, separated by months. If these data were all that were available at some locations, then they were used in the calibration but may not be representative of conditions in the mid-1993.
- **Unaccounted for Heterogeneity**. The SRB groundwater model domain covers an area of both valley floor and mountain front. Estimates of aquifer parameters have been made between

known lithologic data points, but there is a significant area between these data points. A particular area of uncertainty is in the mountain front area, because no data exists for this area.

- **Numerical Model Cell Size**. The model necessarily generalizes computed water levels over a 100 by 100 foot area. This generalized or average water level may not be representative of water levels measured in the field at a particular point, particularly in an area of high groundwater gradients.

Table 3
Calibration Statistics for the SRB Groundwater Model

Calibration Statistic	MODFLOW
Mean Error (ft)	-13.23
Absolute Mean Error (ft)	15.18
Root Mean Squared Error (ft)	22.96

Groundwater Flow Pattern

Another method of evaluating the model fit is to review model-wide head results for general flow relationships. In general, the simulated water level matches well to those observations, except in and around the Conejo well field, where as discussed above, water level was measured in pumping wells.

Water Budget

The water budget is an accounting of groundwater recharge (inflow) as it moves into the SRB study area and groundwater discharge and pumping (outflows). The water budget was developed as an approximation of a steady-state condition. There is no true "steady-state", but the water budget attempts to balance annual average historic inflows and outflows to/from the SRB study area.

Table 4 and **Table 5** summarize the inflow and outflow for the Santa Rosa Basin, respectively. When total inflow is equal to total outflow, there is little change in groundwater storage, indicating that the aquifer system is at or near equilibrium. For steady-state modeling this is an implicit assumption in that there is no change in storage.

Estimated ranges of values by water budget component are summarized in **Table 4**. The purpose of these values was not to conclusively apply fixed numbers to the groundwater model, but to provide guidance and reasonable limits to the groundwater modeling effort. All inflow components of the groundwater model water budget fit within the estimated reasonable range.

Table 4
Steady-State Water Budget Summary of Inflows

Component		Estimated Range (AF/Yr)	Calibration (AF/Yr)
Precipitation	Valley Floor	206-2,397	2,520
	Periphery	130-1,509	
Agricultural Return	Santa Rosa Valley	154-462	
Wastewater Return	Indoor	715	
	Outdoor	765	
	Public and Others	30	
Subsurface	Tierra Rejada	225-301	240
River Leakage	Arroyo Santa Rosa	546	600
	Conejo Creek	1,113	1,030
Total			**4,390**

In the case of Santa Rosa Basin, detailed data on outflow from the groundwater system is not available. For example, private groundwater pumping from most wells is not gauged, and the amount of pumped water from those wells that returns to the aquifer through deep percolation is a further unknown.

Table 5
Steady-State Water Budget Summary of Outflows

Component	Calibration (AF/Yr)
Well Pumping	3,320
Subsurface	290
Evapotranspiration/Consumptive Losses	780
Total	**4,390**

The steady-state total inflow/outflow to the groundwater body in the model area is approximately 4,390 acre-feet per year which is consistent with recharge and discharge estimates based on existing data.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Considerable efforts have been completed to develop an accurate conceptual and numerical model of the Santa Rosa Basin area. In spite of the fact that model-simulated water levels do not exactly match field-measured water levels, the numerical model represents a valuable tool to evaluate a variety of groundwater management alternatives discussed in the groundwater related projects section.

During development and calibration of the SRB groundwater model, a number of unique characteristics of the model became apparent. The most significant of these characteristics is summarized below.

- It was found that converting specific flow to river package for Conejo creek greatly enhanced the stability of the model. The model is very sensitive to the stage elevation and river conductance.
- Water level observation and water quality data have shown that the Bailey fault is a groundwater flow barrier, at least in the central part, but it's not clear if and to what extent the other part of the fault acts as a hydraulic barrier.

As with any groundwater model, uncertainties exist in specific areas. Future efforts to improve the model should focus on:

- Validation of the model based on long-term and systematic groundwater monitoring. The current monitoring program should be updated and expanded based on the preferred water management alternative identified in subsequent tasks. The model should be continuously updated as new information becomes available.
- After continued monitoring, a transient calibration is recommended to improve the reliability of the model results.
- This model represents the area east of the Baily Fault. Continued evaluation of the role of faulting on groundwater flow. The best information on the role of faulting would come from high-volume pump testing adjacent to faults with observations on either side of a fault.
- A gauging station is recommended located on the Conejo Creek at the location where the Creek is out of the Hill Canyon and met the valley floor.
- An elevation profile along the Conejo Creek channel within the model domain would improve model results.
- Further evaluation of the sensitivity of the conductance used in the river package to model simulations.

5.0 References

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Appendix D

Draft Report Comments From Fox Canyon Groundwater Management Agency

FOX CANYON GROUNDWATER MANAGEMENT AGENCY

A STATE OF CALIFORNIA WATER AGENCY

July 5, 2013

Terry Curson, P.E.
Project Engineer
Camrosa Water District
7385 Santa Rosa Rd.
Camarillo, CA 93012

SUBJECT: DRAFT CAMROSA WATER DISTRICT SANTA ROSA BASIN GROUNDWATER MANAGEMENT PLAN, APRIL 2013

Thank you for the opportunity to review the subject (early version) draft report. Some sections of the draft report have not yet been completed and are identified as such.

Section 2-Water Resources Setting describes the Santa Rosa Basin (SRB) and its structure in general terms. An important structural feature, known as the Bailey Fault, trends north-east south-west across the western (approximately) third of the SRB. Based on water level differences (lower water levels west of the fault) the fault is understood to restrict underflow from the SRB east of the fault, into the SRB basin west of the fault. The SRB aquifers west of the fault are managed by the Fox Canyon Groundwater Management Agency (FCGMA) and the fault at this location serves as the Agency boundary.

The draft report describes estimated groundwater underflow from the eastern part of the SRB across the Bailey Fault into the western part of the SRB to be 502 acre-feet per year (Boyle, 1997). Section 3-Basin Yield describes the Bailey Fault as a groundwater flow barrier in its central portion and goes on to describe that it is unclear the extent that the other parts of the fault act as a barrier. The draft report's Appendix C Groundwater Model Documentation and Evaluation of Recharge Projects describes that the Bailey Fault is modeled as a no-flow boundary.

The groundwater model results in the draft report indicate the SRB yield east of the Bailey Fault is 3,320 acre-feet per year. What does the groundwater model indicate the underflow across the Bailey Fault is into the FCGMA under current conditions? What is the model value of potential underflow reduction under likely groundwater development scenarios? Have geologic cross sections been developed through this area as part of this study, and will they be included in a revised draft report?

Section 4-Management Plan Goals and Objectives and Section 5-Plan Components both describe approaches to better understand groundwater quality and groundwater availability for use (including pump and treat of the water) to remove salts. It appears that controlling sources of salts and nutrients may be a limited part of the work described for existing land uses, with a broader goal to achieve groundwater quality improvements through extracting and treating groundwater. Are additional controls on land use necessary (i.e. septic system density, livestock, etc.) to achieve the basin management objectives? Under the proposed groundwater management plan scenarios, how will basin groundwater quality change over time?

800 South Victoria Avenue, Ventura, CA 93009-1610
(805) 654-2014 FAX: (805) 654-3350
Websites: www.fcgma.org or www.fcgmaonline.org

Section 5-Plan Components indicates further assessment of the groundwater model is needed in order to validate and measure model assumptions. Is this further assessment a near term goal (within six months) or a longer term goal? Do these further assessments include validating assumptions about the Bailey Fault's ability to restrict groundwater flow?

Via a July 3, 2012 letter, our office provided comment to Camrosa Water District's Draft Program EIR for the Integrated Facilities Master Plan. That comment letter recommended that the Draft Program EIR be revised to describe any loss of recharge to aquifers in the FCGMA. The draft report which is the subject of this letter has provided a more in depth analysis and we recommend that future versions of the draft report address our questions presented in this letter.

Thank you again for the opportunity to review the draft report and provide comment. Please contact me at (805) 650-4083 if you have any questions.

Sincerely,

Rick Viergutz, CEG
Groundwater Manager

cc: Jeff Pratt

Appendix E

Standard Operating Procedures
Well Water Sampling and Field Measurements

STANDARD OPERATING PROCEDURES

WELL WATER SAMPLING AND FIELD MEASUREMENTS

STANDARD OPERATING PROCEDURES
SOP-5

WELL WATER SAMPLING AND FIELD MEASUREMENTS

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Section **Page**

LIST OF ATTACHMENTS

DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES A GENERAL GUIDANCE ON PROCEDURES RELATING TO TECHNICAL ISSUES TO BE ADDRESSED INVOLVING SAMPLING OF GROUNDWATER MONITORING WELLS. IT IS NOTED, HOWEVER, THAT EACH PROJECT AND SITE IS UNIQUE AND THAT THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. IN ADDITION, INDIVIDUAL CONTRACT TERMS MAY AFFECT THE IMPLEMENTATION OF THESE STANDARD OPERATING PROCEDURES.

1.0 INTRODUCTION

This guideline is a general reference for the proper equipment and techniques for groundwater sampling. The purpose of these procedures is to enable the user to collect representative and defensible groundwater samples and to facilitate planning of the field sampling effort. These techniques should be followed whenever applicable, although site-specific conditions or project-specific plans may require adjustments in methodology.

To be valid, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from time of collection to time of analysis in order to minimize changes in water quality parameters. Acceptable equipment for withdrawing samples from completed wells includes bailers and various types of pumps. The following are primary considerations in obtaining a representative sample of the groundwater:

- Avoid collecting stagnant (standing) water in the well.
- Avoid physically or chemically altering the water by improper sampling techniques, sample handling, or transport.
- Document that proper sampling procedures have been followed.

This guideline describes suggested well evacuation (or purging) methods, sample collection and handling, field measurement, decontamination, and documentation procedures. Examples of sampling and chain-of-custody (COC) forms are attached.

2.0 DEFINITIONS

Annular Space	The space between casing or well screen and the wall of the drilled hole, or between drill pipe and casing, or between two separate strings of casing. Also called annulus.
Aquifer	A geologic formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring.
Bailer	A long narrow tubular device with an open top and a check valve at the bottom that is used to remove water from a well during purging or sampling. Bailers are available in many widths and lengths, and may be made of Teflon, polyvinyl chloride (PVC), polyethylene (PE), or stainless steel. Disposable bailers are widely used, and are available in Teflon and PE.
Bladder Pump	A pump consisting of flexible bladder (usually made of Teflon) contained within a rigid cylindrical body (commonly made of PVC or stainless steel). The lower end of the bladder is connected through a check valve to the intake port, while the upper end is connected to a sampling line that leads to the ground surface. A second line, the gas line, leads from the ground surface to the annular space between the bladder and the outer body of the pump. After filling, under hydrostatic pressure, application of gas pressure causes the bladder to collapse, closing the check valve and forcing the sample to ground surface through the sample line. Gas pressure is often provided by a compressed air tank, and commercial models generally include a control box that automatically switches the gas pressure off and on at appropriate intervals.
Centrifugal Pump	A pump that moves a liquid by accelerating it radially outward in an impeller to a surrounding spiral-shaped casing.
Chain of Custody	Method for documenting the history and possession of a sample from the time of its collection through its analysis and data reporting to its final disposition.
Check Valve	Ball and spring valves on core barrels, bailers, and sampling devices that are used to allow water to flow in one direction only.

Conductivity (electrical)	A measure of the quantity of electricity transferred across a unit area, per unit potential gradient, per unit time. It is the reciprocal of resistivity.
Datum	An arbitrary surface (or plane) used in the measurement of heads (i.e., National Geodetic Vertical Datum, commonly referred to as mean sea level).
Direct-Push Technology	A method of soil boring installation involving pushing a sampling device into the ground and retrieving it for soil description and collection (Geoprobe® is a common trademark name). Groundwater samples can be collected from the borehole by inserting a screen point into the hole and removing groundwater via peristaltic pump or small-diameter bailer. Similar to Hydropunch® (see below).
Decontamination	A variety of processes used to clean equipment that contacted formation material or groundwater that is known to be or suspected of being contaminated.
Downgradient	In the direction of decreasing potentiometric head.
Drawdown	The lowering of the water level or potentiometric surface in a well and aquifer due to the discharge of water from the well.
Electric Submersible Pump	A pump that consists of a rotor contained within a chamber and driven by an electric motor. The entire device is lowered into the well with the electrical cable and discharge tubing attached. A portable power source and control box remain at the surface. Electrical submersible pumps used for groundwater purging are constructed of inert materials such as stainless steel, and are well sealed to prevent sample contamination by lubricants.
Filter Pack	Sand or gravel that is generally uniform, clean, and well rounded that is placed in the annulus between the borehole wall and the well screen to prevent formation material from entering through the well screen and to stabilize the adjacent formation.
Headspace	The empty volume in a sample container between the water level and the cap.

HydroPunch®	An in situ groundwater sampling system in which a hollow steel rod is driven into the saturated zone that allows for the collection of a groundwater sample.
In Situ	In the natural or original position; in place.
Monitoring Well	A well that is constructed by one of a variety of techniques for the purpose of extracting groundwater for physical, chemical, or biological testing, or for measuring water levels or potentiometric surface.
Packer	A transient or dedicated device placed in a well or borehole that isolates or seals a portion of the well, well annulus, or borehole at a specific level.
Peristaltic Pump	A low-volume suction pump. The compression of a flexible tube by a rotor results in the development of suction.
pH	A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. (Original designation for potential of hydrogen.)
Piezometer	An instrument used to measure water level or potentiometric head at a point in the subsurface; a non-pumping well, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface.
Preservative	An additive (usually an acid or a base) used to protect a sample against decay or spoilage, or to extend the holding time for a sample.
Static Water Level	The elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, hydrologic testing, or nearby pumping.
Turbidity	Cloudiness in water due to suspended and colloidal organic and inorganic material.
Upgradient	In the direction of increasing potentiometric head.

3.0 RESPONSIBILITIES

The **Project Manager** selects site-specific water sampling methods, locations for monitoring well installations, monitoring wells to be sampled and analytes to be analyzed (with input from the Field Team Leader and Project Geologist), and is responsible for project quality control and field audits.

The **Field Team Leader** implements the water sampling program; supervises the Project Geologist/Hydrogeologist and Sampling Technician; ensures that proper chain-of-custody procedures are observed and that samples are sampled, transported, packaged, and shipped in a correct and timely manner.

The **Project Geologist/Hydrogeologist** ensures proper collection, documentation, and storage of groundwater samples prior to shipment to the laboratory, and assists in packaging and shipment of samples.

The **Field Sampling Technician** assists the Project Geologist/Hydrogeologist in the completion of tasks and is responsible for the proper use, decontamination, and maintenance of groundwater sampling equipment.

4.0 WATER SAMPLING GUIDELINES

4.1 EQUIPMENT

There are many methods available for well purging (evacuation) and sampling. A variety of issues must be considered when choosing purging and sample collection equipment. These issues include the following:

- Depth and diameter of the well
- Recharge capacity of the well
- Analytical parameters that will be tested
- Governing regulatory requirements

Few sampling devices are suitable for the complete range of groundwater analytical parameters. For example, a bailer is acceptable for collecting major ion and trace metal samples (if turbidity is not a factor), but analytical results may be incorrect if used for the collection of samples that are analyzed for volatile organics, dissolved gases, or even pH. Generally, the best pumps are positive displacement pumps, such as bladder and helical rotor pumps, which minimize the aeration of the groundwater as it is sampled, and therefore yield the most representative groundwater samples. Although it is possible to use different equipment to purge the well and to sample the well, this is not recommended because of the increased decontamination requirements and possibilities for cross contamination. It is recommended that a flow rate as close to the actual groundwater flow rate should be employed to avoid further development, well damage, or the disturbance of accumulated corrosion or reaction products in the well (Puls and Barcelona, 1989).

Positive displacement pumps, such as bladder pumps, are generally recommended for both well evacuation and sample collection. Disposable bailers are also commonly used for well development and evacuation, as well as sample collection in certain cases. Other types of sample collection such as gas lift pumps should be avoided, especially when analyzing for sensitive parameters, because of the geochemical changes that can occur due to the aeration of the water within the well. Also, the use of certain sample devices (e.g., bailers or high-rate centrifugal pumps) may entrain suspended materials, such as fine clays and colloids, which are not representative of mobile chemical constituents in the formation of interest (Puls and Barcelona, 1989).

Specific instructions for the use of several of the sampling devices are discussed in the next sections. All purging and sampling equipment should be decontaminated before beginning work and between wells, in accordance with Section 4.5.

4.1.1 Bailers

Bailers represent the simplest and least expensive method of collecting the sample from a well. However, they may not be suitable for all analyses. Bailers are available as permanent (re-usable or dedicated) and disposable. Permanent bailers are usually constructed of Teflon or stainless steel. Disposable bailers are usually constructed of polyethylene or Teflon.

The advantages to using permanent bailers are:

- Inexpensive
- Easy to use and maintain

The disadvantages to using permanent bailers are:

- Disturb sediment while sampling
- Require decontamination and risk of cross-contamination
- Require disposal of contaminated purge water
- Possibility of splashing (health and safety issue)

The advantages of using disposable bailers are:

- No need for decontamination between.
- Inexpensive
- Easy to use

The disadvantages to using disposable bailers are:

- Disturb sediment while sampling
- Require disposal of contaminated purge water
- Possibility of splashing (health and safety issue)

Disposable bailers are preferred. Since there is no cross- contamination between samples, there is no need for time-consuming decontamination.

Bailers can be lowered and raised using stainless steel wire or polypropylene cord. Polypropylene cord is recommended since it is inexpensive, light, and strong, however it should be discarded after one use to prevent cross-contamination. At no time should the bailer or the line touch the ground during the sampling process. This can be done by coiling the line around one's hands while pulling the bailer out of the well. For deep wells, the line may be coiled into a bucket or on a clean plastic sheet.

During bailing, the purge water is poured out of the top of the bailer into a 5-gallon bucket, 55-gallon drum, or equivalent. Most groundwater sampling protocols require that the amount of water purged be recorded; thus, a 5-gallon bucket with 1-gallon markings is recommended. During sampling, the water can be poured out of the top of the bailer. This should not be done for volatile analyses. Water can also be removed from the bottom of the bailer using a small tube or sampling device that comes with most disposable bailers. This device essentially pushes the ball out of the valve, allowing water to slowly flow out of the bottom of the bailer. This is the recommended method for VOC sampling.

4.1.2 Peristaltic Pumps

Peristaltic and centrifugal pumps are widely used for purging wells with water levels close to the surface (less than 30 feet). They are light, reasonably portable, and easily adaptable to ground level monitoring of field parameters by attaching a flow-through cell. These pumps require minimal downhole equipment. The tubing can easily be cleaned in the field; however, more often dedicated tubing is left in each well, or tubing is replaced after each well. The following procedures should be considered when using these pumps:

- Unless dedicated tubing is used, the interior and exterior of all intake tubing used with the peristaltic/centrifugal pump should be thoroughly washed with a detergent wash, flushed with tap water, and then double rinsed with distilled water prior to use.

- Peristaltic pumps typically run on batteries. However, if a gas-powered generator is used, it should be downwind of the well.

- The intake of the tubing should be lowered to the midpoint of the well screen. Alternatives to this procedure may be necessary if the drawdown from the purging operations causes the water level to fall and begin to pump air. Because of accumulated sediment at the well bottom, the intake should be at least 1 foot above the bottom of the well.

- If parameters are to be monitored continuously, it is recommended that an in-line "flow-through" cell with a multi-parameter water quality meter be used. Connect the discharge tubing from the pump to the "in" port of the flow-through cell and begin evacuating the well (make sure to have the "out" port connected to a bucket or some sort of water containment). Continuously monitor the parameters (typically pH, oxidation reduction potential (ORP or redox), dissolved oxygen (DO), turbidity, temperature, and specific conductivity) and measure the volume of groundwater being pumped.

- After purging is complete (stabilization of parameters), disconnect the discharge tubing from the flow through cell prior to sampling. Do not collect water that has flowed through the flow-through cell.

The advantages of using peristaltic pumps are:

- Typically less purge water to collect and dispose (if low-flow sampling)
- Relatively easy to use
- Very little disturbance of sediment; easy to achieve low turbidity samples
- Low health and safety risk (low splash possibility)

The disadvantages to using peristaltic pumps are:

- Possibly expensive, depending on tubing and pump used.
- Sampling time can be 1 hour or more per well.
- Limited depth applicability; can pump only from depths less than 32 feet.
- Vacuum or negative pressure can potentially alter the geochemistry (VOCs, pH, alkalinity).

4.1.3 Submersible Pumps

Submersible pumps take in water and push the sample up a tube to the surface. The power sources for these pumps may be compressed gas or electricity. The operation principles vary, and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Bladder or helical rotor pumps are recommended for sampling for sensitive parameters. Bladder pumps are available for .05-inch diameter wells and larger, and these pumps can lift water up to several hundred feet. For large sampling projects, dedicated tubing is recommended, as tubing for bladder pumps is typically very expensive ($10 per foot), thus making disposable tubing not efficient. The entire pump assembly (and tubing, if applicable) should be decontaminated before purging and between wells, as described in Section 4.5.

The advantages of using submersible pumps are:

- Less purge water to collect and dispose (if low-flow sampling).
- Very little disturbance of sediment; easy to achieve low turbidity samples.
- Adjustable to very low flow rates.
- Can be used to sample wells 300 or more feet deep.
- Dedicated systems can lower costs over time.
- Low health and safety risk (low splash possibility).
- Some types (e.g., bladder pumps) can be easily disassembled for decontamination.

The disadvantages of submersible pumps are:

- Need power source or gas source, which can be hard to transport to remote well locations.
- High start-up costs; Many models of these pumps are expensive, as is the tubing.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components of some types is difficult and time consuming.

4.1.4 Other Pumps

Gas-Lift Pumps

A pressure displacement system consists of a chamber equipped with a gas inlet line, a water discharge line, and two check valves. When the chamber is lowered into the casing, water floods it from the bottom through the check valve. Once full, a gas (e.g., nitrogen or air) is forced into the top of the chamber in sufficient amounts to displace the water in the discharge tube. The check valve in the bottom prevents water from being forced back into the casing, and the upper check valve prevents water from flowing back into the chamber when the gas pressure is released. This cycle can be repeated as necessary until purging is complete. The potential for increased gas diffusion into the water (and thus loss of volatiles) makes this system unsuitable for sampling volatile organic or most pH critical parameters. This method is not recommended for groundwater sampling, but may be useful for development or evacuation of a well.

Direct-Push Technology Groundwater Sampling

Direct Push Technology provides in situ groundwater samples by using a specially designed sample tool to provide a hydraulic connection with the water table. When used with a mobile laboratory, DPT groundwater sampling can be useful for such applications as relatively rapid delineation of groundwater plumes. It is also ideal for screening for contaminants. Both groundwater and floating layer hydrocarbons may be sampled using this method.

The DPT method utilizes a sampler containing a stainless steel screen point, which is attached to the DPT rods and is inserted into the DPT borehole. When the screen is at the desired depth, the sampler is pulled back, exposing the screen to the formation. Groundwater can then be sampled used a peristaltic pump or a small diameter bailer.

This method may be used to sample groundwater up to approximately 60 feet of soft sediments. In coarse sand, gravel, consolidated rock, or at depths greater than 60 feet, a pilot hole must be drilled prior to using this method.

The advantages of using DPT groundwater sampling techniques are:

- Low cost (relative to installing monitoring wells)
- Able to collect a relatively undisturbed in situ groundwater sample
- The relative speed with which a sample can be collected when compared to drilling, installing, developing, purging, and sampling a monitoring well

The disadvantages of using DPT groundwater sampling techniques are:

- Accurate water levels can not be obtained
- Sampling cannot be repeated if problems occur with the samples after they are collected
- Does not allow for long-term groundwater monitoring

4.2 WELL PURGING METHODS

Well development procedures are covered in SOP-03, "Groundwater Monitoring Well Development."

4.2.1 Calculation of Casing Volume

To ensure that an adequate volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well and the volume of water in the filter pack below the well seal. The volume can be easily calculated by the following method (calculations should be entered in the field logbook):

1. Obtain all available information on well construction (e.g., location, casing, screen, depth).
2. Determine well or casing diameter.
3. Measure and record static water level using an electronic water level meter (depth below top of casing reference point).
4. Use a pre-determined total depth of the well to calculate the water column. Measuring total depth prior to sampling will disturb sediment that has accumulated at the bottom of the well, which will affect sample results.
5. Calculate the volume of water in the casing using the following formula:

$$V = 7.481\ (\pi r^2 h)$$

where:

V	=	Casing volume (gal)
r	=	Well radius (ft)
h	=	Linear feet of water in well = total well depth (ft) - static water depth (ft)

Alternatively, the casing volume can be calculated by multiplying the linear feet of water in the well by the volume per linear feet taken from Attachment 1 or other similar tables. Always be sure that the units in your calculation are consistent. In the equation above, 7.481 is the conversion factor from cubic feet to gallons.

4.2.2 Calculation of Annulus Volume

Some groundwater sampling protocols require the purging of casing and annulus volumes prior to sampling. In these cases the volume of water contained in the annular space between the casing and the borehole wall is calculated by the following formula:

$$Va = (Cb - Cc) \times (h) \times (0.30)$$

where:

Va	=	Volume of water in annulus (gal)
Cb	=	Borehole capacity (gal/ft)
Cc	=	Casing capacity (gal/ft)
h	=	Amount of standing water in the well or total linear height of the sand pack, whichever is less (ft)
0.30	=	Average porosity of typical sand pack

The values for Cb and Cc can be calculated by the formula πr^2. The annulus volume is added to the casing volume prior to multiplying by the number of volumes to be purged.

4.2.3 Purging Requirements

The composition of the water within the well casing and in close proximity to the well is probably not representative of the overall groundwater quality in the target aquifer. This is because important environmental conditions such as the ORP may differ drastically near the well from the conditions in the surrounding water-bearing materials. For this reason it is necessary to either purge the well until it is thoroughly flushed of standing water and contains fresh water from the aquifer, or sample from discrete intervals in the screened interval at low flow rates in order to collect undisturbed aquifer water (Puls and Barcelona, 1996).

Full Well Purging

When full purging is required, the recommended amount of purging before sampling depends on many factors, including the characteristics of the well, the hydrogeological nature of the aquifer, the type of sampling equipment being used, the parameters that are to be analyzed, and the regulatory requirements of the project. The number of casing volumes that should be removed prior to sample collection has been a matter of debate in the groundwater community for some time. However, it is recommended that where possible, between three and five casing volumes should be purged prior to sampling.

Low-Flow Sampling

Many groundwater scientists and regulatory departments have accepted and prioritized the use of low-flow purging and sampling of groundwater. Low-flow purging is defined as pumping rates between 0.1 and 0.5 liters per minute (L/min). Also, rather than relying on the removal of a specific volume of water prior to sample collection, physical parameters, such as pH, DO, ORP, turbidity, specific conductivity, and temperature, are collected at certain intervals (usually every 2 to 5 minutes). In order to minimize contact with the atmosphere, these parameters are typically measured using a multi-parameter meter inside a closed "flow-through" cell attached to the discharge side of a pump system. Once the parameters have stabilized, the groundwater is considered representative of the aquifer and is ready for sample collection. Determining *when* the parameters have stabilized, however, may differ between regulatory agencies. Per the U.S. Environmental Protection Agency (EPA) document *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (Puls and Barcelona, 1996), the parameters are considered stabilized when three consecutive measurements are within the following constraints:

- Temperature ± 10 %
- Conductivity ± 3 %
- pH ± 0.1
- DO ±10 %
- ORP ±10 mV
- Turbidity ±10 % or <10 nephelometric turbidity units (NTUs)

During purging, water levels should be monitored to ensure that drawdown does not exceed 0.1 m (0.3 ft). If the water level drop exceeds this, the flow rate should be decreased until the water level stabilizes. If water levels in low yield wells do not stabilize at flow rates near 0.1 L/min, the well should be purged to dryness once and then sampled (EPA, 1986). Samples should be collected when the well has recovered to 80 percent of its original capacity or at 24 hours from being purged to dryness, whichever comes first. At no time should the well be pumped to dryness if the recharge rate causes the formation water to vigorously cascade down the sides of the screen and cause an accelerated loss of volatiles. In this case, samples should be collected at a rate slow enough to maintain the water level at or above the top of the screen to prevent cascading.

4.2.3 Purge Water Handling and Disposal

Because of the potential for spreading environmental contamination, planning for purge water disposal is a necessary part of well monitoring. Alternatives range from releasing it on the ground (not back down the well) to full containment, treatment, and disposal. If the well is believed to be contaminated, the best practice is to contain the purge water and store it in drums labeled "purge water" or in aboveground portable storage tanks (i.e., Baker Tanks) until the water samples have been analyzed. Include the date that the waste was generated on the container. Once the contaminants are identified, appropriate treatment or disposal requirements can be determined.

4.3 FIELD MEASUREMENTS

A variety of field measurements are commonly made during the sampling of groundwater including water level, pH, conductivity, turbidity, temperature, DO, and ORP. The accuracy, precision, and usefulness of these measurements are dependent on the proper use and care of the field instruments. Valid and useful data can only be collected if consistent practices (in accordance with recommended manufacturer's instructions) are followed. The instruments should be handled carefully at the well site and during transportation to the field and between sampling sites.

4.3.1 Water Level

Water levels can be measured by several techniques, but the most common method is using an electronic water level meter. The proper sequence is as follows:

1. Check operation of measurement equipment aboveground. Prior to opening the well, don personal protective equipment as required.

2. Record the following information on a sampling form or in the field notebook if a form is not available:

   – Well number
   – Top of casing elevation
   – Surface elevation, if available.

3. After opening the well, observe any pressure in the well. Allow 10-30 seconds for the water levels to equilibrate and stabilize. Repeat measurement after 30 seconds to assure the water level has stabilized.

4. Measure and record static water level and total depth (only if necessary) to the nearest 0.01 foot (0.3 cm) from the surveyed reference mark on the top edge of the inner well casing. If no reference mark is present, record in the log book where the measurement was taken (e.g., from the north side of the inner casing).

5. Record the time and day of the measurement.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable or tape and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact. For accurate readings, the probe should be lowered slowly into the well.

Oil/Water Interface Probes

If oil or free product is encountered in the well, an oil/water interface probe can be used to measure the thickness of the product on top of the water. Most models exhibit two distinct electronic sounds for oil (usually a solid beep) and water (an intermittent beep). The most accurate method for measuring the oil/water interface is to first measure the top of the free product, then go through the product until the probe registers water, and then slowly raise the probe until a solid beep is encountered. This prevents a false thickness of product being measured, since product may stick to the probe causing the probe to read product when it really is in water.

4.3.2 MULTI-PARAMETER PROBES

Typically, groundwater parameters such as pH, temperature, and dissolved oxygen are measured in a flow-through cell using a probe that measures several parameters at once. Certain sampling techniques may preclude the use of these probes, and individual probes may need to be used instead.

Instruments should be calibrated at the beginning of every day, and if readings become suspect. Most instruments claim to hold their calibration longer than a day; if so, their calibration can be checked every morning. If the values do not match the expected numbers, the instrument should be calibrated again. The manufacturer's directions for calibration, maintenance, and use should be read and closely followed. Any problems with the functioning of the meter should be noted in the field log and reported to the office equipment manager.

4.4 SAMPLE COLLECTION METHODS

4.4.1 Sample Containers

A complete set of sample containers should be prepared by the laboratory prior to going into the field. The laboratory should provide the proper containers with the required preservatives. The laboratory's QA manual should provide a complete description of the procedures used to clean and prepare the containers. The containers should be labeled in the field with the date, well designation, project name, collectors' name, time of collection, and parameters to be analyzed. The sample containers should be kept in a cooler (at 4 degrees centigrade) until they are needed (i.e., not left in the sun during purging). One cooler should be used to store the unfilled bottles and another to store the samples.

The sample bottles should be filled in order of the volatility of the analytes so that the containers for volatile organics will be filled first, and samples that are not pH-sensitive or subject to loss through volatilization will be collected last. A preferred collection order (EPA, 1986) is as follows:

- Volatile organics (VOCs)

- Total petroleum hydrocarbons
- Total organic halogens
- Total organic carbon
- Extractable organics (e.g., BNAs, pesticides, herbicides)
- Total metals
- Dissolved metals
- Phenols
- Cyanide
- Sulfate and chloride
- Nitrate and ammonia
- Radionuclides

Field measurements, such as temperature, pH, and specific conductance, should be measured and recorded in the field before and after sample collection to check on the stability of the water samples over time.

4.4.2 Field Filtration for Dissolved Metals

Filtering groundwater samples has been a subject of considerable debate in recent years. In many cases, samples passing a 0.45-micron filter were used to provide an indication of dissolved metals concentrations in groundwater. Puls and Barcelona (1989) report that the use of a 0.45-micron filter was not useful, appropriate, or reproducible in providing information on metals mobility in groundwater systems, nor was it appropriate for determination of truly "dissolved" constituents in groundwater. A dual sampling approach is recommended to collect both filtered and unfiltered samples.

Any filtration for estimates of dissolved species loads should be performed in the field with no air contact and immediate preservation and storage. In-line pressure filtration is best with as small a filter pore size as practically possible (e.g., 0.45, 0.10 micron). Disposable, in-line filters are recommended for convenience and avoiding cross-contamination. The filters should be pre-rinsed with distilled water; work by Jay (1985) showed that virtually all filters require pre-washing to avoid sample contamination.

In the absence of filters, low-flow sampling techniques can reduce turbidity to values less than 10 NTUs.

4.4.3 Sampling from Non-Monitoring Wells and Springs/Seeps

Municipal/Residential Wells

Residential water supply wells should be sampled in a similar manner to monitoring wells, although allowances must be made for the type of pumping equipment already installed in the well. In most cases, this will involve sampling directly from the tap on each well and before the water has gone through any chlorination or treatment system. The sampling point should be a cold-water tap located as close to the pump as practical. Domestic supply samples should not be taken from taps delivering chlorinated, aerated, softened, or filtered water. Faucet aerators should be removed if possible before sampling. Outdoor spigots are generally preferable, since they are usually provide untreated water and are less of an intrusion into the residence. Field parameters (temperature, DO, ORP, etc.) can be measured in a flow-through cell connected via hose to an outside spigot. The water sample can be collected after parameters stabilize. For sampling, the flow rate should be set to low flow sampling rates (or approximately 0.1 L/min). If field parameter measurement is not possible, the water tap should be turned on and run for at least 30 minutes unless the water tap is directly adjacent to the well head, and then the water should be allowed to run for no less than 10 minutes before the samples are collected to flush stagnant water from the system. All sample containers should be filled with water directly from the tap and the samples processed as described for monitoring well samples. Components of the plumbing system should be noted to assist in data interpretation.

Spring and Seep Sampling

Samples from springs or seeps should be collected directly into the sample bottles without using any special sampling equipment. The sample will be collected as close as possible to where the spring emanates from the soil or rock. The sampler should always stand downstream of the spring or seep to avoid disturbing sediment or clouding the water.

4.5 DECONTAMINATION

Decontamination procedures will vary from project to project based on the regulations and project-specific Field Sampling Plan (FSP). Generally, decontamination procedure for non-dedicated groundwater sampling equipment (bailers, pumps, water-level probes) consists of the following steps:

1. Scrub and wash with laboratory-grade detergent (such as Alconox™) and tap water.
2. Triple rinse with deionized water.

If equipment is highly contaminated, it may be rinsed with reagent-grade isopropanol alcohol or methanol and allowed to air dry prior to Step 2 above. A hot water pressure washer can also be used for decontaminating sampling equipment. However, dedicated or disposable equipment is preferable since it eliminates any possible cross-contamination pathway that incomplete decontamination may cause. As with other procedures documented in this SOP, decontamination procedures may be determined by the client or regulatory agency involved in the project.

4.6 RECORDS AND DOCUMENTATION

4.6.1 Sample Designation

Sample names vary from project to project, and further instructions are typically described in the project Quality Assurance Project Plan (QAPP) or FSP. Typically, the site name or an abbreviation or acronym of the site name is included along with the well identification. For example, a sample from Hill Air Force Base Operable Unit 1 could be designated HAFB-OU1-2, with the final 2 designating the monitoring well number. Blind duplicate samples should be labeled with the number of a non-existent well, and should not include a sample time on the label. Equipment and trip blanks, collected when non-dedicated equipment is used, may also be labeled with a fictitious well name in a similar manner to the blind duplicate samples.

4.6.2 Sample Label

Sample containers should be labeled using waterproof ink before a sample is obtained. A sample label should be affixed to all sample containers. This label identifies the sample by documenting the sample type, sampler(s) initials, sample location, time, date, analyses requested, and preservation method. A unique sample designation as discussed above is assigned to each sample collected. This sample ID is also noted on the sample label.

4.6.3 Field Notebooks and Sampling Forms

A field notebook should be prepared prior to beginning sampling activities and should be maintained throughout the sample round. The notebook should contain pertinent information about the monitoring wells, such as depth of casing and water levels. During sampling, all the activities should be recorded on a groundwater sampling log (see Attachment 2) and/or in the field notebook. All forms used during sampling should be referenced in the field notebook. A brief description of weather conditions should also be noted as weather can sometimes affect samples. Any deviation from the sampling procedure described in the project work plan or SOP should be outlined in detail and justified in the field notebook. Specialized sampling forms can also be used to record the field measurements and other conditions observed.

4.6.4 Chain-of-Custody

The COC form (see Attachment 3) should be used to record the number of samples collected and the corresponding laboratory analyses. Information included on this form consists of time and date sampled, sample number, type of sample, sampler's name, preservatives used, and any special instructions. The project QAPP will detail the procedure for completing the COC form. A separate COC form may be completed for each cooler, or copies of the completed COC may be placed in every cooler. A copy of the COC form should be retained by the sampler prior to shipment (forms with multiple carbon copies are recommended). The original COC form should accompany the sample to the laboratory and provide a paper trail to track the sample. When transferring the possession of samples, the individuals relinquishing and receiving the samples should sign, date, and note the time on the COC form. Frequent communication with the laboratory after shipment is recommended to assure proper handling and adherence to holding times.

4.7 SAMPLE HANDLING AND SHIPPING

4.7.1 Sample Handling

The samples will be kept cool during collection and shipment with regular ice contained in a plastic bag. Frozen “blue ice” is not recommended. The samples should be stored in a durable, appropriately sized ice chest. The samples should be placed upright on a 1- to 3-inch layer of packing materials, such as vermiculite or bubble packaging, and kept separated, with the intervening voids filled with the packing material more than halfway to the top of the bottles or containers. The ice should be placed above and about the tops of the containers. The COC record should be sealed in a Ziplock plastic bag and affixed to the inside of the top lid of the cooler. The remaining space should be filled with packing material. The cooler should be secured by completely wrapping with strapping tape around both ends and around the lid. If there is a drain on the cooler, it should be taped shut. Chain-of-custody seals should be affixed across the seal between the lid and body of the cooler.

4.7.2 Shipping Instructions

All samples should be shipped overnight delivery through a reliable commercial carrier, such as FedEx. If shipment requires more than a 24-hour period, sample holding times can be exceeded, or the samples may get warm, compromising the integrity of the sample analysis. The sampler should call the laboratory to alert them when the samples will arrive on the following day.

5.0 REFERENCES

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ATTACHMENT 1

MONITORING WELL DEVELOPMENT/SAMPLING FORM

MONITORING WELL DEVELOPMENT/SAMPLING FORM

MWH
MONTGOMERY WATSON HARZA

MONITORING WELL SAMPLIN

PROJECT:

Well ID:		**Screened Interval (ft):**		**Well Diameter (in)**	
Date:		**Pump Depth (ft):**		**Static Water Level (ft):**	
Sample ID:		**Flow Rate (gpm)**		**Standing Water (ft):**	
Time:		**Purging Device:**		**One Well Volume (gal):**	
Analyses:		**Sampling Device:**		**OVA Reading at TOC:**	
QA/QC - Dup ID:		**Water Level Instrument:**		**OVA Reading in BZ:**	
Rinsate ID:		**Water Quality Meter(s):**		**Samplers Signature:**	

Time	Volume Purged (gal)	Flow Rate (gpm)	Water Level (feet - TOC) ± 0.1 ft	SC (µS/cm) 5%	pH ± 0.1	Temp ± 1°C	DO (mg/L) 10%	Turbidity (NTU) < 10 NTU	Other
Final Field Parameter Measurements									

Comments:

ATTACHMENT 2

GROUNDWATER FIELD SAMPLING DATE RECORD

GROUNDWATER FIELD SAMPLING RECORD

MONTGOMERY WATSON

PAGE ____ OF ____

PROJECT ____________ JOB NO. ____________

SAMPLE LOCATION I.D. ________ DATE ________ TIME START: ________ END: ________

WATER LEVEL / WELL DATA

WELL DEPTH ______ FT ☐ MEASURED ☐ HISTORICAL ☐ TOP OF WELL ☐ TOP OF CASING ☐ ________ CASING STICK-UP (FROM GROUND) ______ FT

WATER DEPTH ______ FT

WELL MATERIAL: ☐ PVC ☐ SS ☐ ________

WELL LOCKED? ☐ YES ☐ NO

WELL DIA. ☐ 2 INCH ☐ 4 INCH ☐ 6 INCH ☐ ________

WATER LEVEL EQUIP. USED: ☐ ELECT.COND.PROBE ☐ FLOAT ACTIVATED ☐ PRESS. TRANSDUCER ☐ ________

HEIGHT OF WATER COLUMN ______ FT X ☐ .16 GAL/FT (2 IN.) ☐ .65 GAL/FT (4 IN.) ☐ 1.5 GAL/FT (6 IN.) ☐ ___ GAL/FT (___ IN.) = ______ GAL/VOL. ______ TOTAL GAL PURGED

WELL INTEGRITY:	YES	NO
PROT. CASING SECURE	☐	☐
CONCRETE COLLAR INTACT	☐	☐
OTHER ________	☐	☐

EQUIPMENT DOCUMENTATION

SAMPLE

PURGING/SAMPLING EQUIP. USED:

✓ IF USED FOR: PURGING	SAMPLING		EQUIPMENT I.D.
☐	☐	SUBMERSIBLE PUMP	________
☐	☐	STAINLESS STEEL BAILER	________
☐	☐	TEFLON/BAILER	________
☐	☐	________	________

DECONTAMINATION METHOD:

FIELD ANALYSIS DATA

AMBIENT AIR VOA ______ PPM WELL MOUTH ______ PPM FIELD DATA COLLECTED ☐ IN-LINE ☐ IN CONTAINER

PURGE DATA	@ ____ GAL	@ ____ GAL	@ ____ GAL	@ ____ GAL	@ ____ GAL
TEMPERATURE, DEG C					
pH, units					
SPECIFIC CONDUCTIVITY (umhos/cm. @ 25 deg.c)					
TURBIDITY, NTUs					

SAMPLE OBSERVATIONS: ☐ TURBID ☐ COLORED ☐ CLOUDY ☐ CLEAR ☐ ODOR

SAMPLE COLLECTION REQUIREMENTS

(✓ IF REQUIRED AT THIS LOCATION)

ANALYTICAL PARAMETER	✓ IF FIELD FILTERED	PRESERVATION METHOD	VOLUME REQUIRED	✓ IF SAMPLE COLLECTED	SAMPLE BOTTLE I.D.'S
☐				☐	____/____/____/____
☐				☐	____/____/____/____
☐				☐	____/____/____/____
☐				☐	____/____/____/____
☐				☐	____/____/____/____
☐				☐	____/____/____/____
☐				☐	____/____/____/____
☐				☐	____/____/____/____

NOTES:

SIGNATURE OF SAMPLER

ATTACHMENT 3

CHAIN-OF-CUSTODY RECORD

CHAIN OF CUSTODY RECORD

MONTGOMERY WATSON HARZA CHAIN OF CUSTODY RECORD MWH CONTACT PERSON:

FED EX #: ______ COOLER #: ______ COC ID: ______ LOGCODE: LAB:

SAMPLER(S) PRINTED NAME AND SIGNATURE

PROJECT NAME:
CLIENT ID
PROJECT NUMBER:

ANALYSIS REQUEST

SAMPLE ID	LOC ID	SBD	SED	DATE	TIME	ERPIMS CODES SA	SN	SM	MC	BC	CT	PR												REMARKS

Comments/Instructions:

Note:

	Signature:	Print Name:	Company Name/Title:	Date:	
RELINQUISHED BY:			Montgomery Watson Harza		
RECEIVED BY:					
RELINQUISHED BY:					
RECEIVED BY:					

For Lab Use Only: Sample Condition Upon Receipt:

Legend
SBD: Sample Beginning Depth
SED: Sample Ending Depth

Sample Type Code (SA): From ERPIMS Handbook
Sample Number (SN): From ERPIMS Handbook
Sampling Method Code (SM): From ERPIMS Handbook
Sampling Matrix Code (MC): From ERPIMS Handbook

Bottle Count (BC): 1,2,3, etc.
Container Type (CT): S = Sleeve, A= Amber Glass, G = Clear Glass, P = Plastic, E = Encore sample
Preservative (PR): NA = None, A = HNO3, B = H2SO4, C = HCl, D = NaOH

ORIGINAL: Send with sample (sign only in blue or black ink)

COPIES: Retained by Sampler, Sent to Office

ATTACHMENT 4

VOLUME OF SCHEDULE 40 PVC PIPE

VOLUME OF PVC PIPE

Schedule	Diameter (inches)	OD (inches)	ID (inches)	Volume/LF (gallon)
40	1.25	1.660	1.380	0.08
40	2	2.375	2.067	0.17
40	3	3.500	3.068	0.38
40	4	4.500	4.026	0.66
40	6	6.625	6.065	1.50
40	8	8.625	7.981	2.60
40	12	12.750	11.938	5.82
80	2	2.375	1.939	0.15
80	4	4.500	3.826	0.60

Appendix F

Standard Operating Procedures
Surface Water Sampling

STANDARD OPERATING PROCEDURES

SURFACE WATER SAMPLING

MWH

STANDARD OPERATING PROCEDURES

SURFACE WATER SAMPLING

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DISCLAIMER

THE FOLLOWING STANDARD OPERATING PROCEDURE PROVIDES A GENERAL GUIDANCE RELATING TO TECHNICAL ISSUES TO BE ADDRESSED INVOLVING SURFACE WATER SAMPLING FOR ENVIRONMENTAL INVESTIGATIONS. IT IS NOTED, HOWEVER, THAT EACH PROJECT AND SITE IS UNIQUE AND THAT THESE GUIDELINES ARE NOT A SUBSTITUTE FOR COMMON SENSE AND GOOD MANAGEMENT PRACTICES BASED ON PROFESSIONAL TRAINING AND EXPERIENCE. .

1.0 INTRODUCTION

This Standard Operating Procedure describes methods and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either on-site examination or chemical testing, or for laboratory analysis.

The information presented in this guideline is generally applicable to all environmental sampling of surface waters, except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Such innovations should be described in the sampling plan (or addendum to the sampling plan if the remedial investigation is ongoing) and brought to the attention of the project manager.

2.0 DEFINITIONS

Environmental Sample	Low constituent-concentration sample typically collected off site and not requiring Department of Transportation (DOT) hazardous waste labeling or Contract Laboratory Program (CLP) handling as a high hazard sample.
Hazardous Waste Sample	Medium to high constituent-concentration sample (e.g., source material, sludge, leachate) requiring DOT labeling and CLP handling as a high hazard sample.

3.0 RESPONSIBILITIES

The **Field Team Leader** has overall responsibility for the correct implementation of surface water and sediment sampling activities, including review of the sampling plan with, and any necessary training of, the sampling technician(s). The actual collection, packaging, documentation (sample label and log sheet, chain-of-custody record, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

4.0 PROCEDURES

4.1 BACKGROUND

Collecting a representative sample from surface water is often difficult because of water movement, stratification, or the intermittent nature of these media. To collect representative samples, sampling bias must be standardized relative to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only for assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are no better than the confidence that can be placed in the representativeness of the samples.

4.2 DEFINING THE SAMPLING PROGRAM

Factors that must be considered in developing a sampling program for surface water, including study objectives, are accessibility; site topography; flow, mixing, and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. The professional developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

4.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving, or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or in a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills).

The following are major pathways for surface water contamination (not including airborne deposition):

- Overland runoff
- Leachate influx to the water body
- Direct waste disposal (solid or liquid) into the water body
- Groundwater influx

The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include the following:

- Slopes and runoff direction
- Areas of temporary flooding or pooling
- Tidal effects
- Artificial surface-runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation)
- Locations of springs, seeps, marshes, etc.

In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., should not be overlooked.

The distribution of particulates within a sample is an important consideration. Many organic compounds are only slightly water-soluble and tend to be adsorbed by particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device should include transferring a proportionate amount of the suspended material.

The first steps in selecting sampling locations, therefore, are to 1) review site history, 2) define the hydrologic boundaries and features of the site, and 3) identify the sources, pathways and potential distribution of contamination. Based on these considerations, the numbers, types, and general locations of required samples upgradient (for background measurement) on site and downgradient can be identified.

4.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those locations on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low enough that skin contact will not produce adverse health effects. This provides a built-in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler should be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician should wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle. The same precautions mentioned above with regard to sediment disturbance will apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed to ensure, as closely as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gauging station is not conveniently located on a selected stream, the project hydrologist should explore the possibility of obtaining streamflow data by direct or indirect methods.

4.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the work plan. For single-event site- or area-characterization sampling, both bottom material and overlying water samples should be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples should be collected at a pre-established and constant interval as specified in the work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material should be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water-quality data should be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

4.3 SURFACE WATER SAMPLE COLLECTION

4.3.1 Streams, Rivers, Outfalls, and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls, and drainage features at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multipoint sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (defined below).

Samples from different depths or cross-sectional locations in the water course taken during the same sampling episode should be composited. However, samples collected along the length of the watercourse or collected at different times may reflect differing inputs or dilutions and therefore should not be composited. Generally, the number and type of samples to be taken depend upon the width of the river, depth, discharge, and the suspended sediment the river transports. The greater number of individual points that are sampled, the more likely that the composite sample truly will represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite should be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. Measurements of dissolved oxygen (DO), pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites should be collected.

4.3.2 Lakes, Ponds, and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams do. The relative lack of mixing requires that a high number of samples be obtained to adequately represent the overall characteristics of the water body.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, measurements of DO, pH, temperature, etc., are to be conducted on each aliquot of the vertical composite. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites should be composited to form a single sample. These verticals are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the upper, warmer, and less dense layer of lake water (above the thermocline) that is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer that is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones thus may have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epiliminion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality since it is likely that only poor mixing will occur between these areas. Similarly, additional samples should be taken where discharges, tributaries, land-use characteristics, and other such factors are suspected of influencing water quality.

Most lake measurements should be made in-situ using sensors and automatic readout or recording devices. Single and multiparameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential, specific conductance, dissolved oxygen, some cations and anions, and light penetration.

4.3.3 Estuaries

Estuarine areas are by definition zones where inland fresh waters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types, depending on freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations. Following are the three types of estuaries:

- Mixed estuary—characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Since they are well mixed, the sampling locations are not critical in this type of estuary.

- Salt wedge estuary—characterized by a sharp increase in salinity with depth and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic estuary—characterized by salinity approaching full-strength oceanic waters. Seasonally, freshwater inflow is small, with the preponderance of the fresh-saline water mixing occurring near, or at, the shoreline.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs should include vertical salinity measurements at 1- to 5-foot increments coupled with vertical DO and temperature profiles.

4.3.4 Sampling Equipment and Techniques

The selection of sampling equipment depends on the site conditions and sample type required. In addition, the chemical compatibility of the sampling equipment with the constituents of concern must be addressed prior to initiating the sampling program. The following are the most frequently used samplers:

- Open-mouth bottle sampler (dip sampler)
- Weighted bottle sampler
- Hand pump
- Thief samplers
- Depth-Integrating sampler

The open-mouth bottle sampler (dip sampler) and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include the following:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation, particularly if personnel protection required is above Level D
- Nonreactive/noncontaminating—Teflon®-coated, glass, stainless steel, or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) should be measured for the following:

- Specific conductance
- Temperature
- pH (optional)
- DO (optional)

These items should be measured for as soon as the sample is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

Open-Mouth Bottle Sampling (Dip Sampling)

Water is often sampled by filling a container, either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample [Figure 1]). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not truly represent the total concentration distributed throughout the water column and in the cross section. Therefore, dip samples should be augmented whenever possible with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

Sample bottles containing preservatives should never be used to directly collect surface water samples.

Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and then raised to the surface at a uniform rate. In this manner the sample will be collected throughout the depth interval and will be filled just before it reaches the surface. Using either method, the resulting sample will roughly approach what is known as a depth-integrated sample.

A closed, weighted bottle sampler consists of a stoppered glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle (Figure 1). The procedure for sampling is:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).

2. Pull out the stopper with a sharp jerk of the sampler line.

3. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.

4. Raise the sampler and cap the bottle

5. Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

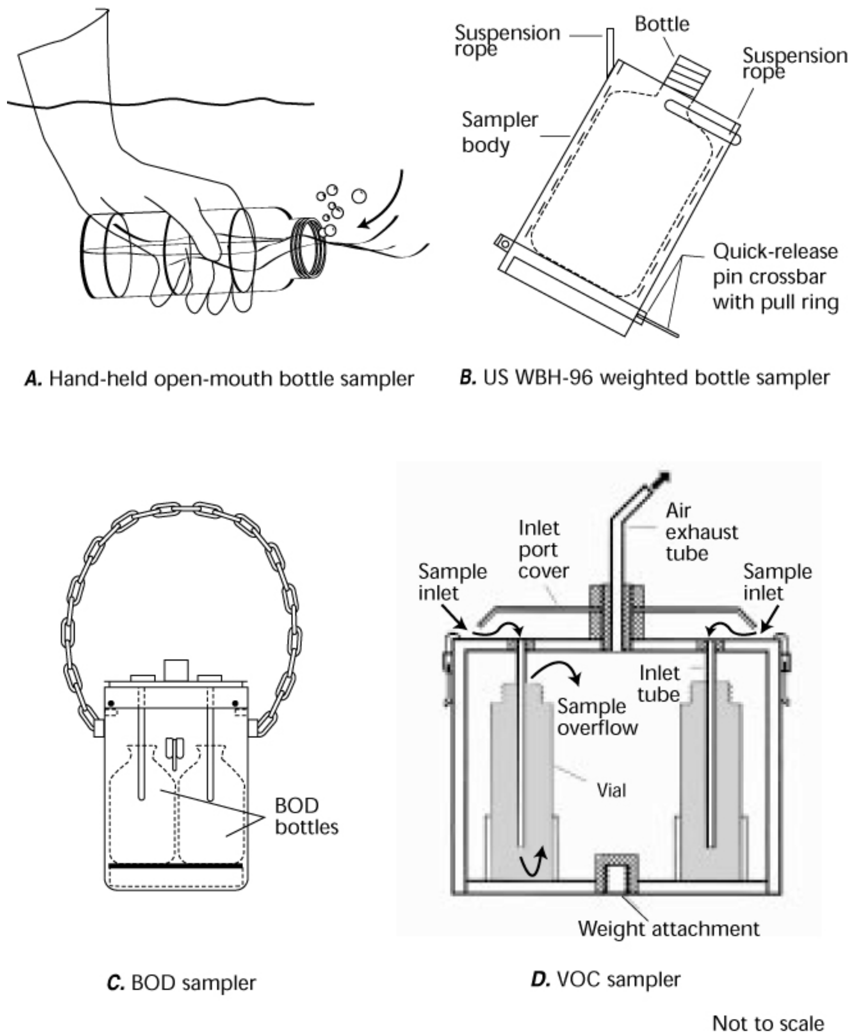

Figure 1 Examples of Open Mouth Samplers

(Source: USGS, 1997-1999)

Hand Pumps

Hand pumps may operate by peristaltic, bellows, diaphragm, or siphon action. Hand pumps that operate by bellow, diaphragm, or siphon action should not be used to collect samples that will be analyzed for volatile organics because the slight vacuum applied may cause loss of these contaminants. To avoid contamination of the pump, a liquid trap consisting of a vacuum flask or other vessel to collect the sample should be inserted between the sample inlet hose and the pump.

Tubing used for the inlet hose should be nonreactive (preferably Teflon®). The tubing and liquid trap must be thoroughly decontaminated between uses (or disposed of after one use).

When sampling, the tubing is weighted and lowered to the desired depth. The sample is then obtained by operation of the pump, and subsequently transferred from the trap to the sample container.

Thief Samplers

Thief samplers are used to collect “point” samples from a specific depth. Examples of thief samplers include Kemmerer and Van Dorn samplers, and double check-valve bailers (Figure 2). The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In both the Kemmerer and Van Dorn samplers, a "messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. A double check-valve bailer is similar to a Kemmerer sampler in that it allows free passage of water through the cylinder until the desired sampling depth is reached. However, the check valves automatically close when the bailer is retrieved. Water is removed through a valve to fill sample bottles.

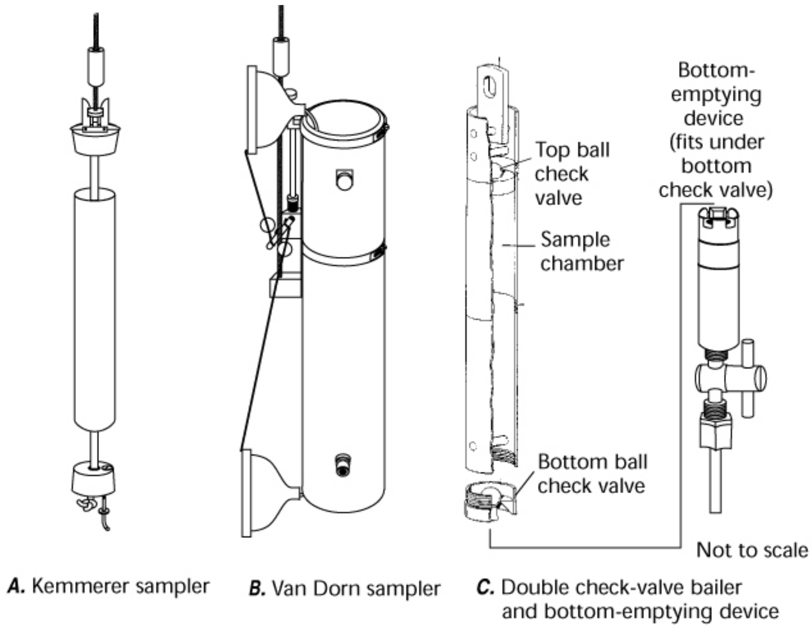

Figure 2 Examples of Thief Samplers

(Source: USGS, 1997-1999)

Depth-Integrated Sampling

Depth integration is used to collect a water and suspended material sample, in direct proportion to relative velocity at each increment of depth. This means that the volume of water and suspended material must enter the sample bottle at a rate proportional to the velocity of the flow passing the intake of the sampler. If a depth-integrating sampler is lowered from the surface to the bed and back at the same rate, and presuming that the sampler is not overfilled during the course of the sampling operation, each increment of flow in that vertical is sampled proportionately to the velocity. The minimum stream velocity must be greater than 1.5 feet per second (ft/s) for a depth-integrated sampler with a rigid bottle, or greater than 3.0 ft/s for a depth-integrated sampler with a bag (USGS, 1998).

One method of collecting depth-integrated samples is the EWI technique. Samples are taken at several equally spaced verticals across the stream, with the transit rate of the sampler (that is, the velocity at which the sampler is passed through the water column) the same in all verticals. The samples collected in each vertical are then composited into a single sample representative of the entire flow in the cross section. Because the volume collected in each vertical sample will be directly in proportion to depth and velocity at the vertical location, the composite sample of the water-sediment mixture flowing in the cross section will be discharge-weighted.

In the EDI technique, the positions of sampling verticals across the stream are based on incremental discharges rather than width (i.e., deeper or higher velocity areas of the stream cross section are sampled at a closer spacing). This method provides the most accurate measure of total discharge of the contaminant for streams that are not well mixed; however, it requires knowledge of the cross-sectional stream flow distribution.

The EDI method has these advantages: variable transit rates may be used because samples can be composited in proportion to known stream flow distribution, fewer verticals need to be sampled, and cross-section discharge information is obtained. The primary disadvantage of the method is that the streamflow distribution in the cross section must be known or measured each time before sampling.

The EWI method has these advantages: discharge measurements are not needed, the technique is learned easily, and the technique is applicable where cross-sectional stream flow distribution varies because of shifting beds or other causes. The main disadvantages are that the procedure is time consuming for large streams and does not provide quantitative information on cross-sectional discharge because this parameter does not need to be measured for the EWI method. Furthermore, the EWI method requires sampling at equally spaced verticals and use of identical transit rates within each vertical.

Because these multi-point sampling techniques can become very time consuming and expensive, an alternate method often used involves sampling at the quarter points or other equal intervals across the width of the stream. Composites of individual samples collected at the quarter points can be fairly representative, providing the stream cross section is properly located.

Several depth-integrating samplers specifically designed and suitable for collecting representative samples are available and include the US DH-81, US DH-95, US DH-77 samplers (Figure 3). US DH-81 or US DH-95 samplers can be used where flowing water can be waded or where a bridge is accessible. The US DH-77 (or the D-77 Bag, or Frame-Bag sampler) is a cable-and-reel sampler for use when flowing water cannot be waded.

Because of the number and diversity of analyses that may be performed on collected surface water or water-sediment mixtures, a sample splitter will often be required. A churn splitter is a practical means for splitting composited samples into representative subsamples.

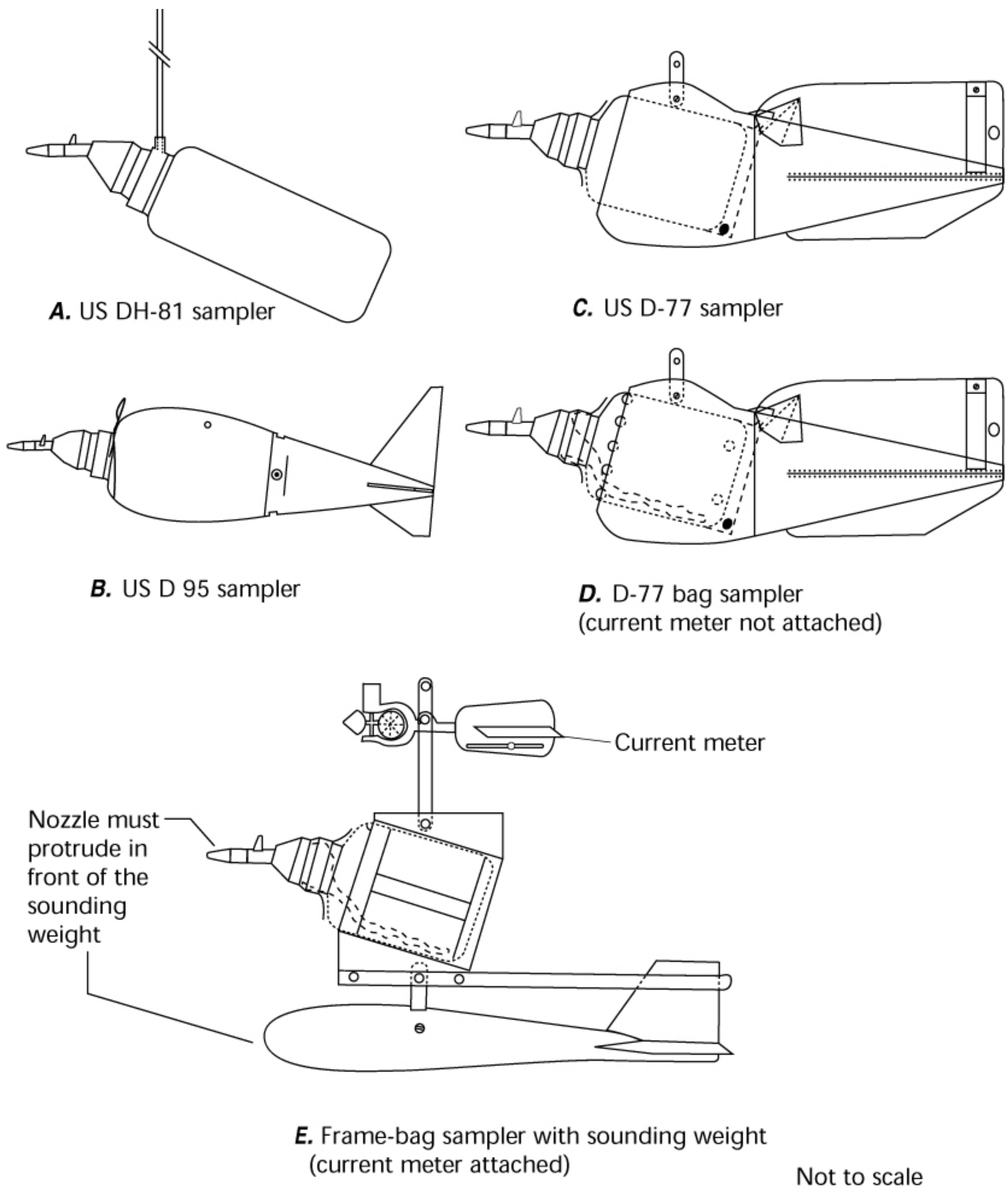

Figure 3 Depth-Integrating Samplers

(Source: USGS, 1997-1999)

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Appendix G

Summary of Santa Rosa Basin Pumping East of Baily Fault

Table F-1
Summary of Santa Rosa Basin Pumping East of Baily Fault
(all units in acre-feet)

Local ID	SRMWC No.9	Snow	Ventura Farms	Penny	SRMWC No.10	Conejo 2	Conejo 1	Conejo 3	SRMWC No.8	SRMWC No.3	Conejo 4	Total	Notes
State ID	**021919P2**	**021920M1**	**021920M3**	**021920M4**	**022024Q3**	**022025C1**	**022025C2**	**022025C5**	**022025C6**	**022025D1**	**022025C07**		
1955												3,967	No well records exist. Totalized values digitized from Figure 2.11 of Final Draft Report on Santa Rosa Groundwater Basin Management Plan by Boyle, 1987
1956												4,078	
1957												3,508	
1958												2,933	
1959												5,204	
1960												4,610	
1961												5,235	
1962												3,459	
1963												3,973	
1964												4,561	
1965												2,633	
1966												3,894	
1967												3,741	
1968												4,261	
1969												2,388	
1970												2,376	
1971												3,422	
1972												3,860	No well records exist. Totalized values digitized from Table 2-1 in Final Draft Report on Santa Rosa Groundwater Basin Management Plan by Boyle, 1987
1973												3,460	
1974												3,540	
1975												3,200	
1976												2,940	
1977												2,870	
1978												2,540	
1979												3,090	
1980												2,870	
1981												3,340	
1982												2,780	
1983												2,710	
1984												ND	No data exists
1985												ND	No data exists
1986	85.8	349.3	154.1	124.8		1,465.3	794.1		232.6	244.8		3,451	Well Extraction Data in: Santa Rosa Basin Groundwater Management Plan, Boyle Engineering Corporation, April 24, 1997 Note the 1996 Record from January to July
1987	60.3	364.5	216.2	183.1		1,458.3	727.2		236.7	193.0		3,439	
1988	65.8	50.2	296.2	34.4		1,326.9	219.2		249.5	200.7		2,443	
1989		181.2	386.1	126.0		1,218.3			239.1	198.0		2,349	
1990			513.3			966.4	147.0		218.9	190.0		2,036	
1991			451.7			601.0	323.6	98.3	168.9	256.3		1,900	
1992	22.7		349.7			802.9	396.3	145.8	141.1	278.1		2,137	
1993	61.6		278.2		80.0	853.7	388.4	1,048.3	350.1	116.8		3,177	
1994	86.8		466.6		69.0	803.4	293.2	1,361.4	308.0	69.0		3,457	
1995	124.9		380.6		139.5	867.7	22.3	1,371.5	286.3	73.5		3,266	
1996	72.2		186.4		129.1	38.2	-	903.4	210.3	55.8		1,595	
1997						165.4		270.9			626.4	1,063	*Record from July to December
1998						576.5		991.8			958.4	2,527	
1999						705.5		1,356.2			599.2	2,661	
2000						784.6		1,268.6			280.4	2,334	
2001						354.1		905.4	**421.5***		855.9	2,115	*Four (4) months of record
2002					**2.4***	574.7		944.9	1,342.9		-	2,863	*One (1) month of record
2003					595.0	440.7		749.6	1,250.4		510.5	3,546	
2004					276.0	328.4		628.7	1,190.8		381.0	2,805	
2005					300.7	270.9		705.6	1,204.1		384.4	2,866	
2006					336.1	272.0		795.7	1,275.3		481.8	3,161	
2007					335.9	530.9		837.9	1,190.8		266.4	3,162	
2008	**422.6***				701.9	661.1		485.0	1,095.7		683.0	4,049	*Eight (8) months of record
2009	547.3				329.1	260.1		726.9	1,206.9		88.6	3,159	
2010	467.1				264.3	203.9		561.6	658.6	**10.8***	145.9	2,312	*Two (2) months of record
2011	554.5				249.7	247.6		548.8	726.9	243.6	187.8	2,759	
2012	**559.9***				**156.3***	**315.2***		**826.9***	**1118.4***	**180.6***	**92.9***	3,250	*Eleven (11) months of record

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