SANTA MARGARITA
Groundwater Agency

Public Review Draft

Section 2. Plan Area and Basin Setting

Santa Margarita Basin
Groundwater Sustainability Plan

July 23, 2021

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ACRONYMS & ABBREVIATIONS

1,2-DCA.........1,2-dichlorothane
AB..................Assembly Bill
AF ....acre foot/acre feet
AFY................acre foot/feet per year
AMI................Advanced Metering Infrastructure
amsl................above mean sea level
ASHCP...........Anadromous Salmonid Habitat Conservation Plan
Basin Plan ......Water Quality Control Plan, Central Coast Region
bgs..................below ground surface
BMOs.............Basin Management Objectives
BMPs.............Best Management Practices
cfs...................cubic feet per second
CALEPA........California Environmental Protection Agency
CASGEM.......California Statewide Groundwater Elevation Monitoring
CCR................Consumer Confidence Report
CCRWQCB....Central Coast Regional Water Quality Control Board
CDFW............California Department of Fish and Wildlife
CECs..............Contaminants of Emerging Concern
CGPS.............Continuous Global Positioning Station
CISDCE cis-1,2-dichloroethene
COC ....constituent of concern
CWC ....California Water Code
DAC...............disadvantaged communities
DDW..............State Water Resources Control Board Division of Drinking Water
DEA ....diethanolamine
DoD................Department of Defense
DTSC ....Department of Toxic Substances Control
DWR..............California Department of Water Resources
DWSAP..........Drinking Water Source Assessment and Protection
SCEH ....County of Santa Cruz Environmental Health Services Agency
EIR.................Environmental Impact Report
GAC...............granular activated carbon
GDEs.............groundwater dependent ecosystems
GIS.................Geographic Information System
GPCD.............gallons per capita per day
GSP................Groundwater Sustainability Plan
GWMP...........Groundwater Management Plan
HCM ....hydrogeologic conceptual model

HCP................Habitat Conservation Plan
InSAR ....Interferometric Synthetic Aperture Data
ITP..................Incidental Take Permit
JPA.................Joint Powers Agreement
LAMP ....Local Area Management Plan
LID.................low impact development
LUST..............leaking underground storage tank
MCL...............maximum contaminant levels
MHA ....Mount Hermon Association
MTBE ....methyl tertiary-butyl ether
N.....................nitrogen
NMFS.............National Marine Fisheries Service
NO_3 ....nitrate
OWTS ....onsite wastewater treatment systems
PCE ....tetrachloroethene
Qal..................alluvium
Qt....................terrace deposits
SCWD............Santa Cruz Water Department
SLVWD ....San Lorenzo Valley Water District
SMGWA ....Santa Margarita Groundwater Agency
SMGWBAC...Santa Margarita Groundwater Basin Advisory Committee
SqCWD..........Soquel Creek Water District
SVWD............Scotts Valley Water District
SWRCB..........State Water Resources Control Board
SWS ....Small Water System
Tbl..................Lower Butano Sandstone
Tbm................Middle Butano Sandstone
Tbu.................Upper Butano Sandstone
TCE................trichloroethene
TDS................total dissolved solids
Tl....................Locatelli Formation
Tlo..................Lompico Sandstone
Tm..................Monterey Formation
TMDL ....Total Maximum Daily Load
TNC................The Nature Conservancy
Tp...................Purisima Formation
Tsc..................Santa Cruz Mudstone
Tsm ....Santa Margarita Sandstone
UCMR............Unregulated Contaminant Monitoring Rule
USDA.............U.S. Department of Agriculture

USEPA...........United States Environmental Protection Agency
USFWS ....United States Fish and Wildlife Service
USGS ....United States Geological Survey
UWMP ....Urban Water Management Plan
VC ....vinyl chloride
VOCs..............volatile organic compounds
WAAP............Wasteload Allocation Attainment Program
WHO ....World Health Organization
WRF ....Water Reclamation Facility
WY ....Water Year

2 PLAN AREA AND BASIN SETTING

2.1 Description of the Plan Area

2.1.1 Summary of Jurisdictional Areas and Other Features

2.1.1.1 Area Covered by the GSP

This GSP covers the entire Santa Margarita Basin (DWR Basin 3-027) as defined in DWR Bulletin 118 (DWR, 2016b). The Basin is located at the northern end of the Central Coast hydrologic region. The area of the Basin is 34.8 square miles (22,249 acres). To the south and southeast of the Basin is the Santa Cruz Mid-County Basin, and to the south is the West Santa Cruz Terrace Basin. The Santa Margarita Basin includes the City of Scotts Valley, and the communities of Boulder Creek, Brookdale, Ben Lomond, Lompico, Zayante, Felton, and Mount Hermon. The Santa Margarita Basin's neighboring basins are shown on Figure 2-1. Based on 2010 census block data, the population of the Basin is approximately 29,000 (U.S. Census Bureau, 2010).

2.1.1.2 Adjudicated Areas

There are no adjudicated areas within the Basin.

2.1.1.3 Alternative Groundwater Sustainability Plans

There are no areas within the Basin covered by Alternative GSPs.

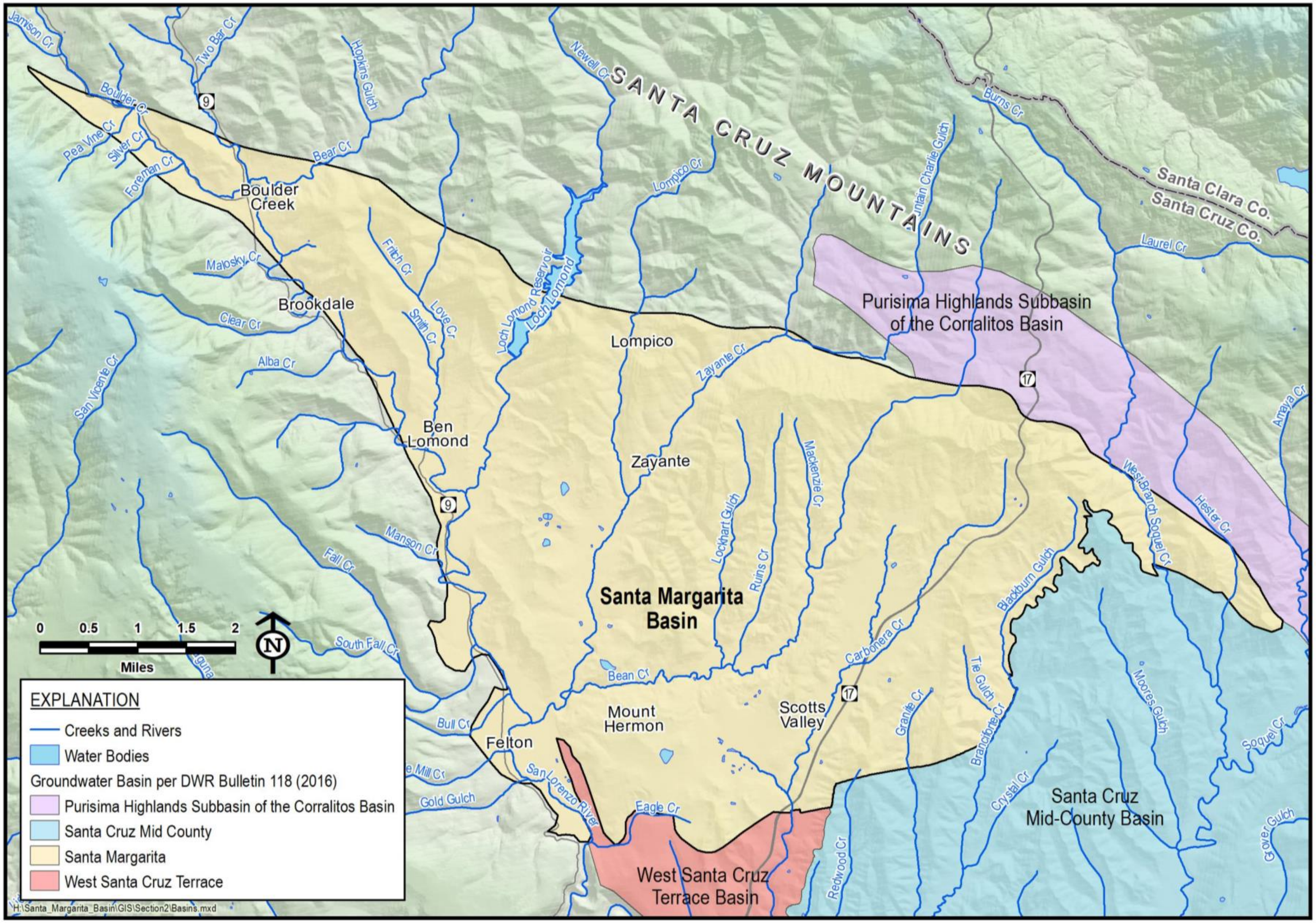


Figure 2-1. Groundwater Basins Adjacent to the Santa Margarita Basin

2.1.1.4 Jurisdictional Areas

2.1.1.4.1 County of Santa Cruz

The Basin is completely within the County of Santa Cruz (County) as shown on the inset map of Figure 2-2. Jurisdictional Areas within the Santa Margarita Basin. The County was founded in 1850 as 1 of the 27 original California counties at the time of statehood. The County has a total area of 607 square miles (388,480 acres), 445 square miles of which is land area (73%) and the remaining 162 square miles is water (27%) (US Census, 2010). The County has land use jurisdiction for all unincorporated areas outside of the City of Scotts Valley and is the largest agency with land use jurisdiction in the Basin. The population residing in the Basin's unincorporated areas is approximately 18,300 (California Department of Finance, 2020). Of the population in unincorporated areas, it is estimated that 5,300 people are within the jurisdictional area of 1 of the Basin's 2 water districts, but because there is no water service to those parcels, they rely on small water systems or private wells. The County is not a supplier of water but does permit and regulate private groundwater wells and small water systems that serve this population. The County of Santa Cruz Environmental Health Division (SCEH) of the County's Health Services Agency includes the Water Resources Program which participates in countywide planning and management efforts on a variety of water resource programs, including groundwater management, water quality, stormwater management, water conservation, fish (steelhead) monitoring, and watershed and stream habitat protection. The County is a member agency of the Santa Margarita Groundwater Agency (SMGWA).

2.1.1.4.2 Water Districts

2.1.1.4.2.1 San Lorenzo Valley Water District

The San Lorenzo Valley Water District (SLVWD) is a member agency of the SMGWA. SLVWD, established in 1941, supplies water to the communities of Boulder Creek, Brookdale, Lompico, Ben Lomond, Zayante, Mañana Woods and Felton, and to a portion of the City of Scotts Valley, through a network of over 185 miles of distribution lines, pump stations and reservoirs. SLVWD's jurisdictional boundaries encompass approximately 62 square miles (39,680 acres, Figure 2-3). Its current service area served by existing infrastructure in the Basin is approximately 5.6 square miles (3,885 acres, Figure 2-3). There are more than 7,900 connections that serve approximately 26,000 customers throughout its service area, some of which is outside of the Basin. The SLVWD serves approximately 13,000 customers in the Basin. Water used to supply customers in the Basin is from 3 sources within the Basin:

1. Stream diversions on tributaries to the San Lorenzo River. Currently, 4 of 9 diversion are active due to damage sustained to the other diversions in the CZU Lightning Complex wildfire in the summer of 2020. The estimated reconstruction timeframe for these damaged diversions is 2 to 4 years.
2. One groundwater spring

3. Seven active groundwater production wells

SLVWD owns, operates, and maintains 2 water systems:

1. The *San Lorenzo Valley System* is split into 2 sub-systems: north and south. The North San Lorenzo Valley System includes the unincorporated communities of Boulder Creek, Brookdale, Lompico (SLVWD annexed the Lompico County Water District in 2016), and Ben Lomond. Its source of water is surface water and groundwater. Part of the North San Lorenzo Valley System is outside of the Basin (Figure 2-3). The South San Lorenzo Valley System encompasses portions of the City of Scotts Valley and adjacent unincorporated neighborhoods. The Mañana Woods subdivision became part of the San Lorenzo Valley System as a result of the District's annexation of the Mañana Woods Mutual Water Company in July 2006. The southern portion of the system is supplied by groundwater pumped in the Pasatiempo area and through an emergency intertie with the northern portion of the system. SLVWD is pursuing efforts to utilize its emergency interties on a routine basis for conjunctive use and improved resiliency.

2. The *Felton System* was acquired by SLVWD from California American Water in September 2008 and includes the town of Felton and adjacent unincorporated areas. It was owned and operated by Citizen Utilities Company of California prior to 2002. The system is supplied by surface water and springs and covers an area of 2.9 square miles or 1,884 acres. Part of the Felton System is outside of the Santa Margarita Basin (Figure 2-3). The Felton System is connected to the San Lorenzo Valley System by an intertie that is only used at this time for emergencies.

2.1.1.4.2.2 Scotts Valley Water District

The Scotts Valley Water District (SVWD) is a public agency responsible for the management and supply of water to the Scotts Valley area (Figure 2-2). SVWD is a member agency of the SMGWA.

SVWD was formed under the County Water District Law, specifically California Water Code Section (CWC§) 30321 and received certification from the California Secretary of State in 1961. SVWD serves an area of about 5.5 square miles (3,520 acres, Figure 2-2) in northern Santa Cruz County, and is located approximately 5 miles inland from the Monterey Bay. It provides water to most of the incorporated area of the City of Scotts Valley and a portion of an unincorporated area north of the City. SVWD supplies potable water to approximately 10,700 customers through 4,300 service connections, excluding fire services. SVWD relies exclusively on groundwater from municipal wells for potable water supply, while supplementing non-potable demand with recycled water from the City of Scotts Valley Tertiary Treatment Plant. Non-potable recycled water is primarily used for landscape irrigation.

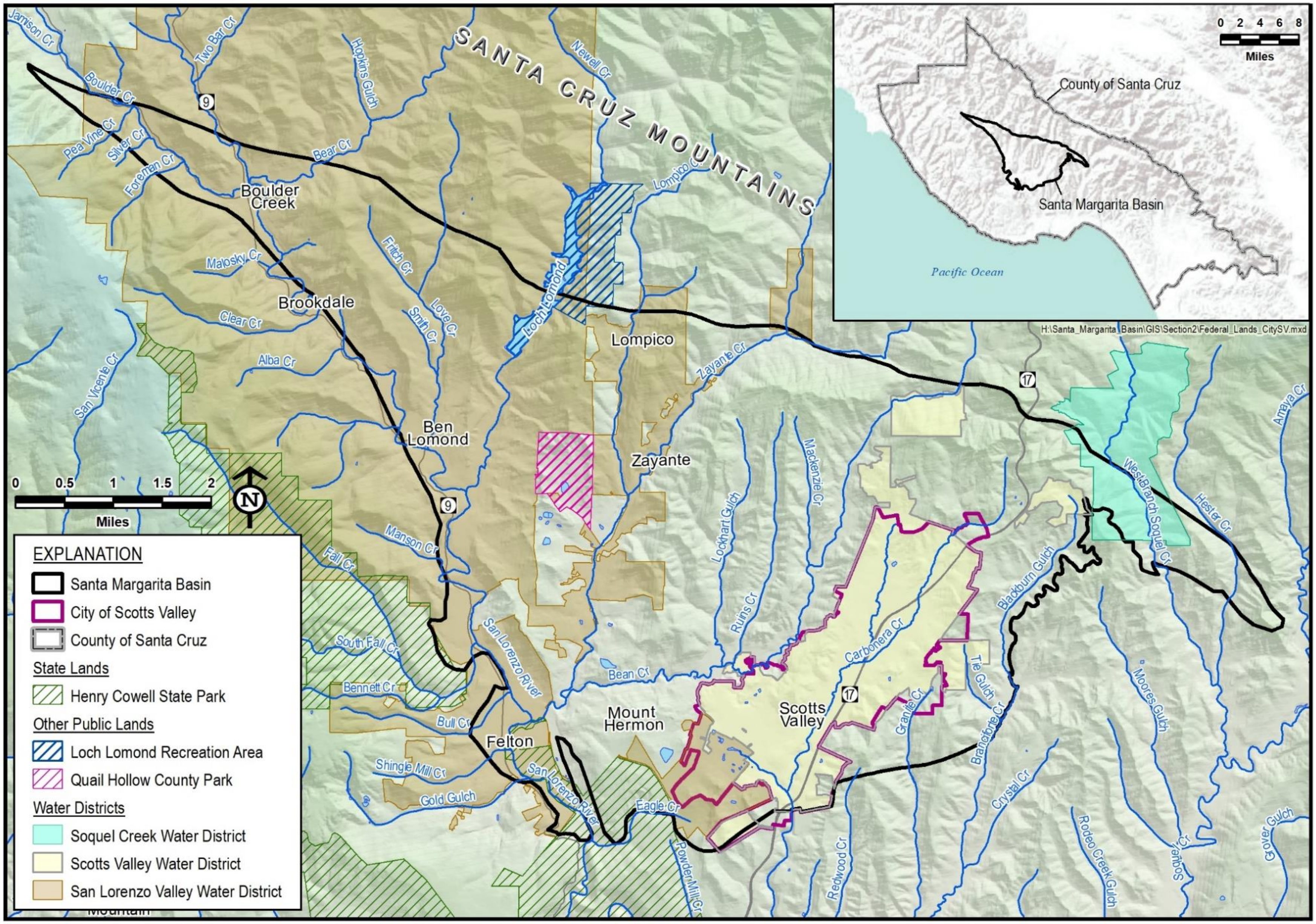


Figure 2-2. Jurisdictional Areas within the Santa Margarita Basin

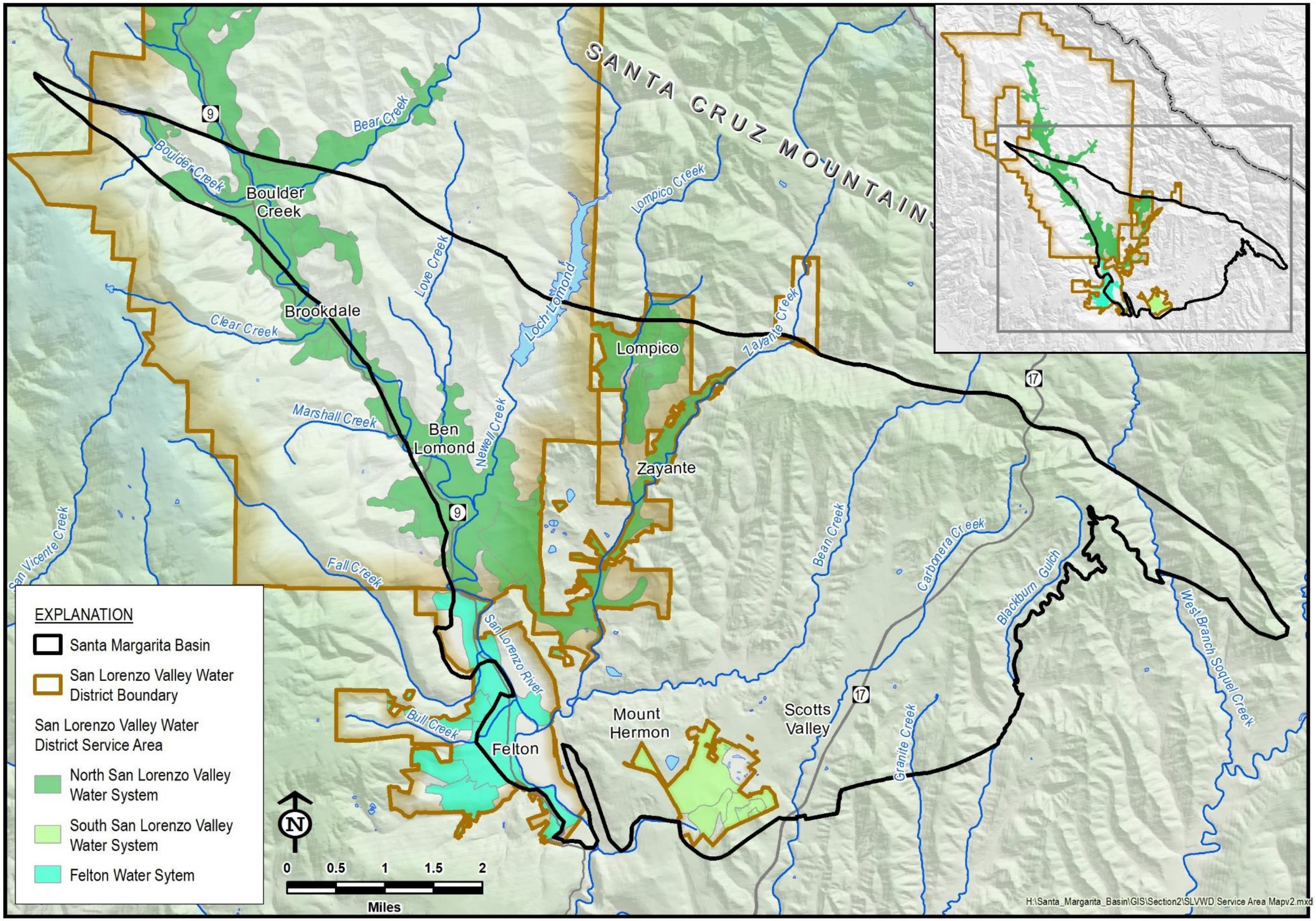


Figure 2-3. San Lorenzo Valley Water District Boundary and Water Systems

2.1.1.4.2.3 Soquel Creek Water District

The Soquel Creek Water District (SqCWD) extracts its water supply from aquifers within the neighboring Santa Cruz Mid-County Basin and does not have any active service area or extract groundwater in the Santa Margarita Basin. Figure 2-2 shows a small portion of the SqCWD within the northeastern part of the Basin. The jurisdictional area is a legacy of a now-abandoned plan to construct a reservoir on the West Branch of Soquel Creek.

2.1.1.4.3 City of Scotts Valley

The City of Scotts Valley is not a potable water supplier, but it is responsible for storm water and wastewater management. City of Scotts Valley residents and businesses are supplied potable water by SVWD and SLVWD (Figure 2-2). The City of Scotts Valley and SVWD Recycled Water Program is a cooperative effort to reuse treated wastewater. The City of Scotts Valley operates the Scotts Valley Water Reclamation Facility (WRF) and the Tertiary Treatment Plant which since 2002 has produced recycled water for its own use and for distribution by SVWD. The recycled water is non-potable and is used primarily for landscape irrigation and to a lesser extent for dust control. Effluent from the WRF that is not used in the Basin is transported through a land outfall to the City of Santa Cruz marine outfall in the Monterey Bay operated and maintained by the City of Santa Cruz Public Works Department.

2.1.1.4.4 Federal and State Lands

The only state managed land in the Basin is Henry Cowell State Park (Figure 2-2). There are no federal lands. The USGS National Map (USGS, 2019) show portions of the Loch Lomond Recreation Area and Quail Hollow County Park as state lands (Figure 2-2). They are however, managed by the City of Santa Cruz and County of Santa Cruz, respectively.

2.1.1.4.5 Tribal Lands

There are no federally designated tribal lands and no federally recognized tribes in the Basin. The Basin is located within a California Tribal and Cultural Area that historically belonged to a division of the Ohlone people known as the Awaswas. The Awaswas people inhabited the land from present-day Davenport to Aptos. Descendants of the Awaswas people are members of the Amah Mutsun Tribal Band. The Tribal Band is petitioning the federal government for tribal recognition and has formed the Amah Mutsun Land Trust to access, protect, and steward lands important to the tribe (Amah Mutsun, 2019).

2.1.1.5 City of Santa Cruz

The City of Santa Cruz has no service area in the Basin and is not a member agency of the SMGWA. However, the City is an indirect groundwater user in the Basin because the surface water it diverts from the San Lorenzo River for municipal use partially comprises baseflows supported by Basin groundwater discharge to creeks. The City owns property, which is partly located in the Basin, associated with water supply use and construction of the Loch Lomond Reservoir (Figure 2-2).

The San Lorenzo River and Loch Lomond Reservoir provide about 69% of the water supplied to approximately 95,000 City of Santa Cruz Water Department customers (City of Santa Cruz, 2016a). Surface water from Loch Lomond Reservoir is conveyed by the Newell Creek Pipeline to the Graham Hill Water Treatment Plant in the City of Santa Cruz. Surface water from the San Lorenzo River is diverted in 2 locations for use by the City of Santa Cruz. There is 1 diversion location in the Basin in Felton that is used to divert water upstream to the Loch Lomond Reservoir and 1 location downstream of the Basin that is used to divert water to the City treatment plant. Between 2006 and 2015, 14% of the City of Santa Cruz water supply was from Loch Lomond Reservoir and 55% was from the San Lorenzo River. Additional details are provided in Section 2.2.4.8 on surface water bodies in the Basin.

2.1.1.6 Existing Land Use Designations

Land use planning in the Basin is the responsibility of the County of Santa Cruz and the City of Scotts Valley. Boulder Creek, Felton, Lompico, and Ben Lomond are all census-designated areas within the county but are not incorporated towns. Current land use designations in the Basin are shown on Figure 2-4 and are summarized in Table 2-1 by major land use groups. The land use features on Figure 2-4 were developed by the County of Santa Cruz, in collaboration with the Cities of Capitola, Santa Cruz, Scotts Valley, and Watsonville, to aggregate individual land use designation datasets into a summarized single dataset for use in the July 2015 Wasteload Allocation Attainment Program (WAAP) for Watersheds in Santa Cruz County (County of Santa Cruz, 2016).

Table 2-1. Santa Margarita Basin Land Use Designation Summary

Land Use Category	Area		Relative Percent
	Acres	Square Miles	
Open Space/Undeveloped	10,117	15.8	45.5%
Rural Residential	5,755	9.0	25.9%
Suburban Residential	2,930	4.6	13.2%
Roads/Parking Lots/Utilities	1,491	2.3	6.7%
Camps/Church/Institutions	772	1.2	3.5%
Industrial/Sand Quarries	741	1.2	3.3%
Commercial	425	0.7	1.9%
Agriculture	18	0.03	0.1%
Total	**22,249**	**34.8**	**100%**

Just under half the Basin is identified as open space/undeveloped (Table 2-1). Open space includes areas for outdoor recreation, preservation of natural resources, or vacant lands. Rural residential land use is the next largest land use covering 5,755 acres of the Basin (25.9% of the Basin, Table 2-1). This land use consists primarily of single-family residential housing located outside of the suburban centers and typically between the tributaries of the San Lorenzo River. Suburban residential housing (13.2% of the Basin) occurs within the San Lorenzo Valley and south of Bean Creek. It includes the City of Scotts Valley, and the communities of Mount Hermon, Felton, Ben Lomond, Brookdale, Boulder Creek, Lompico, and Zayante (Figure 2-4). The Basin has several camps and conference centers which account for approximately 3.5% of land use.

Commercial land use is concentrated in the City of Scotts Valley and the community of Felton. Much of this development occurred during a period of population expansion between 1980 and 2000, which coincided with construction of commercial and industrial complexes. Three large sand quarries exist within the Basin area: Hanson (also known as Kaiser) Quarry, Olympia (also known as Lone Star) Quarry, and Quail Hollow Quarry. Hanson and Olympia Quarries ceased operations in the early 2000s and are currently undergoing restoration. Quail Hollow is still active.

Most irrigated areas in the Basin are in or near Scotts Valley, and consist of schools and large parks. Agriculture within the Basin is limited due to the steep and forested nature of the Basin, and relatively shallow soils. Currently, only approximately 0.1% of the Basin is zoned agricultural. There are a few very small wineries that cumulatively irrigate less than 2 acres. Currently, there are no official records of cannabis cultivation and water use in the Basin although there is speculation that it is occurring.

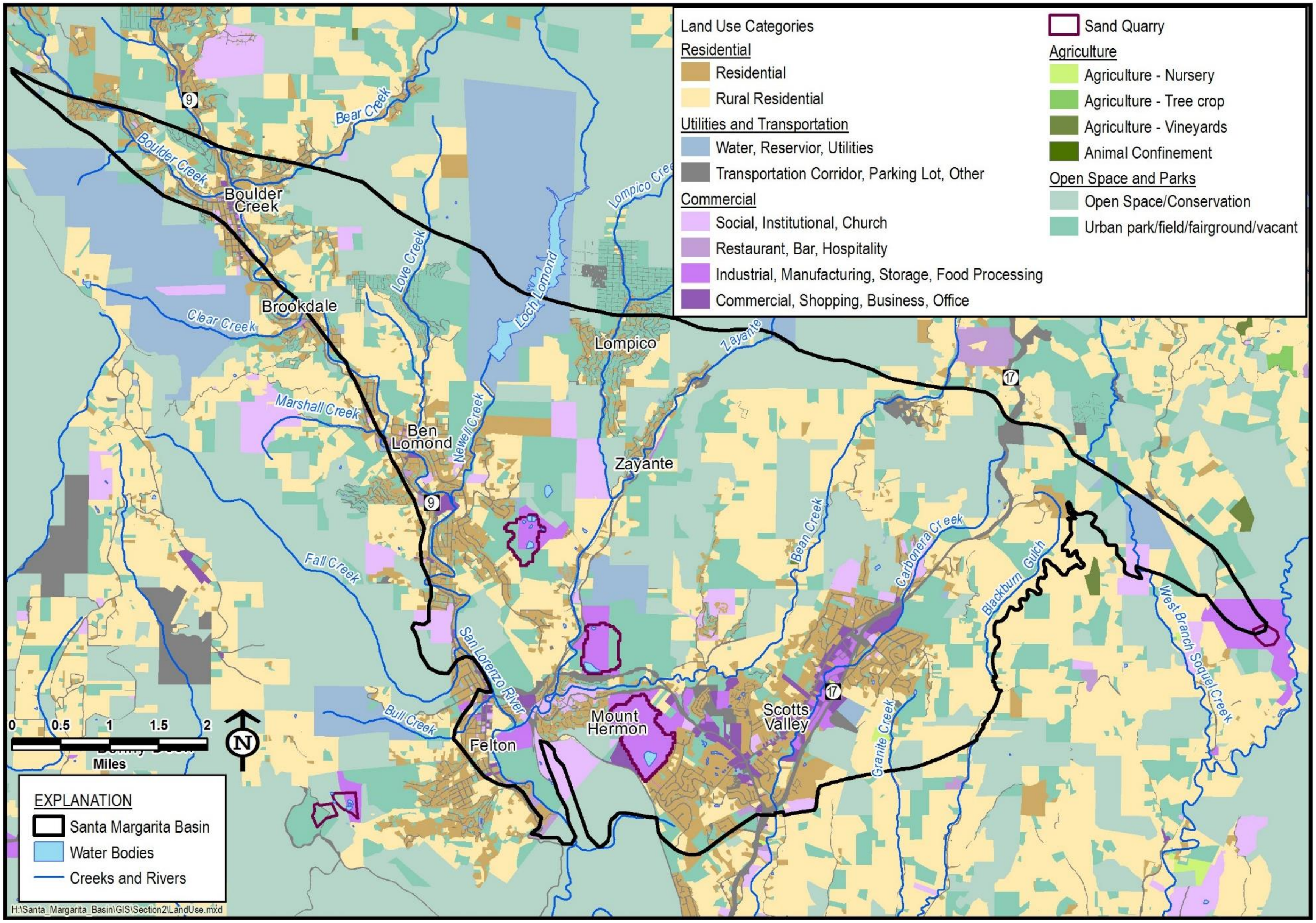


Figure 2-4. Land Use in the Santa Margarita Basin

2.1.2 Water Resources Monitoring and Management Programs

Groundwater resources in the Basin have been used as a shared resource for many decades and collaboratively managed for nearly 2 decades by local agencies. The SMGWA was preceded by a local advisory committee called the Santa Margarita Groundwater Basin Advisory Committee (SMGWBAC) that had some of the same functions and same member agencies as the SMGWA. The SMGWBAC was formed by a Memorandum of Understanding in 1995 by the SVWD, SLVWD, Mount Hermon Association, Lompico County Water District (merged with SLVWD in 2016), City of Scotts Valley and County of Santa Cruz. The SMGWBAC consisted of 1 representative and 1 alternate from each member agency. The committee met biannually and was actively involved in all facets of groundwater management of the Basin. In 2016, the SMGWBAC established a GSA Formation Committee, which led the effort of preparing a draft Joint Powers Agreement for the SMGWA. With the creation of the SMGWA, the SMGWBAC function became redundant and the committee was dissolved in 2017.

The SMGWA cooperating agencies have had active roles in groundwater resource management and monitoring in the Basin as members of the SMGWBAC and independently to support their water supply operations. The subsections that follow describe the cooperating agencies' groundwater elevations, groundwater extraction, groundwater quality, and surface water flow and quality management and monitoring programs. The purpose of these monitoring efforts is to responsibly manage the water resources relied upon for public water supply.

None of the existing water resources monitoring and management programs that use water within the Basin have triggers that limit operational flexibility with respect to groundwater or surface water use. However, the City of Santa Cruz, which diverts San Lorenzo River surface water at Felton to Loch Lomond Reservoir and at Tait Street (downstream of the Basin has explicit triggers related to bypass flows at the San Lorenzo River Big Trees gauge. The water rights permit for Fall Creek diversions, a tributary to the San Lorenzo River, has similar bypass flow requirements on the San Lorenzo River that influence SLVWD diversion timing and rates. Groundwater and surface water monitoring programs that are in operation in the Basin are incorporated into SMGWA's monitoring network described in Section 3.

2.1.2.1 United States Geological Survey

The United States Geological Survey (USGS) has operated and reported on the Big Trees streamflow gauge (11160500) on the San Lorenzo River, south of Felton (Figure 2-5), since October 1937.

2.1.2.2 California Department of Water Resources CASGEM Program

The Santa Cruz County Environmental Health Services Department administers the DWR California Statewide Groundwater Elevation Monitoring (CASGEM) program to evaluate regional groundwater elevations. The CASGEM well network includes monitoring locations throughout the County, including six wells within the Basin. Statewide groundwater elevation monitoring through CASGEM has provided DWR with data needed to track seasonal and long-term groundwater elevation trends in groundwater basins throughout the state. Following submittal of the GSP, CASGEM wells within the Basin will be migrated into the SMGWA's monitoring network to monitor groundwater conditions resulting from GSP implementation.

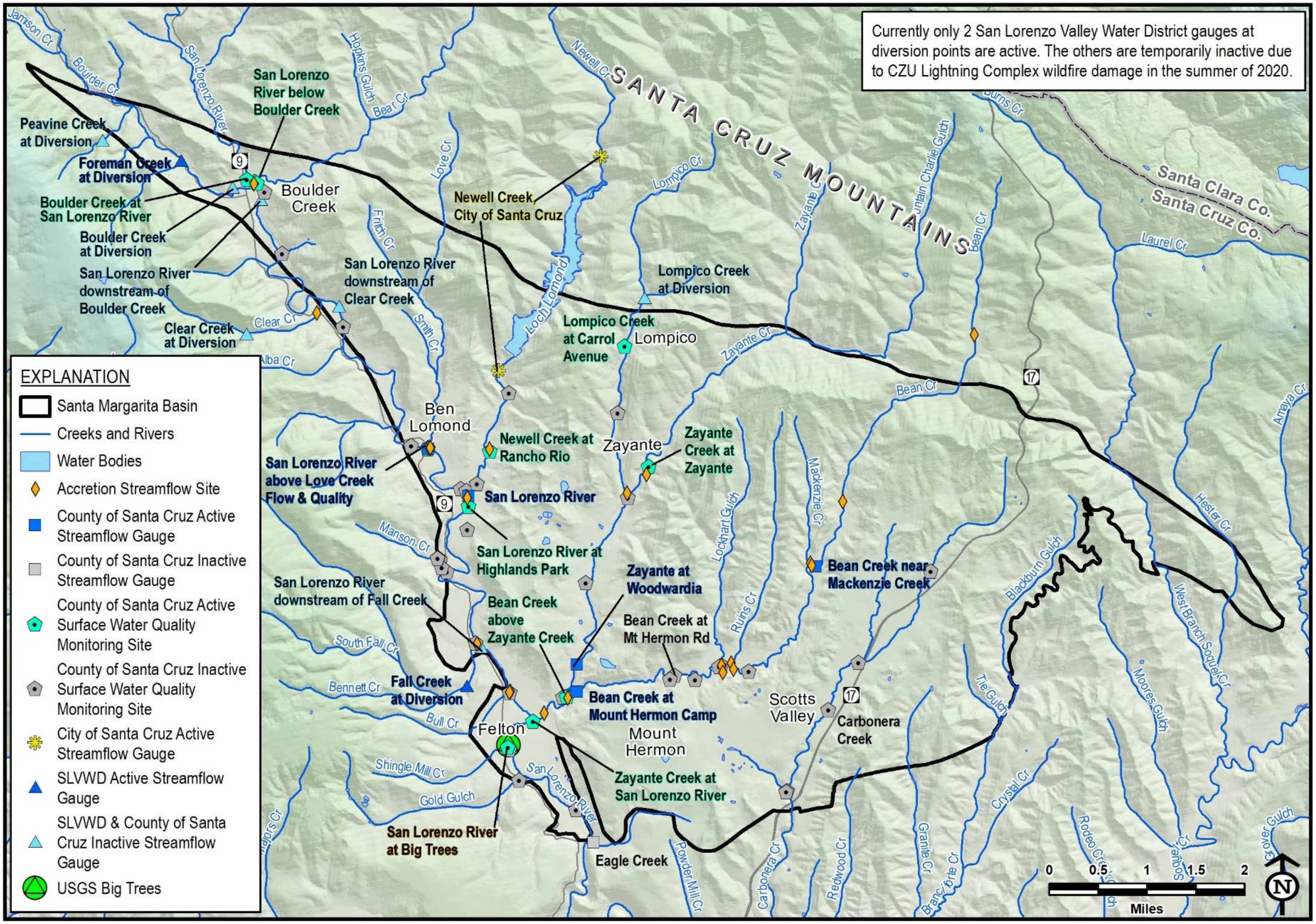


Figure 2-5. Surface Water Monitoring Sites

2.1.2.3 Central Coast Regional Water Quality Control Board Basin Plan

Surface water and groundwater quality in the Basin is managed per the water quality objectives and beneficial uses described in the Central Coast Region, Water Quality Control Plan (Basin Plan; Central Coast Regional Water Quality Control Board (CCRWQCB), 2019). The Basin Plan is developed by the CCRWQCB, together with the State Water Resources Control Board (SWRCB), and California Environmental Protection Agency (CALEPA). The Basin Plan lists various beneficial water uses and describes the water quality which must be maintained to allow those uses. Present and potential future beneficial uses for inland waters in the Basin Plan are surface water and groundwater as municipal supply; agricultural; industrial; groundwater recharge; water recreation; cold fresh water habitat; wildlife habitat; sport fishing; rare, threatened or endangered species; migration of aquatic organisms; and, spawning, reproduction, and/or early development of fish.

Water quality is an important factor in determining water use and benefit. For example, drinking water must be of higher quality than the water used to irrigate pastures. Since the Santa Margarita Basin does not have its own Basin-specific groundwater quality objectives, the broad groundwater objectives of the Central Coast Region Basin Plan are summarized in Table 2-2. Site-specific median groundwater quality objectives are provided at 2 locations within the Basin: near Felton and near Boulder Creek (

Table 2-3). It is unclear from the Basin Plan which aquifers these apply to. The County has interpreted the location near Felton to apply to the Santa Margarita Sandstone, and the location near Boulder Creek to apply to the Butano Sandstone within the Basin (personal communication with John Ricker, March 2020). The Basin Plan also includes mean surface water quality objectives for total dissolved solids (TDS), chloride, sulfate, boron, sodium for Boulder Creek, Zayante Creek, and the San Lorenzo River (

Table 2-3 and Figure 2-5).

The Basin Plan addresses the problem of nitrate loading in the San Lorenzo River. Nitrate released from septic systems, livestock, fertilizer use, and other sources passes readily through the sandy soil, into the Basin groundwater, and eventually into the San Lorenzo River. As such, the San Lorenzo River has been designated as impaired by the State and the United States Environmental Protection Agency (USEPA) due to elevated levels of nitrate, which stimulate increased algal growth and release of compounds that degrade drinking water quality and require increased cost for treatment. Increased nitrate and algal growth also cause impacts in the San Lorenzo lagoon[1], degrading salmonid habitat and potentially creating harmful algal blooms. Approximately 65% of the nitrate load in the San Lorenzo River originates from the Basin's Santa Margarita Sandstone, the majority of which comes from septic systems (County of Santa Cruz, 1995).

Table 2-2. Central Coast Basin Plan Groundwater Water Quality Objectives Applicable to the Santa Margarita Basin

Chemical Constituent	General Objectives for Groundwater	Objectives for Municipal & Domestic Groundwater Supply
Tastes and odors	Groundwaters shall not contain taste or odor producing substances in concentrations that adversely affect beneficial uses.	---
Radioactivity	Radionuclides shall not be present in concentrations that are deleterious to human, plant, animal, or aquatic life; or result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal, or aquatic life.	Groundwaters shall not contain concentrations of radionuclides in excess of the limits specified in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 5, Section 64443. This incorporation-by-reference is prospective including future changes to the incorporated provisions as the changes take effect.
Bacteria	---	The median concentration of coliform organisms over any seven-day period shall be less than 2.2/100 mL
Organic Chemicals	---	Groundwaters shall not contain concentrations of organic chemicals in excess of the maximum contaminant levels for primary drinking water standards specified in California Code of Regulations, Title 22, Division 4, Chapter 15, Article 5.5, Section 64444, Table 64444-A. This incorporation-by-reference is prospective, including future changes to the incorporated provisions as the changes take effect.

[1] The San Lorenzo lagoon is found at the mouth of the San Lorenzo River and is most prominent when a sandbar disconnects the river from the ocean.

Inorganic Chemicals	---	Groundwaters shall not contain concentrations of inorganic chemicals in excess of the maximum contaminant levels for primary drinking water standards specified in California Code of Regulations, Title 22, Division 4, Chapter 15, Sections 64431 and 64433.2. This incorporation-by-reference is prospective, including future changes to the incorporated provisions as the changes take effect.

Table 2-3. Central Coast Basin Plan Groundwater and Surface Water Quality Objectives Applicable in the Santa Margarita Basin (Source: Central Coast Regional Water Quality Control Board, 2019)

	Median Groundwater Quality Objectives (mg/L)			Mean Surface Water Quality Objectives (mg/L)		
Chemical Constituent	**Near Felton**	**Near Boulder Creek**	**San Lorenzo River (above Bear Creek)**	**San Lorenzo River (at Tait Street Check Dam)***	**Zayante Creek**	**Boulder Creek**
Total dissolved solids	100	250	400	250	500	150
Chloride	20	30	60	30	50	10
Sulfate	10	50	80	60	100	10
Boron	0.2	0.2	0.2	0.2	0.2	0.2
Sodium	10	20	50	25	40	20
Nitrate as N	1	5	---	---	---	---

* Downstream of the Santa Margarita Basin

To reduce nitrate levels in the San Lorenzo River, the County developed the San Lorenzo Nitrate Management Plan in 1995, and the CCRWQCB adopted a Nitrate Total Maximum Daily Load (TMDL) in the Basin Plan. These plans call for various measures to prevent any increased nitrate discharge and to reduce existing sources, particularly requiring individual enhanced treatment systems as existing septic systems in sandy soils are replaced or upgraded. Further, the use of recycled water in the basin requires additional treatment for denitrification before the water can be used.

The Basin Plan update in 2003 described the San Lorenzo River as impaired for both sediment and pathogens. The San Lorenzo River Technical Advisory Committee was formed to help the CCRWQCB develop actionable plans to decrease the levels of these constituents in the river. Responsibility for tracking, reporting status, and evaluating the effectiveness of voluntary implementation actions, is shared by the Regional Board and participating members of the San Lorenzo River Technical Advisory Committee. TMDLs have been adopted for both sediments and pathogens and are being implemented to reduce the sources of those pollutants. The technical advisory committee has found that the highly erodible soils of the Santa Margarita Sandstone have been a significant source of sediment in the River. Measures are needed to reduce site disturbance, reduce runoff, promote infiltration, and implement erosion control practices. The pathogen TMDL calls for improved septic system management to reduce failures and address other sources such as livestock, stormwater runoff, and homeless encampments.

2.1.2.4 County of Santa Cruz Monitoring

The County of Santa Cruz has several water resources monitoring and management programs, including programs for groundwater levels, groundwater quality, surface water flow, and nitrate control from septic sources.

2.1.2.4.1 Groundwater Elevation Monitoring

County of Santa Cruz Environmental Health (SCEH) has a private well groundwater elevation monitoring network in parts of the County, including in the adjacent Santa Cruz Mid-County Basin. While this network does not currently include wells in the Santa Margarita Basin, SCEH staff expects to add Santa Margarita Basin wells in the near future.

2.1.2.4.2 Groundwater Quality Monitoring

2.1.2.4.2.1 Private Wells

SCEH requires submission of data on well production and water quality (nitrate, chloride, total dissolved solids, iron, and manganese) as a condition of approval for all new developments served by an individual well. Since 2010, the County requires submittal of those quality data for any new well construction. There are no ongoing monitoring requirements for private wells after the initial sample is collected and reported to the County.

2.1.2.4.2.2 Small Water Systems

SCEH Drinking Water Program regulates state small water systems (5-14 connections) and public water systems (15-199 connections) to ensure the water provided through these small water systems meets federal and state water quality standards. The County requires sampling, testing, and reporting of chemical and biological parameters and oversees regulatory compliance for these systems. All systems are also required to report their monthly water production at the end of each year.

- State Small Water Systems with 5-14 connections are regulated under both county and state regulations through the SCEH Drinking Water Program. State small water systems are required to provide quarterly bacteriologic water quality results to the County, and additional results on a less frequent basis.

- Public Water Systems located within communities serving 15-199 connections and those that serve more than 25 people for more than 60 days a year through non-community or transient uses (businesses, schools, restaurants, etc.) are regulated by the SCEH Drinking Water Program acting for the State Water Resources Control Board Division of Drinking Water (DDW) through a Local Primacy Agency agreement. Public water systems are required to provide monthly bacteriologic sampling results to the County, with other results provided on an annual or less frequent basis.

2.1.2.4.2.3 Wasteload Allocation Attainment Program

The County's WAAP identifies, prioritizes, and describes programs to reduce contaminant loads in surface water that could impact the health of the community's surface water and drinking water. The program monitors surface water quality for nitrate and *E. coli*, identifies impaired waters by comparing monitoring results to federal water quality standards, identifies the sources of pollution, and prioritizes best management practices to bring impaired surface waters into compliance with federal standards.

2.1.2.4.3 Surface Water Flow Monitoring and Management

The County currently operates 5 low-flow stream gauges (Figure 2-5) within the Basin with the goal of understanding dry-season flows in support of coho and steelhead habitat-enhancement efforts. More recently, stream flow monitoring has supported the ongoing GSP process. The 5 gauging locations with their periods of record by water year (WY) are:

- Zayante Creek at Woodwardia (WY2009 – WY2010; WY2017 – current)
- Bean Creek at Mount Hermon Camp (WY2009 – WY2012; WY2017 – current)
- Bean Creek at Mount Hermon Road (WY2012 – WY2013 sponsored by SVWD, WY2019 – current)
- Newell Creek 100 feet upstream of the San Lorenzo River (WY2019 – current)
- Eagle Creek above its entry into the San Lorenzo River (WY2018 – current)

These gauges are only operated during the dry season, with monthly site visits to make field observations, repair equipment, calibrate devices, and measure flow and specific conductance. Each gauge is equipped with a pressure transducer, which collects continuous water depth data at 15-minute intervals. Field observations and measurements are used to calibrate the gauging records. In addition to collecting data at these gauge locations, flow at specific tributaries (e.g., Ferndell Creek) are measured to improve understanding of the Santa Margarita boundary aquifer conditions. Balance Hydrologics has made these observations and prepared annual reports as deliverables to the County.

The USGS operated a gauge on Bean Creek at the Mount Hermon Road site (Figure 2-25) from WY1998 through WY2007, also with continuous flow measurements calibrated by monthly visits. No record of specific conductance or other water-quality measurements were published.

Beginning in 2017, Balance Hydrologics conducted annual late-season stream observation walks ("accretion runs"), where flow, nitrate, and specific conductance are measured at select locations along the San Lorenzo River and its tributaries. Measurements are collected along the reach from Felton up through Boulder Creek. The goal of the accretion study is to improve understanding of the surface water and groundwater interactions within the Basin. As part of the GSP process, sites along Zayante Creek, Lompico Creek, and Bean Creek were added to the accretion runs in the summer of 2019. Most of the added sites are focused along Bean Creek and its tributaries. During the summer and fall of 2019, three separate accretion runs (May, July, and September) were conducted on the San Lorenzo River, Lompico Creek, Zayante Creek, Bean Creek, and Eagle Creek. Measurements were collected at all sites over a period of 1 to 2 days for each run. The number of accretion runs was increased during 2019 to capture the changes in flow during the dry-season recession and to aid in understanding the surface-water groundwater interactions within the Basin.

2.1.2.4.4 Local Area Management Plan

The County's Local Area Management Plan (LAMP) was developed in 2021. The purpose of the LAMP is to provide for the continued use of Onsite Wastewater Treatment Systems (OWTS, also known as septic systems) in Santa Cruz County while providing protection of water quality and public health. The LAMP updates and expands the wastewater management approaches conducted by Santa Cruz County since 1985.

2.1.2.5 San Lorenzo Valley Water District Groundwater Monitoring and Management

SLVWD conducts routine groundwater extraction, groundwater level, and streamflow monitoring to support its water resource management. SLVWD has monitored groundwater production since 1984, with current monthly production monitoring ongoing in the SLVWD's 7 active extraction wells. Groundwater elevations have also been monitored in production areas since the 1960s, with consistent monitoring since the mid-1970s. SLVWD monitors groundwater elevations in all its production wells plus monitoring wells listed in Table 2-4. SLVWD monitors streamflow downstream of its diversions.

Table 2-4. SLVWD Groundwater Production and Groundwater Elevation Monitoring Wells

Well Name	Well Status	Reference Point Elevation (feet msl)	Primary Screened Formation	Screen Interval Depth (feet bgs)
SLVWD Production Wells – Groundwater Production and Groundwater Elevation Measured Monthly				
San Lorenzo Valley System – Northern Portion				
Quail Hollow #4A	active	597	Santa Margarita	180 – 250
Quail Hollow #5A	active	516	Santa Margarita	124 – 164
Olympia #2	active	528	Santa Margarita	225 – 245, 275 – 298
Olympia #3	active	538	Santa Margarita	230 – 308
San Lorenzo Valley System – Southern Portion				
Pasatiempo #5A	active	750	Lompico	400 – 700
Pasatiempo #7	active	734	Lompico	380 – 440, 495 – 525
Pasatiempo #8	active	790	Lompico	560 – 660, 680 – 780
Mañana Woods #1	inactive	~515	Santa Margarita /Lompico	136 - 436
Mañana Woods #2	inactive	516	Santa Margarita /Lompico	156 – 196, 236 – 276, 306 – 326
SLVWD Monitoring Wells – Groundwater Elevation Measured Monthly				
San Lorenzo Valley System – Northern Portion				
Quail Hollow MW-A	active	425	Santa Margarita	38 – 88

Well Name	Well Status	Reference Point Elevation (feet msl)	Primary Screened Formation	Screen Interval Depth (feet bgs)
Quail Hollow MW-B	active	593	Santa Margarita	95 – 195
Quail Hollow MW-C	active	650	Santa Margarita	120 – 220
Quail Hollow Ranch	inactive	627	Santa Margarita	225 – 275
Quail Hollow #8*	active	407	Santa Margarita	100 – 130
Olympia #1*	active	448	Santa Margarita	131 – 159, 127-157
San Lorenzo Valley System – Southern Portion				
Pasatiempo MW-1	active	775	Lompico	600 – 660
Pasatiempo MW-2	active	775	Santa Margarita	280 – 340

*Former production well
feet msl = elevation in feet relative to mean sea level
feet bgs = depth in feet below ground surface

2.1.2.6 Scotts Valley Water District Groundwater Monitoring and Management

SVWD has been actively managing groundwater since the early 1980s; with the goal of increasing water supply reliability and protecting local water supply sources. In 1983, SVWD instituted a Water Resources Management Plan to monitor and manage water resources in the Scotts Valley area. In 1994, SVWD formally adopted a Groundwater Management Plan ([GWMP], Todd Engineers, 1994) in accordance with Assembly Bill 3030 (AB 3030), also known as the Groundwater Management Act (CWC §10750 *et seq.*). The overall purpose of the GWMP was to provide a planning tool that helps guide SVWD manage the quantity and quality of its groundwater supply, and to comply with the requirements of AB3030. The goal of the SVWD GWMP is stated as:

> *By implementation of a groundwater management plan for Scotts Valley, SVWD hopes to preserve and enhance the groundwater resource in terms of quality and quantity, and to minimize the cost of management by coordination of efforts among agencies.*

Development of Basin Management Objectives (BMOs) are required for the GWMP under CWC § 10753.7(a)(1) as a systematic process to support groundwater basin management. The BMOs for SVWD's GWMP are summarized as:

- Encouraging public participation through an annual report of groundwater management activities and its presentation at 1 or more public meetings
- Coordinating with other local agencies
- Continued monitoring and evaluation of groundwater conditions

- Implementing groundwater augmentation projects
- Investigating groundwater quality and preventing groundwater contamination

These BMOs guided the SVWD groundwater management program and served as major objectives of groundwater management for SVWD. Groundwater management covered by the GWMP will be replaced by this GSP.

Starting in 1994, annual reports that analyze and describe the condition of the Basin were produced as part of GWMP implementation. The format of the annual reports has evolved over time to meet the needs of SVWD. Starting in 2013, the format began following a 2-year cycle with more comprehensive reports being produced in even years. Based on past experience, there were only incremental year-to-year changes in the Basin; therefore, the 2-year cycle provided a more cost-effective approach to accomplish the objectives of the annual report. The odd year reports are concise summaries focused on SVWD operations whereas the even year reports provide more regional assessments that include an evaluation of data from neighboring water districts and private suppliers, an assessment of water quality issues, an assessment of Basin conditions and change in groundwater in storage simulations from the updated Basin's groundwater model.

Development of a monitoring network to track Basin conditions within SVWD's service area has been part of GWMP implementation. Table 2-5 lists the SVWD monitoring wells that are currently included in their monitoring network. All existing monitoring wells will be incorporated into the SMGWA monitoring network.

Table 2-5. Wells Used for the Scotts Valley Water District Groundwater Management & Monitoring Program

Well Name	Well Status	Top of Casing Elevation (feet msl)	Primary Screened Formation	Screen Interval Depth (feet bgs)
SVWD Production Wells – Measurements taken monthly for both static and dynamic levels				
SVWD Well #3B	active	672.5	Lompico, Butano	700-730, 880-1050, 1180-1370, 1400-1670
SVWD Orchard Well	active	723	Lompico, Butano	705-784, 805-1063, 1084-1455
SVWD Well #9	inactive	528.1	Monterey	155-195, 315-355
SVWD Well #10	inactive	510.9	Lompico	190-220, 240-270, 325-355
SVWD Well #10A	active	512.0	Lompico	280-380, 400-450
SVWD Well #11A	active	602.6	Lompico	399-419, 459-469,495-515
SVWD Well #11B	active	588.0	Lompico	348-388, 423-468, 500-515
SVWD Monitoring Wells - Key Indicator Wells – Measurements taken monthly				
#15 Monitoring Well[2]	active	660.0	Lompico, Butano	700-1100
#9 Monitoring Well	active	528.0	Monterey	N/A

Well Name	Well Status	Top of Casing Elevation (feet msl)	Primary Screened Formation	Screen Interval Depth (feet bgs)
SVWD Monitoring Wells - Measurements taken semi-annually				
SVWD AB303 MW-1[1,2,3]	active	561.1	Santa Margarita	114-124
SVWD AB303 MW-2[2]	active	524.2	Lompico	705-715, 810-850
SVWD AB303 MW-3A[1,2,3]	active	522.7	Lompico	630-680
SVWD AB303 MW-3B[1,2,3]	active	522.1	Santa Margarita	120-125
Canham Well [2]	active	782.8	Butano	1,281-1,381
Stonewood Well [2]	active	898.5	Butano	799-859
SV1-MW	inactive	704.3	Santa Margarita	60-80
SV3-MW A [2]	active	584.7	Santa Margarita	60-80
SV3-MW B [2]	active	584.7	Santa Margarita	100-110
SV3-MW C [2]	active	584.7	Lompico	150-160
SV4-MW	active	447.8	Santa Margarita	50-60
TW-18[1,2,3]	active	715.0	Santa Margarita	285-345
TW-19[1,2,3]	active	659.5	Lompico	960-1060

Notes:[1] Groundwater elevation measurement data submitted to DWR CASGEM Program
[2] Equipped with electronic data transducer
[3] CASGEM well
feet msl = elevation in feet relative to mean sea level
feet bgs = depth in feet below ground surface

2.1.2.7 Mount Hermon Association Groundwater Monitoring and Management

The Mount Hermon Association measures monthly depth to groundwater and extraction data from their actively pumped wells and reports it to SVWD as part of the GWMP described in Section 2.1.2.6.

Table 2-6. Wells Used for the Mount Hermon Association Groundwater Management & Monitoring Program

Well Name	Well Status	Top of Casing Elevation (feet msl)	Primary Producing Formation	Screen Interval Depth (feet bgs)
MHA Production Wells – Measurements taken monthly for both static and dynamic levels				
MHA #1	inactive	772	Monterey, Lompico	255-265, 285-395, 435-495
MHA #2	active	740	Lompico	290-300, 400-415, 430-460, 490-590, 600-615, 625-725
MHA #3	active	584	Lompico	680-800, 860-980

2.1.2.8 City of Santa Cruz Surface Water Monitoring and Environmental Management

As both an in-Basin user (Loch Lomond Reservoir, Felton diversion) and downstream user (Tait diversion) of San Lorenzo River watershed surface water, the City of Santa Cruz actively participates in surface water monitoring and management in the Basin. The key issues that have implications on the City of Santa Cruz water supply are nitrate impacts on surface water quality from the more than 13,000 septic systems in the San Lorenzo River watershed and groundwater use impacts on surface water baseflow supporting anadromous fisheries, particularly in Bean and Zayante Creeks. Reduced surface water baseflow in the Basin that may impact important coho salmon rearing streams increases the regulatory burden on the City, as any impact caused by the City's operations is evaluated within the context of overall habitat and population conditions. Finally, water resource management in the Basin also has impacts on the City of Santa Cruz's ability to fully exercise its water rights, which further complicates its ability to maintain supply reliability and improve habitat conditions for special status salmonids in the watershed.

2.1.2.8.1 Surface Water Monitoring and Management

The City of Santa Cruz monitors surface water stage and discharge in conjunction with their surface water supply diversions on the San Lorenzo River and Newell Creek. The City of Santa Cruz contributes financially to operation of the USGS flow gauge on the San Lorenzo River at Big Trees, upstream of the City operated diversion in Felton. The City monitors surface water discharge on Newell Creek both upstream and downstream of the Loch Lomond Reservoir (Figure 2-25).

The City of Santa Cruz is preparing an Environmental Impact Report (EIR) to support proposed water rights changes that would apply minimum streamflow requirements on its water rights permits and licenses. The EIR will also address the City's water supply reliability issues by, among other things, improving the flexibility of operations and enabling conveyance of water to neighboring agencies, including the member agencies of the SMGWA. These operations could support enhanced conjunctive use of surface water and groundwater for the City of Santa Cruz, and potentially the region. Flexibility in the diversion location for San Lorenzo River water and a consistent place of use for all City water rights may encourage regional water resource management.

2.1.2.8.2 Habitat Management

The City of Santa Cruz is committed to enhancing stream flows and habitat in the San Lorenzo River for local anadromous fisheries, particularly for coho salmon and steelhead. Since 2007, the City has provided bypass flows to benefit salmonids in its water source streams beyond what was required by its water rights. The City has conducted extensive studies on flows needed for all steelhead life stages, and the effect of maintaining flows at various levels in the San Lorenzo River downstream of the Tait Street diversion. The City has also assessed passage flows downstream of Felton Diversion. The City continues to monitor various attributes related to fish habitat in the San Lorenzo River watershed. Under the City of Santa Cruz Water Department Watershed Monitoring Program, the following are specifically monitored:

- Temperature monitoring in a variety of locations throughout the San Lorenzo River watershed
- Turbidity monitoring upstream of Loch Lomond
- Dissolved oxygen and pH monitoring below Loch Lomond
- Juvenile salmonid and habitat in a variety of locations throughout the San Lorenzo River watershed, as a part of a collaborative effort funded by the City of Santa Cruz, SLVWD, SVWD and the County

2.1.3 Land Use Elements

2.1.3.1 General Plans

Land use authority in the Basin falls under the jurisdiction of 2 agencies, the County of Santa Cruz and the City of Scotts Valley. These agencies have each adopted general plans with land use classifications that identify desired areas for development, open space, and conservation purposes. The general plans also cover zoning regulations and development standards that determine the location, type and density of growth allowed in the region, along with various policies for protection of watershed and groundwater resources. General plans are reviewed to understand the adverse environmental impacts they may have when implemented.

State general plan guidance was significantly revised in 2017 (Governor's Office of Planning and Research, 2017). Changes to planning laws triggered these revisions, including SGMA's requirement that general plans consider water supply at their next update. Any significant update to a general plan, including to its housing element, will trigger the SGMA mandate to consider potential development impacts on groundwater supply and consistency between the general plan and the GSP.

2.1.3.1.1 City of Scotts Valley General Plan

The City of Scotts Valley adopted its General Plan in 1994 and began updating it in 2012 to address the changes the city has experienced throughout the past 2 decades since its implementation. The update is not yet complete; however, when it is, it will create a blueprint for development through the year 2040 and will address many topics including physical growth, transportation, quality of life, economic vitality, municipal services, and environmental conservation. A draft EIR associated with the General Plan is currently under development, with a public hearing expecting in early fall 2021 and adoption of the EIR and General Plan shortly thereafter.

2.1.3.1.2 County of Santa Cruz General Plan

The County adopted its current general plan in 1994. A Sustainable Santa Cruz County Plan was adopted in 2015 to promote sustainable land use, housing, economic development, and transportation objectives in the urban areas of the County (County of Santa Cruz, 2014). The Sustainable Santa Cruz County Plan has a timeframe through the year 2035. The County is currently in the process of updating various parts of the General Plan, including the water resource protection policies. The update is expected to be completed in 2022.

The County General Plan contains 2 components that significantly affect the management of water resources within the Basin. Measure J was passed by voters in 1978, which called for a comprehensive growth management system which established population growth limits, affordable housing provisions, the preservation of agricultural lands and natural resources, and the retention of a distinction between urban and rural areas. This has resulted in greatly diminished development density and growth rates in areas that do not receive municipal water service. Each year when the Board of Supervisors adopts the growth goal and annual building permit allocation, limitations of water supply are taken into consideration.

The Conservation and Open Space Element of the County General Plan includes many policies and programs for protection and management of groundwater resources, recharge areas, wetlands, streams, riparian corridors, and sensitive habitat areas. Many of these polices are incorporated into the County Code. An example of such a program is the restriction on building disturbance in Santa Cruz Sandhills habitat. The Sandhills are a unique community of plants and animals found only on Zayante soils, which are derived from the Santa Margarita Sandstone, and mostly found in the Scotts Valley, Ben Lomond, and Bonny Doon areas. Due to their limited geographic range and narrow habitat specificity (Zayante soils), the endemic communities and species of the Sandhills are naturally extraordinarily rare. The Sandhills are also areas of high groundwater recharge potential. Estimated to cover 6,000 acres originally, approximately 40% of Sandhills habitat has been lost, primarily due to sand quarrying and development. A detailed process has been developed by the County to identify whether parcels fall within the Sandhills or not. This process is accessed online at: https://www.sccoplanning.com/Portals/2/County/Planning/env/Permit%20Processing%20Chart.pdf.

These policies, programs, and code requirements were reviewed during development of GSP elements for depletion of surface waters and groundwater dependent ecosystems (GDEs). The County General Plan maps of recharge areas, sensitive habitats, and biotic resources are also used. Several elements including the Conservation and Open Space Element are currently in the process of being updated and wording has been proposed to incorporate references to the GSP into the updated General Plan. The updates are expected to be adopted in 2022.

2.1.3.2 Potential Water Demand Changes due to GSP Implementation

GSP implementation is not expected to increase water demand over the next 20 years. The only water demand changes anticipated as part of GSP implementation are a slight decrease in municipal demand due to water use efficiency achieved through technological improvements and regulatory compliance as well as customer conservation, and reduced water losses due to increased efforts on pressure control, leak detection and innovative data analytics and management. However, increased demand from population growth is projected to slightly outpace water demand reductions from water use efficiency, resulting in slightly increasing demands for the next 20 years (WSC and M&A, 2021).

Pumping reductions are not included as part of GSP implementation. The small amount of increased municipal demand is expected be met by conjunctive use of existing surface water and groundwater sources to raise groundwater levels in the Mount Hermon / South Scotts Valley area to SMGWA's desired elevations. Supplemental water sources in the form of treated surface water from outside of the Basin or indirect potable reuse of purified wastewater may be needed if conjunctive use does not increase groundwater levels as expected. These potential projects are described in more detail in Section 4.

There are no known land use plan changes in neighboring basins that would affect the ability of the SMGWA to achieve groundwater sustainability.

2.1.3.3 Process for Permitting New and Replacement Wells

SCEH is the only agency responsible for issuing water well permits within the Basin. The Santa Cruz County water well permit requirements are outlined in Chapter 7.70 of the County Code and are based on water well standards developed and updated by DWR and are available at: http://www.codepublishing.com/CA/SantaCruzCounty/html/SantaCruzCounty07/SantaCruzCounty0770.html

The County also requires documentation of water efficiency measures as a condition of approval for any well serving any proposed groundwater use expected to use greater than 2 AFY.

The County plans to update its well ordinance to implement elements of this GSP, including metering requirements for non-*de minimis* users by the end of 2022. The County will also address the need to prevent impact on public trust values in surface water from new wells, depending on how this issue evolves in the State. This could include a requirement for increased setbacks from streams and/or deeper seals to reduce the potential to draw from alluvium that is in direct hydraulic contact with a stream.

2.1.3.4 Additional GSP Elements

2.1.3.4.1 Wellhead Protection

The California Department of Health Services' Division of Drinking Water and Environmental Management developed the Drinking Water Source Assessment and Protection (DWSAP) Program in January 1999. The program was developed in response to the 1996 reauthorization of the federal Safe Drinking Water Act, which included an amendment requiring states to develop a program to assess sources of drinking water and encourage protection measures. The DWSAP program enables partnership between local, state, and federal agencies to ensure that drinking water quality is maintained and protected.

Several specific efforts related to wellhead protection in the Basin include the following:

- SLVWD and SVWD have met DWSAP requirements for all active water supply wells since 1999.
- The City of Santa Cruz and SLVWD have completed periodic watershed sanitary surveys of potential sources of contamination in the water supply watersheds, which encompass the entire Basin.
- The State Water Board's 2012 Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems establishes additional setback and design requirements for OWTS located within 600 feet of municipal wells. These requirements are incorporated into the County's Local Area Management Plan for OWTS.

2.1.3.4.2 Well Construction Policies

As discussed above in Section 2.1.3.3, the County permits water wells within the Basin. Well construction standards are found in the County Code, Chapter 7.70. The purpose of the County's well construction standards is to regulate the location, construction, repair, and modification of all wells to prevent groundwater contamination and ensure that water obtained from groundwater wells is suitable for the purpose for which it is used and will not jeopardize the health, safety, or welfare of the people of Santa Cruz County. The County requires well construction and modification standards developed by DWR in Bulletin 74-90.

2.1.3.4.3 Well Abandonment and Destruction Program

The County issues well destruction permits for wells being abandoned within the Basin. The purpose of the County's well abandonment and well destruction policies is to prevent inactive or abandoned wells from acting as vertical pathways for the movement of contaminants into groundwater. Well destruction requirements are found in the County Code, Chapter 7.70.100. SCEH requires that well destruction standards developed by DWR in Bulletin 74-90 be followed.

2.1.3.4.4 Replenishment of Groundwater Extractions

No managed replenishment of groundwater extractions has historically occurred or is currently taking place in the Basin.

2.1.3.4.5 Conjunctive Use and Underground Storage

Conjunctive use is the coordinated operation of multiple water sources to achieve improved supply reliability. Most conjunctive use concepts are based on storing groundwater supplies in times of surplus for use during dry periods when surface water supplies would likely be reduced. Opportunities exist to improve water supply reliability in the Basin using conjunctive use and underground storage.

While there are no formal conjunctive use programs between SMGWA members and other water agencies, conjunctive use practices have been studied and are implemented by SMGWA member agencies with access to surface water. For example, SLVWD meets demand through conjunctive use of surface water and groundwater sources. Since SLVWD has limited storage other than natural groundwater storage, they divert surface water from streams as much as possible to store groundwater for use during dry periods. There are bidirectional interties between SLVWD's water systems that, although only permitted for emergency use, could potentially be used to transfer water supplies within its service area (Exponent, 2019). SLVWD is pursuing efforts to utilize its emergency interties on a routine basis for conjunctive use and improved resiliency. There is also an intertie connecting SLVWD and SVWD systems for transfer of water in emergency situations. Currently, there is no formal conjunctive use agreement between the water districts.

SMGWA members and other agencies are continually exploring regional partnerships to enhance water supplies through a range of potential options that can benefit the Basin as a whole. Projects under consideration are described in more detail in Section 4: Projects and Management Actions.

2.1.3.4.6 Current Water Management Projects and Programs

2.1.3.4.6.1 Groundwater Contamination Cleanup

Environmental contamination assessment and remediation programs within the County and Basin are overseen by the CCRWQCB. The SCEH is also involved with sites with hazardous materials impacts to soils. To protect their potable water supplies and more effectively manage the Basin, SMGWA member agencies are informed about local environmental compliance sites where groundwater quality has been impacted by pollution or chemical spills.

There are currently no contamination sites undergoing active groundwater remediation within the Basin; cleanup efforts taking place in the Basin are only related to soil vapor as described in the subsections below. Historically, groundwater remediation of volatile organic compounds (VOCs) and gasoline-related chemicals in groundwater occurred at several Scotts Valley and Felton sites.

The remediation efforts at these sites concluded after the concentrations of contaminants in groundwater decreased below the established water quality standards. There is always a possibility that groundwater will be re-impacted in the future from these sites if the contaminant source was not completely addressed. Detailed information for all sites regardless of open or closed status is available from the SWRCB GeoTracker website at: https://geotracker.waterboards.ca.gov/ and the Department of Toxic Substances Control (DTSC) Envirostor web site at: www.envirostor.dtsc.ca.gov/public. One additional groundwater contamination cleanup site located 275 feet outside of the Basin at the former Valeteria Dry Cleaners in Felton is included in the summaries below since it impacts water quality in the San Lorenzo River located only 400 feet to the east of it and within the Basin.

Figure 2-6 shows the location of all SWRCB GeoTracker sites, and for reference, those sites described in more detail below are labeled on the map. Sites indicated on Figure 2-6 include cleanup program sites, land disposal sites, and Leaking Underground Storage Tank (LUST) sites. Organic and emerging contaminant threats to water quality in the Basin are discussed in more detail in Section 2.2.5.4.4.

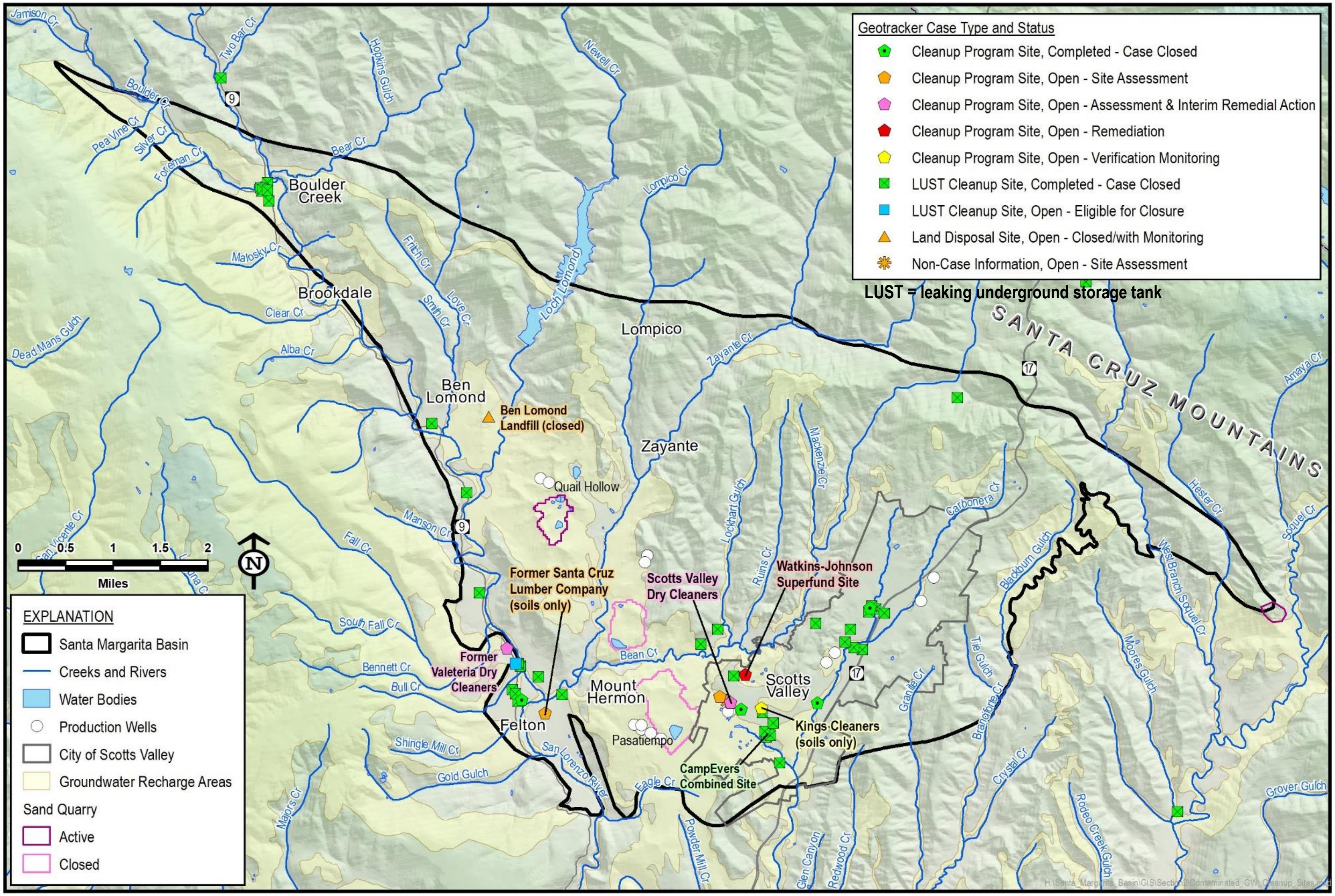


Figure 2-6. Location of Groundwater Contamination Cleanup Sites in the Santa Margarita Basin

Watkins-Johnson Superfund Site

The Watkins-Johnson site, located at 440 Kings Village Road in Scotts Valley, is a former semiconductor manufacturer where industrial processes included metal machining, degreasing operations, metal plating, glass cleaning, glass etching, welding, soldering, painting, and photo lab activities. A variety of organic chemicals, inorganic acids, and metals were used at the site. The site is a Federal Superfund Site listed on the National Priorities List, with remediation activities under the jurisdiction of USEPA Region 9 and the RWCQB.

The site's remedial investigation and feasibility study started in 1984 after organic chemicals were detected in the soil and groundwater at the site and in the surface water of Bean Creek near the site. Groundwater remediation began in October 1986. Key constituents detected in the groundwater include trichloroethene (TCE), cis-1,2-dichloroethene (CISDCE), and vinyl chloride (VC). In the soil, key constituents include TCE, methylene chloride, and chloroform. Of primary interest was the potential for contaminants in the soil to migrate into the underlying aquifers: the Santa Margarita Sandstone and Lompico Sandstone. SVWD Well #9, which is located approximately 400 feet south of the Watkins-Johnson site and screened in the lower Santa Margarita and Monterey Formations, has been impacted by TCE and CISDCE at concentrations below drinking water standards. Although this well is no longer used by SVWD, when it was used, water pumped from it required filtration by a granular activated carbon (GAC) system prior to putting the water into the distribution system.

Groundwater remediation at the site consisted of pumping groundwater beneath the site with a series of extraction wells. The extracted water was treated using a GAC adsorption system. Treated water was used onsite, recharged to the perched zone onsite, and discharged to Bean Creek. The groundwater remediation system was deactivated on July 5, 2016.

More than 3 decades after investigations began at the Watkins-Johnson site, its remediation is moving towards closure, but the current site owner still needs to complete the source control component of the remedial action to ensure protectiveness over the long-term. The site is currently designated by the CCRWQCB as an open case with ongoing remediation for residential use due to existing soil gas plumes of benzene, TCE, tetrachloroethene (PCE), arsenic and cadmium in soils. A draft Focused Feasibility Study proposing potential remediation alternatives including soil excavation was submitted to USEPA in January 2019.

Scotts Valley Dry Cleaners

Remediation of the Scotts Valley Dry Cleaners site, located at 272 Mount Hermon Road in Scotts Valley, is overseen by the CCRWQCB. PCE, which is used as a dry-cleaning solvent, was found in the soils and groundwater both on-site and off-site of the dry-cleaning operations in 1993.

Groundwater extraction remediation systems were used at the site from August 2005 to August 2015. The extracted water was treated by a GAC adsorption system and discharged under a National Pollution Discharge Elimination System Permit to the City of Scotts Valley storm water drain system. In addition to groundwater extraction, injection of sodium permanganate into groundwater through dedicated injection wells in 2009 attempted *in situ* cleanup of chlorinated solvents in groundwater.

Cleanup at the Scotts Valley Dry Cleaners site currently involves operation of soil vapor extraction and air sparging systems. These remediation systems only extract soil vapor in the unsaturated soils above groundwater and thus no groundwater is extracted.

Former Valeteria Dry Cleaners

The former Valeteria Dry Cleaners site, located at 6519-6539 Highway 9 in Felton, released PCE into groundwater just outside of the Basin. It is included in this discussion regarding groundwater cleanup sites because it could potentially impact the Basin even though it is physically located outside of the Basin; it is only 400 feet west of the San Lorenzo River that flows through the Basin and VOC contaminated groundwater discharges to the river via springs.

The PCE in groundwater from the site is thought to have originated from dry cleaning solvent wastes being disposed into the onsite septic system (Integral Consulting Inc, 2020). In the 1980s, PCE was first detected in surface water samples from both the San Lorenzo River and springs on the river's western bank. Associated with PCE are lower concentrations of TCE, and limited detections of CISDCE. PCE and TCE are the only VOCs consistently detected above their drinking water maximum contaminant levels (MCLs) of 5 µg/L (equal to 0.005 mg/L).

Integral Consulting Inc. (2020) summarizes previous environmental assessments and remediation as:

> "Subsequent assessment activities in the 1990s and 2000s included a passive soil gas survey, additional surface water sampling, septic system sludge sampling, aquifer testing, and installation and sampling of numerous groundwater monitoring wells and soil borings. Initial remedial activities were conducted in 2002 with the removal of the historical septic tank and 325 cubic yards of surrounding soils from the onsite area. An on- and offsite area soil vapor assessment was conducted in 2008 followed by installation of a soil vapor extraction and sub-slab venting system in 2009 and sub-slab sampling in onsite area structures in 2010 and 2011. The onsite area soil vapor extraction system has since been operated periodically primarily for soil venting."

A July 21, 2020 Remedial Action Plan describes the plume of chemical constituents of concern (COC) above the MCL to extend laterally 320 feet long by 180 feet wide downgradient from the former source area to Spring 1A at the San Lorenzo River. The vertical extent of the plume in groundwater generally follows the groundwater table at around 20 feet below ground and extends to an approximate depth of 60 feet below ground. The downgradient extent of COCs has been delineated to the extent practical at the springs near the San Lorenzo River.

Camp Evers Combined Site

The Camp Evers combined site is associated with 4 current and former gasoline stations (BP, Shell, Chevron, and Tosco), that were located at or near the intersection of Scotts Valley Drive and Mount Hermon Road. The primary COCs at this site are Methyl-tert-butyl ether (MTBE) and other fuel-related compounds. The Camp Evers combined site cleanup was overseen by the CCRWQCB. Historically, the plume has extended at least 1,700 feet north of SLVWD's Mañana Woods Well #2. When this well was used, its pumped water was passed through a pre-treatment system to remove low MTBE concentrations. The well is no longer pumped by SLVWD.

Remediation at the various sites consisted of underground storage tank (UST) removal, and groundwater extraction and treatment before discharging to the City of Scotts Valley storm water drain system. Remedial efforts started in the early 2000s and the Camp Evers Combined Site completed their remediation efforts and closed all cases as of November 21, 2017.

Ben Lomond Landfill (Closed)

The Ben Lomond Landfill, at 9835 Newell Creek Road in Ben Lomond, operated as a landfill until 2012, but is now a trash transfer station. Groundwater monitoring has been ongoing at the now-closed landfill since 1980, as the site is associated with elevated levels of VOCs and heavy metals. Contamination associated with the site is not predicted to expand its footprint and is not thought to significantly impact 2 municipal Quail Hollow wells operated by SLVWD east of Newell Creek (Johnson, 2009).

The following 2 non-LUST sites do not have groundwater contamination, only soil contamination and cleanup:

King's Cleaners

The King's Cleaners site, located at 222 Mount Hermon Road in Scotts Valley, was found in 2000 to have some PCE in the soil samples and elevated soil gas concentrations. No PCE was detected in groundwater. SCEH assumed oversight responsibility for this site from the CCRWQCB in April 2017.

No remedial actions have occurred at the Kings Cleaners site over the past several years. However, in 2019/2020 there has been regulatory oversight for development of a Work Plan to confirm current soil vapor concentrations and whether residual PCE concentrations detected in soil vapor investigations conducted during September 2000 and November 2009 pose a vapor intrusion health risk at the subject site and adjacent commercial businesses.

Former Santa Cruz Lumber Company

Santa Cruz Lumber Company, located at 5843 Graham Hill Road in Felton, operated from 1945 to 1986. Operations at the site included pressure treatment of a variety of wood products with the chemical Wood-Last, a water-based copper, chromium, and arsenic solution. During initial investigations in 1986, groundwater contamination was not found, but soils were contaminated by CCA.

Remedial excavation and removal of over 2.6 thousand tons of soil took place in 1987 because it contained elevated levels of metals and other constituents associated with wood products. More recent soil sampling, in April 2018, found elevated levels of arsenic, hexavalent chromium, and formaldehyde, though hexavalent chromium may be naturally occurring. Contaminants were not found in groundwater (Trinity Source Group, Inc., 2017). A Work Plan to remove these chemical constituents was requested by SCEH.

A privately owned well screened in the Lompico aquifer, 250 feet west of the site, has elevated arsenic concentrations in groundwater between 0.014 mg/L and 0.026 mg/L (the primary drinking water standard is 0.01 mg/L). Slightly elevated arsenic is also found in other wells in the vicinity, such as SLVWD Pasatiempo #6 and wells just outside the Basin, southeast of Felton. As described above, onsite investigations did not find groundwater contamination, and therefore given the information available, elevated arsenic in this area's groundwater is considered naturally occurring in the Lompico aquifer.

2.1.3.4.6.2 Migration of Contaminated Water

Groundwater quality sampling of supply wells in the Basin allows for analysis of contaminated water migration. Historical supply well water quality data indicates that contaminated water migration is spatially and temporally limited to only a few locations over time. Detected contaminants in supply wells have mostly been from point source contaminant releases related to the regulated sites discussed above and contaminant concentrations were typically at or below relevant drinking water standards. Nitrate has also been detected in supply wells in some areas of the Basin at concentrations less than the drinking water standards, likely due to non-point source septic system releases. More information on groundwater quality is provided in Section 2.2.5.4

Contaminated groundwater detected in supply wells originated from 3 main areas in Scotts Valley: Camp Evers area gas stations, downtown dry cleaners, and the Watkins-Johnson Superfund Site. Contaminated groundwater has generally migrated down-hydraulic gradient from these sites within the Santa Margarita aquifer, but plume migration has also been influenced at various times by the operation of each of the sites' groundwater extraction and treatment systems, and cones of depression created by municipal extraction wells. Currently, all groundwater extraction and treatment systems have been decommissioned, and there is no municipal pumping in the Santa Margarita aquifer in the area where contamination originated.

There are 2 known locations where contamination has migrated down through the Santa Margarita aquifer into the underlying Monterey Formation or Lompico aquifer and impacted SLVWD and SVWD public supply wells. These 2 wells are currently inactive:

- SLVWD Mañana Woods #2 is screened in both the Santa Margarita and Lompico aquifers in an area where the Monterey Formation is absent between the 2 aquifers. This well was impacted with MTBE and other gasoline breakdown products that were first detected in 2006. After discovering the impacts, groundwater pumped from this well was passed through a GAC treatment system to reduce VOCs below drinking water standards (Johnson, 2009).

- SVWD Well #9 is down-hydraulic gradient from Camp Evers and only 300 feet up-hydraulic gradient from onsite Watkins-Johnson monitoring wells impacted with VOCs. It is screened in the Monterey Formation. SVWD Well #9 is impacted with MTBE and several VOCs at concentrations below applicable drinking water standards.

Given that concentrations of contaminants in municipal extraction wells have not increased with time, it is assumed that contaminant sources have been addressed such that there is now limited migration of contaminant plumes. Regulating agencies provide impacted SMGWA member agencies with relevant information on monitoring and clean up. This information combined with regular monitoring of groundwater quality at all municipal extraction wells provides the information the public water supply agencies need to protect their wells.

Nitrate concentrations in groundwater throughout the Basin appear to have stabilized at a level that is well below drinking water standards. County standards now require that any new or replacement septic systems in sandy soils must incorporate enhanced treatment and denitrification to reduce nitrate discharge to groundwater.

2.1.3.4.6.3 Stormwater Recharge

There are intentional efforts to reduce stormwater runoff in the Basin by increasing on-site recharge. Stormwater retention and recharge is required by the City of Scotts Valley guidelines for new development projects (City of Scotts Valley, 2017). The City's guidelines are based on the CCRWQCB adopted Order R3-2013-0032 (July 2013). The Post-Construction Requirements mandate that development projects use Low Impact Development (LID) to detain, retain, and treat runoff. This has resulted and will continue to result in new on-site stormwater recharge in the Basin.

SVWD contributes to stormwater recharge via the implementation of LID projects in Scotts Valley. LID projects consist of applying stormwater best management practices (BMPs) – such as infiltration basins, vegetated swales, bio-retention and/or tree box filters – to retain and infiltrate stormwater that is currently being diverted into the storm drain system.

Infiltrated stormwater recharges the shallow aquifers in a manner similar to natural processes. The infiltration helps augment groundwater elevations and sustains groundwater contributions to stream baseflow that support local fish habitats. A complicating factor in implementing LID projects in the Scotts Valley area is that there is no centralized stormwater collection system, which limits the ability for large-scale projects to implement groundwater augmentation in the most beneficial areas.

Figure 2-7 shows the location of the LID facilities in relation to surface geology and the area where Santa Margarita Sandstone directly overlies Lompico Sandstone due to the absence of the less permeable Monterey Formation. All three LID facilities are located where Santa Margarita Sandstone overlies the Monterey Formation; therefore, there is less potential for the LID facilities to recharge the Lompico Sandstone. Monitoring equipment is installed to assess the performance of the facilities. The total amount of stormwater infiltrated at the 3 LID facilities is summarized in Table 2-7.

Table 2-7. SVWD Low Impact Development Infiltration Volumes

Water Year	Volume Infiltrated, AF			
	Transit Center	**Woodside HOA**	**Scotts Valley Library**	**Total**
2018	1.75	17.30	3.39	22.44
2019	3.08	31.17*	6.11*	40.38
2020	1.50*	14.97*	2.94*	19.42*

* estimated because dataloggers were not recording correctly

Transit Center LID

SVWD obtained grant funding through a County Prop 84 grant from the SWRCB for the planning, design, and construction of an LID retrofit at the Scotts Valley Transit Center site (Figure 2-7). The design included construction of a vegetated swale, a below-ground infiltration basin, and pervious pavement. Construction began in October 2016 and was completed in May 2017. In 2020, SVWD recorded a total of 1.5 acre-feet of infiltrated stormwater at this location (Montgomery & Associates, 2021).

Woodside HOA LID

As part of the Prop 84 grant match, SVWD worked with a local developer to install a stormwater recharge facility at the Woodside HOA along Scotts Valley Drive (Figure 2-7). This facility includes a large below-ground infiltration basin. Stormwater is routed from the development to the basin where it can percolate down into the groundwater. Initial hydrology reports estimated recharge on the order of 20 to 40 AFY might be achieved (Ruggeri, Jensen and Azar, 2010). In 2020, a total of 15 acre-feet of stormwater infiltrated at this location (Montgomery & Associates, 2021).

Scotts Valley Library LID

This LID was an earlier grant-funded project that installed a below-ground infiltration basin at the Scotts Valley Library (Figure 2-7). In 2020, a total of 3 acre-feet of stormwater infiltrated at this location (Montgomery & Associates, 2021).

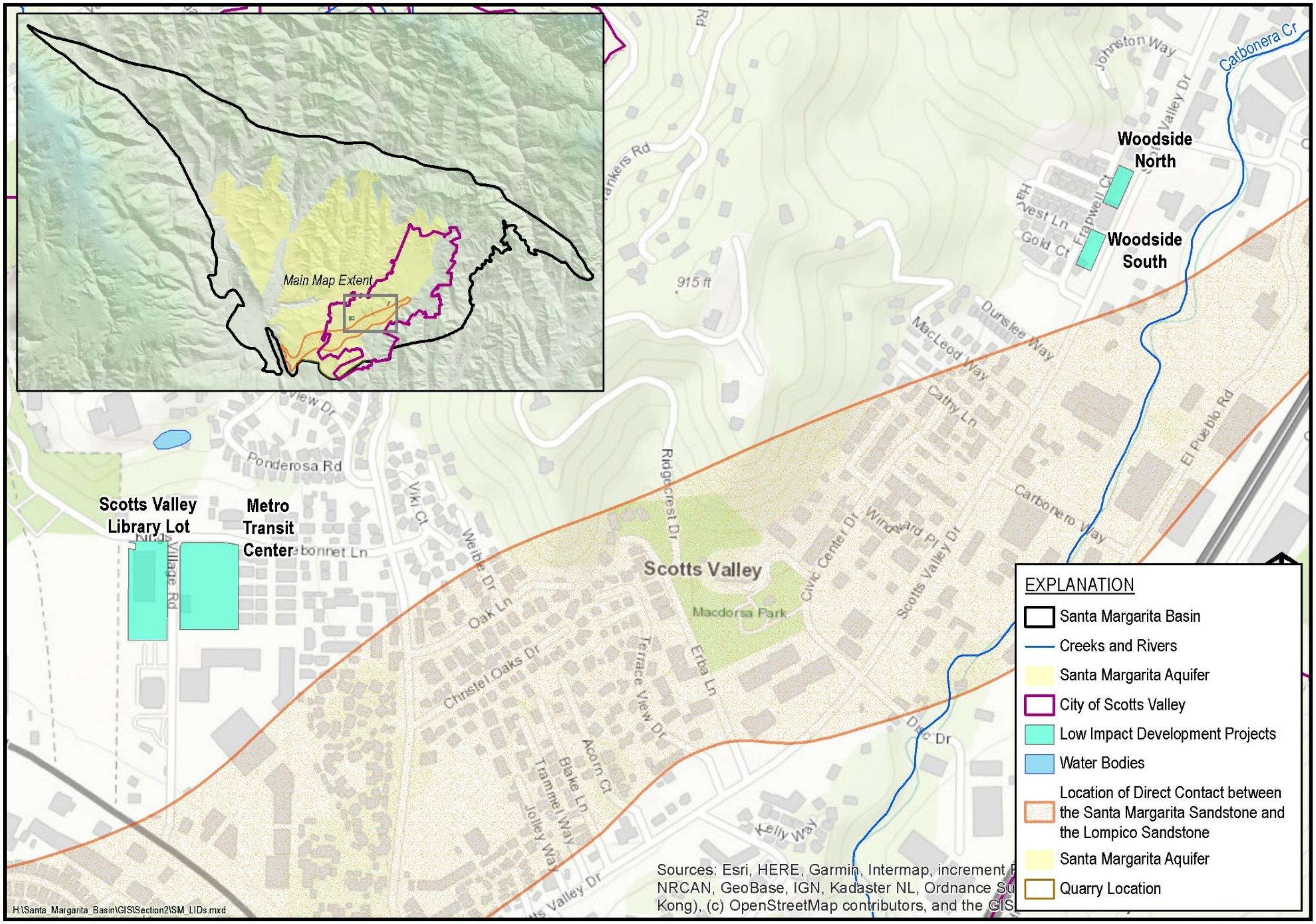


Figure 2-7. Location of SVWD Low Impact Development Projects

In addition to the large LID projects described above, SVWD was part of the Strategic and Technical Resources Advisory Groups for Ecology Action's regional sponsorship of the Prop 84 LID Incentives Grant. SVWD staff provided input on rating criteria for the landscape certification program and the structure of the grant reporting. Through 2018, 32 SVWD customers were awarded grant incentives for making stormwater management improvements to their properties, with strategies such as rainwater harvesting, lawn and hardscape removal, and stormwater retention methods, such as swales and rain gardens. According to SVWD staff records, the program provided 31,733 square-feet (0.73 acres) of permeable recharge area.

2.1.3.4.6.4 Diversions to Storage

SLVWD has limited storage capacity in their distribution system other than natural groundwater stored in the aquifers. In total it has 26 AF of storage within its service area. Of that total storage capacity, 21.8 AF is in 33 tanks serving the North System, 1.3 AF in 5 tanks serving the South System, and 2.9 AF in eight tanks serving the Felton System. Both pumped groundwater and diverted surface water are stored in these facilities. Bennett Spring is designated as a surface water source not permitted to be stored.

SVWD uses tanks to store up to 1.8 AF of recycled water and 13.3 AF of treated groundwater.

The City of Santa Cruz created the Loch Lomond Reservoir in the early 1960s by impounding Newell Creek with construction of the Newell Creek Dam. The reservoir is supplied by runoff from the Newell Creek watershed, as well as by flows diverted from the San Lorenzo River that are pumped up from the Felton Diversion Dam to the Loch Lomond Reservoir. It is the City's only reservoir and raw water storage facility. This makes it an integral part of their water system as it provides water supply for peak season demands and as a drought reserve. When full, the reservoir holds approximately 8,600 AF (or 2.8 billion gallons).

Private individuals who have riparian water rights for surface water diversion in the Basin are not permitted to store surface water.

2.1.3.4.6.5 Water Conservation and Use Efficiency

San Lorenzo Valley Water District Conservation Activities

SLVWD customers continue to demonstrate commitment to ongoing proactive conservation efforts. Currently, they are maintaining at least a 15-22% reduction in yearly water usage from 2013 consumption levels. According to SLVWD's 2020 Urban Water Management Plan (UWMP), its 2025 target water use is 85 gallons per capita per day (GPCD). The population served by SLVWD has met the 85 GPCD target during the latter part of the 2012-2015 drought and from 2018 to 2020. Since 1995, per capita water usage varied from a high of 104 GPCD in 2006 to a low of 70 GPCD in 2015.

SLVWD actively pursues incidents of water waste by investigating, recommending corrective action, and providing follow-up documentation of resolution. The water waste prevention ordinance (106) was most recently revised in May 2018 (Water Shortage Emergency Ordinance 106).

All SLVWD service connections are currently metered, and customers are billed by monthly volume of usage. As of July 2016, SLVWD's Board of Directors approved the Badger Meter project with the goal of installing the advanced metering technology at all meters. As of April 2020, about 20% of the meters have been upgraded. The new meters, combined with the Badger Eye on Water engagement portal, allow customers to view hourly usage history, setup leak detection alerts, and receive high bill notifications.

The majority of SLVWD's customer accounts are residential; therefore, they target indoor and outdoor water savings programs toward these customers. Residential water conservation is promoted by disseminating technical information on methods to reduce indoor and outdoor water use and by offering credits on customer bills for installation and/or replacement of appliances and lawns with approved water saving appliances and plantings. In Fiscal Year 2017/2018, SLVWD issued 46 rebates with an estimated water savings of 630,044 gallons.

SLVWD conducts a variety of public education activities such as a dedicated Water Use Efficiency Page on its website, e-Newsletters, billing inserts, and Instagram and Facebook postings. As a member of the Santa Cruz Water Conservation Coalition (watersavingtips.org), SLVWD contributes to presentations to the general public and professional organizations, and informational workshops.

In compliance with SB555, SLVWD has been conducting and submitting water loss audit reports to DWR. The SLVWD audit score was consistently between 49 and 51 in 2016 to 2019.

Scotts Valley Water District Water Use Efficiency Activities

SVWD recognizes that using water efficiently is an integral component of a responsible water management strategy and is committed to providing education, tools, and incentives to help its customers understand and manage the amount of water they use. SVWD's water demand has already shown significant decline in recent years, which is attributed to SVWD's ongoing water use efficiency activities in conjunction with the expansion of recycled water use for landscape irrigation. Since 2010, SVWD's water demand has been lower than its SB X7-7 2020 target of 154 GPCD (WSC & M&A, 2021). In December 2015, with the continuance of the drought and the Governor's Emergency Drought Regulations, SVWD potable demand was reduced to 93 GPCD. SVWD's calculated GPCD for 2020 is 96 GPCD. Since 2015, SVWD's annual potable demand has averaged 96 GPCD, ranging between 93 and 100 GPCD.

SVWD actively pursues incidents of water waste by investigating, recommending corrective action, and providing follow-up documentation of resolution. A water waste prevention ordinance was first adopted in 1983 and most recently revised in June 2020 (Policy P500-15-1).

All potable and recycled water use in SVWD is metered, and customers are billed by volume of usage on a bimonthly basis. An increasing block rate structure for residential customers has been in place since 1992 incentivizing the efficient use of water.

In 2017, the SVWD Board of Directors approved the advanced metering infrastructure (AMI) project with a goal of installing advanced metering technology at all meters. As of April 2021, all but less than 10 meters in the District have been upgraded. The new meters, combined with the WaterSmart customer engagement portal, allow customers to view hourly usage history, receive leak alerts and high-bill notifications, explore water saving actions and apply for rebates.

SVWD conducts a variety of public education activities such as a dedicated Water Use Efficiency Page on its website, regular ads in the local newspapers, e-newsletters, billing inserts, Instagram, and Facebook postings. SVWD's Water Use Efficiency Coordinator also makes presentations to the general public and professional organizations, conducts informational tours and is available for free water-wise house calls.

In response to the 2012-2015 Statewide drought, SVWD created a Think Twice Water Efficiency Campaign comprised of a customer scorecard, bumper stickers, lawn signs, 2-day per week watering schedule, enhanced rebates, hotel and food service placards, and a direct toilet replacement program. Customer response to the campaign was very positive and resulted in a 24% drop in potable water demand. The trend of efficient water use has continued with no significant bounce back in consumption since 2016.

SVWD continues to use the Think Twice Program, which has been slightly modified since the 2012-2015 drought. The 2020 Program comprises the following components:

1. Education and outreach,
2. Rebates,
3. Water waste policy, and
4. Water targets for potable landscape accounts.

https://www.svwd.org/sites/default/files/documents/reports/Program_Think_Twice.pdf

The Rebate Program is reviewed annually, and components are changed to achieve optimal use of ratepayers' dollars for incentivizing the efficient use of water. The 2020 Rebate Program includes nine categories: lawn or impervious hardscape replacement, spray irrigation replacement, spray to rotator nozzle replacement, greywater irrigation, rainwater cistern, downspout diversion, pressure regulator, toilet replacement, and urinal replacement. An example of the benefit of this program is demonstrated in estimated water savings of 950,00 gallons from 133 rebates in WY2019 and 923,000 gallons from 133 rebates in WY2020. These are estimated annual savings which carry over into subsequent years and realize cumulative savings as more rebates are added every year.

An additional conservation effort by SVWD, in compliance with SB555, involves conducting and submitting annual water loss audit reports to DWR. SVWD's audit score has improved every year: from 51 in 2016 to 53 in 2017 to 60 in 2019.

County of Santa Cruz Conservation Activities

The County of Santa Cruz is not a water purveyor and therefore does not have ratepayers that typically form the backbone of a water conservation rebate program. Despite this, they promote water conservation throughout the County in several ways. The County participates in the Water Conservation Coalition of Santa Cruz County (watersavingtips.org) to provide outreach and education to residents, and to offer trainings to specialists such as landscapers. The County requires source metering and reporting of monthly usage on all public water systems with 5 or more connections. County staff offer well soundings to private well owners who want to see if their water levels have changed.

The County's water conservation program includes the following elements:

- Enforcement of an ordinance on all residential users prohibiting wasteful uses of water
- Requirement for replacement of inefficient toilet and showerheads at time of property sale
- Implementing building code requirements for efficient fixtures for all new construction and remodels
- Requiring water conservation forms as part of any new well permits for wells expected to use over 2 AFY

2.1.3.4.6.6 Recycled Water

The City of Scotts Valley owns and operates the Scotts Valley WRF and Tertiary Treatment Plant. Influent to the WRF is sourced entirely from within the City of Scotts Valley. The recycled water is used by SVWD to augment its water supply and to offset its groundwater extraction for non-potable uses. Recycled water has been used in the Basin since WY2002. Recycled water use increased quickly over the first nine years of its use, and since 2011 use has been between 160 to 200 AF per year. From WY2002 through WY2020, approximately 2,670 AF of recycled water has been used in the Basin (Figure 2-8).

The following specific recycled water programs are implemented by the City of Scotts Valley and SVWD and discussed in more detail in Section 2.1.1.4.3:

- The City of Scotts Valley has an order mandating use of recycled water for irrigation for new construction when permissible and economically feasible.

- Recycled Water Fill Station was activated in 2016-2018 and 2021 to offer free recycled water to District customers and City residents for permitted uses.
- In 2016, the City of Scotts Valley and Pasatiempo Golf Club, located outside of the Basin, reached an agreement for the City of Scotts Valley to provide treated wastewater to the golf course for irrigation. This allows Pasatiempo Golf Club to reduce its reliance on potable water from the City of Santa Cruz during peak-use months when irrigation demand is high. In support of this regional effort, SVWD released 10% of its total recycled water allocation in exchange for compensation that can be applied toward funding future projects. SVWD did not have a current identified use for the amount of recycled water that it supplied to the golf course.

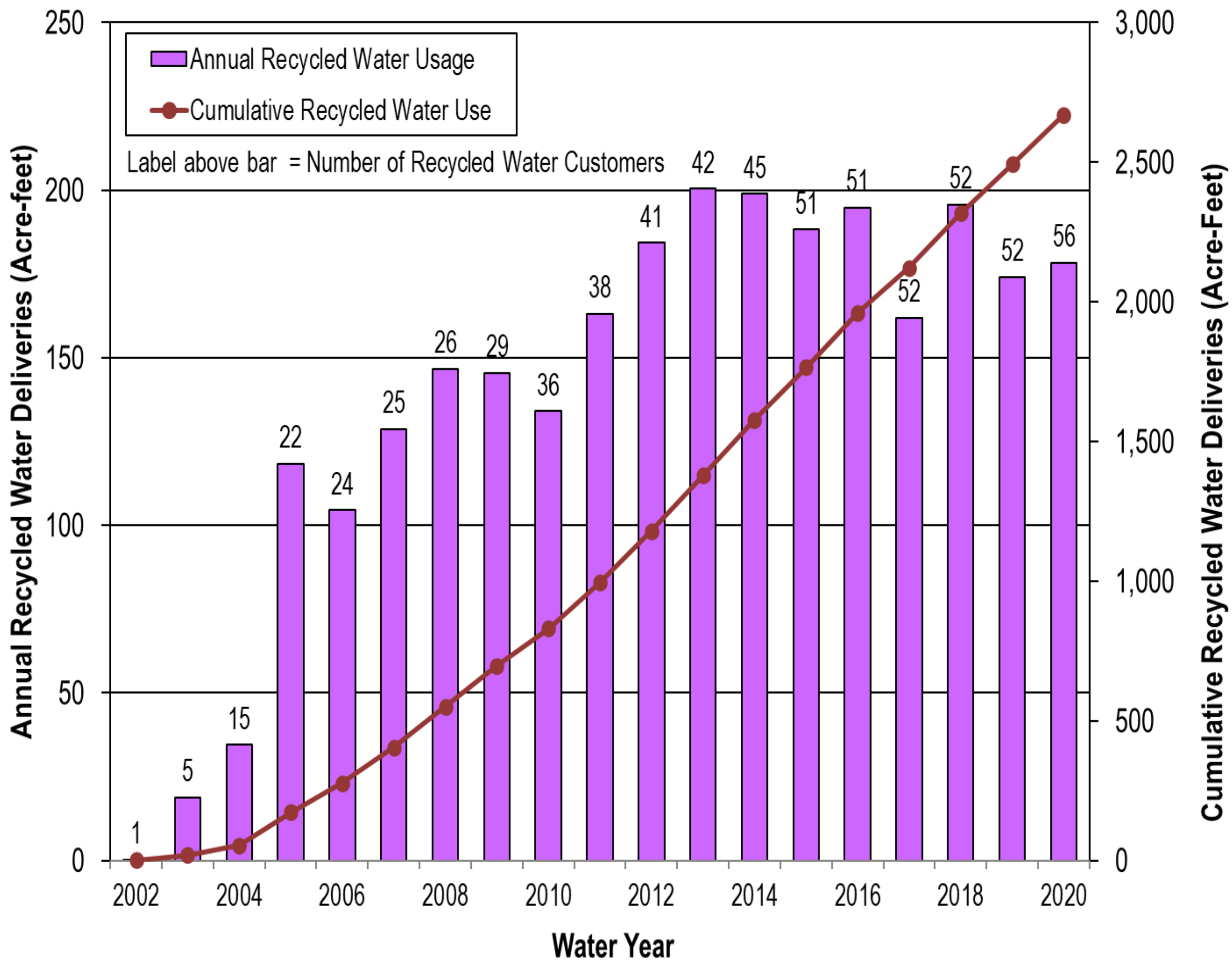


Figure 2-8. SVWD Reycled Water Deliveries, 2002-2020

2.1.3.4.7 Relationships with State and Federal Regulatory Agencies

Section 2.1.2 includes a description of monitoring and management programs that involve coordination with state and federal agencies. The SMGWA coordinated with representatives from the DWR throughout the GSP development. The following state and federal agencies were consulted during the preparation of this GSP:

- California Department of Fish and Wildlife (CDFW)
- California Department of Water Resources (DWR)
- Central Coast Regional Water Quality Control Board (CVRWQCB)
- National Marine Fisheries Service (NMFS, formerly NOAA Fisheries)
- State Water Resources Control Board (SWRCB)
- US Fish and Wildlife Service (USFWS)

As discussed in Section 2.1.4.1.1.2, the SMGWA established a Surface Water Technical Advisory Group that included local resource area experts, non-governmental organizations with extensive resource management and protection experience, and state and federal resource and regulatory agencies. The purpose of this group was to gather experts to discuss the resources, agency mandates, and best available science to develop recommendations for the SMGWA Board to consider when developing its depletion of interconnected surface water sustainable management criteria for the GSP.

In addition to working with various resource management agencies during the development of the GSP, SMGWA member agencies including the County of Santa Cruz, SLVWD, and SVWD have all established long-term working relationships with the resource management agencies identified above. Ongoing coordination and collaboration with these agencies focus on planning for and managing utility and resource protection programs and projects, utility operations, and development and construction of capital improvement projects.

2.1.3.4.8 Land Use Planning Related to Potential Risks for Groundwater Quality or Quantity

The land use change that could potentially affect groundwater quantity would be an expanded suburban population and accompanying increase in municipal groundwater demand. Commercial and suburban residential land development can increase paved surfaces in the Basin, which potentially decrease recharge if not offset with onsite infiltration of runoff. Decreased recharge in areas underlain by the Santa Margarita aquifer could potentially cause reduced quantity and quality of groundwater in that aquifer. Current planning by SVWD, SLVWD, and the County does not anticipate a large increase in the Basin's population. SVWD population is projected to increase annually by 0.87% from 2020 to 2045 and SLVWD's population is projected to increase annually by 0.15% over the same time period (WSC & M&A, 2021). Current CCRWQCB stormwater policies require that all new development and redevelopment include measures to maintain runoff and infiltration rates at pre-development levels (City of Scotts Valley, 2017). Furthermore, projects and management actions to be implemented and included in Section 4 of this GSP increase water supply resiliency and achieve sustainability while considering anticipated future water demands related to population growth.

An increase in the Basin's rural population, most of whom are served by septic systems rather than by municipal wastewater systems, may also affect groundwater quantity and quality by increasing groundwater use and potentially leaching nitrate and other organic compounds to groundwater. There is no expected expansion of communities on septic systems according to the County. Any new rural development using septic systems in the sandy soils of the Basin requires use of enhanced treatment to reduce nitrogen and other constituents prior to wastewater dispersal.

There are several sand quarry sites in the Basin that are now either closed or not operating at full capacity. A land use change at these sites, either to a recurrence of mining or to another land use, has the potential to impact groundwater quality by mobilizing contaminants present on site. Permitting by SCEH should identify and mandate solutions to groundwater quality issues at these sites.

2.1.3.4.9 Impacts on Groundwater Dependent Ecosystems

The SGMA legislation identified protection of GDEs as 1 of the goals of sustainable groundwater management. Per the definitions in the GSP Regulations § 351(m), GDEs refer to "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." Interconnected surface water is defined by § 351(o) as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted."

Impacts to GDEs within the Basin have yet to be identified. The groundwater model shows a Basin-wide reduction in streamflow from pumping, but without GDE monitoring data, a quantifiable correlation has yet to be established. On-going programs such as Santa Cruz County's Juvenile Steelhead and Stream Habitat Monitoring Program have monitored steelhead density and stream habitat since 1994. No correlation between the amount of creek baseflow and fish density or habitat availability has been identified, perhaps because other factors, both anthropogenic and naturally occurring, can affect habitat abundance. GDE data collected per the monitoring plan in Section 3 is anticipated to provide the necessary data to establish whether there is a connection between groundwater conditions and the abundance of GDE habitat and priority species.

2.1.4 Notice and Communication

2.1.4.1 Communication and Engagement

2.1.4.1.1 Decision-Making Process

2.1.4.1.1.1 SMGWA Board of Directors

The JPA between SVWD, SLVWD, and the County of Santa Cruz (included as Appendix 1B) that created the SMGWA requires the GSA to hold public meetings at least quarterly. The meetings are required to be noticed and meet all of the requirements of the Ralph M. Brown Act for transparency in California government. To hold a valid meeting, the SMGWA must have a quorum of the Board of Directors, which consists of an absolute majority of directors plus 1 director. With these requirements in mind, the SMGWA:

- Holds board meetings on a regular schedule (every month)
- Provides written notice of meetings with meeting agenda and meeting materials available at least 72-hours prior to the meeting time
- Sends email meeting reminders to SMGWA's contact lists that includes approximately 345 unique email addresses
- Posts meeting agenda at the meeting location prior to the meeting as required

Under SGMA, the SMGWA Board of Directors is responsible to approve a GSP and submit it to DWR on or before January 31, 2022. Once a quorum is present, most SMGWA decisions require a simple majority of all appointed directors participating in the vote. If a director is disqualified from voting on a matter before the Board because of a conflict of interest, that director shall be excluded from the calculation of the total number of directors that constitute a majority.

There are certain matters that come before the SMGWA Board of Directors that require a unanimous vote of all SMGWA member agency directors participating in the vote. These include approval of any of the following:

- Capital expenditures estimated to cost $50,000 or more
- Annual budget
- GSP for the Basin or any future amendments
- Levying of assessments or fees
- Issuance of indebtedness
- Stipulations to resolve litigation concerning groundwater rights within or groundwater management for the Basin

SMGWA agendas include general public comments at the beginning of each board meeting. General comments allow community members to raise any groundwater related issue that is not on the agenda. Public comment time is also given prior to a vote on all agenda items to ensure public opinion can be incorporated into SMGWA Board of Director decisions. The public may also make submissions to the board for inclusion in the meeting packet.

The SMGWA Board directs agency staff to fulfill the various requirements of SGMA. To do this, SMGWA staff provides the Board with research and recommendation staff reports, work plans, technical summaries, budgets, and other work products as required to support Board decision-making.

2.1.4.1.1.2 Surface Water Technical Advisory Group

Representatives from the following organizations and agencies participated in 2 technical Surface Water Technical Advisory Group (TAG) meetings to assist with development of sustainable management criteria:

- California Department of Fish and Wildlife
- California Department of Water Resources
- City of Santa Cruz Water Department
- County of Santa Cruz Environmental Health
- Environmental Defense Fund
- Land Trust of Santa Cruz County
- National Marine Fisheries Service (formerly NOAA Fisheries)
- The Nature Conservancy
- Resource Conservation District of Santa Cruz County
- San Lorenzo Valley Water District
- Santa Margarita Groundwater Agency
- Scotts Valley Water District
- U.S. Fish and Wildlife Service

The 2 meetings held on August 14, 2020, and February 24, 2021, provided the TAG background information on the hydrogeological setting of the Basin, City of Santa Cruz habitat conservation planning, Santa Cruz County fish monitoring, potential conjunctive use opportunities for SLVWD, water budget, and current understanding of the relationship between surface water and groundwater. Based on the background information available, the technical team shared potential approaches for developing SMC for the depletion of interconnected surface water and plans for

GDE monitoring. The TAG was asked to provide specific input on the SMGWA Board's statement of significant and unreasonable, potential SMC approaches, and GDE monitoring plan. Their expert input was taken into account in the development of SMC and the GDE monitoring plan.

2.1.4.1.2 Communication and Engagement Plan

A Stakeholder Communication and Engagement Plan (C&E Plan) has been developed to assist the SMGWA in its efforts to disseminate and receive feedback on relevant information and to engage the public, including groundwater beneficial users, regarding the development and implementation of SMGWA's GSP with a particular focus on fulfilling and exceeding the requirements of § 354.10 Notice and Communication of the SGMA). The C&E Plan, included as Appendix 2A, is a work plan to ensure sufficient opportunities for public participation are included in the GSP process.

The C&E Plan also provides SMGWA board members and staff a guide to ensure consistent messaging about SGMA requirements and other related information. It establishes a roadmap for GSP development that identifies how and when beneficial users and other stakeholders can provide timely and meaningful input into GSA decision-making. Additionally, the C&E Plan ensures beneficial users and other stakeholders in the SMGB are informed of milestones and offered opportunities to participate in GSP development and implementation.

The C&E Plan covers a 4-phase approach that includes ongoing communication efforts, GSP development, GSP rollout, and future efforts following GSP submission in January 2021 and beyond as the GSP is implemented.

Stakeholder involvement and public outreach is critical to GSP development and implementation because it helps promote the plan development based on input and broad support. Some essential elements of public outreach are providing timely and accurate public reporting of planning milestones through the distribution of outreach materials and posting of materials on the SMGWA website, securing quality media coverage and utilizing social media.

The phased approach to outreach allows opportunities to assess the program and evaluate how the C&E Plan is performing against its goals and objectives. Assessment is conducted by the cooperating agency staff and reviewed by Board members during quarterly communications updates to the Board.

Ongoing activities in the GSP implementation phase starting in 2022 are expected to include: maintenance of the SMGWA website; continued social media presence through Facebook and Instagram; email newsletter; youth engagement efforts; promoting and conducting community meetings, workshops and events; coordination with member agencies to share information; and developing print materials as necessary.

2.1.4.2 Beneficial Users of Groundwater

As part of the GSP process, beneficial users of groundwater in the Basin are identified by the SMGWA based on categories described in the SGMA and codified in CWC §10723.2. Beneficial users of groundwater in the Basin include municipal well operators, agricultural users, private domestic well owners, small water systems, local land use planning agencies, surface water users, environmental users of groundwater, California Native American Tribes, disadvantaged communities (DACs), protected lands (including recreational areas), public trust uses (including wildlife, aquatic habitat, fisheries, recreation, and navigation), and entities engaged in monitoring and reporting groundwater elevations.

CWC §106.3 recognizes that "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes." The Human Right to Water extends to all Californians, including disadvantaged individuals, groups, and communities in rural and urban areas. When developing this GSP, the SMGWA considered impacts on all beneficial uses and users, including domestic well owners and DACs. By addressing all beneficial uses and users, the GSP has addressed California's Human Right to Water

2.1.4.2.1 Municipal Water Agencies

The primary groundwater extractors in the Basin are the 2 municipal water agencies described in Sections 2.1.1.4.2.1 and 2.1.1.4.2.2: SLVWD and SVWD, respectively. Figure 2-9 shows the locations of active municipal water supply wells used by the 2 water districts, and Figure 2-33 shows their historical annual extractions relative to other groundwater extractors. Where the municipal water agencies' source of water supply is groundwater, their customers are beneficial users of groundwater.

The City of Santa Cruz and its customers are indirect user of groundwater in the Basin. Since surface water is interconnected with groundwater in the Basin, the City of Santa Cruz is an indirect groundwater user because the surface water it diverts from the San Lorenzo River for municipal use partially comprises baseflows supported by Basin groundwater discharge to creeks. The City owns property, which is partly located in the Basin, associated with water supply use and construction of the Loch Lomond Reservoir.

2.1.4.2.2 Mount Hermon Association

The Mount Hermon Association (MHA) is located near Bean Creek upstream from the confluence with the San Lorenzo River (Figure 2-9). MHA is a year-round conference center and camp that serves more than 60,000 guests each year and a community of approximately 1,300 people living in 450 homes. Groundwater is the sole source of potable water supply for the conference center and surrounding homes. MHA's water supply is from 2 wells located on MHA property. Figure 2-33 shows MHA's historical annual extractions relative to other groundwater extractors. Average groundwater extracted since MHA started using groundwater in 1991 is 172 AFY. Over the past 5 years pumping has been reduced to around 140 AFY due to increased water conservation awareness in the community. The Joint Powers Agreement (JPA) provides that MHA has 1 representative on the Board.

2.1.4.2.3 Small Water Systems

There are 12 small water systems (SWS) supplying water to 5 or more residential connections within the Basin, serving a population of approximately 1,000. Most SWS use groundwater, but some have water rights to divert surface water as their water source (Table 2-8).

Table 2-8. Small Water Systems in the Santa Margarita Basin

Small Water System	Number of Connections	Water Source
Fern Grove Water Club	67	groundwater
Fernbrook Woods Mutual Water Company	10	groundwater
Forest Springs	126	supplied water from outside the Basin
Hidden Meadow Mutual Water Company	17	groundwater
Karls Dell	8	groundwater
Love Creek Heights Mutual Water Association	7	groundwater
Mission Springs Conference Center	118	groundwater
Moon Meadows Water Company	5	groundwater
Quail Hollow Circle Mutual Water Company	7	spring
Roaring Camp	non-community	groundwater
Vista Robles Association	21	groundwater
Zayante Acres Mutual Water Company	8	spring

Source: State Water Resources Control Board, Division of Drinking Water

2.1.4.2.4 Private Domestic Pumpers

In areas where there is no municipal or small water system supply, private individuals extract groundwater for residential purposes from wells they own or share ownership with fewer than 5 other homes. It is estimated that the population of the Basin depending on private water supply is approximately 3,000. The approximate locations of private domestic pumpers are shown on Figure 2-9. Typically, these users extract less than 2 AFY. Under the SGMA, domestic use less than 2 AFY is called *de minimis* use and is exempt from metering by the SMGWA.

2.1.4.2.5 Disadvantaged Communities

There are 2 DAC Census Block Groups, both of which are partially located within the Basin (Figure 2-9). Within the Basin, the DACs include part of the Census Designated Places of

Boulder Creek, Brookdale, and Ben Lomond. These communities were severely impacted by the CZU Complex wildfires in August 2020. Some of the DAC residents receive their water from SLVWD, but there are also many that rely on private domestic wells as shown on Figure 2-9. All parcels within the DACs are on septic or a small community wastewater disposal system.

Unlike many DACs throughout California, these Block Groups are not a cohesive community. They are generally made up of small parts of several disparate larger communities that have been grouped together by the Census. The Block Group also provides an artificial boundary within which to focus special attention. In all of the communities located within the Basin, there are people who meet the income requirements considered "disadvantaged", but they are not concentrated together in a defined location. Communities within the Block Group are grouped into beneficial user types under their source of water supply, which is either municipal water or privately pumped (Figure 2-9).

2.1.4.2.6 Agricultural Irrigators

Of the approximately 18 acres of agriculture-zoned parcels in the Basin, only less than 0.2 acres are being irrigated. This irrigation is at a vineyard currently owned by Skov Winery. A vineyard has existed here since 1972. Currently, there are no official records of cannabis cultivation and its irrigation in the Basin. In future updates to the GSP, cannabis irrigation should be considered when records are available.

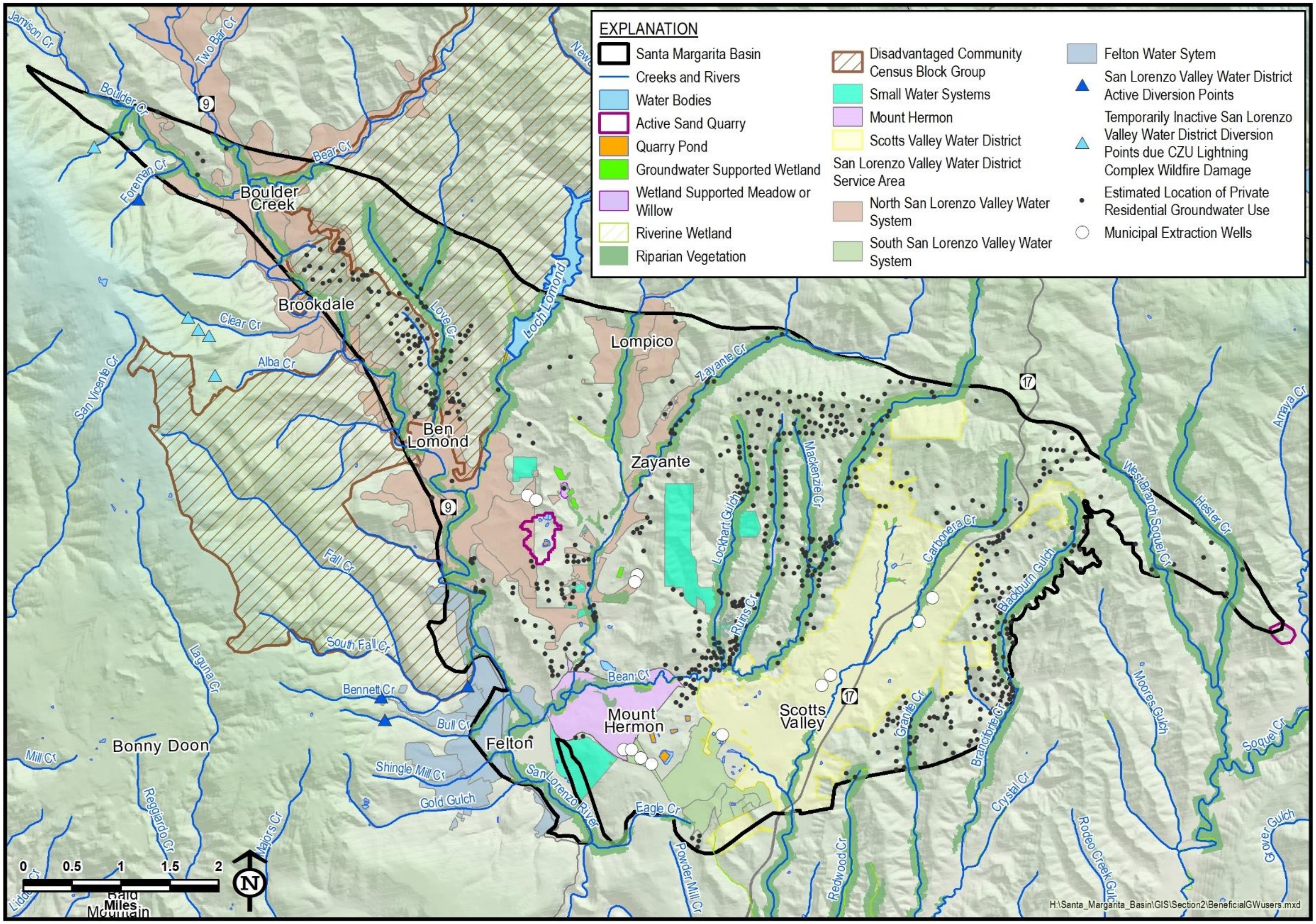


Figure 2-9. Benefical Users of Groundwater in the Santa Margarita Basin

2.1.4.2.7 Industrial Users

Groundwater pumping for industrial use in the Basin is currently minimal. Historically, more groundwater was pumped by the operators of the 3 sand quarries (Hanson Quarry, Olympia Quarry, and Quail Hollow Quarry) for process water and dewatering. Hanson and Olympia Quarries ceased operations in the early 2000s and are undergoing restoration. Quail Hollow is still an active quarry, though concurrent reclamation efforts are underway in some areas where mining has ceased.

2.1.4.2.8 Ecological Users

Groundwater dependent ecosystems in the Basin support many different species, some of which are listed as priority species by either the federal Endangered Species Act of 1973 (U.S.C. §1531 et seq.; USFWS, 2021) or the California Endangered Species Act of 1970 (Fish and Game Code § 2050 et seq.; CDFW, 2021). For example, Central California Coast coho salmon and Central California Coast steelhead trout are federally listed as endangered and threatened, respectively. Other priority species that depend on instream flows for sustenance including lamprey, California red-legged frog, western pond turtle, and California giant salamander.

The San Lorenzo River is an important river for local fisheries. Historically, the river supported the largest coho salmon and steelhead trout fishery south of San Francisco Bay. While coho salmon are critically endangered in the San Lorenzo Watershed (and Santa Cruz and San Mateo counties, in general), the federal recovery plan identifies the San Lorenzo Watershed as an "independent watershed" and critical for recovery within the Central California Coast evolutionary significant unit. Coho salmon successfully reproduced in the San Lorenzo Watershed in 1981, 2005 and 2008 in limited areas. In addition, adult coho salmon have been observed in the lagoon and in Felton during other years. Coho salmon do have the capacity for recovery, as shown by their new intermittent (i.e., not every year) population in Laguna Creek. As required by SGMA, the GSP should conform with existing management plans such as federal recovery plans.

The San Lorenzo River has been designated as a fully appropriated stream during the summer months to maintain environmental flows in the river to support fish habitat. While these bypass flows produce important instream benefits in riverine environments, they produce equally important benefits for the San Lorenzo River estuary/lagoon that provides critical habitat for rearing of juvenile steelhead.

Critical species in the Basin that likely rely on GDEs are compiled from the California Natural Diversity Database and information available from the California Department of Fish and Wildlife (CDFW) and The Nature Conservancy (TNC; CDFW, 2020a; TNC, 2021). The priority species, and their locations either known or thought to be found in the Basin are summarized in Table 2-9. GDEs in the Basin are discussed in more detail in Section 2.2.4.9. Additional species that should be considered but are not listed as priority species are presented in Table 2-10 lists species that are co-beneficiaries of the priority species; if the habitat requirements of the priority species are met then the habitat requirements of the co-beneficiary species are also met. The co-beneficiaries are currently not listed threatened or endangered species.

Table 2-9. Groundwater Dependent Species Identified for Priority Management

Species Common Name	Type of Species	Occurrence Frequency	Location(s)
California Giant Salamander	Amphibian	Frequently present	Probably distributed widely in basin. Bean Creek, Lockhart Gulch, Ruins Creek, Zayante Creek, Lompico Creek, San Lorenzo River
California Red-Legged Frog	Amphibian	-	Bean Creek, Mountain Charlie
Coho Salmon	Fish	Rare	Bean Creek, Zayante Creek, San Lorenzo River
Lamprey	Fish	Occasional to Common	Bean Creek, Zayante Creek, Newell Creek, San Lorenzo River
Steelhead	Fish	Common	Bean Creek, Zayante Creek, Lompico, Mackenzie, San Lorenzo River, Newell Creek, Love Creek, Boulder Creek
Western Pond Turtle	Reptile	Rare	Zayante Creek, Newell Creek, San Lorenzo River

Species with no quantified frequency marked with "-"

Table 2-10. Groundwater Dependent Species Identified as Co-Beneficiaries of Priority Species

Species Common Name	Type of Species	Occurrence Frequency
Belted Kingfisher	Bird	Occasional
California Dipper	Bird	Rare; feeds in streams
California Newt	Amphibian	-
California Roach	Fish	Common
Coastrange Sculpin	Fish	Common
Common Merganser	Bird	Uncommon
Dace	Fish	Common
Deceiving Sedge/Santa Cruz Sedge	Plant	-
Downy Woodpecker	Bird	Common
Marsh Sandwort	Plant	-
Mount Hermon June Beetle	Insect	-
Prickly Sculpin	Fish	Common on Newell Creek
Rough Skinned Newt	Amphibian	-
Sacramento Sucker	Fish	Common
Santa Cruz Black Salamander	Amphibian	-
Slender Salamander	Amphibian	-
Swamp Harebell	Plant	-

Species Common Name	Type of Species	Occurrence Frequency
Tidewater Goby	Fish	Rare
Warbling Vireo	Bird	Uncommon
Western Bumble Bee	Insect	-
Western Pearshell	Bivalve (Mussel)	-
Western Red Bat	Mammal	CA species of special concern
Western Sycamore	Plant	-
Western Wood-Pewee	Bird	Uncommon

Species with no quantified frequency marked with "-"

The City of Santa Cruz has reached a level of agreed flows in the San Lorenzo River and will be formalizing those flows through its pending water rights action. Current regulatory instream flow requirements exist on Fall Creek upstream of its confluence with the San Lorenzo River (see Figure 2-5 for location), Newell Creek below Loch Lomond Reservoir, and the San Lorenzo River at Felton. For Fall Creek, the minimum November through March bypass flow is 0.75 cubic foot per second (cfs) for dry years, and 1.5 cfs for other years; April through October bypass flow is 0.5 cfs for dry years, and 1.0 cfs for other years. Dry years are defined based on cumulative flow volume in the San Lorenzo River at Big Trees from the beginning of the water year. On Newell Creek below Loch Lomond Reservoir, a flow of 1.0 cfs must be maintained year-round to provide adequate depths for fish passage and spawning. On the San Lorenzo River at Big Trees, if flows fall below monthly minimum rates of 10.0 cfs in September, 25.0 cfs in October, or 20.0 cfs November through May, diversions from Fall and Bull Creeks must be terminated (Exponent, 2019).

While these are currently the only locations with mandated flows in the Basin, there are many resources available to evaluate instream flows if a basin-wide approach is warranted. North Coast Instream Flow Policy (R2 Resource Consultants, Inc and Stetson Engineers, 2008) provides guidelines for maintaining instream flows to protect anadromous salmonids. In general, summer rearing flows are just as critical, if not more so than spawning and passage flows. Summer rearing flows when the creek flow mostly comprises baseflows fed by groundwater are more impacted by groundwater extraction than spawning and migration flows, which are primarily influenced by rainfall and runoff.

Table 2-11 lists minimum stream depth and dates for passage, and Table 2-12 lists dates, minimum stream depths, favorable velocities, and useable substrate for spawning.

Table 2-11. Steelhead and Coho Minimum Passage Criteria

Species	Dates	Minimum Passage Depth Criterion (feet)
Steelhead	November 1 to March 31	0.7
Coho	October 1 to February 28	0.6

Table 2-12. Steelhead and Coho Spawning Criteria

Species	Dates	Minimum Depth (feet)	Favorable Velocities (feet/second)	Useable Substrate D_{50} (mm)
Steelhead	December 1 to March 31	0.8	1.0-3.0	12-46
Coho	November 1 to February 28	0.8	1.0-2.6	5.4-35

A variety of other methods and models can be used to estimate instream flow requirements that provide the minimum depths required for fish passage or spawning:

- 1-D and 2-D hydraulic models to assess flow depths and velocities for streams with available topographic data.
- Physical Habitat Simulation developed by the USGS combines both biologic and hydraulic inputs to simulate the relationship between streamflow and physical habitat to establish instream flow requirements (USGS, 2012).
- Regression equations are another option when site-specific topographic data are absent, but streamflow data are available (R2 Resource Consultants, Inc and Stetson Engineers, 2008). These equations were developed by establishing a relationship between cross-sectional data with mean annual flow for unimpaired gaged.
- Field-based approaches such as the Wetted Perimeter Method can also be used by performing repeat transects at various flow rates at known hydraulic bed controls (CDFW, 2020b).

Understanding the biological response of priority species to available habitat is another important consideration. Santa Cruz County's Juvenile Steelhead and Stream Habitat Monitoring Program measures the density of juvenile steelhead and assesses habitat conditions for steelhead and coho salmon in 4 watersheds of Santa Cruz County including the San Lorenzo River watershed. Presence/absence data are collected for select species of fish, amphibian, and reptiles including all the priority species listed in Table 2-9. Habitat data are also collected in select stream reaches. The species and habitat data are compiled into an annual report and a geodatabase for spatially referenced information. This work is ongoing and has occurred in every fall since 1994 (Beck et al., 2019), and can be used to establish links between streamflow, groundwater conditions, GDE habitat, and presence or absence of priority aquatic species.

The City of Santa Cruz is currently in the process of preparing or implementing 3 different Habitat Conservation Plan(s) [HCP(s)] that will help protect environmental beneficial users of groundwater (City of Santa Cruz, 2011 and 2020). An HCP is a planning document required as part of an Incidental Take Permit under the Endangered Species Act. The HCP describes effects of City activities that may result in any harm or damage to threatened and endangered species (incidental take), and how those effects will be tracked, avoided, minimized, and mitigated.

Multiple species are covered by 3 different HCPs for City activities:

- Administrative draft Anadromous Salmonid HCP submitted to the National Marine Fisheries Service (NMFS) and CDFW on July 10, 2020
- Administrative draft USFWS HCP for 10 species that are state or federally listed as threatened, endangered, or species of special concern is currently in final review
- Low Effect Mount Hermon June beetle HCP currently being implemented

The City of Santa Cruz has agreed with NMFS and CDFW on long-term minimum streamflows (Agreed Flows). The City of Santa Cruz plans to complete the Anadromous Salmonid HCP with NMFS and an Incidental Take Permit with CDFW by 2023.

2.2 Basin Setting

2.2.1 Overview

The Santa Margarita Groundwater Basin lies in the north central portion of Santa Cruz County (Figure 2-1) in the Santa Cruz Mountains. The Basin is a geologically complex area that was formed by the same tectonic forces along the San Andreas fault zone that created uplift of the Santa Cruz Mountains and the rest of the California Coast Range.

The Basin consists of a section of sandstone, siltstone, and shale/mudstone overlying a basement of granitic and metamorphic rocks, all of which have been folded into a geologic trough called the Scotts Valley Syncline. The sedimentary rocks are divided into numerous formation based on the types of rock and their relative ages, as determined by field mapping and paleontological studies performed by the United States Geological Survey (Clark, 1981; Muir, 1981; Brabb et al, 1997; McLaughlin et al, 2001). The sandstone formations make the best aquifers due to their large porosity and permeability. Three serve as the primary aquifers that are pumped to supply much of the Basin's water demand: Butano Sandstone, Lompico Sandstone, and Santa Margarita Sandstone.

2.2.2 Topography

In general, surface elevation within the Basin increases to the north and east. Elevations within the Basin range from approximately 300 feet above mean sea level (amsl) in the vicinity of the San Lorenzo River at the southern end of the Basin, to more than 1,500 feet amsl along the northern boundary of the Basin at the peak of Mount Roberta. Figure 2-10 is a topographic map for the Basin.

At its northern margin, the Basin is characterized by a series of ridges and peaks running roughly parallel to the Zayante-Vergeles Fault. Named peaks include Mount Roberta (~1,500 ft amsl) and Eagle Dell Peak (~1,400 ft amsl). The rugged terrain of the northern part of the Basin is comprised of north-south trending, steep ridges alternating with V-shaped valleys. The topography is gentler and rolling in the southern and central parts of the Basin where the weakly consolidated Santa Margarita Sandstone occurs at the surface. At the south end of the Basin a relatively low-lying area stretches from Scotts Valley to Felton, where it joins the San Lorenzo River Valley. The San Lorenzo River Valley crosses the entire Basin near its western margin. Similarly, low-elevation valleys contain Newell Creek, Zayante Creek and Bean Creek, which are tributaries to the San Lorenzo River. The varied topography in the Basin is illustrated in a 3-dimensional rendering in Figure 2-11.

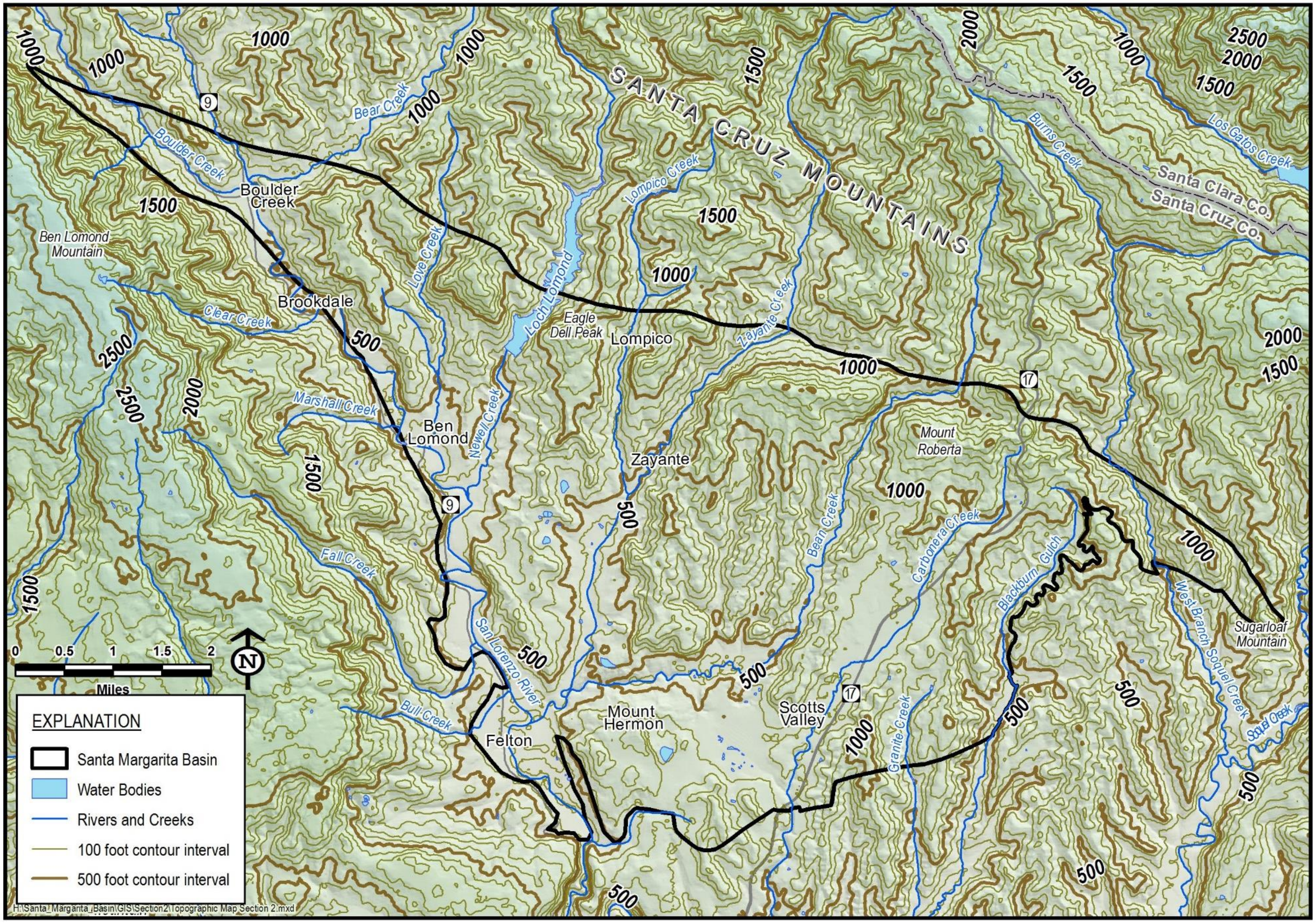


Figure 2-10. Santa Margarita Basin Topography

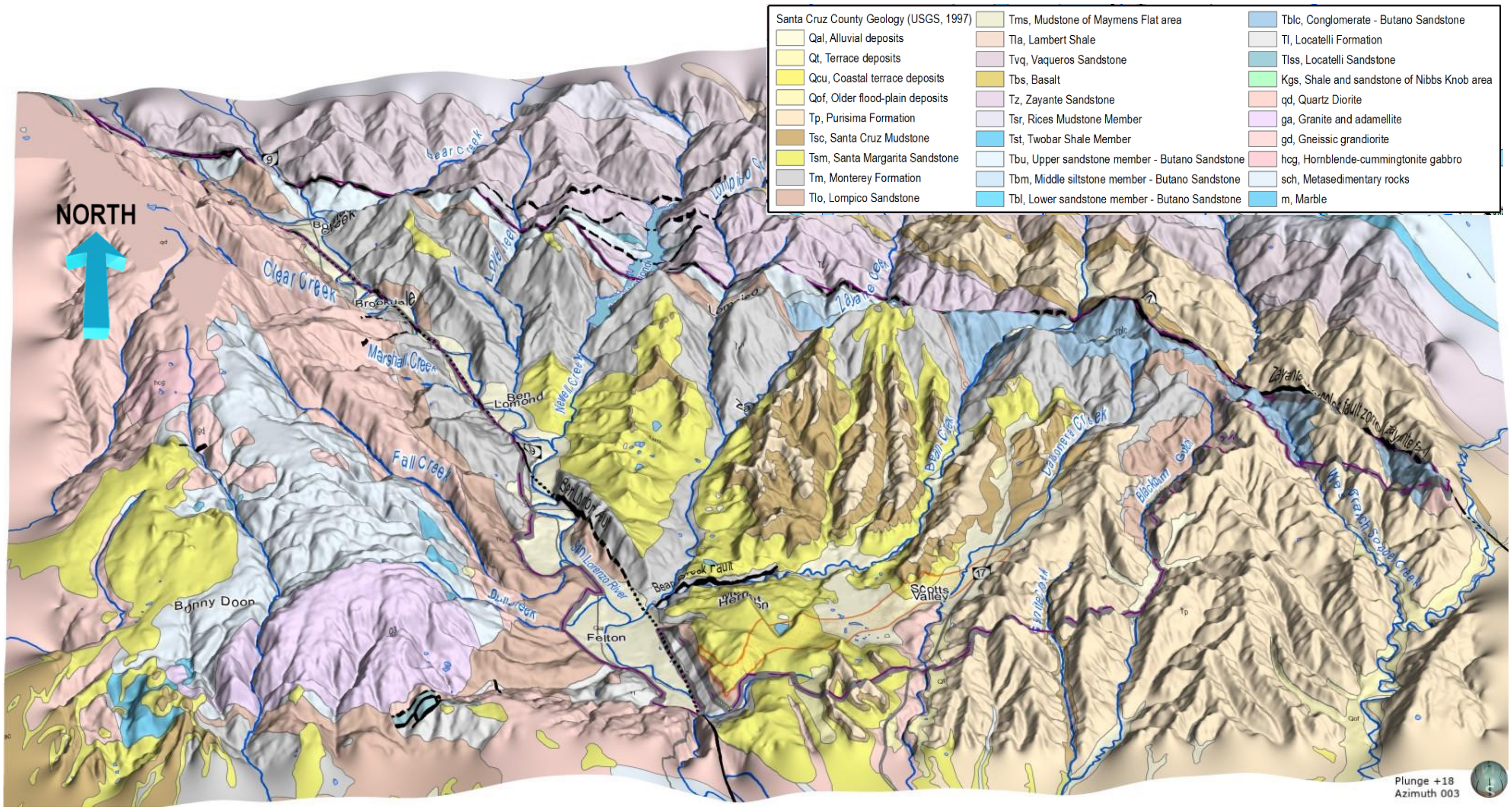


Figure 2-11. Three-Dimensional Topography of the Santa Margarita Basin with Surface Geology (3x exaggeration)

2.2.3 Climate

2.2.3.1 Historical Climate

The climate in Santa Margarita Basin is classified as Mediterranean, characterized by distinct rainy and dry seasons, warm summers, and mild winters (Kennedy/Jenks Consultants, 2015b). In an average year, almost all the Basin's precipitation occurs from November through April. Almost all precipitation is rainfall, though occasionally snow falls at the higher elevations. Precipitation increases across the Basin east to west from about 42 inches per year to 52 inches per year due to increased elevation and the orographic effect of Ben Lomond Mountain west of the Basin. The distribution of precipitation across the Basin from 1981-2010 is displayed on Figure 2-12.

Precipitation and temperature are measured at the El Pueblo Yard weather station in Scotts Valley (elevation ~580 feet above mean sea level [amsl]) and at the Boulder Creek weather station in downtown Boulder Creek (elevation ~508 feet amsl). Station-specific precipitation range, average, and annual departure from the average for the period between 1947 and 2018 are provided on Figure 2-12 and Figure 2-13. Average annual precipitation at the El Pueblo Yard station is 42 inches, with a maximum of 86 inches in WY1983, and a minimum of 20 inches in WY2014 (Table 2-13). Average annual precipitation at the Boulder Creek station is 52 inches, with a maximum of 112 inches in WY1983, and a minimum of 19 inches in WY1986 (Table 2-13). The temperature record is similar at the 2 stations. The average minimum and maximum temperatures are about 32ºF and 77ºF, respectively. In the warmer dry season, from May to October, average minimum and maximum monthly temperatures are around 41ºF and 95ºF, respectively.

Water year type is determined using the City of Santa Cruz water year classification. This classification is based on total annual runoff in the San Lorenzo River measured at the USGS Big Trees gauge, just south of its confluence with Bean and Zayante Creeks. The water year types are displayed on most of the hydrographs in this GSP.

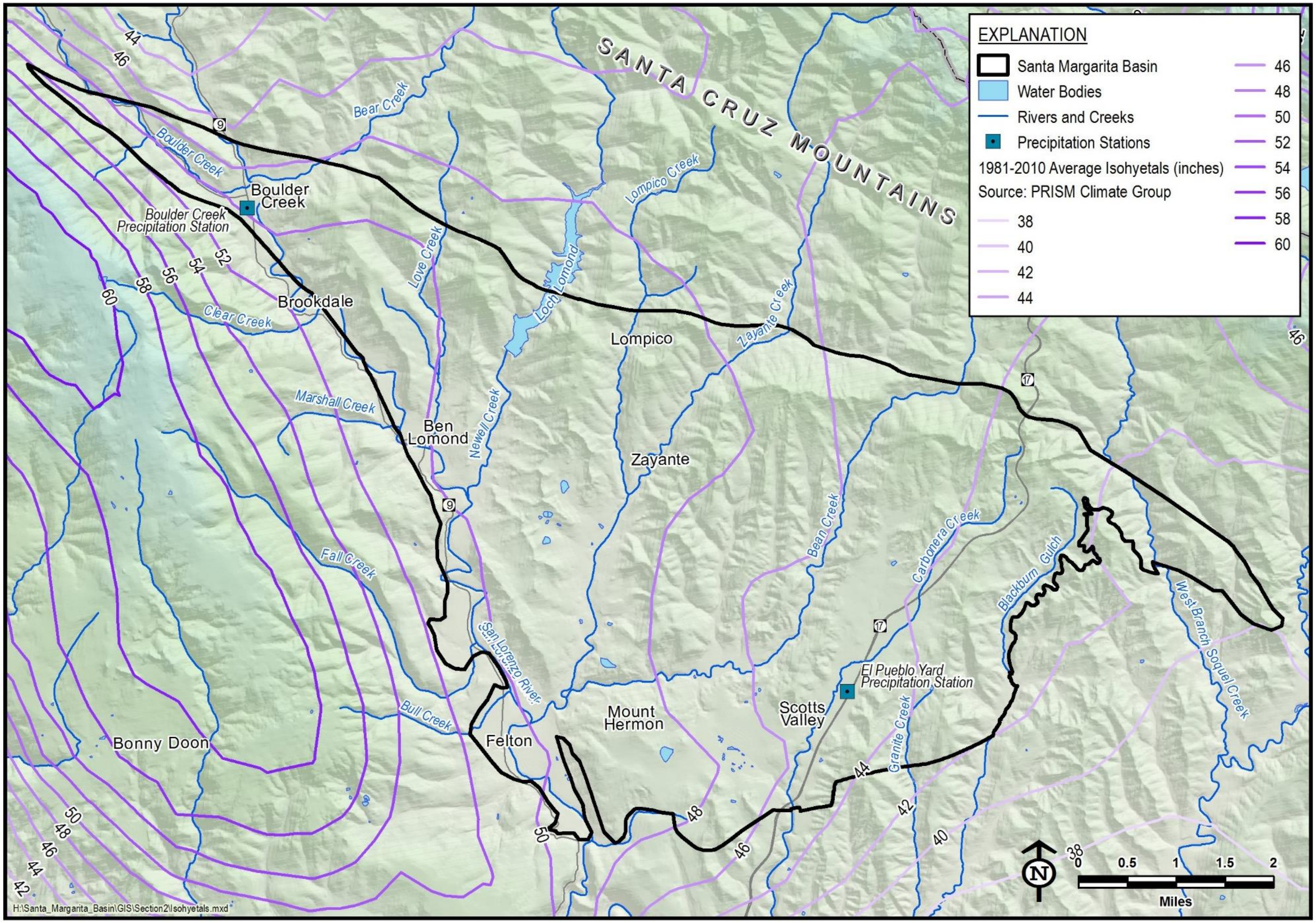


Figure 2-12. Distribution of Precipitation Across the Santa Margarita Basin

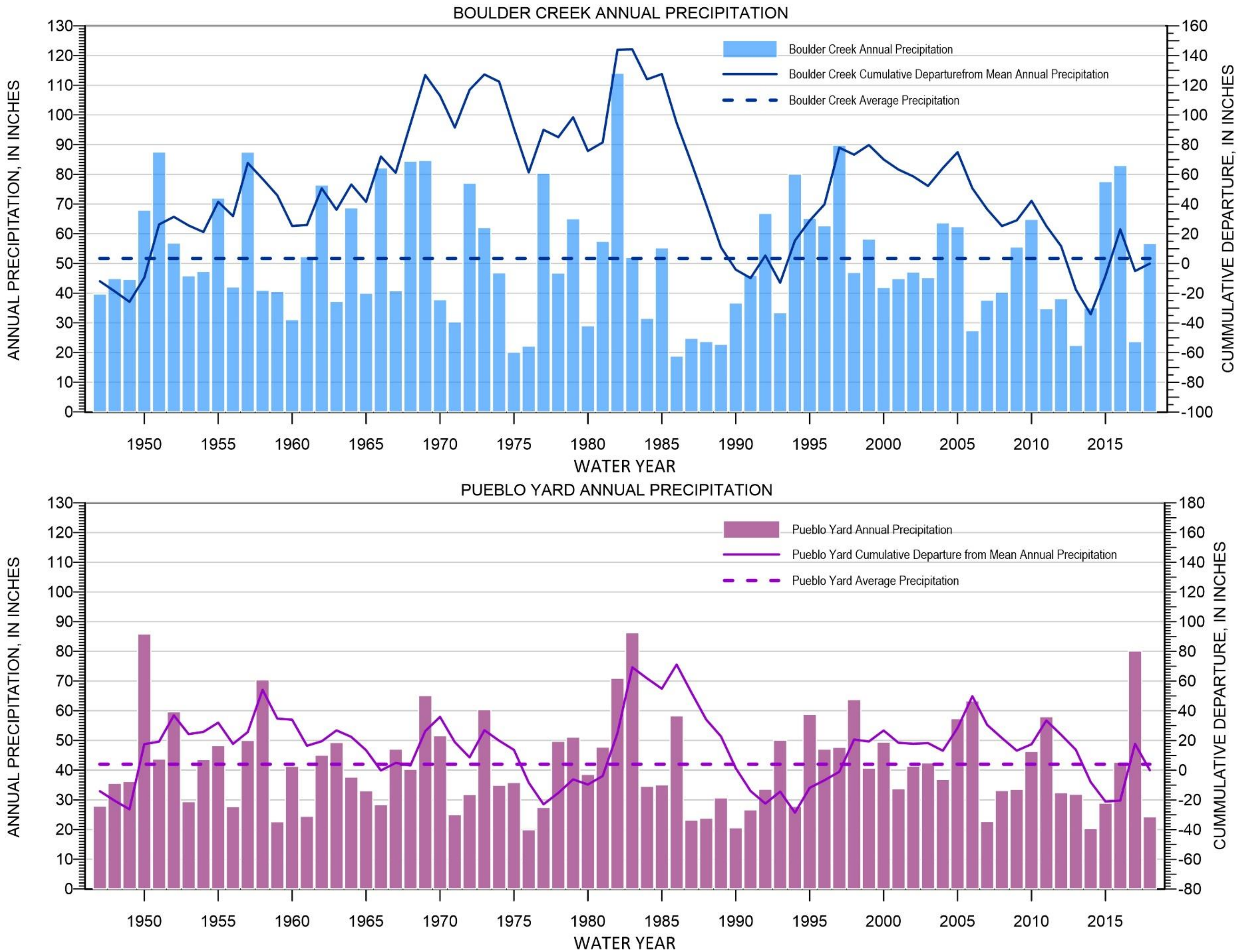


Figure 2-13. Annual Precipitation and Cumulative Departure from Mean Annual Precipitation in the Santa Margarita Basin

Table 2-13. Santa Margarita Basin Monthly Climate Summary

Month	Boulder Creek (SLVWD)			El Pueblo Yard (SVWD)		
	Average Rainfall (inches)	Average Monthly Minimum Temperature (ºF)	Average Monthly Maximum Temperature (ºF)	Average Rainfall (inches)	Average Monthly Minimum Temperature (ºF)	Average Monthly Maximum Temperature (ºF)
January	10.4	29.3	71.6	8.7	31.3	73.4
February	10.0	32.2	71.5	7.6	30.2	72.9
March	7.3	32.3	81.6	6.1	34.3	80.6
April	2.9	37.6	85.6	2.9	37.9	85.7
May	1.1	40.2	85.5	0.9	41.3	85.9
June	0.2	42.2	97.3	0.2	45.2	96.9
July	0.0	47.7	101.9	0.1	14.4	96.5
August	0.1	48.3	100.8	0.1	50.1	94.6
September	0.2	40.7	102.1	0.4	44.2	100.0
October	2.0	37.6	87.0	2.1	41.5	89.8
November	5.6	31.8	82.4	5.1	34.3	83.2
December	9.3	30.4	66.2	7.8	30.4	69.0

Sources:
SVWD rainfall data based on measurements from 8/1946 – 9/1/2019,
temperature data based on measurements from 10/2016 – 7/2020
SLVWD rainfall data based on measurements from 10/1980 – 9/2019,
temperature data based on measurements from 1/2017 – 12/2019

2.2.3.2 Projected Climate

Climate change is expected to impact the Basin in the future because of a rise in atmospheric greenhouse gases such as carbon dioxide and methane. Projecting climate change is a challenging task that has inherent uncertainty regardless of the method selected. The DWR provides 1 set of assumptions that can be used for GSP development, but the SMGWA elected to use a slightly different approach that better suited the groundwater model already developed for the Basin. The method described below was selected for use in the GSP projected scenario because it is based on the best available science, is consistent with other regional planning efforts, and provides a conservative estimate of future conditions in the Basin.

The DWR provides projected climate change data sets for use in GSP development that incorporate a single set of assumptions about future temperature, evapotranspiration, precipitation, and hydrology in 2 future years (2030 and 2070). Generally, DWR anticipates future regional climate conditions to be warmer than current conditions, with greater evapotranspiration, and more variable precipitation and streamflow (DWR, 2018). In part because this steady-state approach is not directly applicable to transient groundwater models where model inputs vary over time (i.e. the Santa Margarita GSP groundwater model), the DWR guidance document on climate change states that other climate change approaches can be used for developing projected water budgets in the GSP. The DWR climate change guidance states:

> *Local considerations and decisions may lead GSAs to use different approaches and methods than the ones provided by DWR for evaluating climate change. For example, the use of a transient climate change analysis approach may be appropriate where local models and data have been developed that include the best available science in that watershed or groundwater basin.*

The climate projection approach used for the GSP, described generally below and in more detail in the groundwater model description in Appendix 2D Section 7.1, is a transient climate projection developed based on an ensemble of 4 commonly used and scientifically defensible global climate models. The approach is similar to that being used by the City of Santa Cruz to develop their recent HCPs. The climate projection generally results in more variable precipitation (i.e., longer and more extreme droughts with fewer but more extreme rainfall events), slightly lower total precipitation, and warmer temperatures in the future in comparison to current conditions. Projected trends for the 4-model ensemble projection are compared against historical data and other climate models on Figure 2-14. Streamflow and evapotranspiration are simulated based on the precipitation and temperature projections. Figure 2-15 shows projected reference evapotranspiration controlled by temperature. It is important to note that the set of assumptions used in the climate projection used in developing this GSP is 1 scenario selected to be representative of the region, is consistent with other regional planning efforts, and is conservative about future climate change. There are many other equally likely climate scenarios that could also occur.

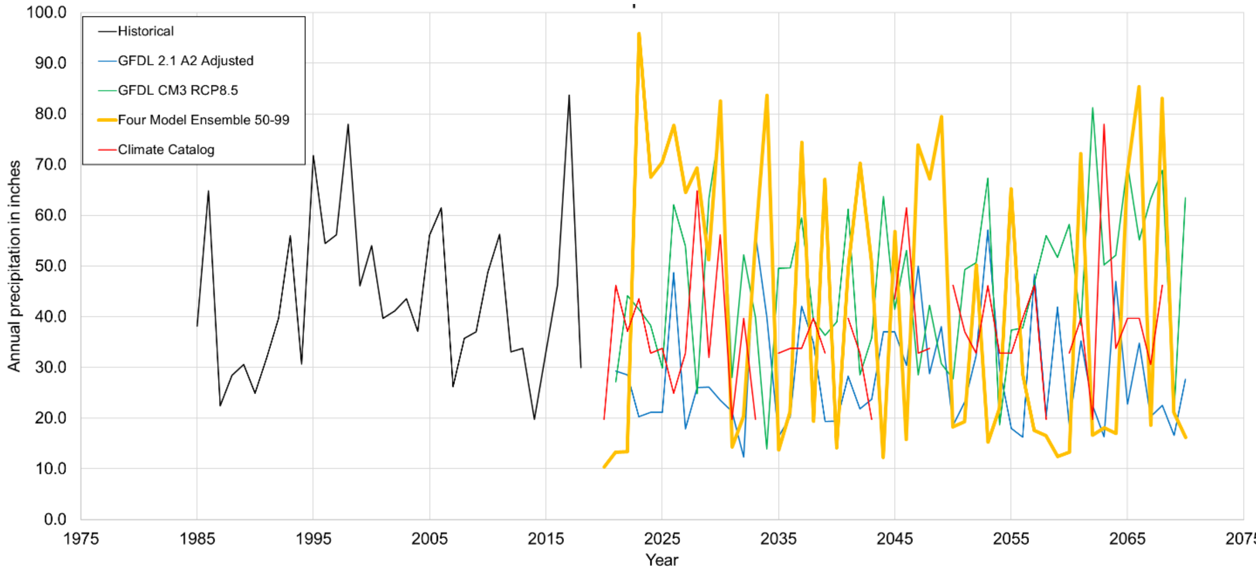


Figure 2-14. Precipitation Variability between Climate Models

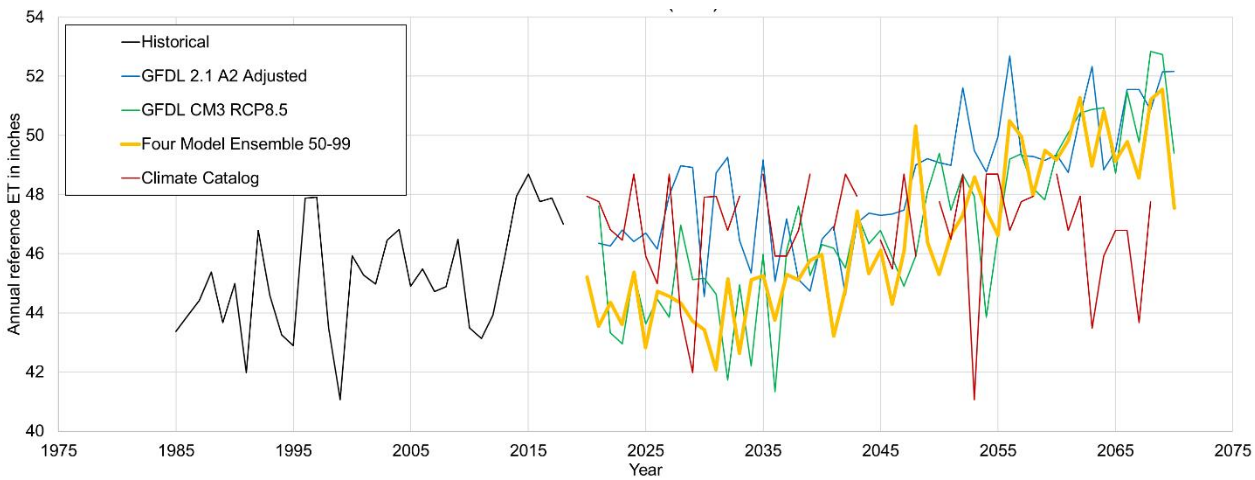


Figure 2-15. Variation of Annual Reference Evapotranspiration Betweeen Climate Models

2.2.4 Hydrogeologic Conceptual Model

This subsection describes the Hydrogeologic Conceptual Model (HCM) of the Basin, including its boundaries, geologic formations and structures, and principal aquifer units. Also described is general Basin groundwater quality, interactions between groundwater and surface water, and generalized groundwater recharge and discharge areas. The HCM primarily relies upon previously published studies:

- Nicholas M. Johnson (2009) San Lorenzo Valley Water District Water Supply Master Plan
- Kennedy/Jenks Consultants (2015b) Santa Margarita Basin Groundwater Modeling Technical Study

- SVWD annual groundwater management program reports (2008 – 2019)

2.2.4.1 Basin Boundaries

The Basin forms a roughly triangular area that extends from Scotts Valley in the east, to Boulder Creek in the northwest, to Felton in the southwest (Figure 2-16). Sedimentary rocks within the Basin include, from oldest to youngest, the Tertiary-aged Butano Sandstone, Lompico Sandstone, Monterey Formation, and Santa Margarita Sandstone. The sandstone formations form the Basin's principal aquifers. The Basin is bounded on the north by the Zayante trace of the active, strike-slip Zayante-Vergeles fault zone, on the east by a buried granitic high that separates the Basin from Santa Cruz Mid-County Basin, and on the west by the Ben Lomond fault except where areas of alluvium (previously designated as the Felton Basin lie west of the fault). The southern boundary of the Basin with the West Santa Cruz Terrace Basin is located where the Tertiary sedimentary formations thin over a granitic high and give way to young river and coastal terrace deposits.

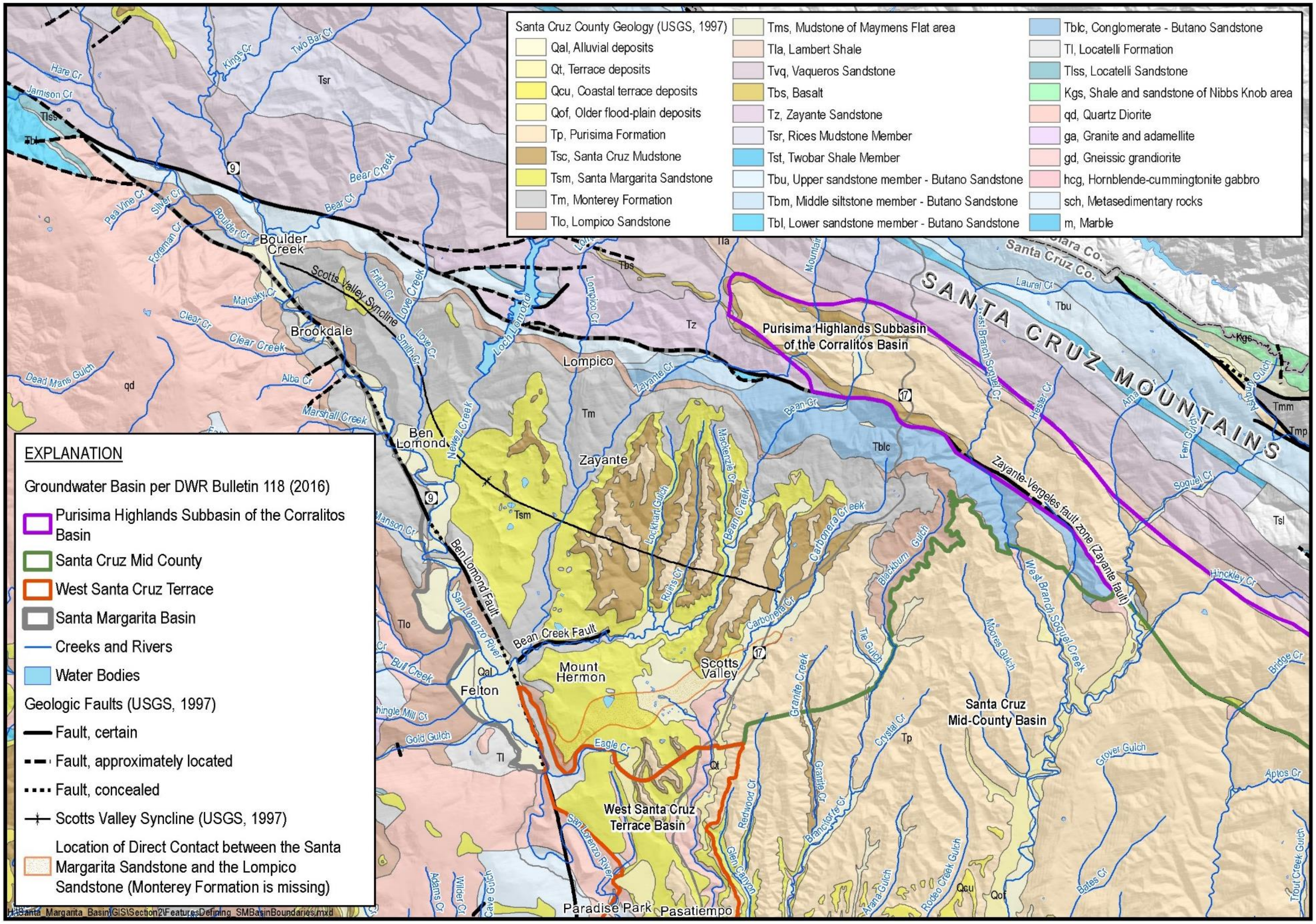


Figure 2-16. Features Defining the Santa Margarita Basin Boundaries

2.2.4.2 Basin Stratigraphy

Figure 2-17 is a generalized stratigraphic column for the Basin that shows the age relationships of geologic units and the thicknesses of the sedimentary formations. The thick section of Tertiary-age sedimentary formations does not represent a continuous marine depositional sequence. Episodes of deformation and uplift combined with changes in global sea level led to erosion that resulted in 4 unconformities, or gaps, in the geological record represented by wavy lines on the stratigraphic column. These episodes of folding followed by erosion account for the thickness variations across the Basin of the sedimentary layers or their local absence, with important consequences for the hydrogeologic conceptual model.

The subsections below describe the stratigraphic units from oldest to youngest and indicate where they occur in the Basin as depicted in the geologic map shown on Figure 2-18.

Era	Period	Series	Geologic Formation	Lithology	Maximum Thickness in Basin (feet)
Cenozoic	Quaternary	Pleistocene-Holocene	Alluvium (Qal) and	Alluvium – unconsilidated, moderately sorted silt, sand and gravel	40
			Terrace Deposits (Qt)	Terrace Deposits – weakly consolidated, poorly sorted sandy gravel to medium-grained sands	60
	Tertiary	Pliocene	Purisima Formation (Tp)	Very thickly bedded tuffaceious and diatomaceous siltstone with thick interbeds of semi-friable andestic sandstone	200
		Miocene	Santa Cruz Mudstone (Tsc)	Medium- to thick-bedded and faintly laminated pale siliceous mudstone with scattered speriodal dolomite concretions; locally graded to sandy siltsone	250
			Santa Margarita Sandstone (Tsm)	Very thick bedded and thickly crossbedded friable arkosic sandstone	450
			Lompico Sandstone (Tlo) – Monterey Formation (Tm)	Medium- to thick-bedded and laminated subsiliceous organic mudstone and sandy siltstone with few thick dolomite interbeds	2,000
			Lompico Sandstone (Tlo)	Thick-bedded to massive arkosic sandstone	400
		Eocene	Butano Sandstone – Upper (Tbu)	Thin- to very thick-bedded medium arkosic sandstone with thin interbeds of siltstone	3,000
			Butano Sandstone – Middle (Tbm)	Thin- to medium-bedded nodular pyritic siltstone	250 – 750
			Butano Sandstone – Lower (Tbl)	Very thick bedded to massive arkosic sandstone with thick to very thick interbeds of sandy pebble conglomerate in lower part	1,500
		Paleocene	Locatelli Formation (Tl)	Nodular micaceous siltstone; micaceous arlosic sandstone locally at base	800
Mesozoic	Cretaceous		Crystalline Basement	Metasedimentary rocks intruded by granodiorite and quartz diorite	

unconformity

principal aquifer

Modified after Johnson (2009) and Kennedy/Jenks Consultants (2015b)

Figure 2-17. Santa Margarita Basin Stratigraphic Column

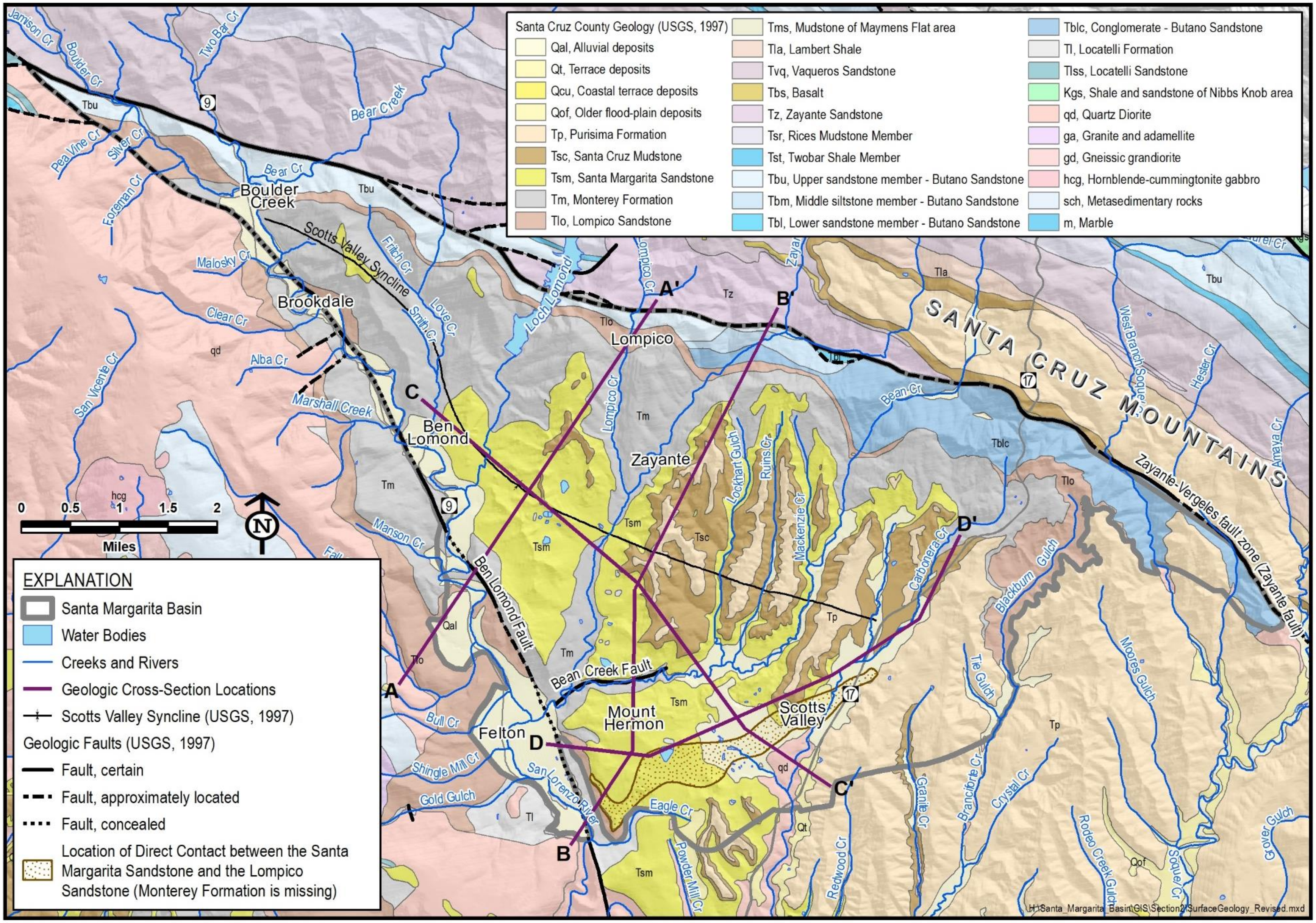


Figure 2-18. Surface Geology of the Santa Margarita Basin

2.2.4.2.1 Granitic Basement

The local basement for the Basin consists of metasedimentary rocks (including marble) that have been intruded by quartz diorite and granodiorite of Cretaceous age. The basement rocks are exposed only at the southernmost margin of the Basin, along Carbonara Creek; however, they underlie the southern part of the Basin at shallow depths. A buried high of basement rocks is defined by DWR as the boundary that separates the Basin from the Santa Cruz Mid-County Basin to the east.

The basement rocks are part of the Salinian Block, which constitutes a continental terrain that originated more than 1,200 miles south of its present location and collided with the North American plate prior to Eocene time. Since about 20 million years ago, the Salinian Block has been transported northward along the San Andreas Fault Zone as a part of the Pacific Plate. It was profoundly eroded prior to the Eocene, accounting for the limited occurrence of Paleocene sediments like the Locatelli Sandstone. It also means that sedimentary units Eocene and younger in age were deposited on an irregular erosional surface, which results in some of the near-shore sedimentary units like the Lompico Sandstone and the Santa Margarita Sandstone showing a range of original depositional thicknesses across the Basin.

2.2.4.2.2 Locatelli Sandstone

The Paleocene Locatelli Sandstone (Tl on Figure 2-18) is a grey sandy siltstone with a thin basal sandstone. It is exposed at the southern margin of the Basin, on both sides of the San Lorenzo River, where it is lapping onto the basement. It is, however, present widely in the subsurface, with a thickness as great as 800 feet thick (Kennedy/Jenks Consultants, 2015b).

2.2.4.2.3 Butano Sandstone

The Eocene Butano Sandstone is a thick sedimentary unit that was deposited in deep water (Clark, 1991) in an environment analogous to where modern-day shelf sediments are swept down submarine Monterey Canyon to be deposited off the continental shelf in the Monterey submarine fan.. It has 3 defined members defined on Figure 2-18: an upper sandstone member (Tbu), a middle siltstone member (Tbm), and a lower massive sandstone with conglomerate near its base (Tbl) (Clark, 1981). The middle member is more fine-grained and contains pyrite, making it unsuitable as an aquifer, but the upper and lower sandstone units are important aquifers in the Basin

The Butano Sandstone is exposed in the south-dipping limb of the Scotts Valley syncline at the northern margin of the Basin in a band parallel to the Zayante-Vergeles fault (Figure 2-18). The upper, middle, and lower members outcrop from northwest to southeast across this band, respectively. The thickness of the Butano Sandstone varies across the Basin, from several hundred to as much as 5,000 feet thick (Clark, 1982; Kennedy/Jenks Consultants, 2015b).

2.2.4.2.4 Lompico Sandstone

The Miocene Lompico Sandstone (Tlo on Figure 2-18) is a thick-bedded to massive, fine- to medium-grained arkosic sandstone that was deposited on the continental shelf at moderate depths (Clark, 1991). The Lompico Sandstone has a relatively uniform thickness of up to 400 feet, though it is slightly thinner and finer grained in the northern and eastern areas of the Basin (Kennedy/Jenks Consultants, 2015b). As is the case for the underlying Butano Sandstone, the Lompico Sandstone outcrops as a strip parallel to the Basin's northern boundary (Figure 2-18). The width of this outcropping strip ranges from approximately 2,000 feet in the northwest near Boulder Creek to 100 feet in the southeast, where it joins up with another significant outcrop alongside the headwaters of Blackburn Gulch near the Basin's boundary with the Santa Cruz Mid-County Basin (Figure 2-18). Although the Lompico Sandstone has limited surface exposure, it is present throughout the Basin in the subsurface, making it an important aquifer.

2.2.4.2.5 Monterey Formation

The Miocene Monterey Formation (Tm on Figure 2-18) is composed mostly of medium- to thick-bedded and organic mudstone and shale with sandy siltstone interbeds. It represents deposition in a deeper-water continental-shelf environment as sea level rose following deposition of the Lompico Formation (Clark, 1991). The Monterey Formation is thickest near the center of the Basin, where it is more than 2,000 feet thick. It is absent near the southeastern margin of the Basin (see the brown stippled area on Figure 2-18). The absence of Monterey Formation in this area has important consequences for the hydrogeologic conceptual model, as the Lompico aquifer and the overlying Santa Margarita aquifer are in direct contact, allowing for greater recharge of the Lompico aquifer through the Santa Margarita aquifer than in areas where the Monterey Formation aquitard intervenes.

The Monterey Formation is not a principal aquifer, but because it is exposed widely in the Basin, it is utilized in many private wells. These generally tap sandy intervals in the lower part of the formation for relatively small volumes of water

2.2.4.2.6 Santa Margarita Sandstone

The Miocene Santa Margarita Sandstone (Tsm on Figure 2-18) is a massive, fine- to coarse-grained, moderately sorted arkosic sandstone containing lenses of gravel and cobbles. It formed in a near-shore, high-energy environment as indicated by fossils of shallow marine organisms as well as fossils of terrestrial animals swept in by rivers (Clark, 1991) This poorly consolidated and easily erodible formation can be observed in natural and quarried cliffs around Scotts Valley and forms the basis of the distinctive Sand Hills ecosystem. It is often referred to as "white sand" in drillers' logs. In areas where the Santa Margarita Sandstone directly overlies the Lompico Sandstone, the two sandstones can be difficult to distinguish from one other, although the Lompico Sandstone is typically finer grained and more cemented (Johnson, 2009).

The Santa Margarita Sandstone is thickest along the axis of the Scotts Valley Syncline between the community of Ben Lomond and City of Scotts Valley; it thins and becomes more fine-grained to the northeast (Clark, 1981). In the Quail Hollow and Olympia areas, it is as much as 450 feet, though much has been removed by quarrying (Johnson, 2009). In the Scotts Valley area, it is up to about 350 feet thick. The relatively easily eroded sandstone is incised, in some areas, through its entire thickness by overlying creeks, forming several isolated areas within the Basin.

2.2.4.2.7 Santa Cruz Mudstone

The Miocene Santa Cruz Mudstone lies conformably atop the Santa Margarita Sandstone, indicating a deepening of the marine depositional environment (Clark, 1991). The Santa Cruz Mudstone makes up the upper slope of the ridges between Zayante Creek and Carbonera Creek (Tsc in Figure 2-18) and can be up to 250 feet thick (Johnson, 2009). The medium- to thick-bedded and faintly laminated pale siliceous mudstone restricts surface recharge where present.

2.2.4.2.8 Purisima Formation

East of Zayante Creek, the shallow marine sediments of the Purisima Formation are discontinuously exposed along ridge tops separated by streams (Tp on Figure 2-18). It has a maximum thickness of about 200 feet within the Basin but thickens considerably west of Carbonera Creek and into the Santa Cruz Mid-County Basin where it is one of the principal aquifers (Johnson, 2009).

2.2.4.2.9 Coastal Terrace Deposits

There are small outcrops of marine coastal terrace deposits in the southernmost part of the basin along Carbonera Creek and Powder Mill Creek (Qt on Figure 2-18). Present as isolated outcrops no thicker than 50 feet, these superficial deposits are not considered an aquifer and contain no known water supply wells.

2.2.4.2.10 Alluvium

Quaternary alluvium consisting of unconsolidated sands and silts associated with the Basin’s rivers and creeks valleys occurs locally along the San Lorenzo River, portions of Bean and Carbonera Creeks, the length of the West Branch of Carbonera Creek, and in an ancestral drainage near Camp Evers (Qal on Figure 2-18). Ranging in thickness from less than 10 to 40 feet thick, these alluvial deposits are generally too thin to constitute a major aquifer; however, they may play a part in the connection between surface water in the river and creeks with underlying Santa Margarita and Lompico Sandstones (Johnson, 2009).

2.2.4.3 Geologic Structure

2.2.4.3.1 Tectonic Setting

The geologic structure of the Basin is a reflection of its location along the boundary between the North American and Pacific tectonic plates. The Pacific plate is moving northward with respect to the North American plate an average of about 2 inches per year, with much of this motion distributed over a number of fault strands within the greater San Andreas fault zone. The Basin is bound on the north by one of these: the Zayante-Vergeles fault which has active seismicity.

Although the overall motion along the plate boundary is right-lateral, the local details are more complicated. There is a slight bend in the San Andreas fault east of the Santa Cruz Mountains. This bend interferes with the plates slipping past one another; this so-called restraining bend causes local compression in the rocks that causes them to fold or to break along high-angle fault planes in which one side of the fault moves up and over the rocks on the other side of the fault. The M7.1 1989 Loma Prieta earthquake occurred along the restraining bend and exhibited this type of behavior: there was 4.3 feet of vertical motion along the fault as well as 6.2 feet of right-lateral motion (Plafker and Galloway, 1989). Analysis of global positioning system data along with geochronological studies show that there is currently a component of compression along the San Andreas fault in the Santa Cruz Mountains, and that the contraction that causes folding and uplift along faults in an otherwise strike-slip setting (Burgmann et al., 2006; Gudmundsdottir et al., 2008) are the cause of the complicated fault geometries in the region, including the Zayante-Vergeles and Ben Lomond Mountain fault zones.

This transpressive regime may have started when there was a reorganization of Pacific Plate motion about 5 million years ago (Engebretson et al., 1985). Since that time, folding and faulting have resulted in the uplift that created the California Coast Range.

2.2.4.3.2 Faults

Faults can be barriers to groundwater flow in 2 ways:

(1) As rocks on either side of a fault slide past each other, mineral grains along the fault are ground and transformed into a fine-grained, clay-rich, impermeable material referred to as gouge. Zones of gouge impede the lateral flow of groundwater, and may deflect the water upwards, where it can emerge at the surface as springs.

(2) Translation of rock layers along a fault can juxtapose a rock layer that is an aquifer against one that is an aquiclude, blocking groundwater flow.

The Basin is bounded by 2 regional faults, the Zayante-Vergeles fault zone to the north and the Ben Lomond Fault to the west. Figure 2-18 shows the location of these faults with respect to the Basin.

The Zayante-Vergeles fault zone, which forms the northern Basin boundary, is a major northwest-striking structural element of the Santa Cruz Mountains restraining bend of the larger San Andreas fault zone. It is a major right-lateral reverse-oblique-slip fault with late Pleistocene and possible Holocene displacement with an estimated vertical slip rate of 0.2 millimeters per year (Bryant, 2000). The easternmost end of the fault is currently seismically active; the section that is the northern boundary of the Basin is not.

Areas south of the Zayante-Vergeles fault zone are underlain primarily by granitic and metasedimentary basement rock, while in contrast, areas north of the fault zone are underlain by gabbroic basement rock and overlain by sedimentary formations not present within the Basin. The juxtaposition of these continental (90-million years ago) and oceanic (165-million years ago) crustal formations illustrates the significant displacement associated with the movement of the fault zone, reflects the long-term right-lateral translation of the Salinian block along the San Andreas fault system, and marks the fault zone as a major feature of this system..

In contrast, the Ben Lomond Fault, which is the western boundary of the Basin, has more limited, largely vertical motion. It extends from northwest of the community of Boulder Creek, where it merges with the Zayante-Vergeles fault zone, through the communities of Ben Lomond and Felton, and south to the coast, where it continues for a further 2.5 miles offshore (Johnson et al., 2016). The steep eastern face of Ben Lomond Mountain reflects the presence of the fault, as does the course of the San Lorenzo River, which exploited shattered, easily eroded rocks in the fault zone in making its way southward to the coast.

Movement along the near-vertical Ben Lomond fault has uplifted the basement rocks of Ben Lomond Mountain with respect to the sedimentary formations of the Basin by about 600 feet (Stanley and McCaffery, 1983). Evidence for lateral motion is lacking. This steep reverse fault is best interpreted as a minor fault in the complex fault geometry that results from the restraining bend in the San Andreas fault zone in the Santa Cruz Mountains.

The Ben Lomond fault is not currently seismically active. Stanley and McCaffery (1981) argued that most of the movement on the fault took place during the deposition of the Santa Margarita Sandstone, as this unit thickens against it. Small offsets of the Purisima Formation and uplift in marine terraces suggest that at least some slip occurred in Pleistocene time. A minor fault called the Bean Creek Fault is aligned along the lower reach of Bean Creek where the Monterey Formation outcrops in the Bean Creek valley (Figure 2-18). It is unknown if this fault impacts the movement of groundwater in the Basin (Johnson, 2009).

2.2.4.3.3 Folding and Geologic Structure

Caught between faults of the Santa Cruz Mountain restraining bend of the San Andreas fault zone, the sediments of the Santa Margarita Basin have been folded and uplifted several times, resulting in synclines and anticlines in and around the Basin. The dominant feature defining the

Basin is the Scotts Valley syncline, a geologic trough whose northwest-southeast-trending axis roughly bisects the Basin (Figure 2-18). This folding of the sedimentary rocks is illustrated in 4 geologic cross sections (Figure 2-19 through Figure 2-22) constructed along lines of section shown on the geologic map (Figure 2-18). The cross sections were developed as part of SLVWD's water supply master plan (Johnson, 2009).

The southwest-northeast trending cross sections in section A-A' (Figure 2-19) and section B-B' (Figure 2-20) cross through the area of the Quail Hollow and Olympia well fields, respectively. Constructed approximately perpendicular to the axis of the Scotts Valley syncline, these cross sections illustrate the syncline and the location of the deepest part of the Basin beneath the wellfields, some 4,000 feet deep (Figure 2-20). They also show the prominent influence of the Ben Lomond fault as a boundary to the Basin, displacing the Lompico Sandstone by just under 400 feet, and juxtaposing aquicludes against aquifers. These cross sections also illustrate the steep dips of the Butano Sandstone, Lompico Sandstone, and Monterey Formation at the northern end of the basin, due to deformation near the Zayante-Vergeles fault zone. It is these steep dips that result in the relatively narrow strips of surface exposure of the Butano Sandstone and Lompico Sandstone (Figure 2-19 and Figure 2-20), the only places where they can receive direct recharge from infiltrating precipitation and percolation through creek beds, thereby limiting the amount of direct recharge these aquifers can receive.

The northwest-southeast-trending cross-section C-C' (Figure 2-21) is constructed approximately parallel to the axis of the Scotts Valley syncline. This cross section illustrates how the Basin's sedimentary rocks were folded against a basement highland forming the eastern margin of the Basin. Thus, the sedimentary rocks constitute a structural "bowl" across much of the Basin, making it hydrologically isolated from other basins. It also illustrates the shallowing of the granitic basement that forms the eastern margin of the Basin.

The southwest-northeast-trending cross section D-D' (Figure 2-22) is constructed to pass through the Mount Hermon, Pasatiempo, Camp Evers, and the southern and northern Scotts Valley well areas. The deepest wells in the Basin are in the northern Scotts Valley area, where they tap down to the deepest aquifer, the Butano Sandstone.

The Monterey Formation is present widely in the Basin and in most places forms a thick aquitard between the Santa Margarita aquifer and the Lompico aquifer as shown in section A-A' (Figure 2-19). There is a narrow, southwest-northeast-trending area running from Pasatiempo to Scotts Valley (shown as a stipple pattern on the geologic map in Figure 2-18) in which the Monterey Formation is absent, so that the Santa Margarita Sandstone and the Lompico Sandstone are in direct contact. The cross section in Figure 2-22 illustrates this well in the area of Camp Evers. The hydrogeologic connection between these 2 units in this area affects the quantity and quality of groundwater recharge to the Lompico Sandstone, and so is an important feature in the hydrogeologic conceptual model.

Most of the folding to form the Scotts Valley syncline must have occurred in the time between deposition of the Monterey Formation and the Santa Margarita Sandstone, as the Santa Margarita Sandstone and younger formations are only weakly affected by the folding, as can be seen in Figure 2-19, Figure 2-20, and Figure 2-22.

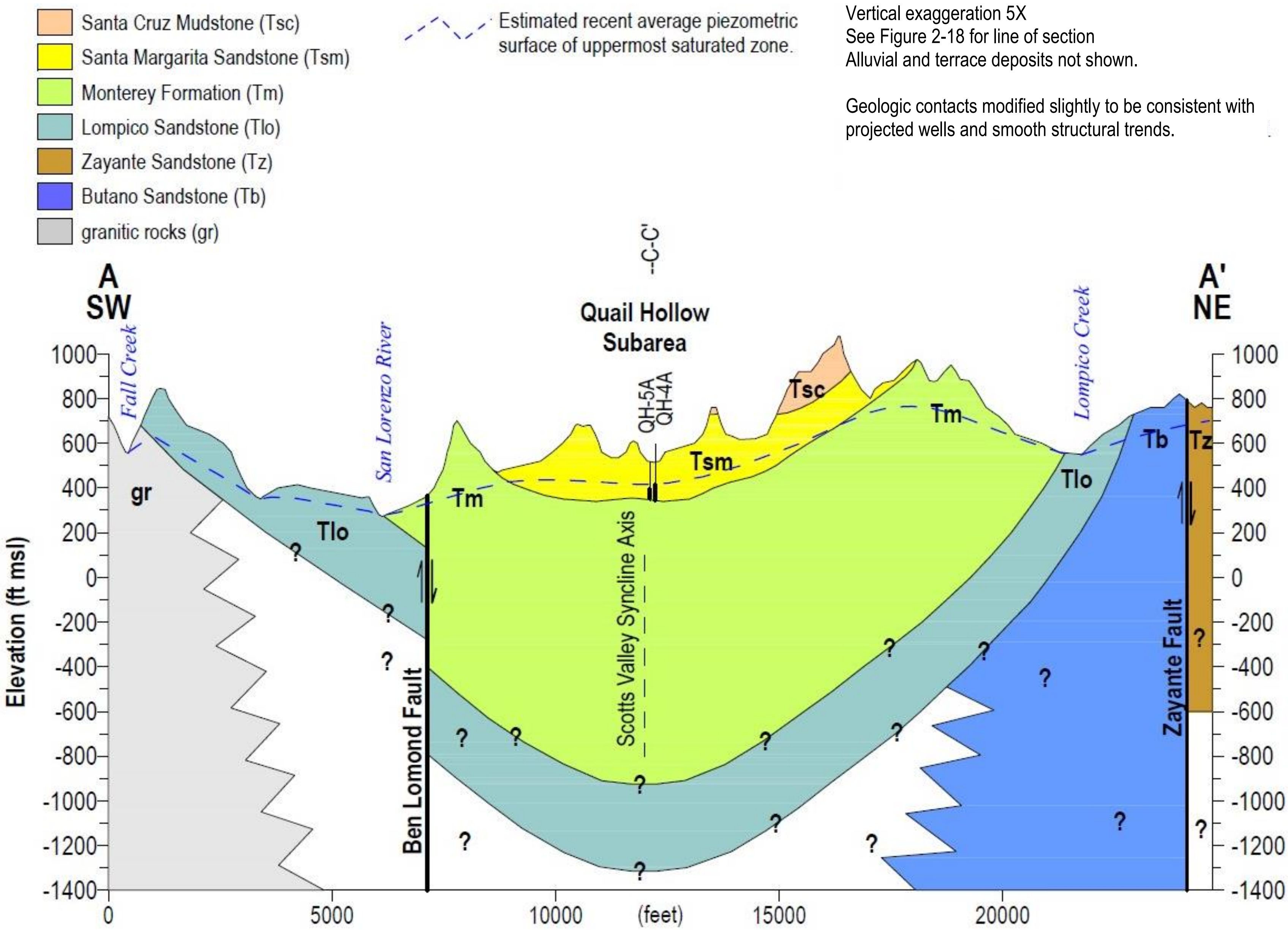


Figure 2-19. A-A' Geologic Cross-Section through the Santa Margarita Basin (Johnson, 2009)

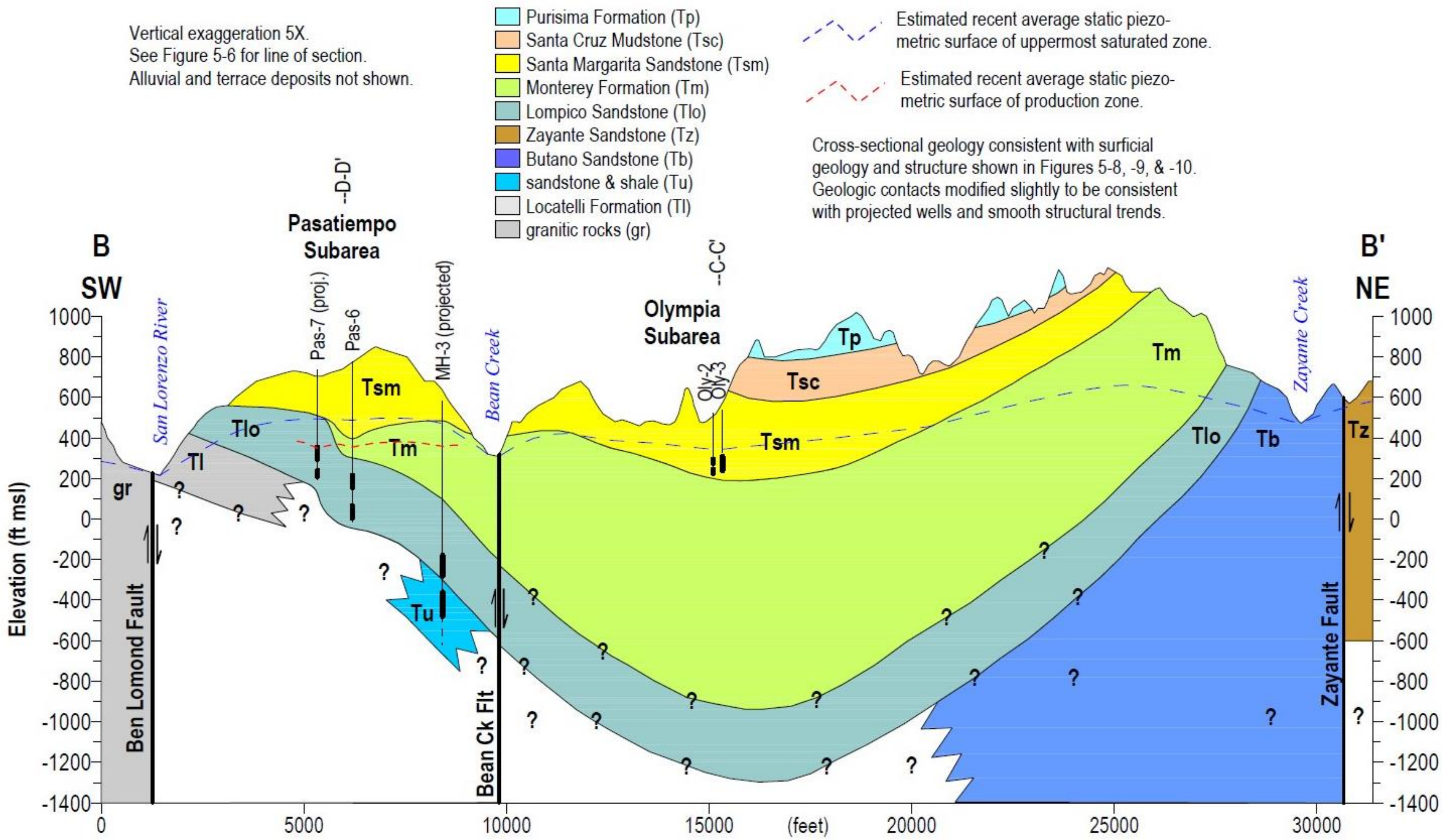


Figure 2-20. B-B' Geologic Cross-Section through the Santa Margarita Basin (Johnson, 2009)

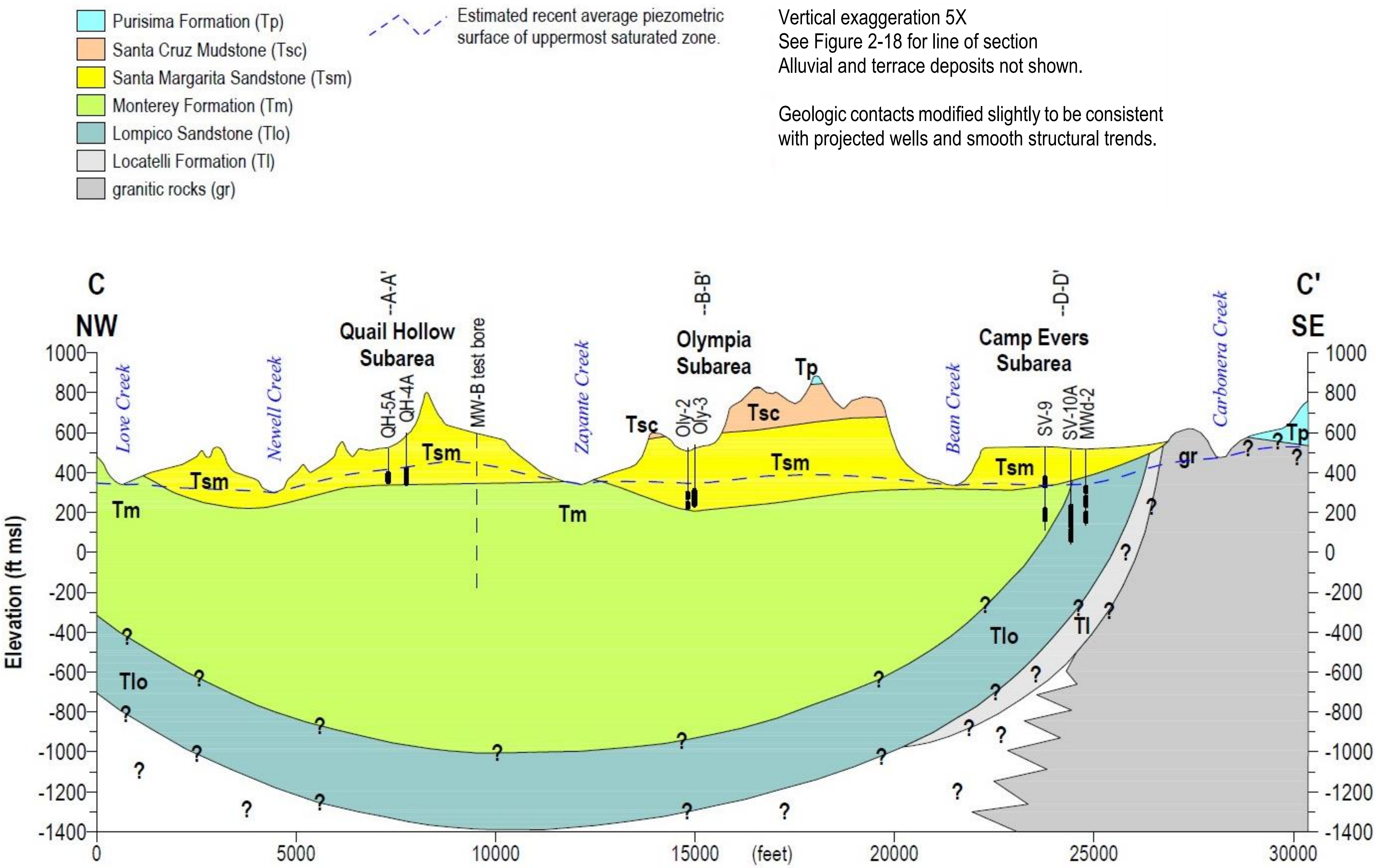


Figure 2-21. C-C' Geologic Cross-Section through the Santa Margarita Basin (Johnson, 2009)

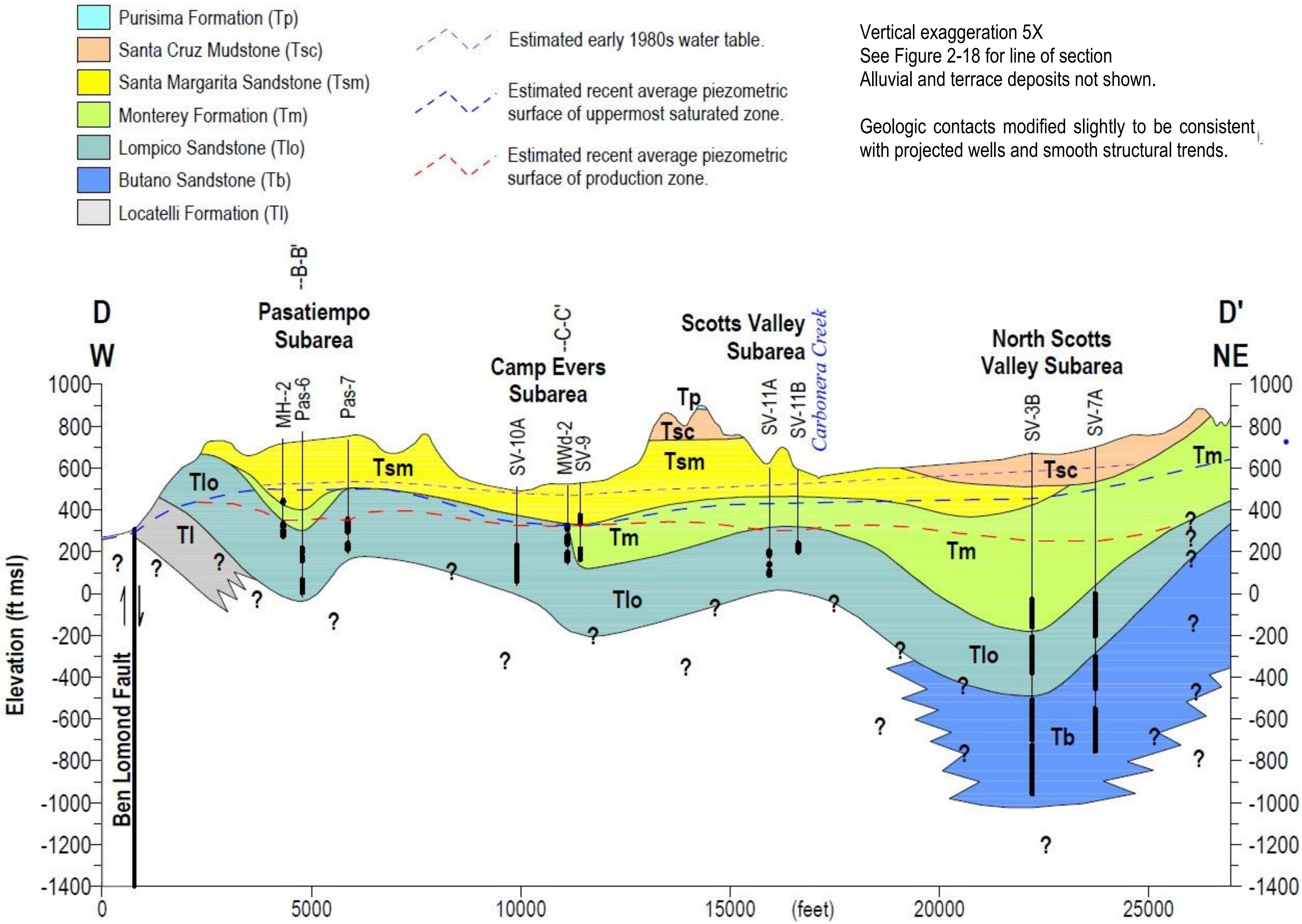


Figure 2-22. D-D' Geologic Cross-Section through the Santa Margarita Basin (Johnson, 2009)

2.2.4.4 Principal Hydrogeologic Units

Sandstone units within the sedimentary rocks of the Scotts Valley syncline supply nearly all the groundwater extracted in the Basin. The Santa Margarita, Lompico, and Butano Sandstones, are the principal aquifers utilized by municipal suppliers.

The Santa Margarita Sandstone, which is the shallowest of the 3 sandstone units, has a long history as a source of water in the Basin, with many water supply wells extracting groundwater from this unit (Muir, 1981). The Lompico Sandstone is currently the principal groundwater producing unit in the Scotts Valley area. Silty and sandy intervals within the otherwise fine-grained Monterey Formation provide smaller volumes of groundwater to domestic pumpers. The subsections below describe these aquifers.

Table 2-14 summarizes representative aquifer hydraulic parameters for these units obtained from aquifer testing and included in reports by Johnson (2009) and Kennedy/Jenks Consultants (2015b). Definitions of the aquifer parameter terminology used in this section are provided below.

Hydraulic Conductivity: Property of geologic materials that controls the ease with which groundwater flows through pore spaces or fractures. Higher hydraulic conductivity allows water to travel faster through geologic media. Units with very low hydraulic conductivity slow or may prevent groundwater flow. Hydraulic conductivity has units with dimensions of length per time (e.g., feet per day).

Transmissivity: A measure of how much water can be transmitted horizontally. It is derived from the hydraulic conductivity of an aquifer unit multiplied by its total thickness. High transmissivity units are very conducive to groundwater flow, very thick, or both. Transmissivity is usually expressed in units of $length^2$ per time, or occasionally as volume per length per time.

Storativity (or storage coefficient): The volume of water (e.g., cubic feet) released from aquifer storage per unit decline in hydraulic head in the aquifer (e.g., foot), per unit area of the aquifer (e.g., square feet). Storativity is a volumetric ratio and therefore unitless. A large value for storativity implies a highly productive aquifer. Storativity is applied only to aquifers under local or regional confinement; specific yield is a roughly equivalent measure of aquifer productivity in an unconfined aquifer.

Specific Yield: The volume of water released from storage by an unconfined aquifer per unit surface area of aquifer per unit decline of the water table. Specific yield is a volumetric ratio and therefore unitless. Specific yield is used to characterize unconfined aquifers; high specific yield indicates a productive aquifer unit.

Table 2-14. Principal Hydrogeologic Units Hydraulic Properties

Principal Hydrogeologic Unit	Hydraulic Conductivity (feet/day)	Transmissivity (feet²/day)	Storativity[1]	Specific Yield[2]
Santa Margarita Aquifer Entire Basin	2 – 130	430-7,700	0.008 – 0.02	0.02 – 0.25
Santa Margarita Aquifer Quail Hollow/ Olympia	2 – 50	430 – 6,200	0.008 – 0.02	0.12 – 0.25
Santa Margarita Aquifer Central Portion of Basin	3 – 130	2,000 – 7,700	NA	0.02 – 0.13
Santa Margarita Aquifer Scotts Valley Area	12 – 35	1,000 – 1,700	NA	0.02 – 0.13
Monterey Aquifer [3]	0.05 – 6	170 – 1,000	0.00001 – 0.001	0.01 – 0.03
Lompico Aquifer	0.5 – 7	500 – 3,200	0.000001 – 0.001	0.02 – 0.07
Butano Aquifer	0.1 – 6	100 – 1,070	0.000001 – 0.0007	

Adapted from Kennedy/Jenks Consultants (2015b); NA = non-applicable given unconfined conditions
[1] Storativity is the volume of water released from confined aquifer storage per unit decline in hydraulic head in the aquifer per unit area of the aquifer.
[2] Specific yield is the amount of water released from an unconfined aquifer if allowed to drain completely under force of gravity.
[3] The Monterey Formation is not a principal aquifer but is included here as there are aquifer test data available for it, and because its occurrence between 2 principal aquifers plays an important role in the hydrogeology of the Basin.

2.2.4.4.1 Santa Margarita Aquifer

The Santa Margarita Sandstone or Santa Margarita aquifer is the shallowest principal aquifer in the Basin, with widespread surface exposures in the southern and central portions of the Basin. Due to its shallow depth and highly productive lithology, it was the first formation to be developed for municipal and private domestic use (Kennedy/Jenks Consultants, 2015b). The Santa Margarita aquifer is capped in some areas by the Santa Cruz Mudstone and lies unconformably over the Monterey Formation in the north and northwest portions of the Basin. In the southeastern portion of the Basin, in the Pasatiempo and Camp Evers areas, the Monterey Formation has been completely removed by erosion so that the Santa Margarita Sandstone rests unconformably on the Lompico Sandstone, creating a direct groundwater connection between the 2 principal aquifers.

The Santa Margarita aquifer is unconfined, apart from areas in northern Scotts Valley, where it is confined by a few hundred feet of overlying Santa Cruz Mudstone. Due to its wide exposure and high conductivity, the Santa Margarita aquifer responds rapidly to changes in precipitation and recharges quickly, but it also drains relatively rapidly to creeks such that it has little long-term groundwater storage (Kennedy/Jenks Consultants, 2015b).The hydrogeologic properties of the

Santa Margarita Sandstone as a highly transmissive unconfined aquifer reflect its coarse grain size and weak cementing. Estimated hydraulic conductivity ranges from 2 to more than 100 feet/day (Kennedy/Jenks Consultants, 2015b) depending on location within the Basin and specific yield ranges from 0.02 to 0.25, and transmissivity ranges from 430 to 7,700 feet^2/day (Table 2-14; Kennedy/Jenks Consultants, 2015b). Johnson (2009) and Kennedy/Jenks Consultants (2015b) report variations in Santa Margarita aquifer parameters across the Basin that indicate the aquifer is spatially variable in its properties. In particular, aquifer test results from the Camp Evers area indicate the occurrence of highly conductive zones near the base of the aquifer where intervals of conglomerate (gravel-sized particles) occur (Johnson, 2009; Kennedy/Jenks Consultants, 2015b).

2.2.4.4.2 Lompico Aquifer

The Lompico Sandstone is a productive arkosic sandstone aquifer that provides a large proportion of the Basin's municipal supply (Johnson, 2009; Kennedy/Jenks Consultants, 2015b). The Lompico Sandstone is generally uniform, although slightly more fine-grained and cemented towards its base. The restricted exposure of the Lompico Sandstone at the surface, at the northern and northeast margin of the Basin, limits the amount of surficial recharge by precipitation. The Lompico aquifer is primarily recharged via water that percolates through the highly transmissive Santa Margarita Sandstone, where the Santa Margarita and Lompico Sandstones are in direct contact due to the absence of intervening Monterey Formation. The limited exposure of the Lompico Sandstone at the surface and the confined to semi-confined nature of the aquifer makes it relatively slow to respond to rainfall-driven recharge events (Kennedy/Jenks Consultants, 2015b). The Lompico aquifer discharges to the San Lorenzo River at several locations where it is exposed in the riverbed, see cross section B-B' (Figure 2-20). The vertical gradient between the Lompico and Butano aquifers is not known; therefore, it is not known whether there is significant flow between these 2 deeper aquifers.

Available aquifer testing results in the Lompico aquifer reflect a moderately permeable, semi-confined to confined sandstone aquifer. Hydraulic conductivity ranges from 0.5 to 7 feet/day, transmissivity ranges from 500-3,200 feet^2/day, and storativity ranges from 0.000001 to 0.02 (Table 2-14; Kennedy/Jenks Consultants, 2015b). Where the Lompico aquifer is unconfined, specific yield ranges from 0.04 to 0.08. Although generally less conductive than the Santa Margarita aquifer, the transmissivity of the Lompico aquifer, i.e., the amount of groundwater it can produce, is larger due to its much greater thickness (Johnson, 2009).

2.2.4.4.3 Butano Aquifer

The Butano Sandstone or Butano aquifer is composed primarily of arkosic sandstone similar in consistency to the Lompico Sandstone, though with significant mudstone, shale, and siltstone interbeds. The Butano aquifer is recharged primarily by direct infiltration of precipitation and streamflow in the extreme northern portions of the Basin where it outcrops (Figure 2-18).

Review of limited groundwater elevation data indicates that the Butano aquifer groundwater elevations recover more quickly than the Lompico aquifer, suggesting the Butano aquifer is a more actively recharged aquifer likely because of its greater surface exposure area (Kennedy/ Jenks Consultants, 2015b). Since the available Butano groundwater elevation data is collected in wells installed close to where the formation outcrops, and the aquifer is not used extensively as a water supply in the Basin due to its greater depth and lower hydraulic conductivity than the other 2 aquifers, the more stable groundwater elevations in the Butano aquifer may also be related to the location of wells used to characterize the aquifer or a general lack of pumping influence on the aquifer.

Interpretation of limited aquifer tests in the Butano aquifer indicate confined or semi-confined aquifer conditions with moderate hydraulic conductivity. Estimated hydraulic conductivity ranges from 0.01 to 6 feet/day, transmissivity ranges from 100 to 1,070 feet^2/day, and storativity ranges from 0.000001 to 0.0007 (Table 2-14; Kennedy/Jenks Consultants, 2015b).

2.2.4.5 Other Hydrogeologic Units

2.2.4.5.1 Purisima Formation

The Purisima Formation comprises siltstone and sandstone up to 200 feet thick that forms the tops of some of the hills in the Scotts Valley area but is absent over most of the Basin. The more permeable units of the Purisima Formation are principal aquifers in the neighboring Santa Cruz Mid-County Basin to the east. However, in the Santa Margarita Basin, it is not considered a principal aquifer due to its limited thickness and occurrence on ridgetops. No hydraulic property data are available for this formation in the Basin.

2.2.4.5.2 Santa Cruz Mudstone

The Santa Cruz Mudstone is an impermeable layer that locally caps the Santa Margarita Sandstone, limiting recharge to the underlying aquifers where it is present. Slightly higher than normal salinity in Santa Margarita Sandstone groundwater near the Santa Cruz Mudstone indicates that runoff from the mudstone may percolate and recharge adjacent exposures of Santa Margarita Sandstone. No hydraulic property data are available for this formation.

2.2.4.5.3 Monterey Formation

The Monterey Formation is composed primarily of thick mudstone and siliceous shale that form a hydraulic barrier between the Santa Margarita Sandstone and Lompico Sandstone, except where it is missing in the southern portion of the Basin, as discussed above. The Monterey Formation contains sandstone interbeds, especially closer to the base of the formation, that are used for water supply. These interbeds are especially prominent in the southern Scotts Valley area (Kennedy/Jenks Consultants, 2015b). In general, the sandstone interbeds of the Monterey Formation are more hydrogeologically connected to the underlying Lompico Sandstone than to the overlying Santa Margarita Sandstone (Kennedy/Jenks Consultants, 2015b).

Although the Monterey Formation is generally considered an aquitard, the sandstone interbeds and fractured siliceous shales, along with the widespread surface exposure, make the Monterey Formation a locally important aquifer for shallow private domestic wells. Historically, municipal and small water systems pumped from the Monterey Formation, but those wells were not reliable because of low transmissivity.

Similar to the principal aquifers in the Basin, available aquifer test results in the Monterey Formation indicate a relatively large degree of heterogeneity. Reported hydraulic conductivity ranges from 0.05 to 6 feet/day, transmissivity ranges from 170 to 1,000 feet^2/day, storativity ranges from 0.00005 to 0.005, and specific yield ranges from 0.01 to 0.03 (Table 2-14; Kennedy/Jenks Consultants, 2015b).

2.2.4.5.4 Locatelli Sandstone

The Locatelli Sandstone is primarily a sandy siltstone that acts as a local aquitard in the Scotts Valley area; however, it contains a thin basal sandstone that provides water for some wells in the Scotts Valley area. In the northern Scotts Valley area, the Locatelli Sandstone is overlain by 600 feet of Butano Sandstone, whereas in southern Scotts Valley it is unconformably overlain by the Lompico Sandstone. The Locatelli Sandstone is not exposed at the surface within the Basin, and only has a limited outcrop south of the Basin (Figure 2-18). Most recharge to this unit is likely from the overlying Lompico and Butano Sandstones. No hydraulic property data are available for this formation.

2.2.4.5.5 Igneous and Metamorphic Basement Formations

The sedimentary rocks of the Santa Margarita Basin lie unconformably over a basement of igneous and metamorphic rocks. Exposed locally in the southern part of the Basin (e.g., along Carbonara Creek and the San Lorenzo River), the crystalline basement rocks have very low porosities and conductivities so typically behave as aquitards. Where sufficiently decomposed due to long surface weathering or fractured due to proximity to faults, granitic rocks can provide limited volumes of groundwater suitable for private domestic wells (Kennedy/Jenks Consultants, 2015b).

2.2.4.6 Soil Characteristics

The nature of soil and vegetation affect how much precipitation can infiltrate into the soil to recharge the regional groundwater aquifers. The character of the soils of the basin are derived from the exposed geologic formations they are developed on, but is also influenced by other factors such as climate, vegetation, and local relief.

The saturated hydraulic conductivity of surficial soils is a good indicator of its infiltration potential. The map on Figure 2-23 presents the distribution in the Basin of the 4 hydrologic groups defined in the U.S. Department of Agriculture (USDA) Natural Resources Conservation

Service, Soil Survey Geographic Database (USDA, 2007). The soil hydrologic groups are characterized by the water-transmitting properties of the soil, which include hydraulic conductivity and percentage of clay in the soil relative to sand and gravel. The groups are defined as:

- Group A – High Infiltration Rate: water is transmitted freely through the soil; soils typically less than 10% clay and more than 90% sand or gravel.
- Group B – Moderate Infiltration Rate: water transmission through the soil is unimpeded; soils typically have between 10 and 20% clay and 50 to 90% sand.
- Group C – Slow Infiltration Rate: water transmission through the soil is somewhat restricted; soils typically have between 20 and 40% clay and less than 50% sand.
- Group D – Very Slow Infiltration Rate: water movement through the soil is restricted or very restricted; soils typically have greater than 40% clay, less than 50% sand.

The hydrologic group of the soil generally correlates with the hydraulic conductivity of underlying geologic formations. Zones of greater soil hydraulic conductivity occur in areas where the Santa Margarita Sandstone outcrops, and lower soil hydraulic conductivity zones are found where siltstones and mudstones occur at the surface.

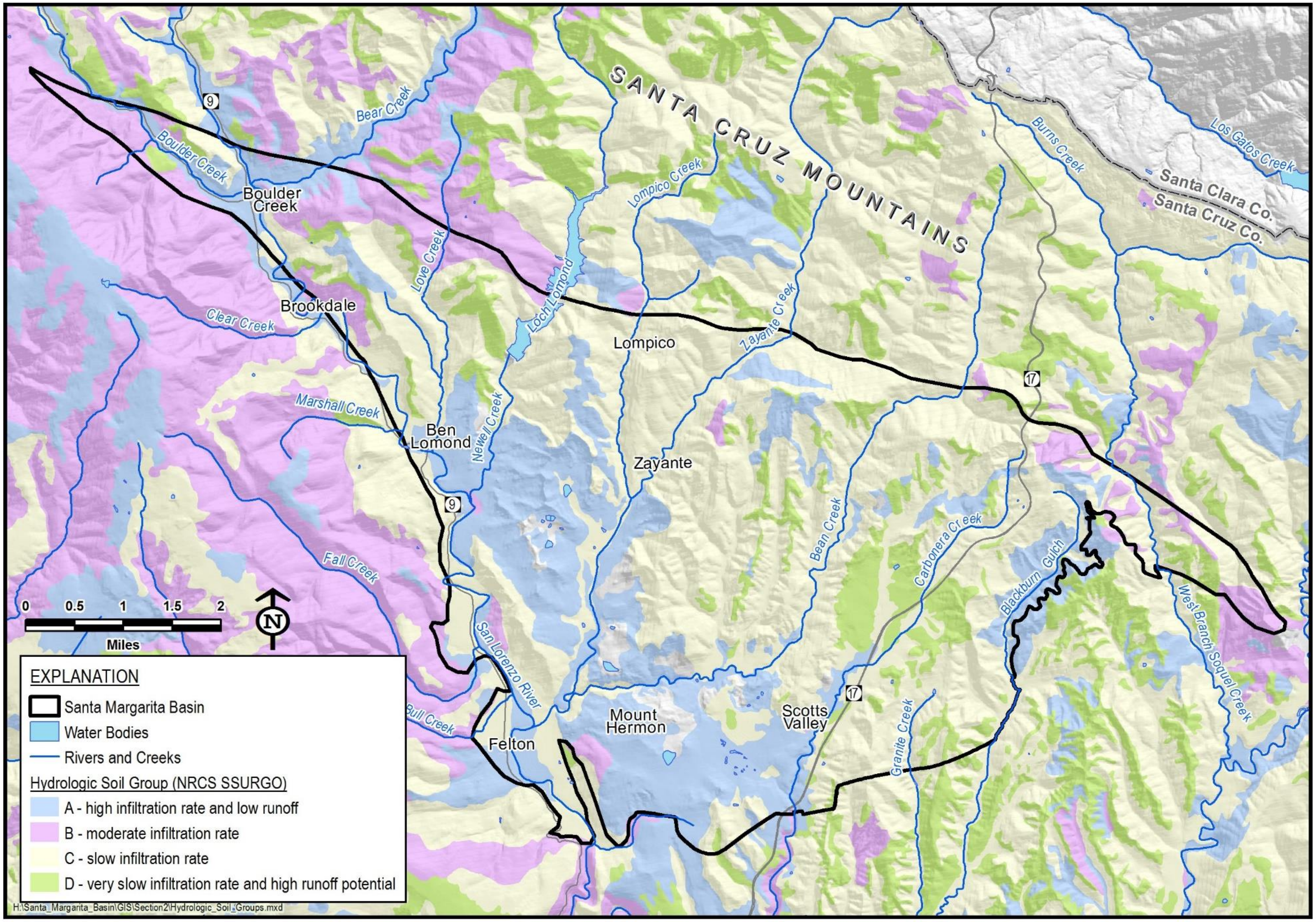


Figure 2-23. Soil Characteristics of the Santa Margarita Basin

2.2.4.7 Recharge Areas

Precipitation is the main source of natural groundwater recharge in the Basin. It enters shallow aquifers either directly by infiltration through the soil or indirectly from streamflow that infiltrates through stream and creek beds. As discussed in Section 2.2.4.9.1, most streams are fed by groundwater that is recharged by precipitation. Reductions in groundwater recharge can occur either naturally or anthropogenically. Natural reduction to groundwater recharge is caused by reduced precipitation or increased evapotranspiration due to changes in climate. Anthropogenic reduction to groundwater recharge is caused by land use changes such as increasing paved impermeable surfaces or changing vegetative cover that increase runoff and evapotranspiration.

Figure 2-24 shows County-mapped recharge areas (brown stipples). Most are areas with soils of high to moderate infiltration capacity developed on productive aquifer units. Areas of higher recharge capacity correspond closely with soils developed on the Santa Margarita Sandstone. Areas of lower recharge capacity are clay-rich soils with slower infiltration rates developed on geologic units with less productive potential: the Monterey Formation and the Santa Cruz Mudstone.

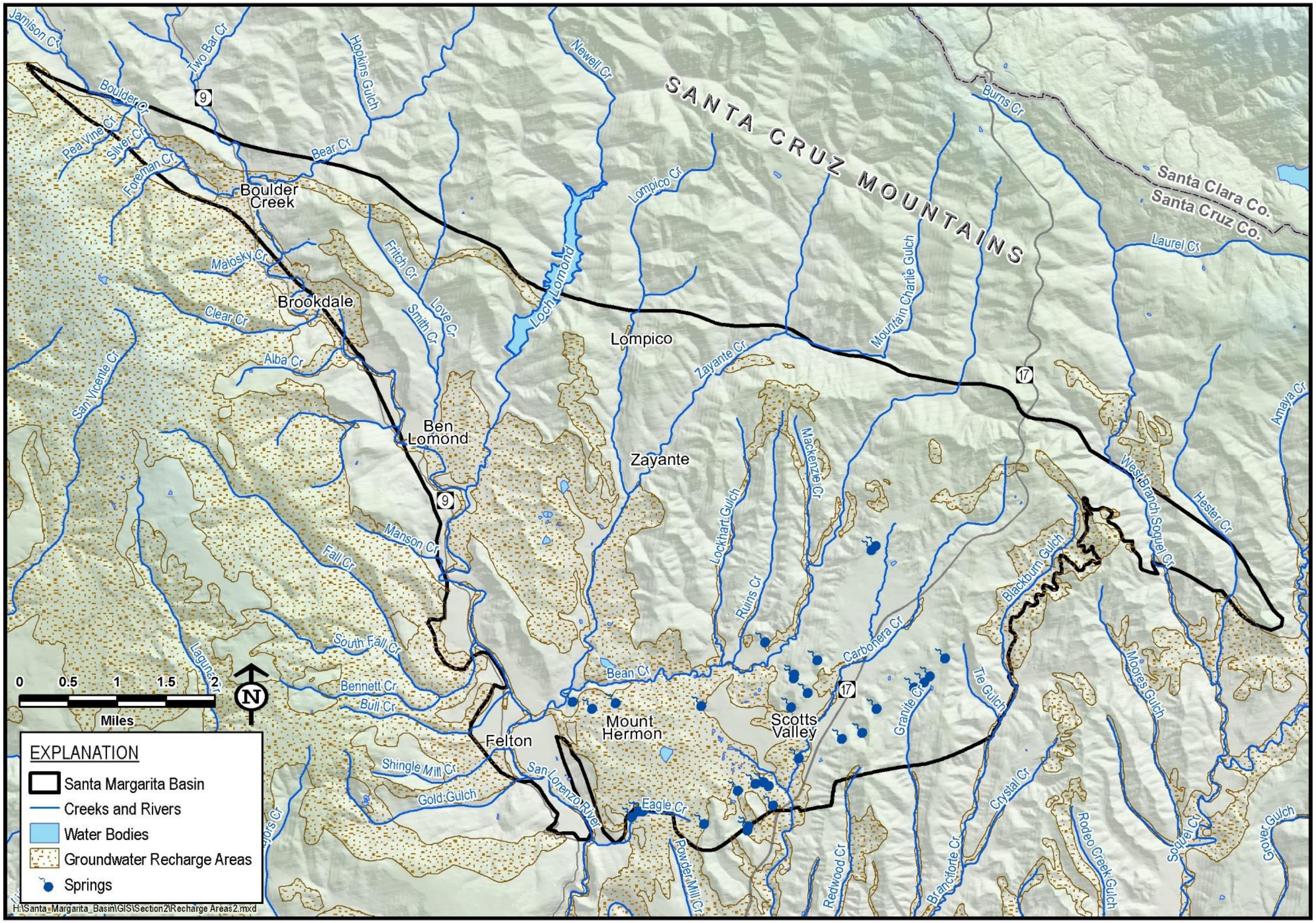


Figure 2-24. Recharge Areas in the Santa Margarita Basin

2.2.4.8 Surface Water

2.2.4.8.1 Rivers and Creeks

Figure 2-25 shows the location of rivers and creeks throughout the Basin. Significant rivers and creeks in the Basin include the San Lorenzo River, Boulder Creek, Love Creek, Newell Creek, Lompico Creek, Zayante Creek, Bean Creek, and Carbonera Creek. Many of these rivers and creeks are home to protected species such as coho salmon and steelhead, as described in Section 2.2.4.9.1.

Previous studies examining streamflow in the Basin concluded that the portion of streamflow that is sustained by groundwater (known as baseflow) peaks around April, at the tail end of the Basin's rainy season. In the dry season, from roughly late May through October, essentially all water flowing in the Basin's streams and creeks is derived from groundwater (Johnson, 2009). This pattern is illustrated on Figure 2-26, originally presented by Johnson in 2009, where representative streamflow hydrographs show streamflow comprised entirely of baseflow from about June through October. From November to May, streamflow is from both baseflow and stormflow. The amount of contribution from baseflow increases through the wet season as a result of rising groundwater elevations.

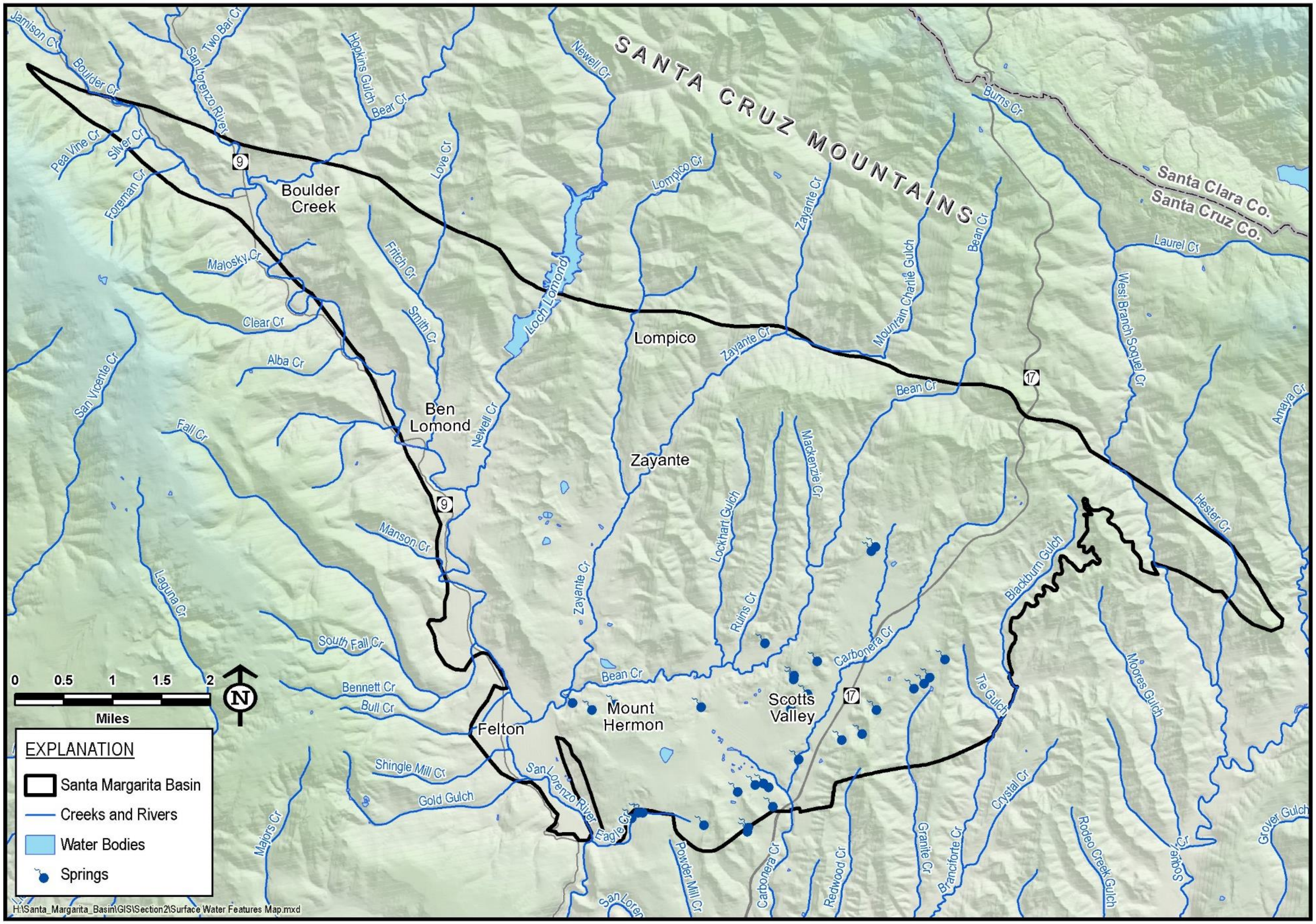


Figure 2-25. Surface Water Features

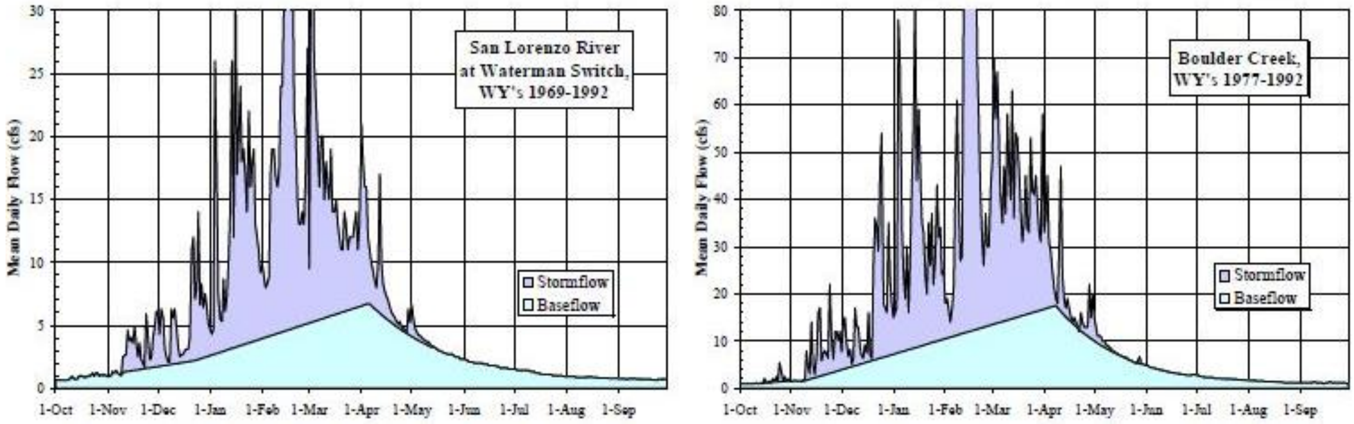


Figure 2-26. Stormflow and Baseflow in San Lorenzo River and Boulder Creek (from Johnson, 2009)

2.2.4.8.2 Water Impoundments

There is 1 permanent surface water impoundment within the Basin operated by the City of Santa Cruz Water Department. The Newell Creek Dam constructed in the early 1960s impounded Newell Creek and formed the Loch Lomond Reservoir (Figure 2-25). The Loch Lomond Reservoir is 2.5 miles long, no more than 1,500 feet wide, and has a maximum storage capacity of approximately 8,600 AF. Water stored in the reservoir is a major supply source for the City of Santa Cruz in summer and during droughts when flowing source availability declines.

There is 1 temporary surface water impoundment in the Basin that is operated rarely by the City of Santa Cruz Water Department. The diversion consists of an inflatable diversion dam on the San Lorenzo River in Felton that allows the City to impound and divert a portion of the streamflow by conveyance pipeline to the Loch Lomond Reservoir for storage. This dam can be inflated during the wet season as minimum bypass flow requirements, water rights, and storage capacity in Loch Lomond allow. If used, the dam is deflated in the dry season when stream flow is low.

2.2.4.8.3 Springs

Springs in the Basin are often important and reliable sources of cold water during summer, support adjacent wetlands, and by definition indicate groundwater levels are at the ground surface. There is a distinction between ‘basal’ and other springs in the Basin. Basal springs emanate from the base of the Santa Margarita Sandstone, where the underlying and much less permeable Monterey Formation of consolidated shales redirects water percolating down through the Santa Margarita Sandstone to the surface through springs, seeps, or other points of discharge.

2.2.4.8.4 Open Water

Lakes and ponds in the Basin are typically man-made or are modifications of natural springs and seeps. Although not usually natural features, lakes and ponds support unique wetland habitats and may be useful indicators of depth to groundwater and nearby rates of groundwater-to-surface water exchange. All open surface water features are included on Figure 2-25.

2.2.4.9 Groundwater Dependent Ecosystems

The GDE analysis in this GSP includes assessment of the extent of GDE indicator vegetation, groundwater elevations in shallow aquifers, and impacts of seasonal surface water and groundwater interaction or accretion. Where groundwater level data are unavailable, the groundwater model is used to identify where surface water and groundwater are likely connected.

Identification of GDEs in the Basin is based primarily on the database of mapping assembled by Natural Communities Commonly Associated with Groundwater dataset [https://gis.water.ca.gov/app/NCDatasetViewer/#]. This database from sources such as the National Wetland Inventory, National Hydrography Dataset, and Classification and Assessment with Landsat of Visible Ecological Groupings includes GDE indicators such as mapped springs, wetlands, and ponds, as well as vegetation types that may rely on shallow groundwater. In addition, several known springs, seeps, or other groundwater-dependent wetlands were identified as likely GDEs.

Types of identified GDEs include springs, open water, riverine/riparian, and other groundwater-supported wetlands. Springs and open water were described in Sections 2.2.4.8.3 and 2.2.4.8.2, respectively. Riverine/riparian and other groundwater supported wetlands are discussed in more detail in the following subsections. Table 2-15 summarizes the four different GDE classifications in the Basin. Figure 2-27 through Figure 2-30 shows the locations of the Basin's mapped GDEs.

Table 2-15. Santa Margariita Basin Groundwater Dependant Ecosystem Classification

GDE Classification	GDE Types	Mapped GDEs
Springs	Basal springs, and non-basal springs	42 sites
Open Water	Lakes and ponds	35 sites
Riverine/ Riparian	Perennial and ephemeral streams, riparian corridors, on-channel ponds, palustrine wetlands	Sites throughout the basin
Other Groundwater-Supported Wetlands	Seep, seep complex, quarry floor, willow vegetation, terrace	5 sites: Quail Hollow, Glenwood Preserve, Lompico (also mapped as a pond), Graham Hill Rd (also mapped as pond), Olympia Quarry floor

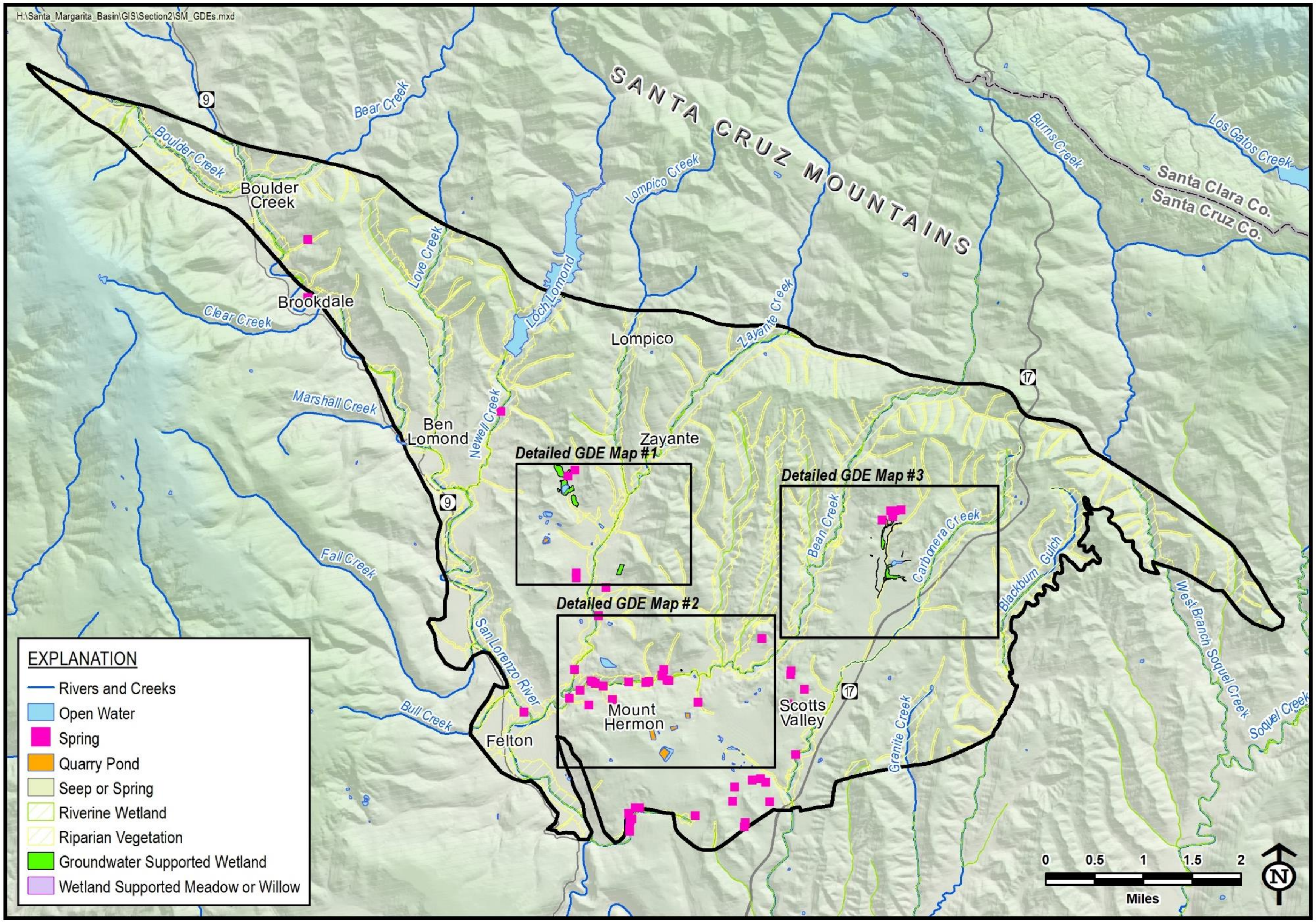


Figure 2-27. Identified Groundwater Dependent Ecosystems in the Santa Margarita Basin

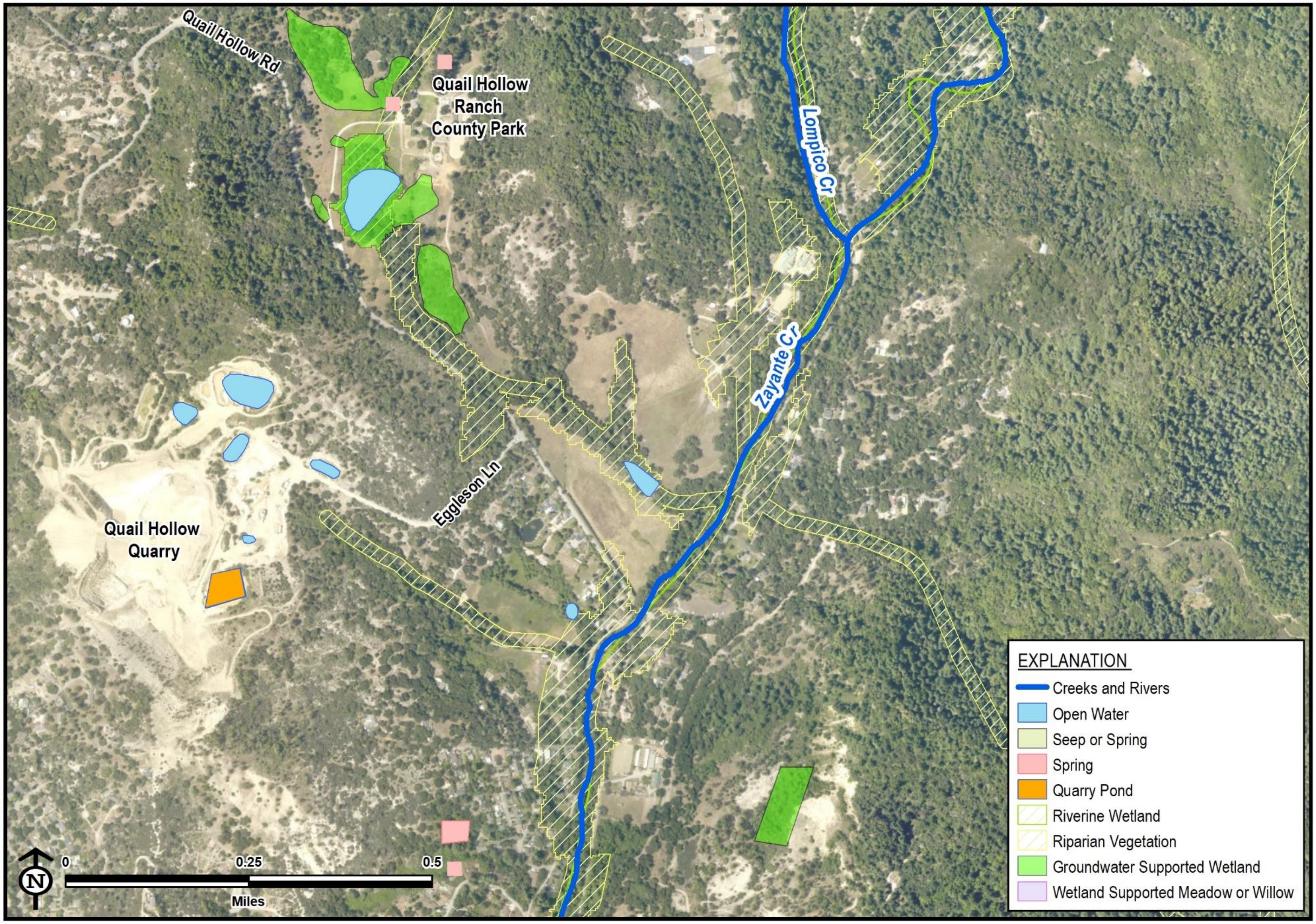


Figure 2-28. Detailed Map #1 of Identified Groundwater Dependent Ecosystems

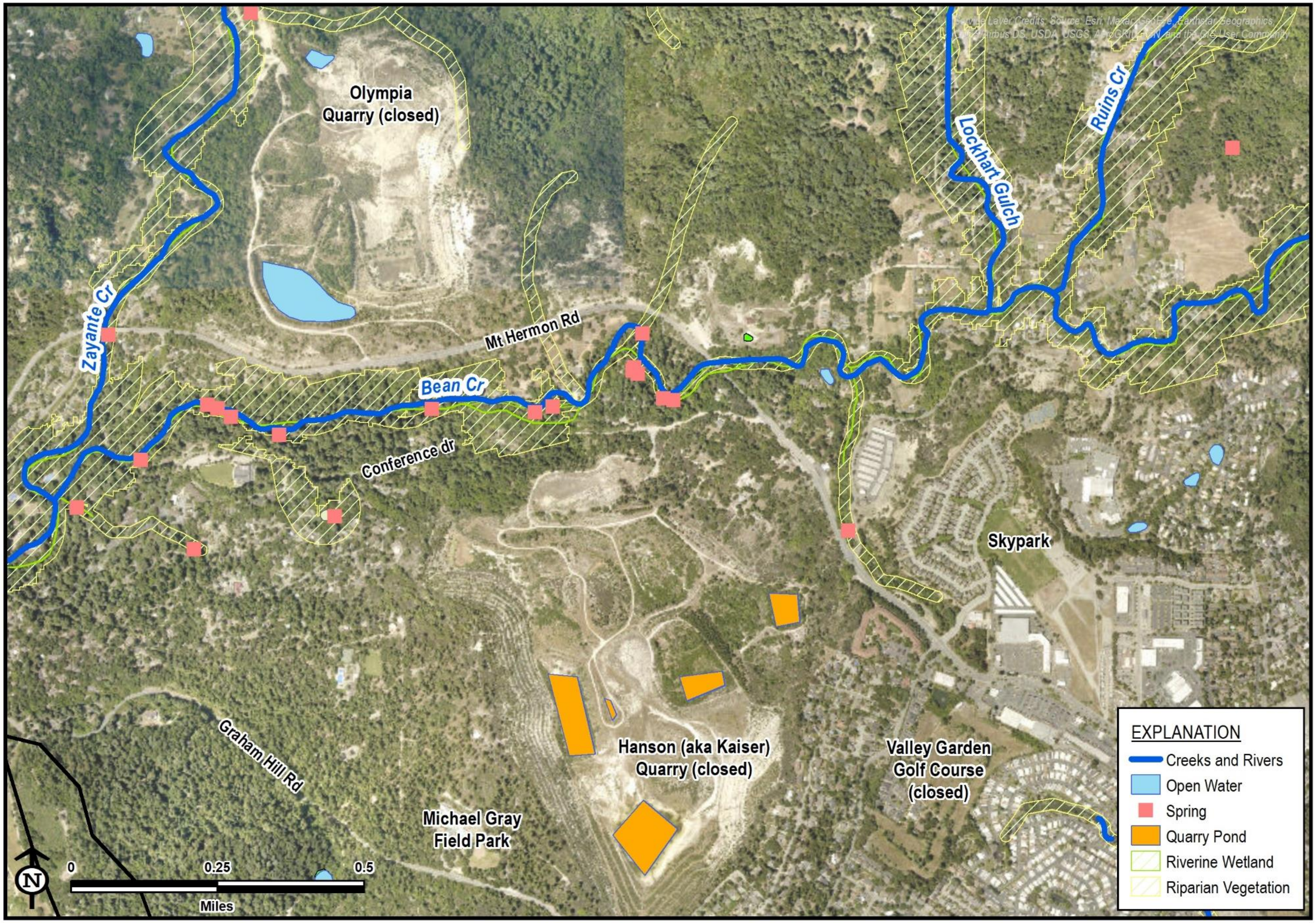


Figure 2-29. Detailed Map #2 of Identified Groundwater Dependent Ecosystems

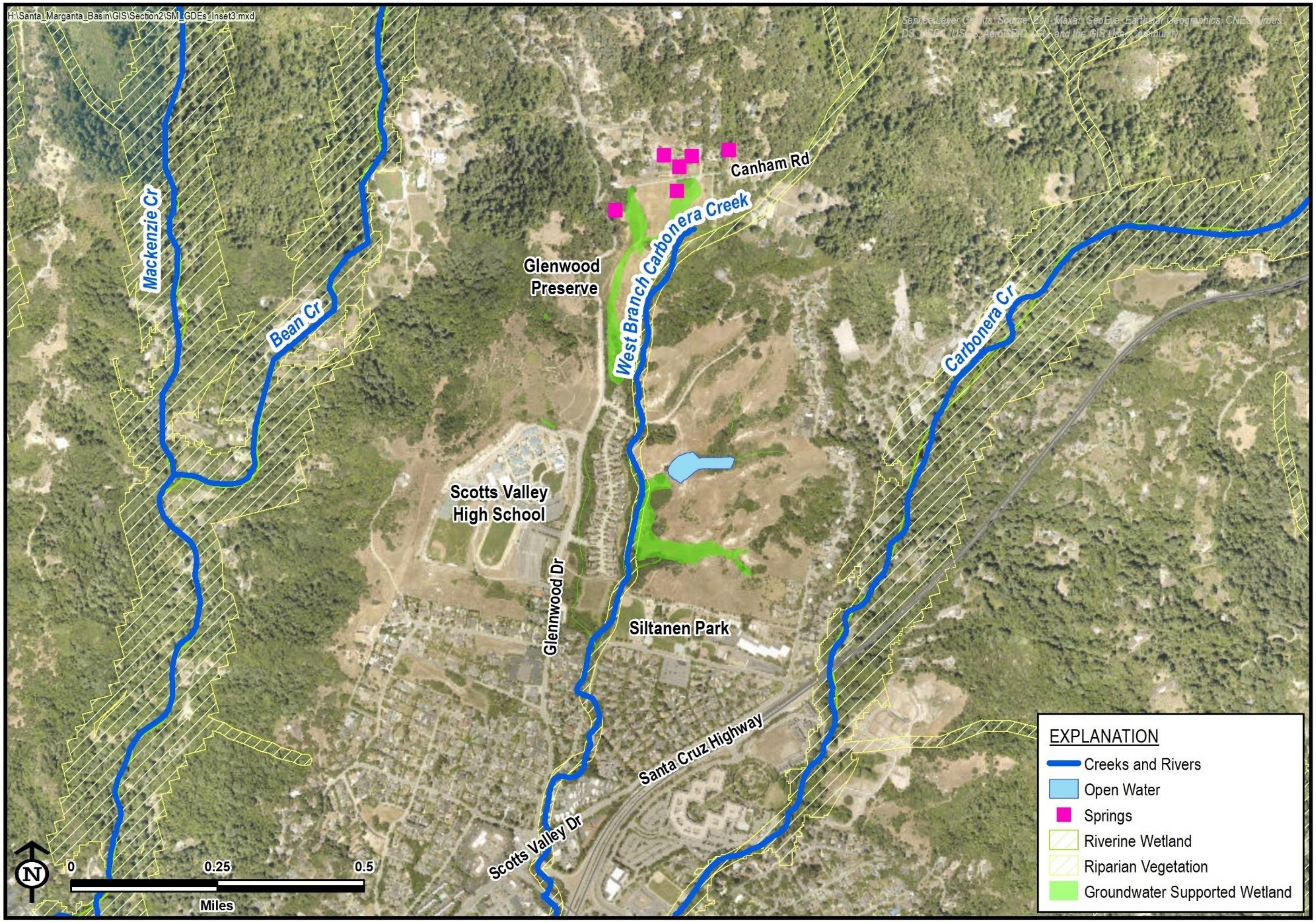


Figure 2-30. Detailed Map #3 of Identified Groundwater Dependent Ecosystems

2.2.4.9.1 Riverine and Riparian GDEs

Riverine and riparian GDEs (including riverine wetlands, on-channel ponds, or other wetland types that occur within the riverine corridor) are distinguished from other GDE types because they have complex interactions with both surface water and groundwater. Riparian vegetation responds to changes in groundwater as well as streamflow, both of which can be influenced by fire, sudden oak death or other infestations, land use changes, and climate change. Further, riparian and watershed vegetation development stage can influence the water budget as older more mature plants have deeper root systems that might access groundwater more efficiently. These complicating factors make correlation of vegetation in riverine and riparian GDEs with groundwater management challenging.

2.2.4.9.2 Other Groundwater-Supported Wetlands

Groundwater supported wetlands in the Basin are a variety of ecologically unique systems. These include spring/seep complexes and quarry floor sites where shallow or emerging groundwater support a variety of wetland vegetation types. Additional investigation is required, but several of these sites are likely supported by local shallow perched groundwater conditions on lower permeability sedimentary deposits as opposed to being supported wholly by baseflow from the high permeability Santa Margarita aquifer.

2.2.4.10 Sources and Points of Water Supply

Almost all water supply within the Basin is derived from local sources. Local water sources in the Basin include groundwater, surface water, and recycled water. Figure 2-31 shows the location of all municipal supply wells, points of surface water diversions, and current service areas of the public suppliers in the Basin. The communities of Forest Springs (126 connections) and Bracken Brae (25 connections) located in the northwesternmost part of the Basin are supplied water from sources within the Boulder Creek watershed but northwest of the Basin through an intertie with Big Basin Water Company.

Figure 2-31 shows the rural areas of the Basin that have no municipal water supply and thus rely on private groundwater wells for domestic and non-domestic water supply. As a requirement per SGMA, Figure 2-32 includes a well density map showing the number of all water supply wells, including municipal, small water systems, private domestic, and industrial, within 1 square mile cells across the Basin.

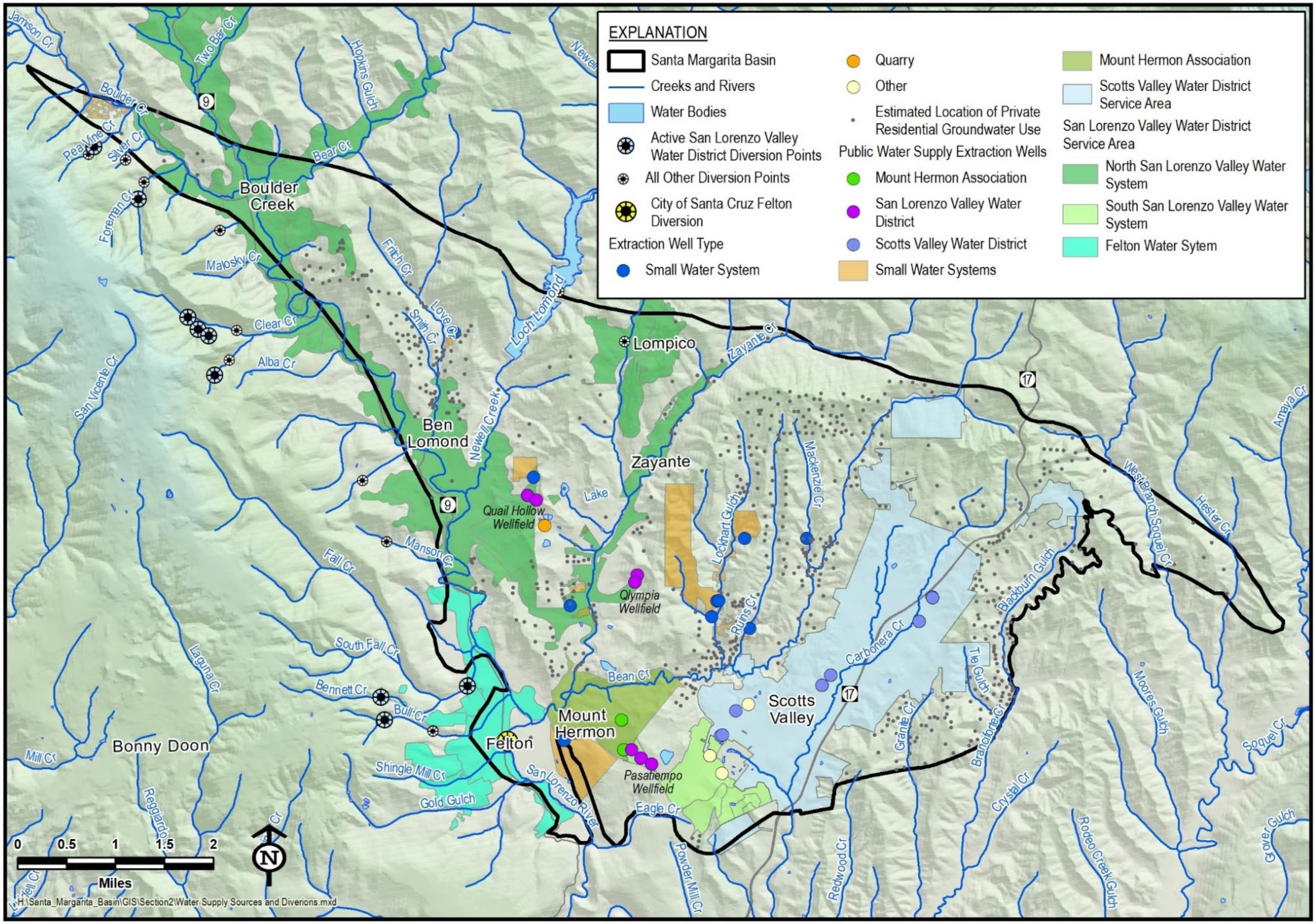


Figure 2-31. Current Water Supply Sources and Service Areas

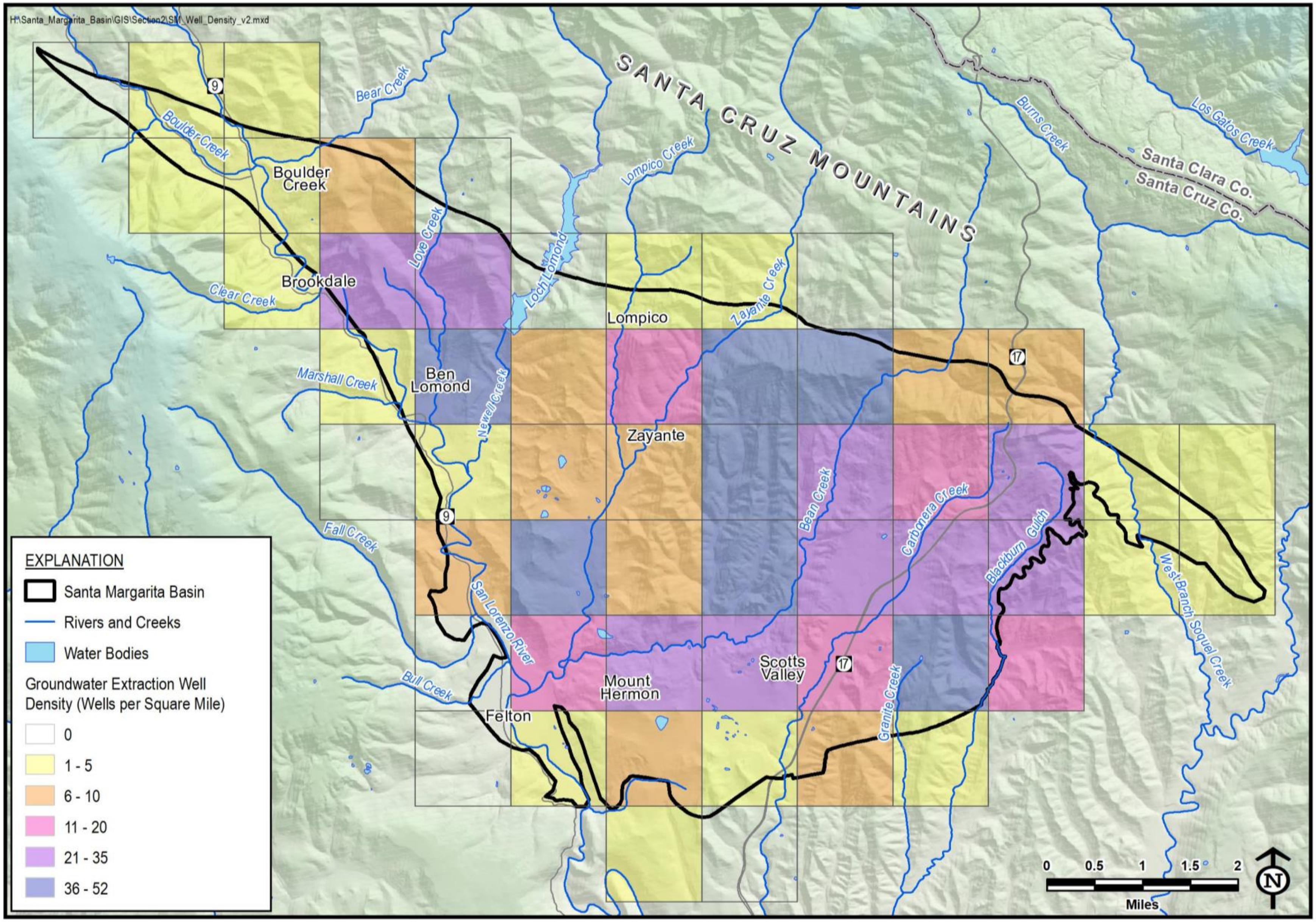


Figure 2-32. Groundwater Extraction Well Density Map for the Santa Margarita Basin

SLVWD uses both surface water and groundwater for its water supply. SLVWD's 9 surface water diversions are shown on Figure 2-31 and listed in Table 2-16. 4 of the 9 points of diversion are currently inactive due to damage sustained in the CZU Lightning Complex wildfire damage in the summer of 2020. It is anticipated that these will be repaired or replaced in 2022/2023. The diversions are all located on tributaries of the San Lorenzo River outside of the Basin. The watersheds of these creeks are also mostly outside of the Basin. Water that is not diverted flows into the San Lorenzo River and is considered a Basin water source. SLVWD appropriative water rights, including pre-1914 appropriative rights on all streams in the San Lorenzo Valley System, are exercised through the active diversions.

Table 2-16. SLVWD Surface Water Diversions

SLVWD System	Points of Diversion	Diversion Status
San Lorenzo Valley System		
Peavine Creek	1	Temporarily inactive
Foreman Creek	1	Active
Clear Creek	3	Temporarily inactive
Sweetwater Creek	1	Temporarily inactive
Felton System		
Fall Creek	1	Active
Bennett Spring	1	Active
Bull Creek	1	Active

Note: gauges that are temporarily inactive were damaged during the CZU Lightening Complex wildfire damage in the summer of 2020

Additionally, SLVWD holds entitlement to a portion of surface water storage in Loch Lomond Reservoir or an equivalent water transfer from the City Santa Cruz Water. SLVWD has not recently exercised its entitlement due mostly to the costly upgrade that would be needed to its Kirby water treatment plant to address the high concentrations of total organic carbon in Loch Lomond raw water.

SLVWD produces stored groundwater from 3 wellfields (Table 2-4 and Figure 2-31). The Quail Hollow and Olympia wellfields extract groundwater from the Santa Margarita aquifer, and the Pasatiempo wellfield extracts from the Lompico aquifer. The 7 active wells are grouped as shown in Table 2-4.

SVWD relies on 5 active groundwater extraction wells for the entirety of its potable water supply (Figure 2-31). These wells extract from the Basin's confined aquifers, namely the Lompico and Butano aquifers. SVWD augments its water supply and offsets its groundwater extraction for non-potable uses with between 160 to 200 AF of recycled water per year. The City of Scotts Valley's WRF treats around 2.9 AF of water daily (or about 1,060 AFY). Influent to the WRF is sourced entirely from within the City of Scotts Valley. Recycled water produced at a Scotts

Valley WRF Tertiary Treatment Plant is used mainly within the city limits but is also available to bulk users outside of city limits.

Groundwater is pumped by private pumpers within the Basin for residential use, and there are some private water rights holders for surface water diversions for non-potable uses. The approximate location of wells used for private use are shown on Figure 2-31.

Other water systems that use groundwater pumped from the Basin as a source of potable water include MHA and 9 small water systems. MHA used springs as their sole water source prior to 1991 (Johnson, 2009) but have since extracted groundwater to meet their full demand. Small water systems primarily use groundwater with several also diverting local surface water to supplement their demand. Section 2.1.4.2.3 provides more information on small water systems.

Table 2-17 summarizes WY2018 water use within the Basin and Figure 2-33 provides annual water use in the Basin from WY1985 through 2018 categorized by water source and user; water year type is shown on the chart (wet, normal, dry, and critically dry; the classification system is described in Section 2.2.3).

The City of Santa Cruz is included in Table 2-17 as it has rights to store and divert surface water in the Basin. The City of Santa Cruz operates the Loch Lomond storage reservoir that impounds water in the Newell Creek watershed that would naturally flow into the Basin. It also operates a diversion on the San Lorenzo River in Felton that conveys water upstream for storage in Loch Lomond. Water diverted and stored in the Basin by the City of Santa Cruz is conveyed out of the Basin by the Newell Creek Pipeline to the City of Santa Cruz water treatment plant.

Table 2-17. Water Year 2018 Santa Margarita Basin Water Use by Source

Water Supplier	Groundwater Use (Acre-Feet)	Surface Water Use (Acre-Feet)	Recycled Water Use (Acre-Feet)	Imported Water Use (Acre-Feet)	Total 2018 Water Use (Acre-Feet)
San Lorenzo Valley Water District (SLVWD)[1]	993	1,166[5]	0	0	2,159
Scotts Valley Water District (SVWD)	1,211	0	196	0	1,407
Mount Hermon Association	129	0	0	0	129
City of Santa Cruz	0	0[6] 1,130[7]	0	0	1,130
Private Domestic Wells[2]	233	0	0	0	233
Other Non-Domestic Private Groundwater Users[3]	145	0	0	0	145
Small Water Systems	79	6	0	48	133
Valley Gardens Golf Course[4]	113	0	0	0	113
Quail Hollow Quarry	25	0	0	0	25
Total	**2,928**	**2,302**	**196**	**48**	**5,474**

Note: The City of Santa Cruz Water Department stores surface water diverted from both the San Lorenzo River and Newell Creek in Loch Lomond Reservoir which is partially within the Basin. Water from Loch Lomond is treated at the City's surface water treatment plant and served to its customers. While SLVWD has a right to a portion of Loch Lomond water to serve to customers within the Basin, this water is currently only delivered to City customers outside the Basin.

[1] includes springs
[2] estimated
[3] other private non-domestic uses include landscape irrigation and water for landscape ponds.
[4] Valley Golf Course closed on December 31, 2018
[5] SLVWD surface water is sourced outside of the Basin in tributaries to the San Lorenzo River
[6] City of Santa Cruz Valley's San Lorenzo River diversion from Felton to Loch Lomond
[7] City of Santa Cruz Valley's San Lorenzo River diversion at Tait Street (5 miles downstream of the Basin) to the City treatment plant

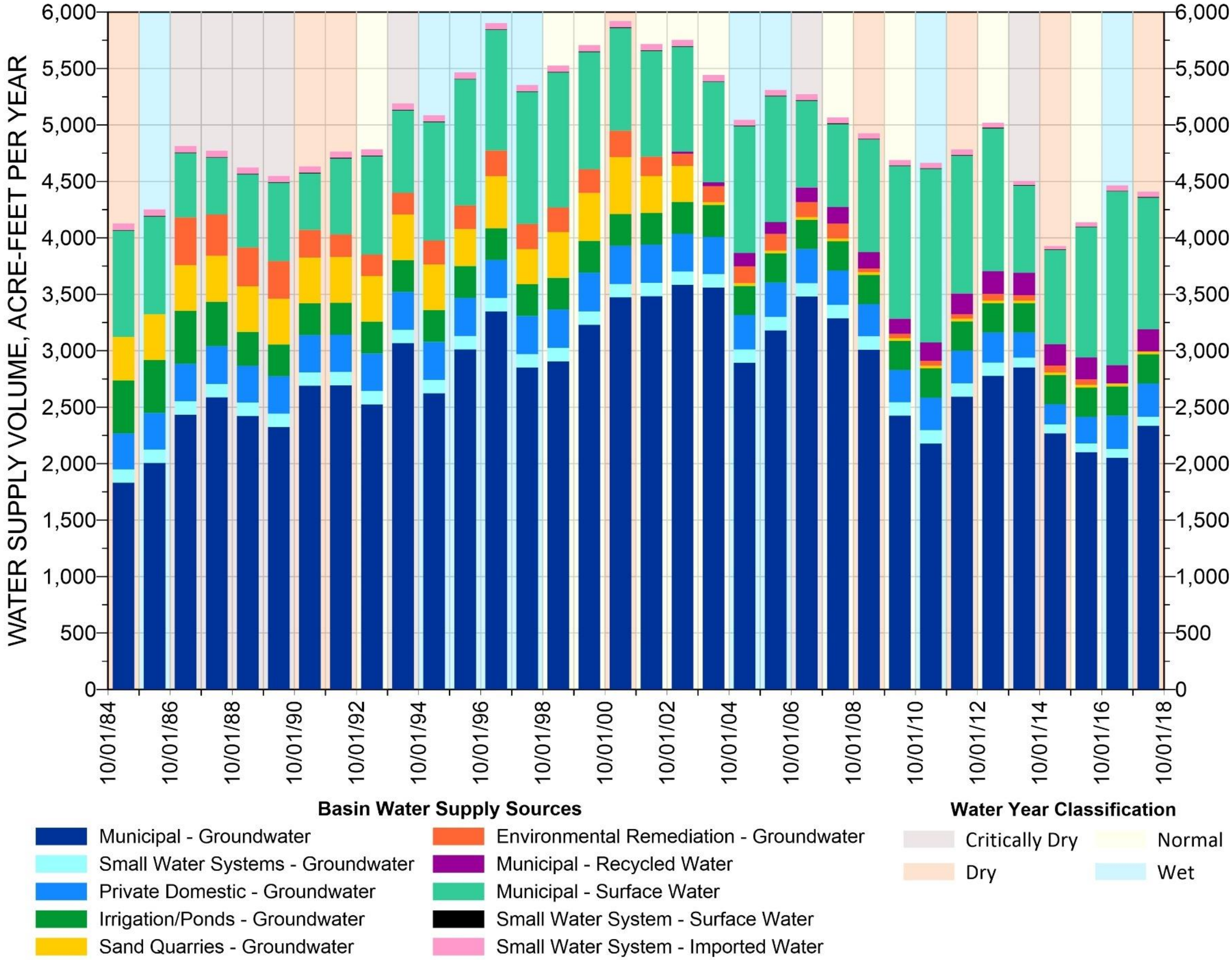


Figure 2-33. Historical Annual Water Use in the Santa Margarita Basin by Source and User

2.2.4.11 Hydrogeologic Conceptual Model Data Gaps

The hydrogeology of the Mount Hermon/South Scotts Valley subarea and portions of the Santa Margarita aquifer in Olympia and Quail Hollow subareas are relatively well understood because of the water supply and monitoring wells that have been drilled, logged, and monitored by SLVWD, SVWD, MHA, and through environmental remediation programs. Areas of the Basin that are lacking these types of data are those that are outside of the jurisdiction of SLVWD, SVWD, and MHA where private domestic groundwater extraction takes place. Additionally, the deep Butano aquifer is poorly understood because it only has 2 dedicated monitoring wells.

These data gaps have led to some uncertainty on how the aquifers interact with each other in parts of the Basin and respond to change in fluxes, such as recharge and groundwater extraction. The 10 new monitoring wells identified and described in Section 3.3.4 will minimize these uncertainties by filling data gaps in the Basin's hydrogeologic conceptual model. These new monitoring wells become part of the overall monitoring network, where implementation of the GSP will ensure ongoing data collection and monitoring that will allow continued refinement and quantification of the hydrogeologic system. Section 5 includes activities to address the identified data gaps and improve the hydrogeologic conceptual model.

2.2.5 Current and Historical Groundwater Conditions

2.2.5.1 Groundwater Elevations

Groundwater has been the primary source of water in the Basin for domestic, municipal, and sand mining users since the early part of the 20th century. The rate of parcel development in the San Lorenzo River watershed between the 1950s and 1980s increased (Figure 2-34) to meet the housing, commercial, and industrial needs of a growing population (Figure 2-35). The parcel development led to increased groundwater demands. Much of the development in this timeframe was in the City of Scotts Valley and the communities of the San Lorenzo Valley (County of Santa Cruz, 2002). Since historical population estimates for all communities within the Basin are not available, Figure 2-35 shows County of Santa Cruz population estimates that can be used as an indication of population growth within the Basin.

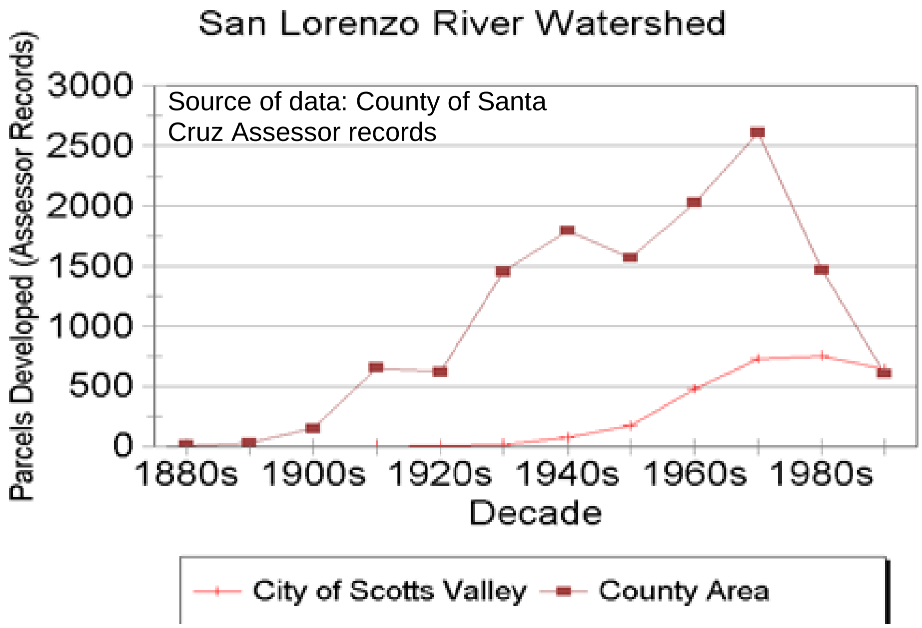


Figure 2-34. County of Santa Cruz Parcel Development in the San Lorenzo River Watershed

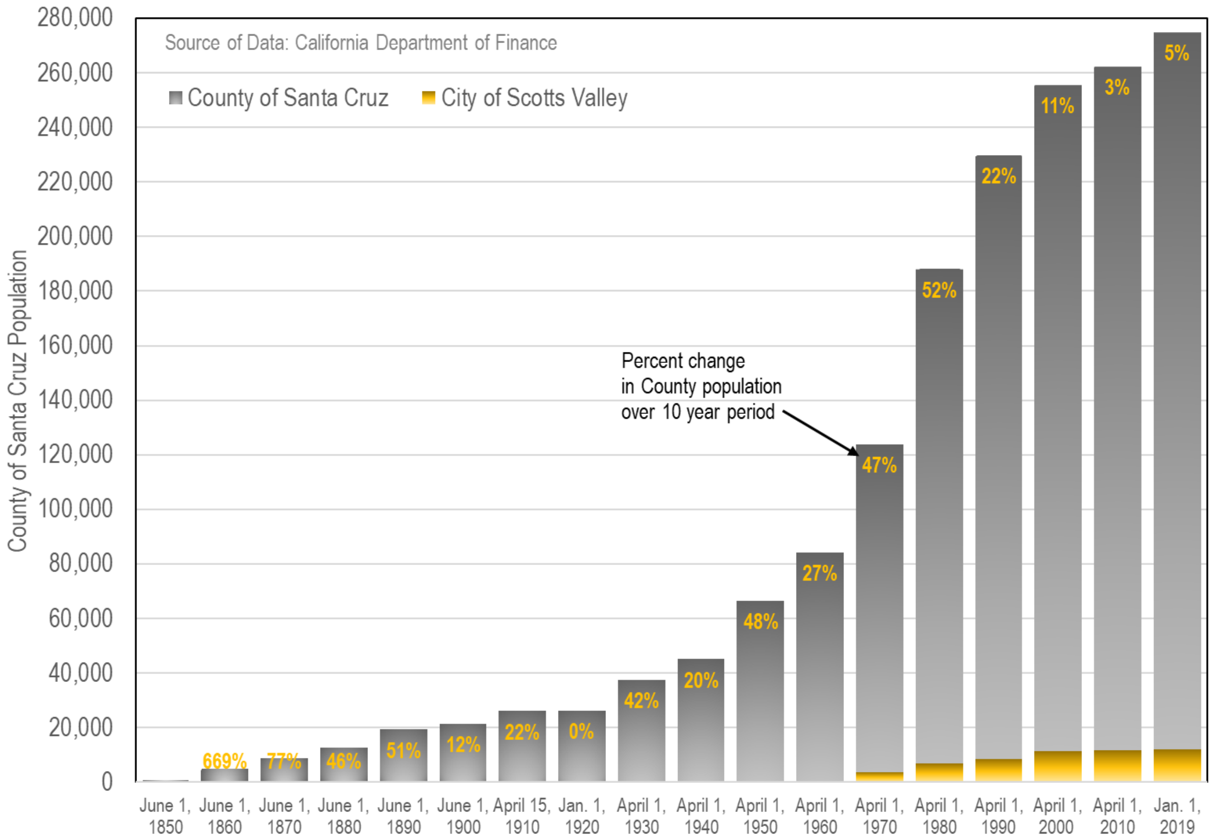


Figure 2-35. County of Santa Cruz Historical Population

The repercussions of historical drought periods, discussed in Section 2.2.6.2.1, and growth in the more developed areas of the Basin has been a decline in groundwater elevations in wells extracting groundwater from the Lompico aquifer. Starting in the 2000s, focused groundwater management and conservation programs by the water districts, reduced environmental remediation pumping, decommissioning of the Hanson and Olympia Quarries, and heightened water use efficiency practices by the Basin's community have largely stabilized groundwater elevations by reducing groundwater extraction to more sustainable volumes (Figure 2-36).

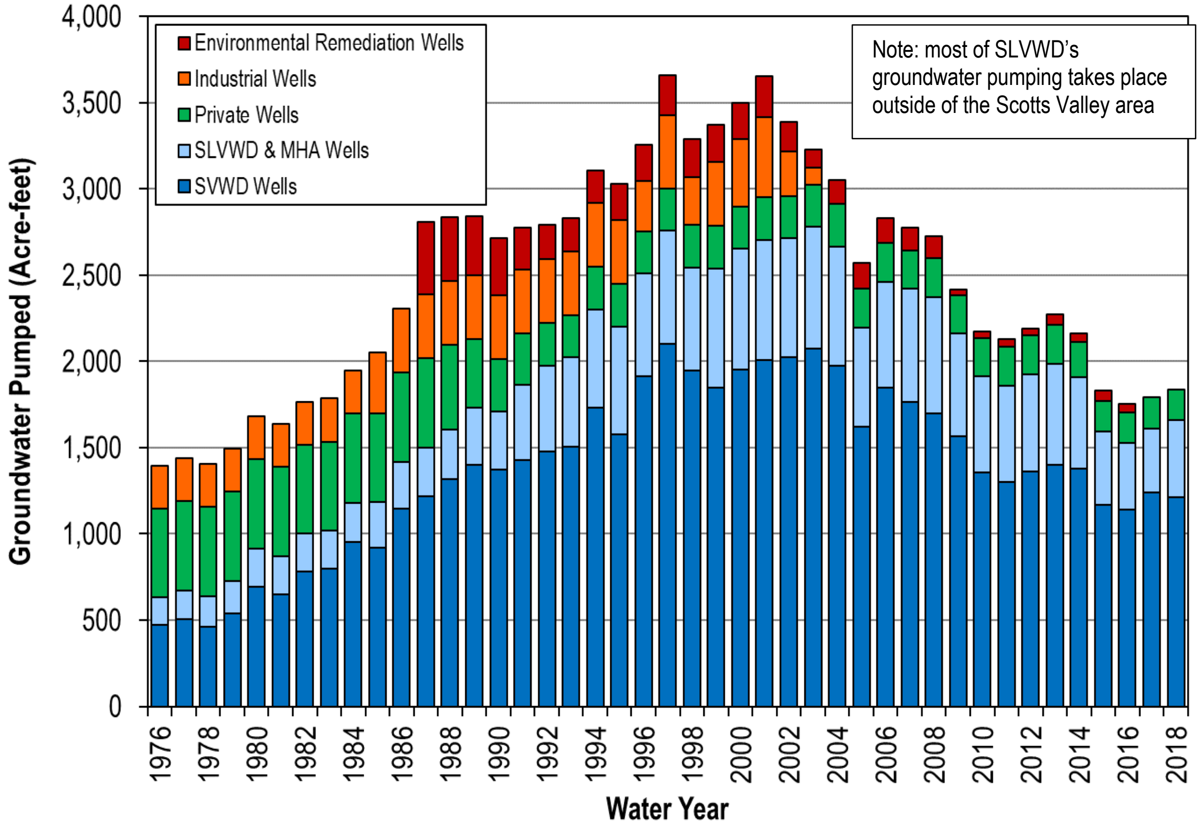


Figure 2-36. Scotts Valley Area (South of Bean Creek) Groundwater Extraction by User Type

2.2.5.1.1 Groundwater Elevation Subareas and Monitoring Wells

The subsections below describe groundwater elevations and gradients by principal aquifers in the Basin). The Monterey Formation is generally an aquitard to flow between the Santa Margarita and Lompico aquifers so is not considered a principal aquifer. To guide discussion in the GSP, the principal aquifers and Monterey Formation are divided into subareas with distinct characteristics.

There are 4 Santa Margarita aquifer subareas shown on Figure 2-37:

1. Quail Hollow
2. Olympia/Mission Springs
3. Mount Hermon/South Scotts Valley
4. North Scotts Valley

The 2 Santa Margarita subareas are generally isolated from each other due to erosion by creeks through the entire thickness of the aquifer are therefore subject to different pumping and recharge regimes (Johnson, 2009). Kennedy/Jenks Consultants (2015b) defined subareas in the Santa Margarita aquifer that are adopted with slight modification for the GSP.

The Quail Hollow area, a roughly 3 square mile hillslope area south of Loch Lomond is largely hydrogeologically separated from other areas of Santa Margarita Sandstone due to erosion and its position on the limb of the Scotts Valley syncline topographically above other outcrops (Johnson, 2009). The only major groundwater pathway between Quail Hollow and the greater Basin is through a narrow bridge of sandstone and stream alluvium beneath Zayante Creek (Figure 2-18). The isolated nature of the Quail Hollow area means that projects and groundwater management actions undertaken in other parts of the Basin are unlikely to influence groundwater conditions in the Quail Hollow area. The other subareas are connected more than Quail Hollow, but still demonstrate unique characteristics due to erosion by creeks.

Subareas are also identified for discussion in the GSP in each of the deeper, more laterally continuous geologic units used for water supply in the Basin. The 3 subareas for the Monterey Formation, Lompico aquifer, and Butano aquifer shown on Figure 2-38 are:

1. North of Bean Creek
2. Mount Hermon/South Scotts Valley
3. North Scotts Valley

The subareas are defined loosely based on the overlying Santa Margarita aquifer subareas, with the subareas south of Bean Creek having identical names and boundaries. Since the majority of the Lompico and Butano aquifer extractions occur in the southern portions of the Basin, there are no monitoring wells in the aquifers and formations in the deeper geologic units in the North of Bean Creek subarea. MHA-MW1, the only Lompico aquifer well north of Bean Creek, is a pilot well that was not completed for extraction and a new addition to the GSP water level monitoring network.

The sections below describe the groundwater conditions measured historically in monitoring wells in the Basin and simulated by the groundwater model. Well locations and the aquifer or formation they are screened in are shown on Figure 2-39. The groundwater elevation contour maps are generated using simulated groundwater model results. The model is calibrated to the groundwater levels in wells and discharge in creeks where data are available and is based on inferences where data are not available.

Appendix 2B contains hydrographs for all wells with current records in the Basin. Note that all hydrographs included in this GSP identify the climatic year type of each water year by different background colors on the graphs (wet, normal, dry, and critically dry; the classification system is described in Section 2.2.3).

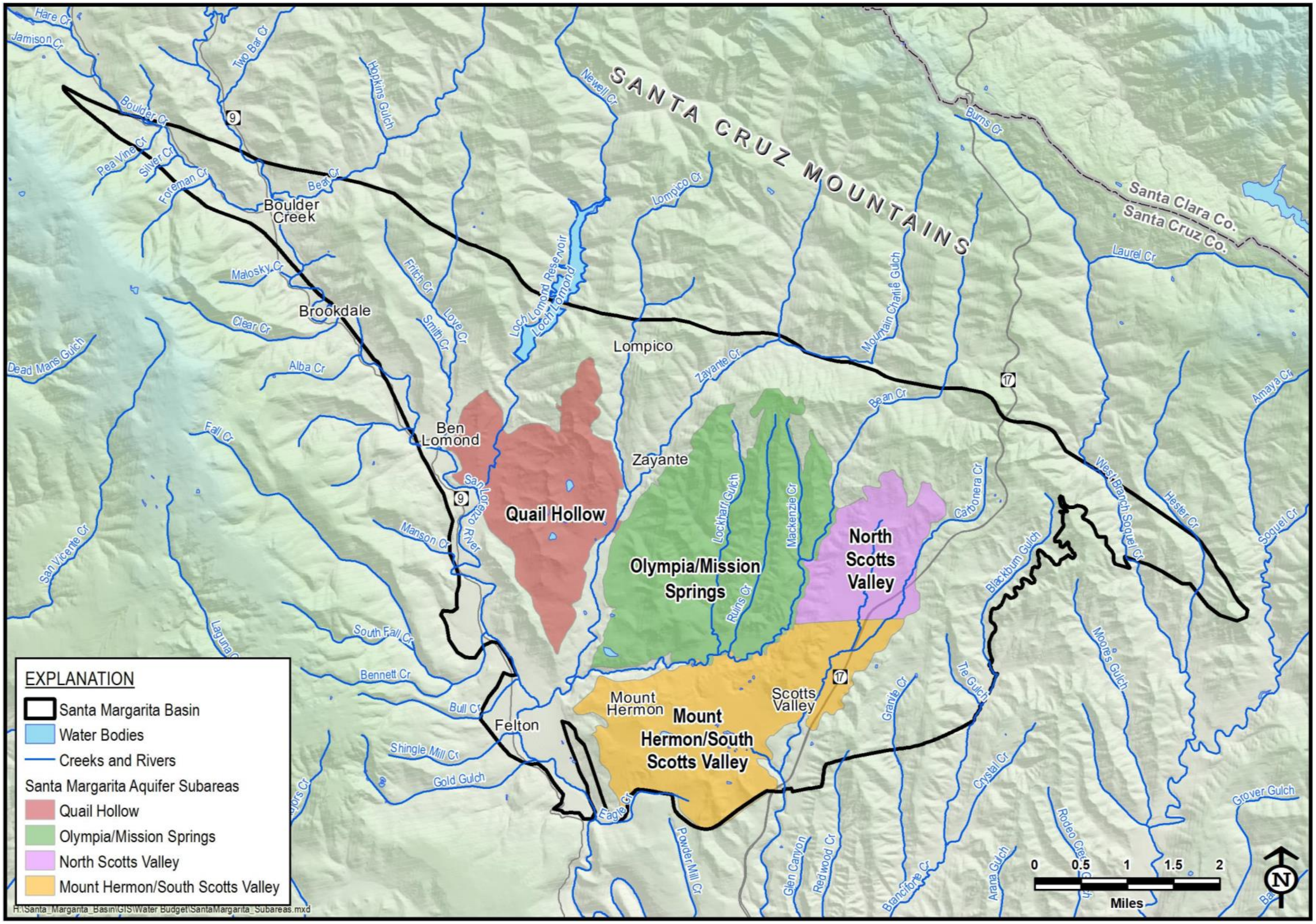


Figure 2-37. Santa Margarita Aquifer Subareas

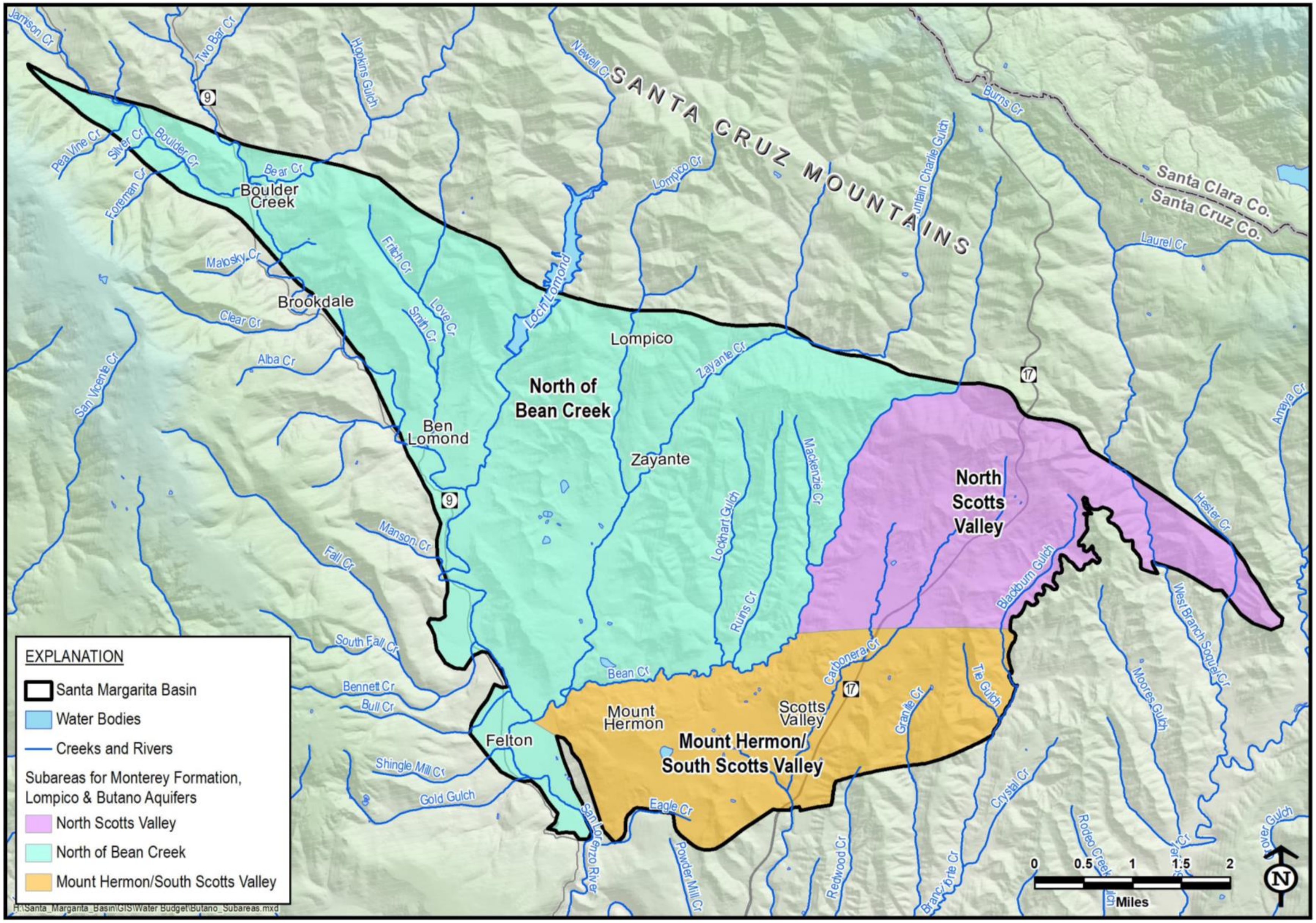


Figure 2-38. Monterey Formation, Lompico Aquifer and Butano Aquifer Subareas

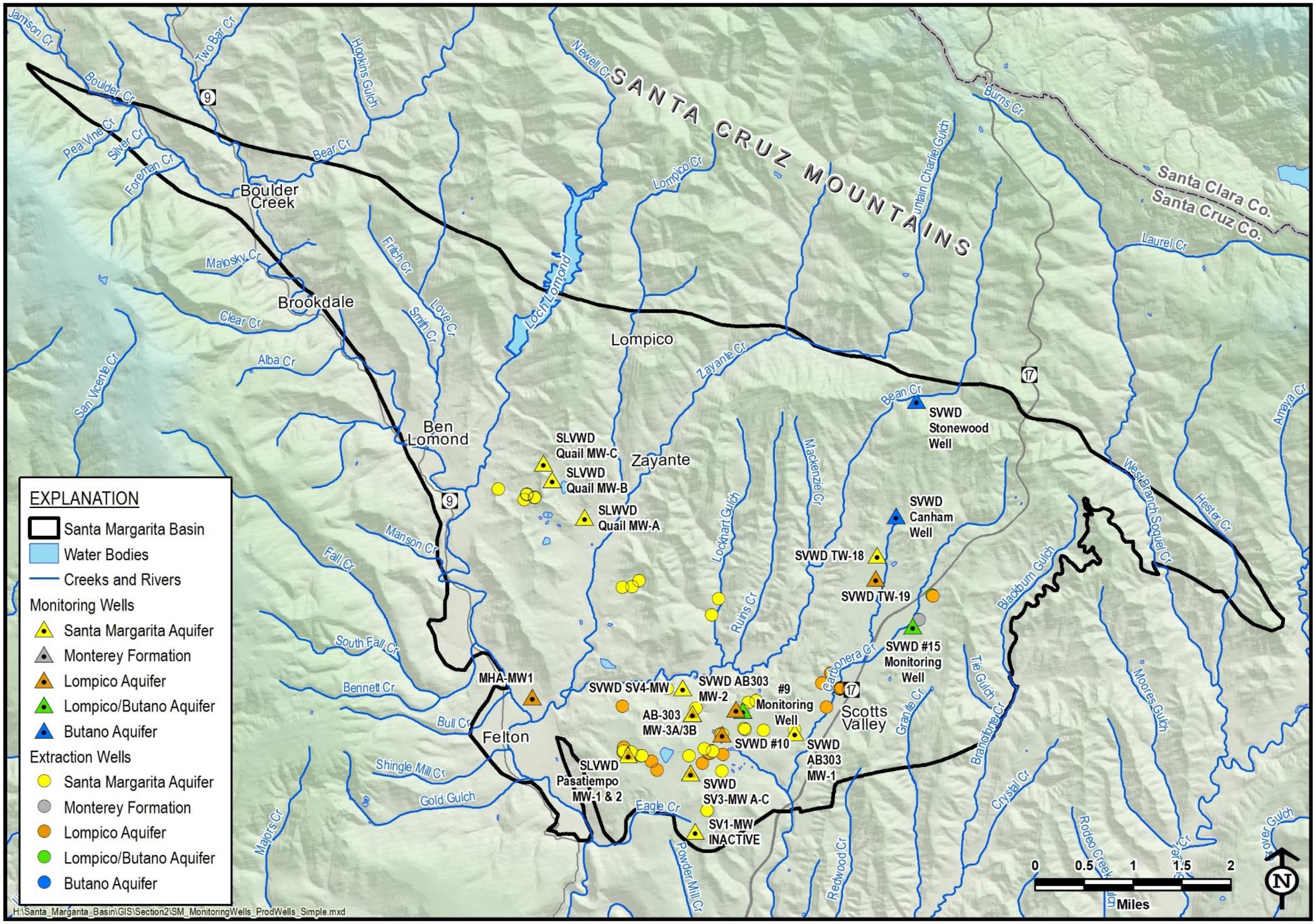


Figure 2-39. Location of Wells Used for Monitoring Groundwater Levels

2.2.5.1.2 Santa Margarita Aquifer Groundwater Elevations

2.2.5.1.2.1 Santa Margarita Aquifer Groundwater Elevations over Time

The Basin's primary unconfined aquifer is the Santa Margarita aquifer as described in Section 2.2.4.4.1. Relatively high hydraulic conductivities and widespread surface exposure result in the Santa Margarita aquifer being one of the most important hydrogeologic units within the Basin for water supply, recharge, and as a source of baseflow for creeks and rivers. The Santa Margarita aquifer's high hydraulic conductivity and extensive surface exposure allow it to recharge quickly after rainfall, but also become dewatered by overpumping in underlying formations as demonstrated on hydrographs in Figure 2-40.

As discussed in Section 2.2.5.1.1, the Santa Margarita aquifer has isolated subareas with distinct groundwater level trends. The groundwater elevations in the Quail Hollow and Olympia/Mission Springs subareas north of Bean Creek demonstrate greater seasonal variability related to groundwater pumping. The Santa Margarita aquifer in the Mount Hermon/South Scotts Valley south of Bean Creek near Pasatiempo and Camp Evers was dewatered in the 1980s by overpumping in the Santa Margarita and underlying Lompico aquifer in an area where the Monterey Formation aquitard is absent. Groundwater elevations have not recovered and as a result, there is no longer groundwater pumping in most of the Santa Margarita aquifer in this portion of the subarea. There is very little pumping in the Santa Margarita aquifer in the North Scotts Valley subarea, resulting in long-term stable groundwater elevations.

This section describes groundwater level fluctuations in representative hydrographs in each subarea. The following section describes the overall groundwater elevations and flow directions for the aquifer in each subarea as simulated by the groundwater model in WY2018.

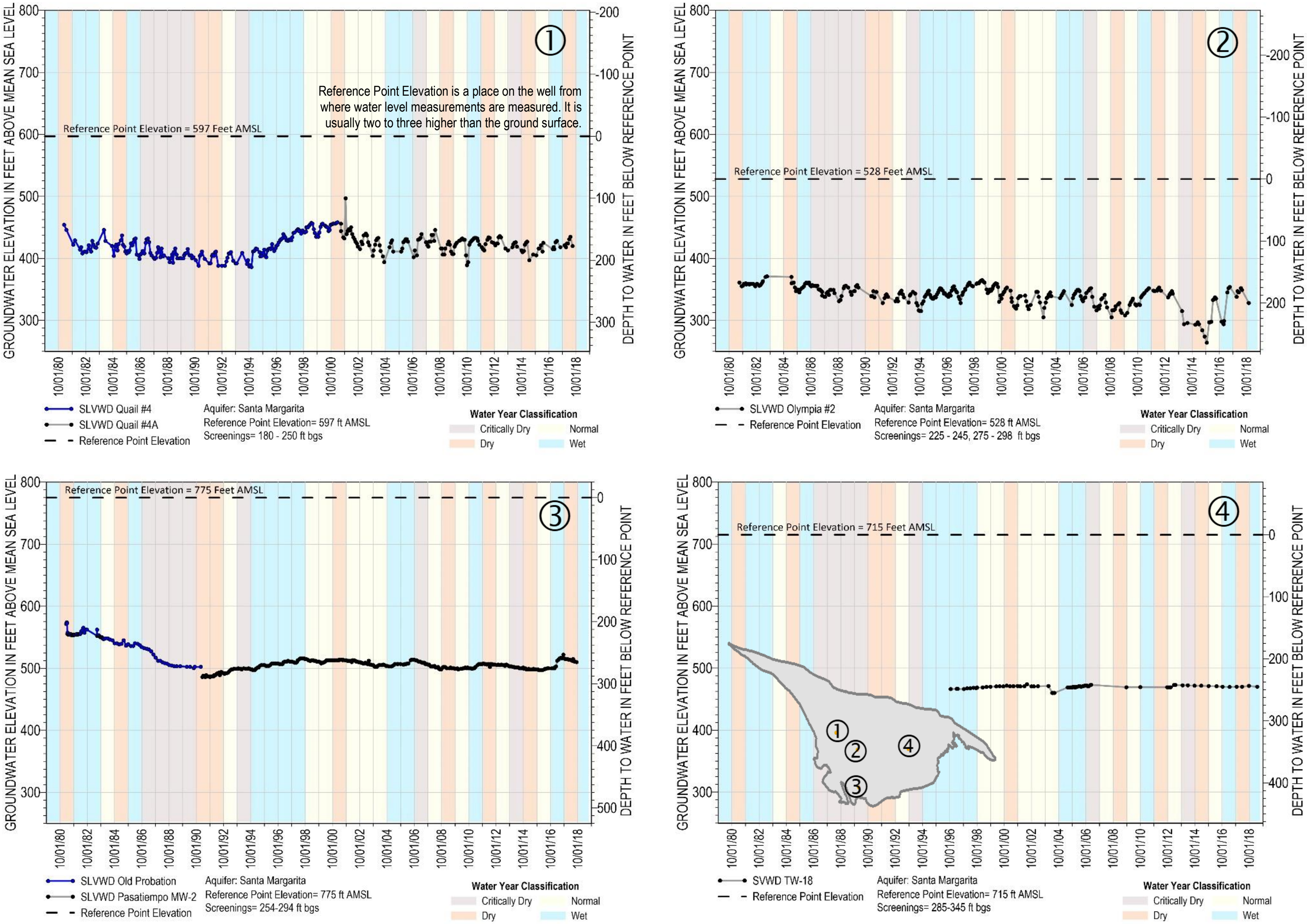


Figure 2-40. Santa Margarita Aquifer Hydrographs

Quail Hollow and Olympia/Mission Springs Subareas

Groundwater elevations in the Santa Margarita aquifer in the Quail Hollow and Olympia/Mission Springs subareas are similar and have remained consistent over time. Groundwater elevations exhibit seasonal fluctuations from pumping and decadal responses to dry and wet periods (Figure 2-40).

The severity of the long-term groundwater level decline that took place in the Basin's deeper confined aquifers over the extended drought in the late 1980s through mid-1990s is not observed in the Santa Margarita aquifer in the Quail Hollow and Olympia areas. The hydrograph for SLVWD's Quail Hollow Well #4 on Figure 2-40 shows that, based on seasonal low elevations, there was a decline of only about 10 feet over that period. Groundwater elevations then recovered 40 feet above pre-drought levels by the end of 4 consecutive wet years that followed the drought. Rapid groundwater elevation recovery is observed during every wet period, as is typical in aquifers that have a high hydraulic conductivity and direct exposure to recharge from rainfall. The 30-foot decline in the Santa Margarita aquifer's Olympia area during the 1987 through 1994 drought was greater than in the Quail Hollow area, as shown on the SLVWD Olympia #2 hydrograph on Figure 2-40. This is probably because there was more pumping from the Olympia well field during this time, especially towards the latter part of the drought.

Mount Hermon South Scotts Valley Subarea

The Santa Margarita aquifer hydrograph for SLVWD Old Probation and SLVWD Pasatiempo MW-2 in the Mount Hermon/South Scotts Valley subarea demonstrate greater groundwater level decline. In the Pasatiempo and Camp Evers area, dewatering of the Santa Margarita aquifer was induced by historical pumping (Johnson, 2009). Dewatering took place because of unsustainable pumping by a combination of users: nearby sand quarry, environmental remediation to clean up contaminated groundwater, and municipal water suppliers. Declining groundwater elevations of up to 200 feet in the deeper Lompico aquifer caused the Santa Margarita aquifer to become unsaturated and eventually completely dewatered in the vicinity of where the Santa Margarita aquifer and Lompico aquifer are in direct contact (Figure 2-18). The combined hydrograph for SLVWD Old Probation and SLVWD Pasatiempo MW-2 on Figure 2-40 shows groundwater elevations in the Santa Margarita aquifer declining 60 feet from the early 1980s to 1989.

In the early 1990s, municipal water supply wells screened in the dewatered Santa Margarita aquifer in this subarea were replaced with deeper wells screened entirely in the Lompico aquifer. As a result of this change in groundwater source, along with reduced environmental remediation and quarry pumping in the Santa Margarita aquifer, by the end of 4 years of above average rainfall ending in 1998, groundwater elevations recovered approximately 25 feet (Figure 2-40). Other than an almost 20-foot increase during the very wet year in 2017, groundwater elevations are stable since 1999. The Pasatiempo and Camp Evers areas currently remain mostly dewatered even though municipal water agencies no longer pump from the Santa Margarita aquifer.

Induced recharge through the aquifer is likely the main reason why it has not completely recovered in dewatered areas. Induced recharge through the dewatered portions of the aquifer generally follows 1 of 2 pathways depending on the underlying formation: 1) infiltration to the top of the underlying low permeability Monterey Formation from where it flows until it emerges as seeps to Bean Creek, and 2) into the Lompico aquifer where it directly underlies the Santa Margarita aquifer. A secondary factor may be reduced local recharge. In the mid-1980s, most septic systems in the Scotts Valley area were converted to a sewer system. Moreover, development over time created increased impervious surfaces. These changes have resulted in less recharge and return flows to the Santa Margarita aquifer in the Scotts Valley area than prior to the 1980s.

North Scotts Valley Subarea

The Santa Margarita aquifer in the North Scotts Valley subarea is not pumped by SVWD. Because this part of the City of Scotts Valley is supplied water by SVWD, there are very few private wells. SVWD TW-18 is the only Santa Margarita monitoring well in the subarea and its groundwater elevations have fluctuated slightly since the start of the monitoring record in 1996 (Figure 2-40). Its trends are notably different than the Quail Hollow and Olympia/Mission Springs subareas, which demonstrate seasonal fluctuations related to groundwater pumping. Since the Monterey Formation underlies the aquifer in the North Scotts Valley subarea, groundwater levels are not influenced by pumping occurring in the deeper Butano and Lompico aquifers in the subarea.

2.2.5.1.2.2 Santa Margarita Aquifer Groundwater Elevation Contours and Flow Directions

Groundwater flow in the Santa Margarita aquifer generally mimics the surface topography. Groundwater flows from areas of higher elevation where the Santa Margarita aquifer is exposed at the surface and can be directly recharged, towards areas of lower elevations where groundwater is discharged. Groundwater discharge occurs in seeps at the contact between the Santa Margarita aquifer and underlying Monterey Formation, in springs, or as baseflow in Bean Creek, Zayante Creek, Newell Creek, and the San Lorenzo River in the Glen Arbor area.

As required per the GSP regulations, seasonal high and fall seasonal low contour maps are provided in this subsection. Figure 2-41 and Figure 2-42 show Santa Margarita aquifer groundwater elevations and flow directions for the spring (seasonal high) and fall (seasonal low) of WY2018, respectively. The groundwater elevations included on the Santa Margarita aquifer and all other aquifer contour maps are both a combination of interpreted contours from measured elevations at wells, and model-simulated elevations in areas where there are no measured data. The contour maps are produced for this and other following sections to show that seasonal groundwater flow patterns are similar at the regional scale despite local groundwater elevation fluctuation during wet and dry seasons. The subsections below describe groundwater elevations and flow for each of the subareas.

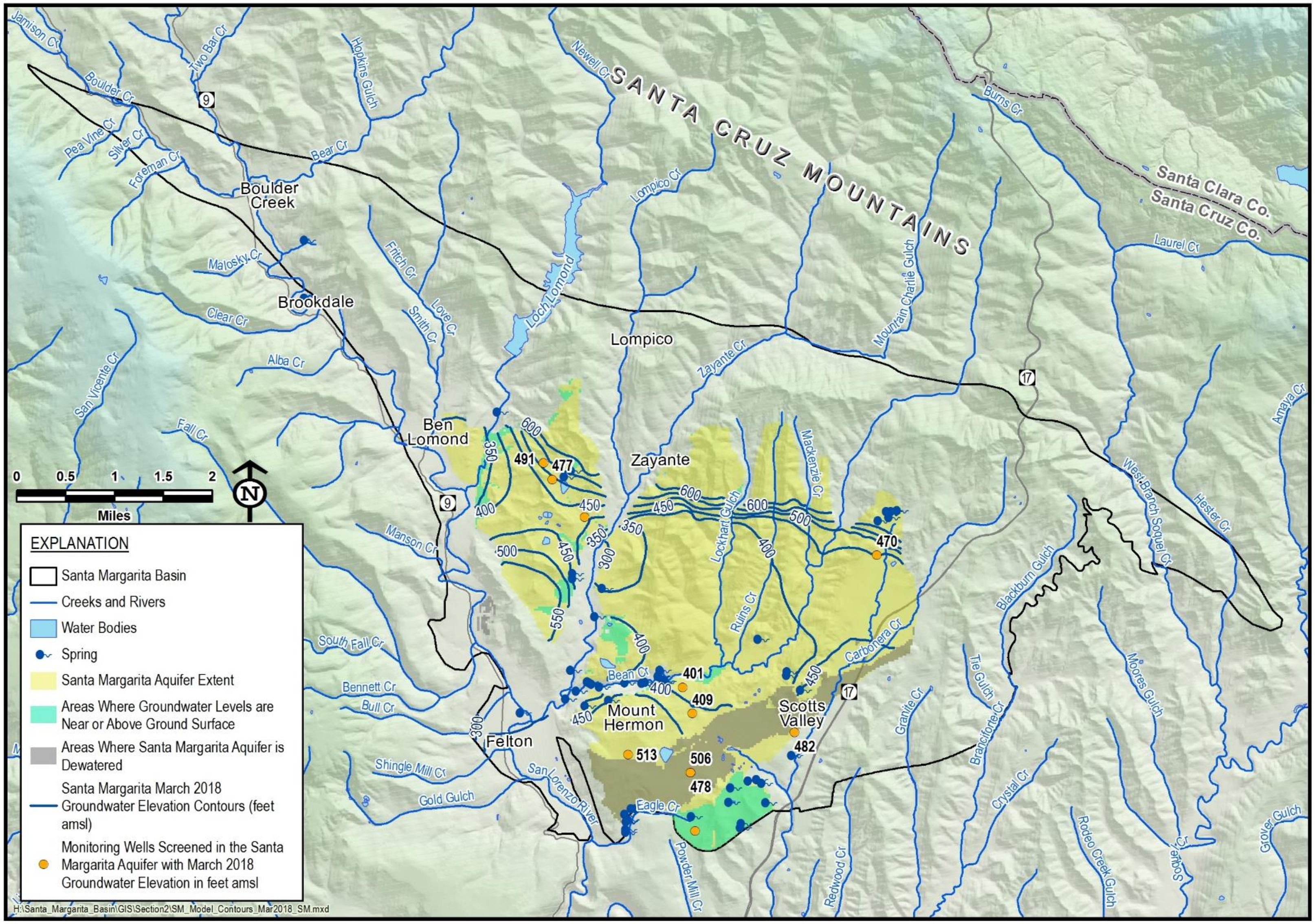


Figure 2-41. Spring (March) Water Year 2018 Groundwater Elevations in the Santa Margarita Aquifer

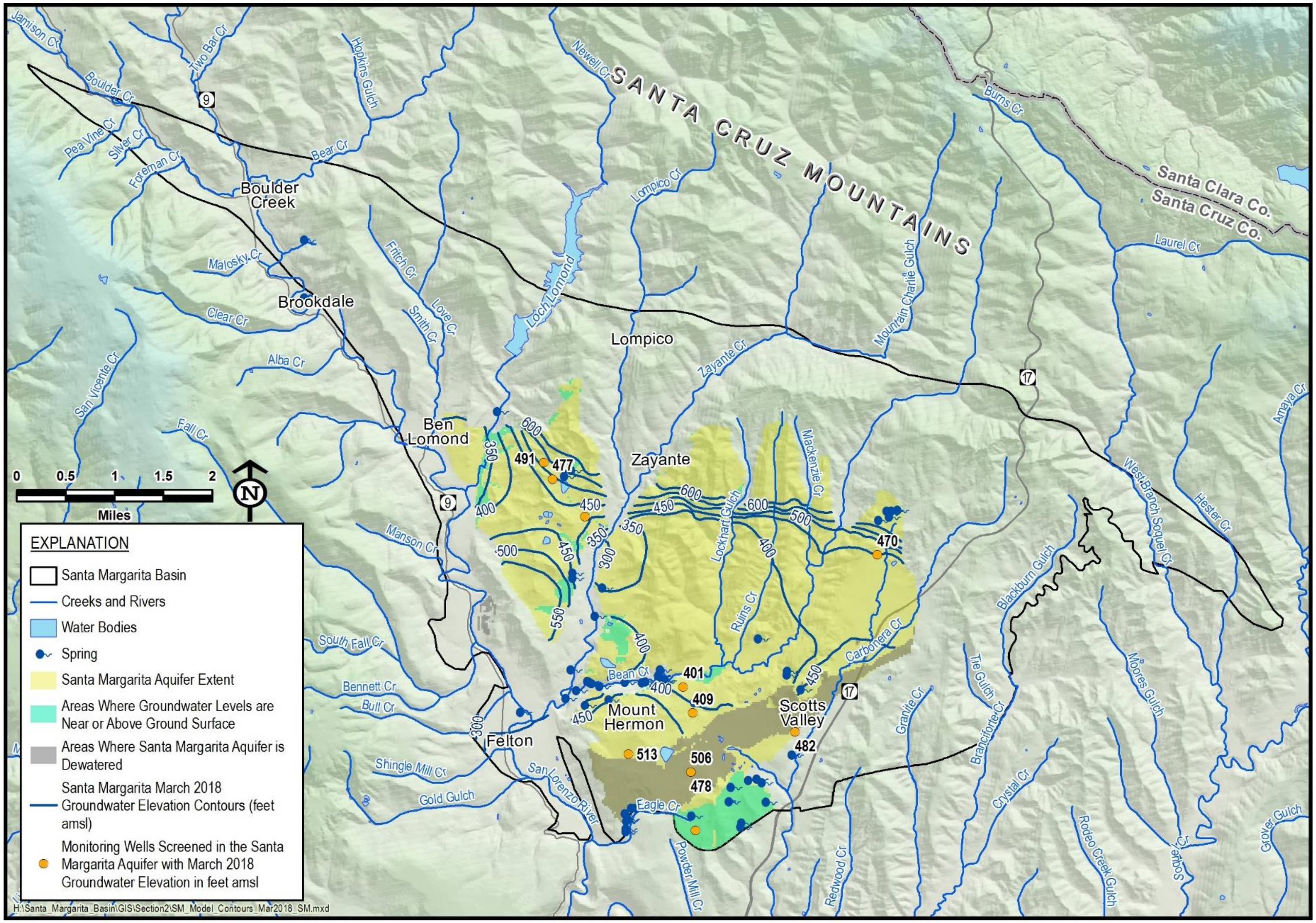


Figure 2-42. Fall (September) Water Year 2018 Groundwater Elevations in the Santa Margarita Aquifer

Quail Hollow Subarea

The Quail Hollow subarea is located in the central portion of the Basin, between the communities of Ben Lomond, Glen Arbor, Felton, Zayante, and Lompico (Figure 2-37). It lies between Love Creek and Lompico/Zayante Creek and is intersected by Newell Creek. Almost the entire subarea has Santa Margarita aquifer exposed at the surface. Groundwater in this subarea is pumped by SLVWD’s Quail Hollow wellfield, the Quail Hollow sand quarry, and private domestic pumpers.

Johnson (2009) and Kennedy/Jenks Consultants (2015b) describe the subarea groundwater elevations as mimicking the topography in a subdued manor as a result of mounded recharge beneath hills and ridges and groundwater discharge to downcut streams. Perennial streams and springs are generally an expression of the groundwater table. Under high groundwater table conditions, the saturated thickness of the Santa Margarita sandstone reaches 130 feet thick. During drought conditions, the groundwater surface partially flattens but maintains a similar shape. Groundwater flows toward the center of Quail Hollow from the north and south, east toward Zayante Creek, west toward the Quail Hollow wellfield where there is a localized pumping depression and then toward Newell Creek. Under drought conditions, some groundwater flows west under Newell Creek toward the San Lorenzo River. Springs occur where the groundwater table intersects the ground surface. Most springs in the subarea occur on the northern flank of the lower Zayante Creek valley where the contact between Santa Margarita Sandstone and Monterey Formation outcrops at the surface, forcing groundwater perched above the Monterey Formation to emerge as springs and seeps.

Olympia/Mission Springs Subarea

The Olympia/Mission Springs subarea is north of Bean Creek and lies between the communities of Mount Hermon, Zayante, and Scotts Valley (Figure 2-37). The subarea is a hillslope area where hilltop ridges are capped by Santa Cruz Mudstone and Purisima Formation, which limits recharge to the Santa Margarita aquifer below. Private domestic pumpers and small water systems provide the majority of water to the residents in the subarea. The only municipal pumping occurs in the western portion of the subarea where SLVWD has its Olympia wellfield.

The highest groundwater elevations are in upland areas in the northern portion of the subarea (Figure 2-41 and Figure 2-42) where recharge to the exposed portions of the aquifer occurs by direct percolation of precipitation and streambed percolation in the upper reaches of creeks. Groundwater flows from the upland areas to lower elevations discharging at: 1) Zayante Creek, west of the Olympia wellfield, 2) near the confluence of Lockhart Gulch and Ruins Creek with Bean Creek, and 3) in springs that occur at the contact of the Santa Margarita aquifer and Monterey Formation along the sides of Zayante and Bean Creeks. A localized pumping depression is associated with the Olympia wellfield.

The Olympia/Mission Springs subarea is separated from the Pasatiempo/Camp Evers/Scotts Valley subarea by Bean Creek, which is a groundwater discharge location in the Santa Margarita aquifer, as shown on the groundwater elevation contour maps (Figure 2-41 and Figure 2-42). Groundwater level declines north of Bean Creek are unlikely to influence groundwater elevations south of Bean Creek, and vice versa.

North Scotts Valley and Mount Hermon/South Scotts Valley Subareas

The Santa Margarita aquifer south of Bean Creek is divided into 2 subareas: North Scotts Valley and Mount Hermon/South Scotts Valley (Figure 2-37). Most of the Santa Margarita aquifer in the North Scotts Valley subarea is overlain by the Santa Cruz Mudstone. There has not been municipal pumping in the subarea, and there is limited private domestic pumping.

The Mount Hermon/South Scotts Valley subarea lies south of the lower to mid-reach of Bean Creek (Figure 2-37), both where it is exposed at the surface and locally overlain by the Santa Cruz Mudstone. It includes most of the City of Scotts Valley, the communities of Camp Evers and Mount Hermon, and the Hanson Quarry (Figure 2-37). It is considered separately from the Northern Scotts Valley subarea because it contains the dewatered portion of the aquifer.

Most of the groundwater pumping in the Mount Hermon/South Scotts Valley subarea is by municipal suppliers, SVWD, SLVWD, and Mount Hermon Association, who pump from the deeper Lompico aquifer and not from the Santa Margarita aquifer. Historically, municipal, environmental remedial, and sand quarry pumping from the Santa Margarita aquifer took place in the subarea, but that use no longer occurs, as described in Section 2.2.5.1.1. There is limited pumping by private domestic pumpers in the subarea.

The highest groundwater elevations are in the upland areas in the North Scotts Valley subarea (Figure 2-41 and Figure 2-42). Groundwater recharge is mostly from precipitation and streambed percolation where the Santa Margarita aquifer is exposed at the surface. Santa Cruz Mudstone overlying much of the Santa Margarita Aquifer limits the amount of precipitation and return flows reaching the aquifer. Groundwater recharge also occurs along Carbonera Creek where it flows in the Santa Margarita aquifer or the alluvium directly overlying the Santa Margarita aquifer (Kennedy/Jenks Consultants, 2015b).

Groundwater flows south from the northern upland area and north from Mount Hermon to the central part of the subarea. Groundwater flow converges toward Bean Creek where the lowest groundwater elevations are found along the subarea's boundary with the Olympia/Mission Springs subarea. Bean Creek is the primary groundwater discharge area for groundwater in the subareas south of Bean Creek. In the western portion of the Mount Hermon/South Scotts Valley subarea, groundwater discharges at numerous springs along the Santa Margarita Sandstone outcrop areas bordering Bean, Eagle, and Camp Evers Creeks. Figure 2-41 and Figure 2-42 indicate areas where groundwater elevations simulated in the groundwater model lie above the land surface. These areas correlate with known springs, which are indicated on the contour maps.

Historically, some of Mount Hermon Association's water supply was from the Ferndell and Redwood springs. Water discharged by these springs is now sourced from the upland areas of the Santa Margarita aquifer adjacent to the springs.

In the past, when there was environmental remediation, quarry, and municipal pumping in the Santa Margarita aquifer, there were localized pumping depressions in the aquifer, but those have dissipated since that pumping ceased. Figure 2-41 and Figure 2-42 show the location where the Santa Margarita aquifer is unsaturated or dewatered for its entire thickness. Even with portions of the aquifer dewatered, groundwater flow in this area is still toward Bean Creek.

2.2.5.1.3 Monterey Formation Groundwater Elevations

As described in Section 2.2.4.5.3, the Monterey Formation is not a high yielding aquifer and is not considered a principal aquifer, but its groundwater is pumped by some Basin residents because there is no alternative water source. Groundwater elevation data for wells screened in the Monterey Formation in the Basin are very limited. The only long-term record is from SVWD Well #9 previously thought to be screened in the Santa Margarita aquifer (Kennedy/Jenks Consultants, 2015b). The lack of monitoring data in the Monterey Formation indicates a data gap that should be addressed by adding some private wells to the County's private well monitoring network described in Section 2.1.2.4.1 or by installing dedicated monitoring wells.

The single hydrograph for the Monterey Formation on Figure 2-43 shows that groundwater elevations have a much more pronounced response to drought and increased water usage than the Santa Margarita aquifer, presumably because recharge to sandy layers tapped in the Monterey Formation is impeded by the low conductance of the surrounding mudstone and shale layers. A decline in groundwater elevations of about 150 feet corresponds with an extended dry period that started in the mid-1980s (Figure 2-43) and population growth in the Basin. It is notable that the SVWD Well #9 was pumped more between 1983 and 1988 than in the years before and after. Groundwater elevations stabilized in 1994 during a period of 4 consecutive wet years. Since 1998, a more typical rainfall pattern and a 50% reduction in extraction from SVWD Well #9 allowed groundwater elevations to recover by about 30 feet (Figure 2-43).

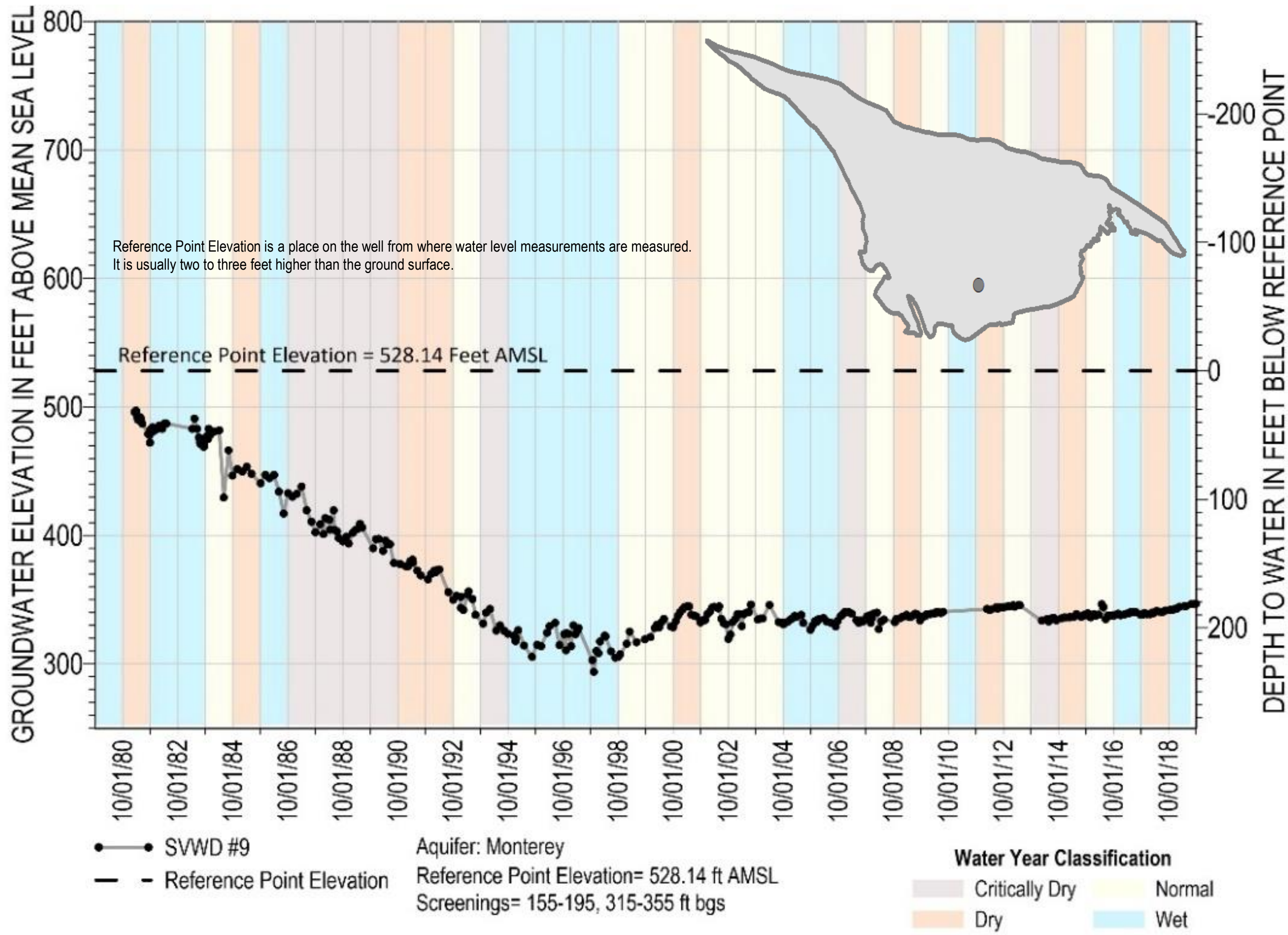


Figure 2-43. Monterey Formation Hydrograph

2.2.5.1.4 Lompico Aquifer Groundwater Elevations

2.2.5.1.4.1 Lompico Aquifer Groundwater Elevations over Time

Most of the groundwater pumped from the Lompico aquifer in the Basin is extracted in the Scotts Valley area, because this area has the sole potable source available to SVWD. The Lompico aquifer is also pumped by the SLVWD Pasatiempo and Mount Hermon Association wellfields to the south of Scotts Valley. There is little to no Lompico aquifer pumping north of Bean Creek and therefore there has been no historical groundwater level monitoring conducted in the North of Bean Creek subarea (Figure 2-39).

In the Mount Hermon/South Scotts Valley subarea of the Basin, which includes central Scotts Valley south of Bean Creek, Camp Evers, and Pasatiempo, groundwater elevations in the Lompico aquifer declined as much as 200 feet in well SVWD #10 during the drought period between 1985 and 1994 (Figure 2-44). Other nearby wells have a shorter measurement record but display similar trends. The groundwater elevation declined more in this subarea than in other parts of the Basin during the drought due to population growth, remediation pumping at 2 cleanup sites, and pumping at the Hanson Quarry that led to overextraction of groundwater. Subsequent groundwater management efforts and reduced pumping due to conservation slowed the decline in groundwater levels, stabilizing them in the early 2000s. Since 2017 there has been a small but sustained increase in groundwater elevations of about 10 feet per year (Figure 2-44). The SVWD TW-19 monitoring well installed in the North Scotts Valley subarea demonstrates similar overall trends, though the record only starts in 1996 and has a short-term groundwater level increase between 1996 and 2000 not observed in the other hydrographs (Figure 2-44).

For the purposes of groundwater management in the Basin, it is important to highlight that elevation data for wells in the Lompico aquifer indicate that sometime around 2012, pumping volumes ceased to be unsustainable. Most wells exhibited more or less constant seasonal lows in groundwater elevation during the recent drought of 2012-2015. Moreover, it appears that groundwater elevations have been recovering since 2017. These facts suggest that over-pumping is no longer occurring in the Lompico aquifer.

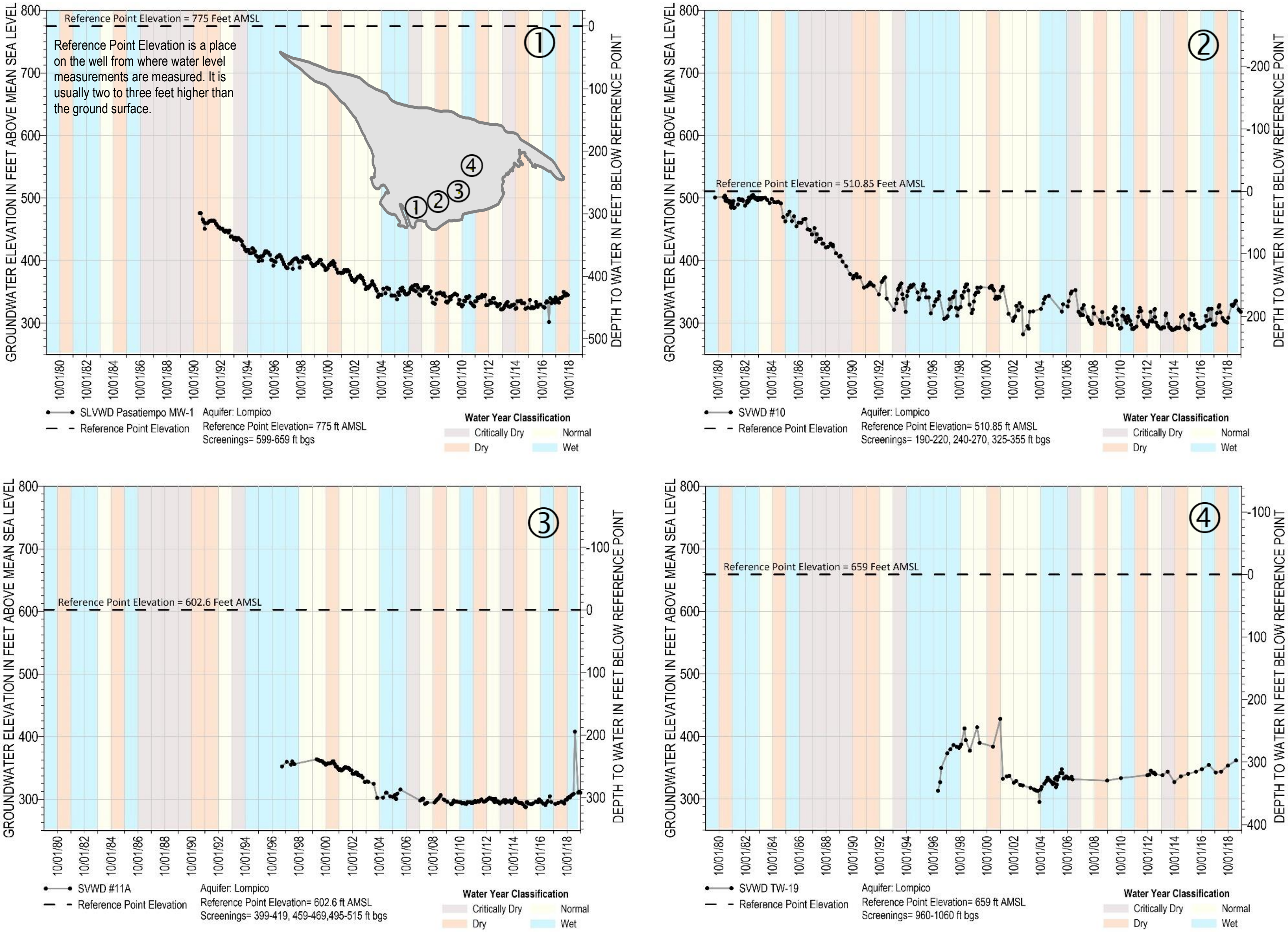


Figure 2-44. Lompico Aquifer Hydrographs

2.2.5.1.4.2 Lompico Aquifer Groundwater Elevation Contours and Flow Directions

The highest groundwater elevations in the Lompico aquifer occur at the northern boundary of the Basin, where the Lompico Sandstone is exposed at the surface in a narrow strip parallel to the Zayante-Vergeles fault. This is the only area the Lompico aquifer can be recharged directly by percolation of precipitation or streamflow; elsewhere it is covered by younger geologic units that either prevent direct recharge. Groundwater flow in the southern portion of the Lompico aquifer is primarily controlled by municipal pumping in the Scotts Valley area by SVWD and in the Pasatiempo area by SLVWD and Mount Hermon Association. Extraction of water causes depression of groundwater levels around the wells, such that groundwater flows down-gradient from the north and south toward the pumping wells. Groundwater elevation contours for Spring and Fall of WY2018 are shown on Figure 2-45 and Figure 2-46, respectively.

Measured groundwater elevation data are only available in the Pasatiempo, Camp Evers, and Scotts Valley areas. Consequently, the contour maps (Figure 2-45 and Figure 2-46) include large areas that display model-simulated contours. The simulated contours reveal 3 primary discharge points along the San Lorenzo River where there is outcrop of Lompico Sandstone. These include outcrops on the west side of the Ben Lomond fault near Felton and further upstream near the communities of Ben Lomond and Boulder Creek. These locations are where the Lompico aquifer contributes to San Lorenzo River baseflow.

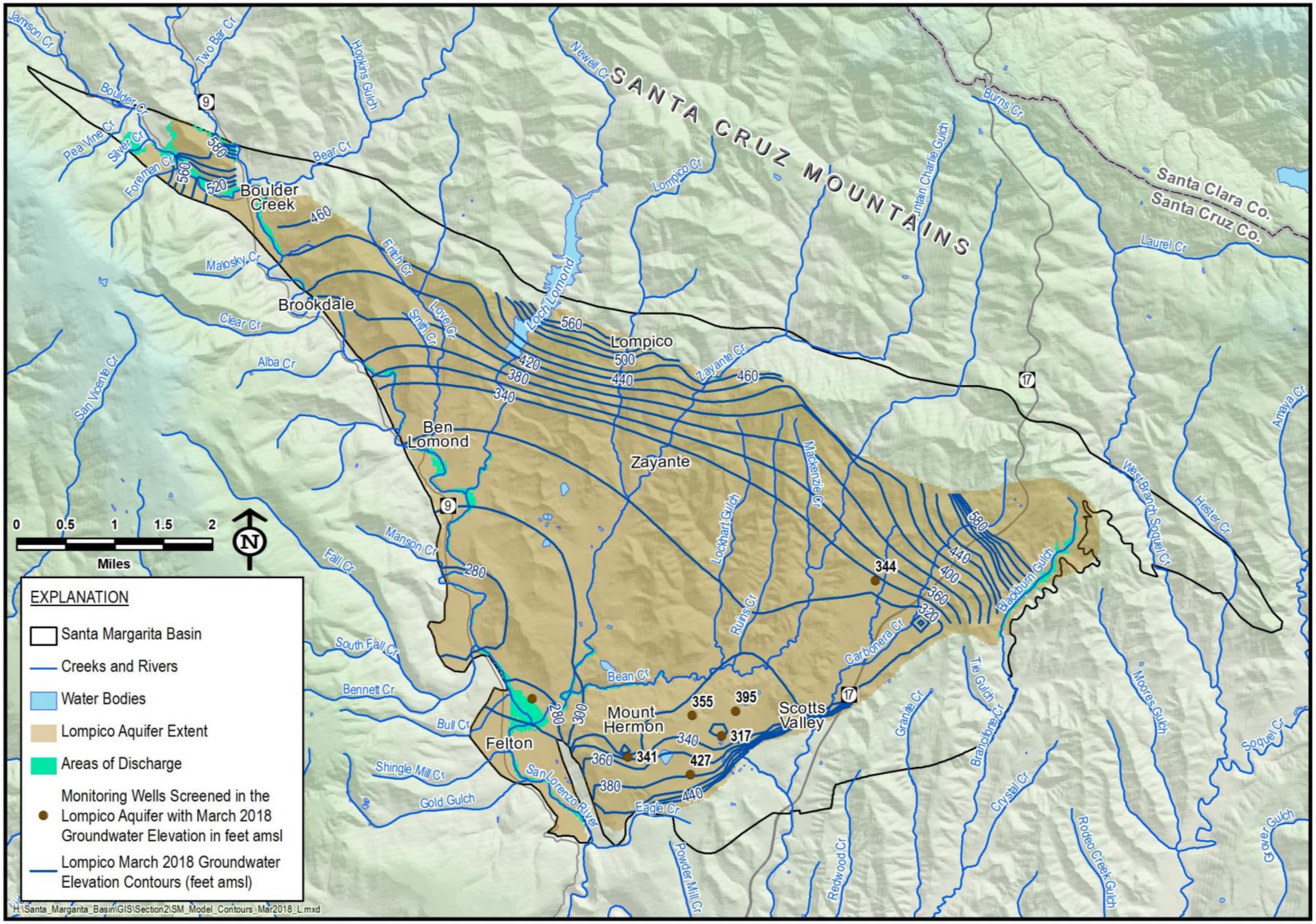


Figure 2-45. Spring (March) Water Year 2018 Groundwater Elevations in the Lompico Aquifer

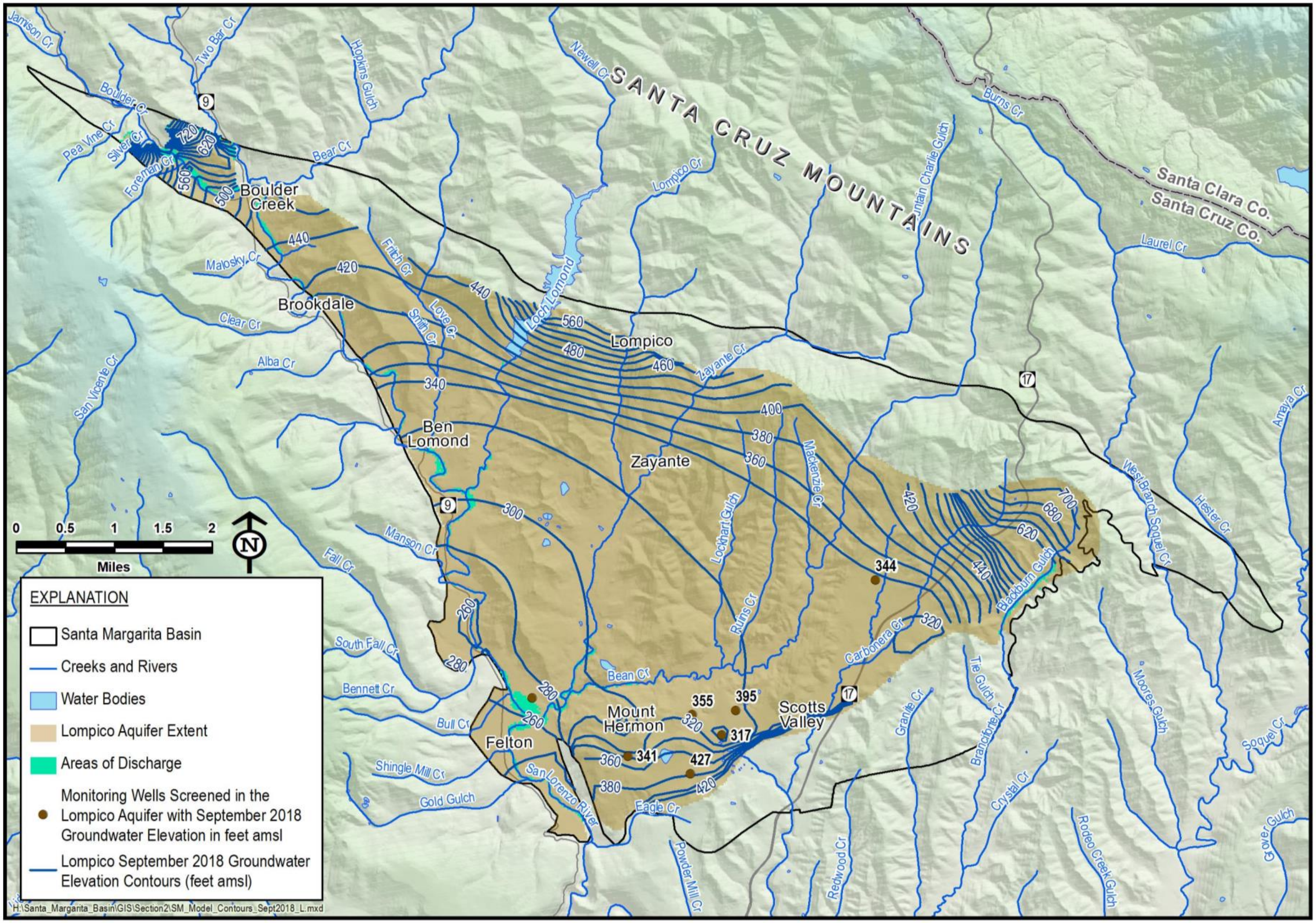


Figure 2-46. Fall (September) Water Year 2018 Groundwater Elevations in the Lompico Aquifer

2.2.5.1.5 Butano Aquifer Groundwater Elevations

2.2.5.1.5.1 Butano Aquifer Groundwater Elevations over Time

The Butano aquifer is the deepest of the productive aquifers in the Basin. Due to its great depth, there are few wells completed in it, and limited groundwater elevation data available for analysis. SVWD's water supply wells in the aquifer are SVWD #3B and #7A/Orchard Well (#7A was replaced in WY2018 by the similarly screened Orchard Well). The SVWD supply wells are screened in both the Butano Formation, at depths greater than 1,000 feet, and the overlying Lompico Formation; hence groundwater elevations measured in these supply wells are a composite elevation from both aquifers. As such, the groundwater elevations are not specific to the Butano aquifer making them difficult to interpret. The SVWD Canham and Stonewood monitoring wells are installed entirely within the Butano aquifer though not close to the SVWD supply wells (Figure 2-39).

Hydrographs shown on Figure 2-47 reflect long-term stable groundwater elevation trends since 1994, especially in the Butano-specific monitoring wells. The monitoring wells do not have seasonal groundwater elevation fluctuations. The supply wells show seasonal groundwater elevation fluctuations of greater than 50 feet, due to pumping during high-demand summer months, and the influence of flow to the supply wells from multiple aquifers.

For the long-term management of the Butano aquifer, a dedicated monitoring well in the Butano aquifer closer to these water supply wells will be drilled in 2022.

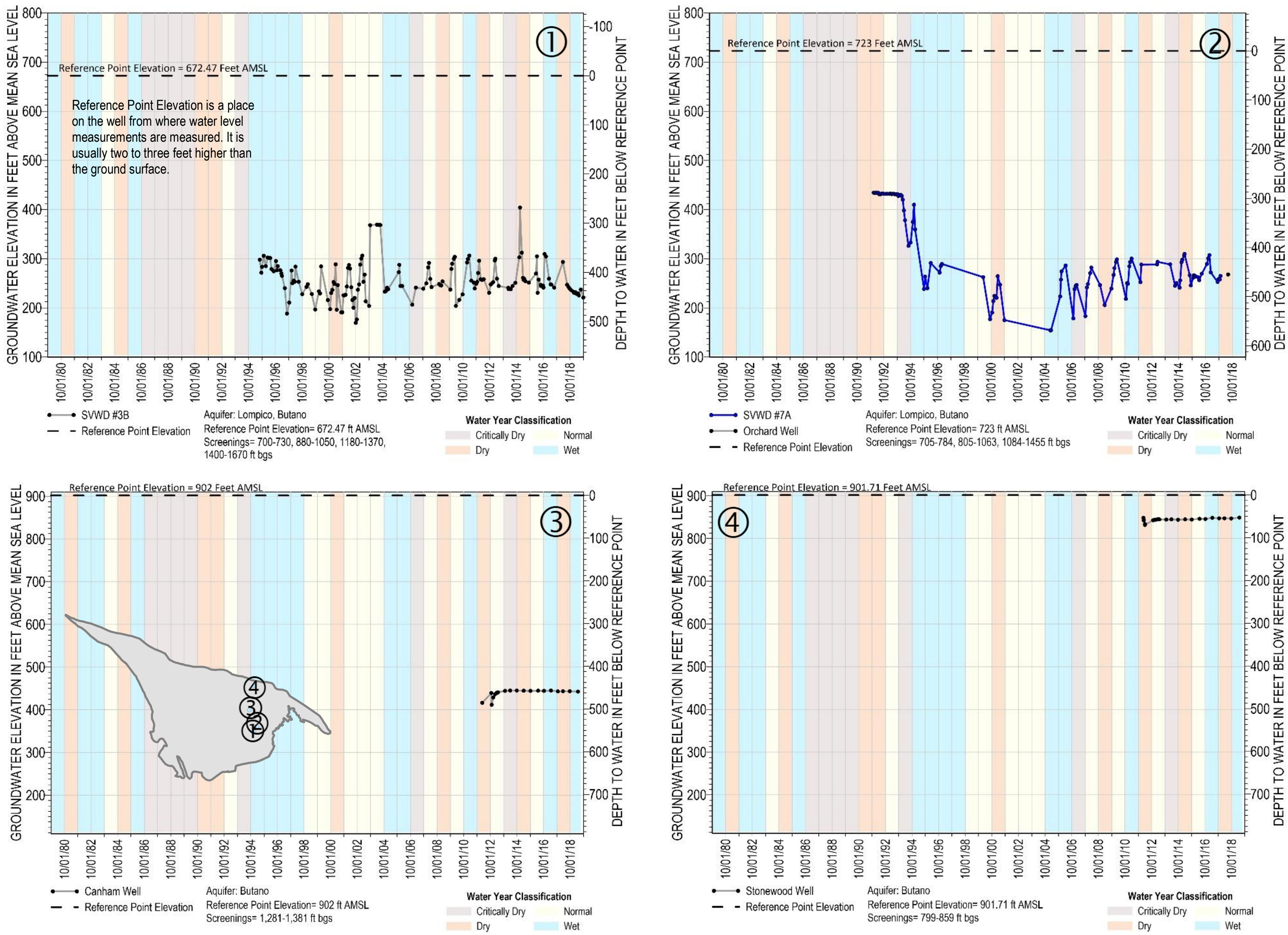


Figure 2-47. Butano Aquifer Hydrographs

2.2.5.1.5.2 Butano Aquifer Groundwater Elevation Contours and Flow Directions

The limited wells available to contour groundwater elevations in the Butano aquifer are:

- SVWD's Canham and Stonewood monitoring wells screened solely in the Butano aquifer (Figure 2-39),
- Monitoring well SVWD #15 screened roughly in equal lengths in the Lompico and Butano aquifers (Figure 2-39), and
- SVWD's 2 active supply wells, #3B and Orchard Well, screened in the Lompico and Butano aquifers are not suitable for control points for contouring because 1) they do not consistently have static levels unless they are offline for an extended period of time, and 2) although in the past it has been assumed their groundwater levels are more representative of the Butano aquifer than the Lompico aquifer because a greater percentage of their screened interval is within the Butano aquifer (Kennedy/Jenks Consultants, 2015b), this has not been confirmed with downhole flow surveys. Monitoring well SVWD #15 located very close to these 2 pumping wells is therefore a better control point for contouring.

Groundwater elevation contour maps for spring and fall of WY2018, respectively, are shown on Figure 2-48 and Figure 2-49. The extent of the Butano aquifer contours is limited to just the area of available control points. Since these are the same points used for model calibration there is greater uncertainty in the simulated contours with distance from the control points. Also, complicating the simulated elevations is that each of the 3 Butano Sandstone members (upper, middle, and lower) are assigned their own model layers and thus each has its own simulated groundwater elevations which makes it difficult to produce a realistic combined contour map.

Like groundwater elevations in the Lompico aquifer, the Butano aquifer's highest groundwater elevations are where it is exposed at the surface along the Basin's northern boundary parallel to the Zayante-Vergeles fault. This is an important recharge area for the aquifer as it can only be recharged directly by percolation of precipitation and streamflow where it is exposed at the surface. The drawdown caused by pumping the SVWD's Well #3B and Orchard Well forms a pumping depression around them. The Canham and Stonewood monitoring wells have higher groundwater elevations than the water supply wells, which indicates that groundwater flow is mostly north to south towards the pumping center caused by the Lompico/Butano aquifer water supply wells. Model-simulated groundwater elevations indicate that south of the pumping depression there is south to north flow towards the depression.

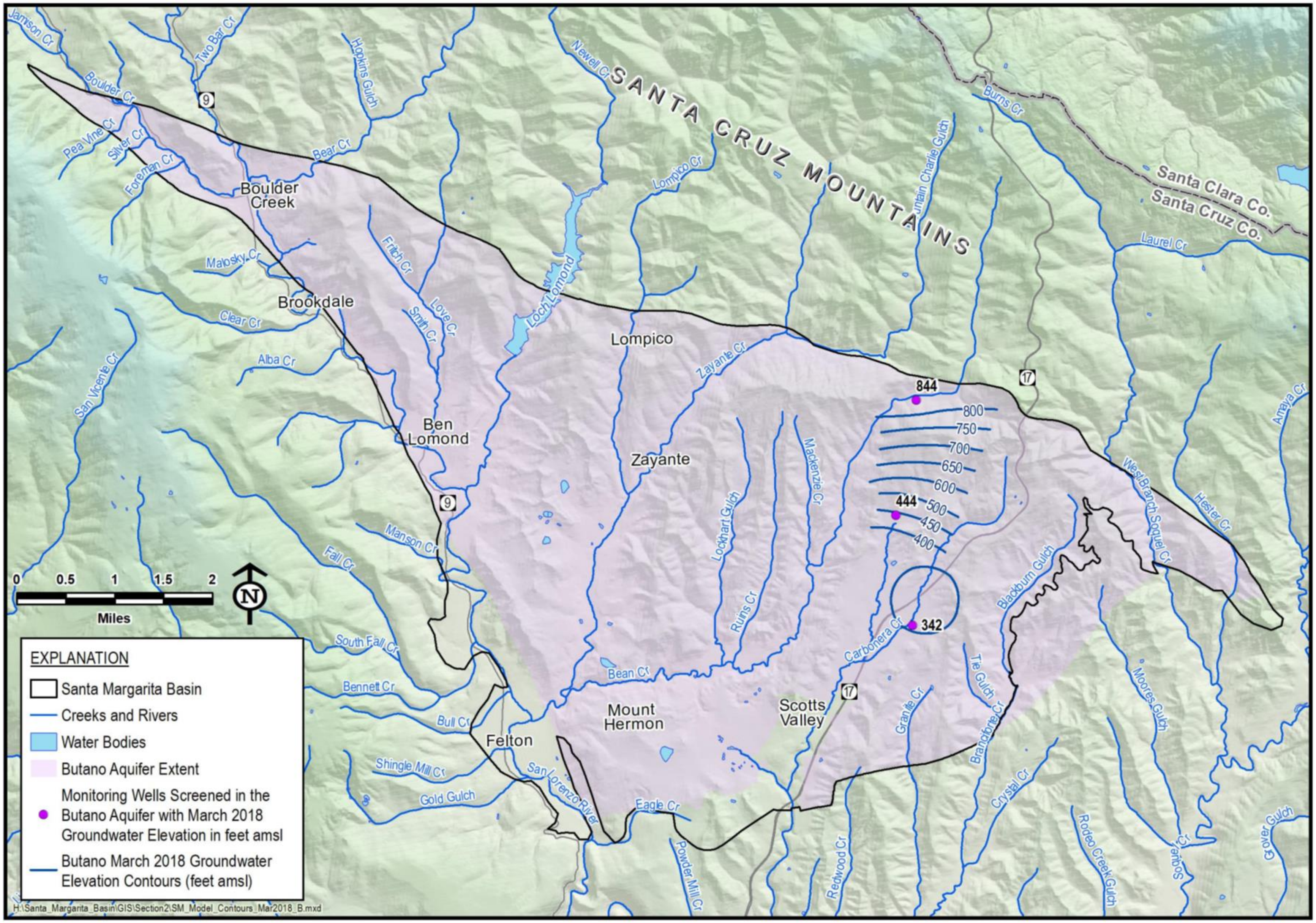


Figure 2-48. Spring (March) Water Year 2018 Groundwater Elevations in the Butano Aquifer

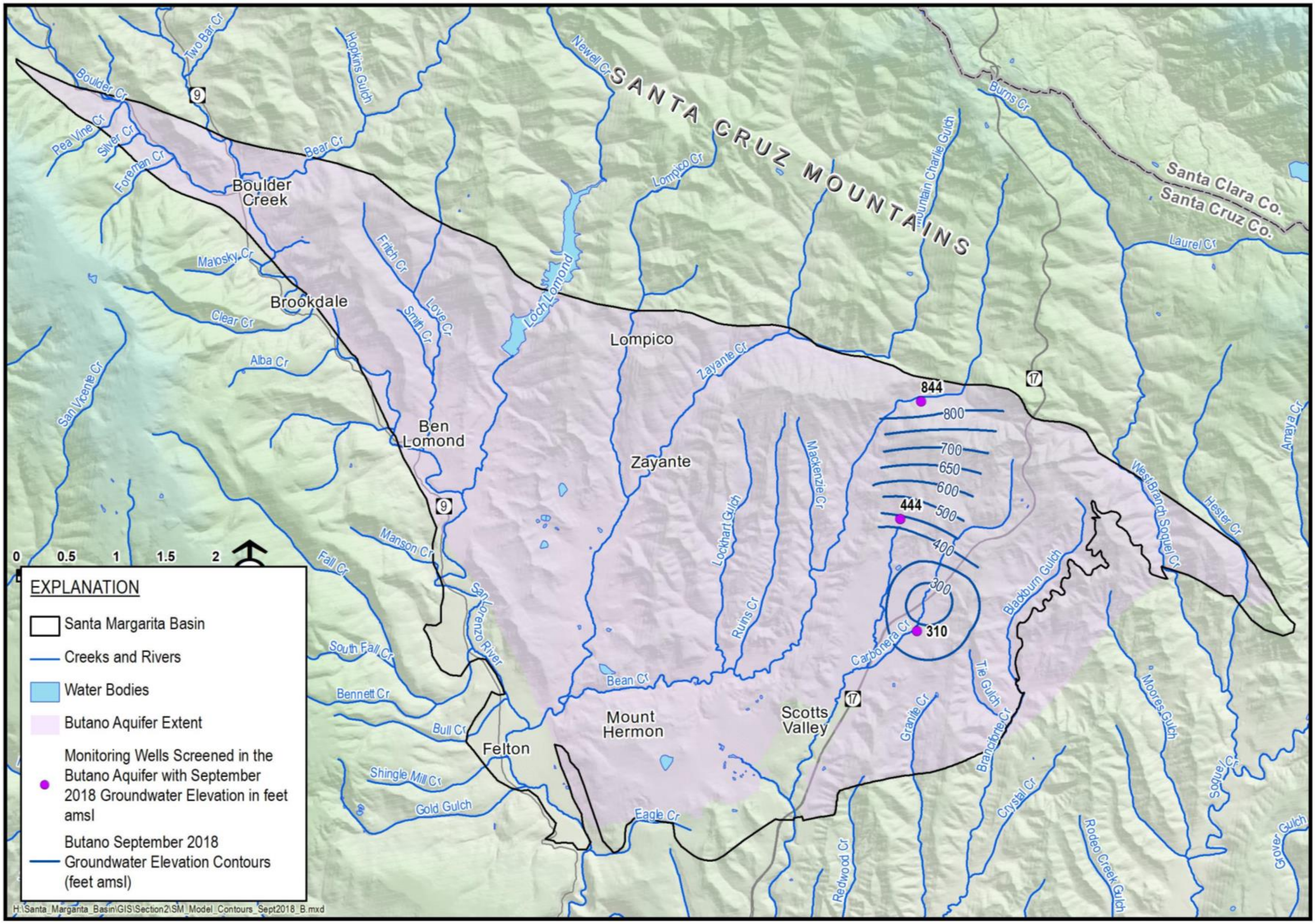


Figure 2-49. Fall (September) Water Year 2018 Groundwater Elevations in the Butano Aquifer

2.2.5.2 Vertical Hydraulic Gradients

Differences in groundwater elevations between the Basin's aquifers and within some of the thicker aquifer units create vertical hydraulic gradients. Vertical gradients produce upward or downward flow within aquifers, or flow between overlying or underlying aquifers. Previous studies have identified substantial vertical gradients in the Pasatiempo, Camp Evers, and Scotts Valley areas, where overpumping in the Lompico aquifer has created local pumping depressions that cause groundwater to flow downward (Johnson, 2009; Kennedy/Jenks Consultants 2015b).

In the relatively small area of the Basin where the Santa Margarita and Lompico aquifers are in direct contact with each other (Figure 2-18), the vertical hydraulic gradient induces recharge from the unconfined Santa Margarita aquifer into the deeper Lompico aquifer (Kennedy/Jenks Consultants 2015b). For most of the Basin where the fine-grained Monterey Formation separates the Santa Margarita and Lompico aquifers, downward vertical flow is significantly reduced (Kennedy/Jenks Consultants 2015b).

Figure 2-50 and Figure 2-51 show groundwater elevation hydrographs for 2 sets of multi-level monitoring wells located in the Pasatiempo / Camp Evers area. Groundwater elevations in the Santa Margarita aquifer at these locations are currently at least 50 feet to 150 feet higher than in the confined Lompico aquifer that is separated from the Santa Margarita aquifer by the Monterey Formation. The hydrographs on Figure 2-54 for the Pasatiempo monitoring wells illustrate how continually lowered groundwater elevations in the Lompico aquifer progressively increased the downward vertical gradient over time. At the start of the hydrograph record, groundwater elevation differences are around 10 feet, and increase to roughly 150 feet. It is possible that prior to 1990, the vertical hydraulic gradient may have been upward, with the Lompico aquifer elevations being higher than those in the Santa Margarita aquifer.

Vertical hydraulic gradient information is only available in the Pasatiempo/Camp Evers/southern Scotts Valley area because this is the only area where groundwater elevation data from nested or multi-level monitoring wells are available. There is not enough information to assess vertical gradient between the Lompico and Butano aquifers.

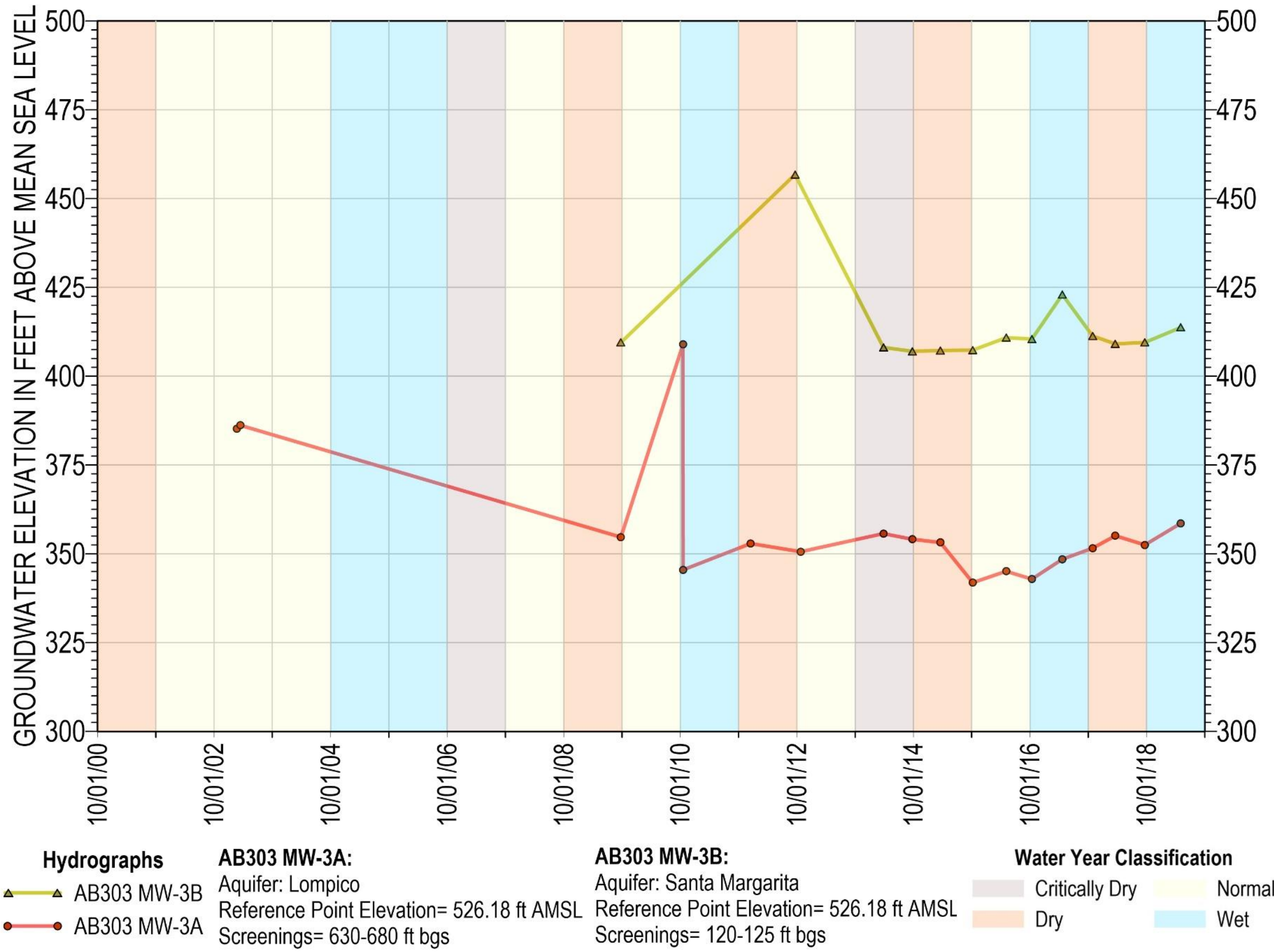


Figure 2-50. Monitoring Well AB303 MW-A and AB303 MW-B Hydrographs Illustrating Vertical Gradients Over Time

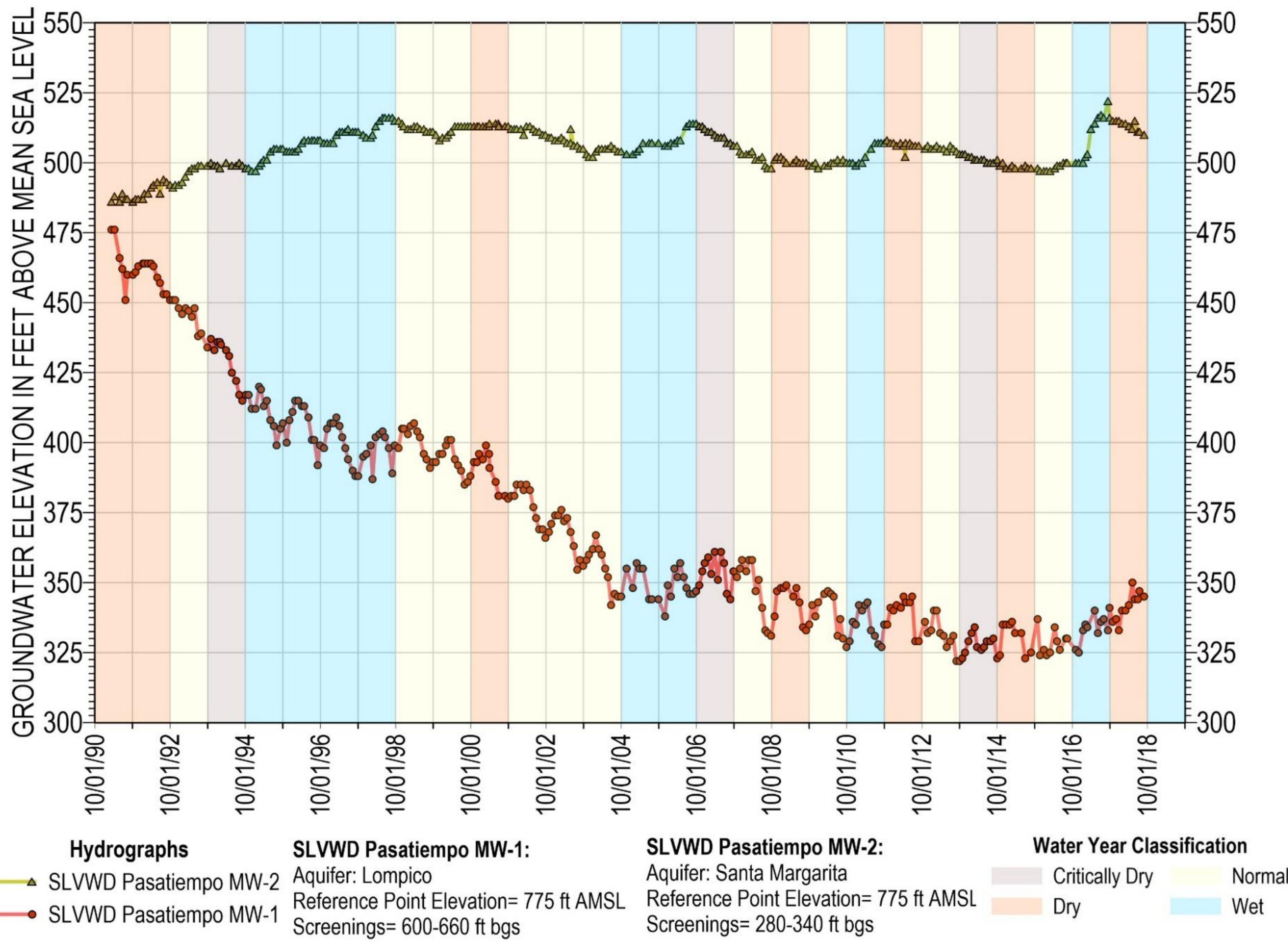


Figure 2-51. Monitoring Well SLVWD Pasatiempo MW-1 and SLVWD Pasatiempo MW-2 Hydrographs Illustrating Vertical Gradients Over Time

2.2.5.3 Change of Groundwater in Storage

Since the 1980s, and even possibly starting in the 1960s, there has been a consistent loss of groundwater stored in the Basin due primarily to over-pumping of the Lompico aquifer in the south Scotts Valley area. Figure 2-52 shows groundwater model simulated annual change in storage with the color of the bars correlating with the water year type, and the solid line reflecting the cumulative change in storage.

Individual annual increases of groundwater stored in the Basin correlate with wet years and normal years if they precede a dry year. Historically, normal or drier water year types generally result in groundwater lost from storage. This is reflected on Figure 2-52 where cumulative storage change shows a consistent decline. After WY2014, cumulative change in storage appears to be leveling out but it is anticipated that the overall below average rainfall from 2018 to present will continue the trend of declining groundwater in storage.

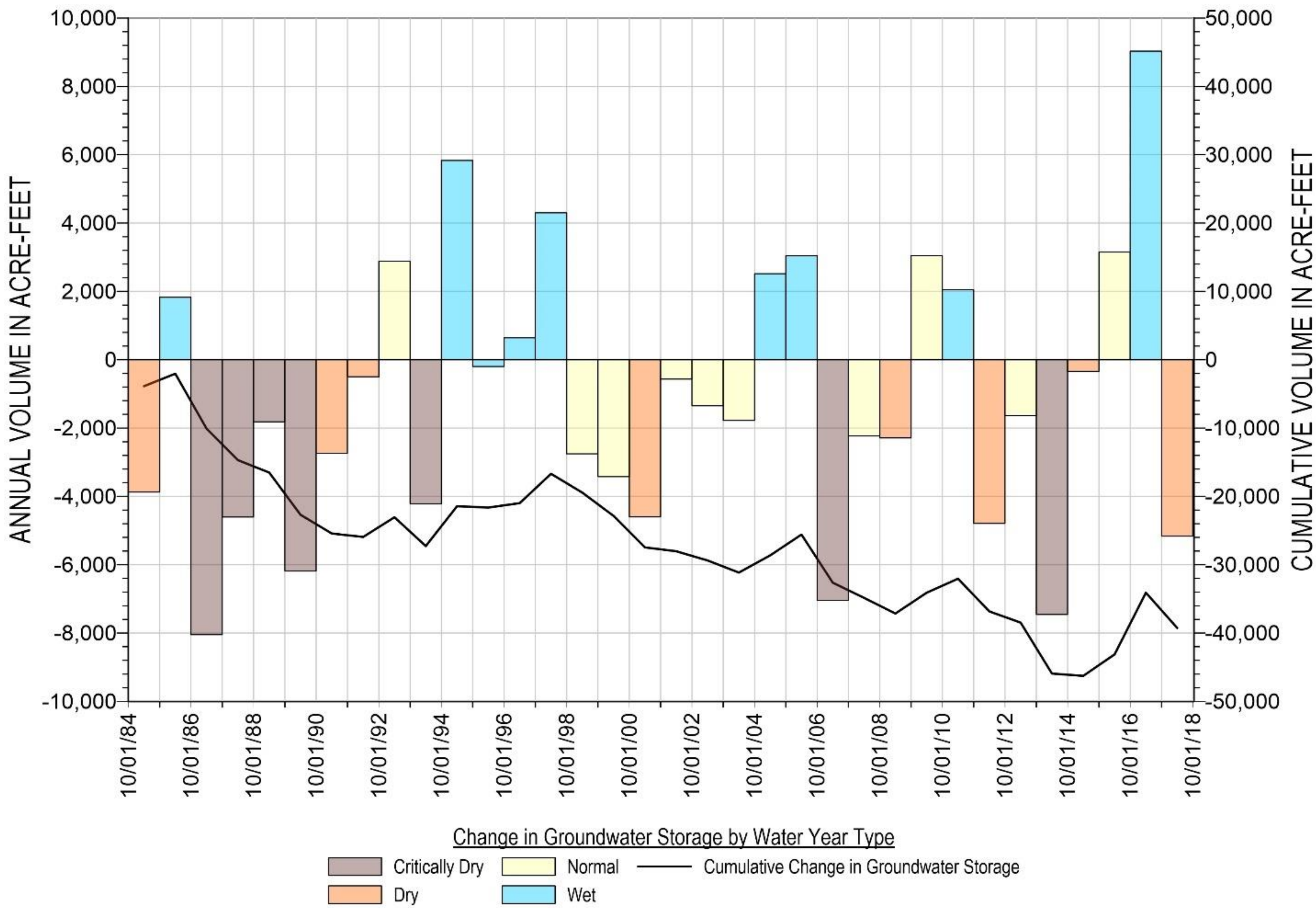


Figure 2-52. Santa Margarita Basin Annual Change of Groundwater in Storage

2.2.5.4 Groundwater Quality

Groundwater in the Basin is generally of good quality and does not regularly exceed primary drinking water standards. However, both naturally occurring and anthropogenic groundwater quality concerns are present in some aquifers and areas. The following subsections discuss general groundwater quality with a focus on chemical constituents that have concentrations above state drinking water standards. The chemical constituents included in this section are used as the basis for COC for which SMC are developed in Section 3. Appendix 2C contains chemographs for wells with current groundwater quality data in the Basin.

2.2.5.4.1 Groundwater Quality Standards

As a relative measure of groundwater quality, this section compares groundwater quality in the Basin’s different aquifers to primary and secondary drinking water standards. These standards are established by the US Environmental Protection Agency (USEPA) and the California State Water Resources Control Board’s Division of Drinking Water (DDW). Standards for contaminants in drinking water established by the USEPA represent the legal maximum allowable concentration for a constituent in public water systems. The maximum limits, referred to as maximum contaminant levels (MCLs), have been developed under the Safe Drinking Water Act. Some states, including California, have state laws or regulations which set MCL values consistent with or lower than federal MCLs, or for chemicals for which no federal MCL has been established. For example, the federal MCL for benzene is 0.005 milligrams per liter (mg/L) but the state MCL is 0.001 mg/L. Methyl-tert-butyl ether (MTBE), on the other hand, does not have a federal MCL but California established an MCL of 0.013 mg/L.

California MCLs are in accordance with Title 22 of the California Code of Regulations and are categorized as either primary or secondary. Primary MCLs are those which address health concerns, whereas secondary MCLs address aesthetics such as taste and odor. Not all constituents with an established primary MCL have a secondary MCL, and not all constituents with a secondary MCL have a primary MCL. Using the example of MTBE above, the primary MCL is 0.013 mg/L whereas the secondary MCL is 0.005 mg/L. Manganese, on the other hand, has no primary MCL yet has a secondary MCL of 0.05 mg/L. The California Office of Environmental Health Hazard Assessment establishes public health goals based on lifetime exposure risk for constituents with an established MCL or those for which an MCL will be established in the future, and MCL values may be revised based on the public health goal.

In addition to regulated constituents, California DDW has established notification levels and response levels for some constituents which do not have an established MCL. Recommended actions for constituents exceeding these levels are established by DDW.

2.2.5.4.2 Groundwater Quality Testing

Municipal water suppliers regularly sample and test both raw and treated water sources per state requirements contained in the California Code of Regulations, Title 22. Groundwater quality parameters typically tested for include general minerals, general physical parameters, and organic/inorganic compounds. All municipal water sources are treated to state drinking water standards.

The Code of Regulations requires that public water systems annually provide their customers with an annual water quality report called a Consumer Confidence Report (CCR). This includes information on source water, levels of any detected contaminants, and compliance with drinking water regulations (including monitoring requirements), along with some educational information. CCRs for SLVWD and SVWD are available at the following websites: https://www.slvwd.com/water-quality/pages/consumer-confidence-reports-ccrs and https://www.svwd.org/resources-information/reports, respectively.

Groundwater quality is not regularly tested at SLVWD and SVWD monitoring wells. There have been some one-off samples collected and tested over the years, but there is no long-term groundwater quality record in any municipal monitoring well. There are longer groundwater quality records in monitoring wells associated with contamination cleanup sites. These only provide data for the period during active site assessment and remediation. Many of these monitoring wells are destroyed once clean up goals have been achieved.

Private domestic use wells are not subject to DDW drinking water regulations. However, the County requires one-time testing of nitrate, TDS, chloride, iron, and manganese for any new private well. Small water systems that supply groundwater to 15 – 199 service connections also report water quality to the County. These water quality constituents include inorganics, nitrates, arsenic, perchlorate, chromium, radiation, synthetic organic compounds, VOCs, and fuel oxygenates, which include MTBE. The frequency of monitoring ranges between 1 year and 9 years depending on the constituents. Smaller water systems with between 5 and 14 service connections have limited one-time testing requirements for inorganics and report quarterly bacteriologic water quality to the County.

2.2.5.4.3 Naturally Occurring Groundwater Quality

2.2.5.4.3.1 Salinity

Elevated salinity in groundwater can occur from both natural geologic sources and as a result of anthropogenic groundwater contamination. Salinity in groundwater is often measured using TDS and chloride concentrations. There are no primary drinking water standards for TDS and chloride, but rather secondary drinking water standards that are set at 1,000 and 250 mg/L, respectively.

Natural waters contain some dissolved solids (salinity) from contact with soils, rocks, and other natural materials. Geologic formations can influence groundwater quality, and formations often have their own unique groundwater salinity signature. Surface activities by humans can artificially introduce salts into groundwater through the natural recharge process where infiltrating rainfall dissolves anthropogenic salts on the land surface allowing salts to enter the underlying aquifers. Slight differences in salinity occur across the Basin due to its geology. Improperly constructed wells can also allow salts to migrate from 1 aquifer to another.

Total Dissolved Solids

The regulatory drinking water limit for TDS is a SWRCB secondary MCL, that differs from a primary MCL because it is based on aesthetics rather than health risk. Santa Cruz County enforces the 1,000 mg/L upper limit of the secondary MCL. TDS concentrations in portions of the Santa Margarita aquifer are generally low as a result of its high permeability, exposure at the surface, and associated high rate of aquifer "flushing" (Johnson, 2006; Johnson, 2009). In areas where wells pump from the Santa Margarita aquifer and data on TDS concentrations are available, the following observations on Santa Margarita aquifer TDS are made:

- Quail Hollow has relatively low TDS concentrations typically below 150 mg/L (Figure 2-53)
- The Olympia area has higher TDS concentrations typically ranging between 200 and 600 mg/L (Figure 2-53)
- Historical TDS concentrations in Santa Margarita aquifer wells in the Pasatiempo/Camp Evers/southern Scotts Valley area were lower and more stable than TDS concentrations in the Olympia wells (Johnson, 2009). Since the Santa Margarita aquifer is no longer pumped by municipal suppliers in the Pasatiempo/Camp Evers/southern Scotts Valley area there is no current testing of groundwater quality to determine if this is still the case.

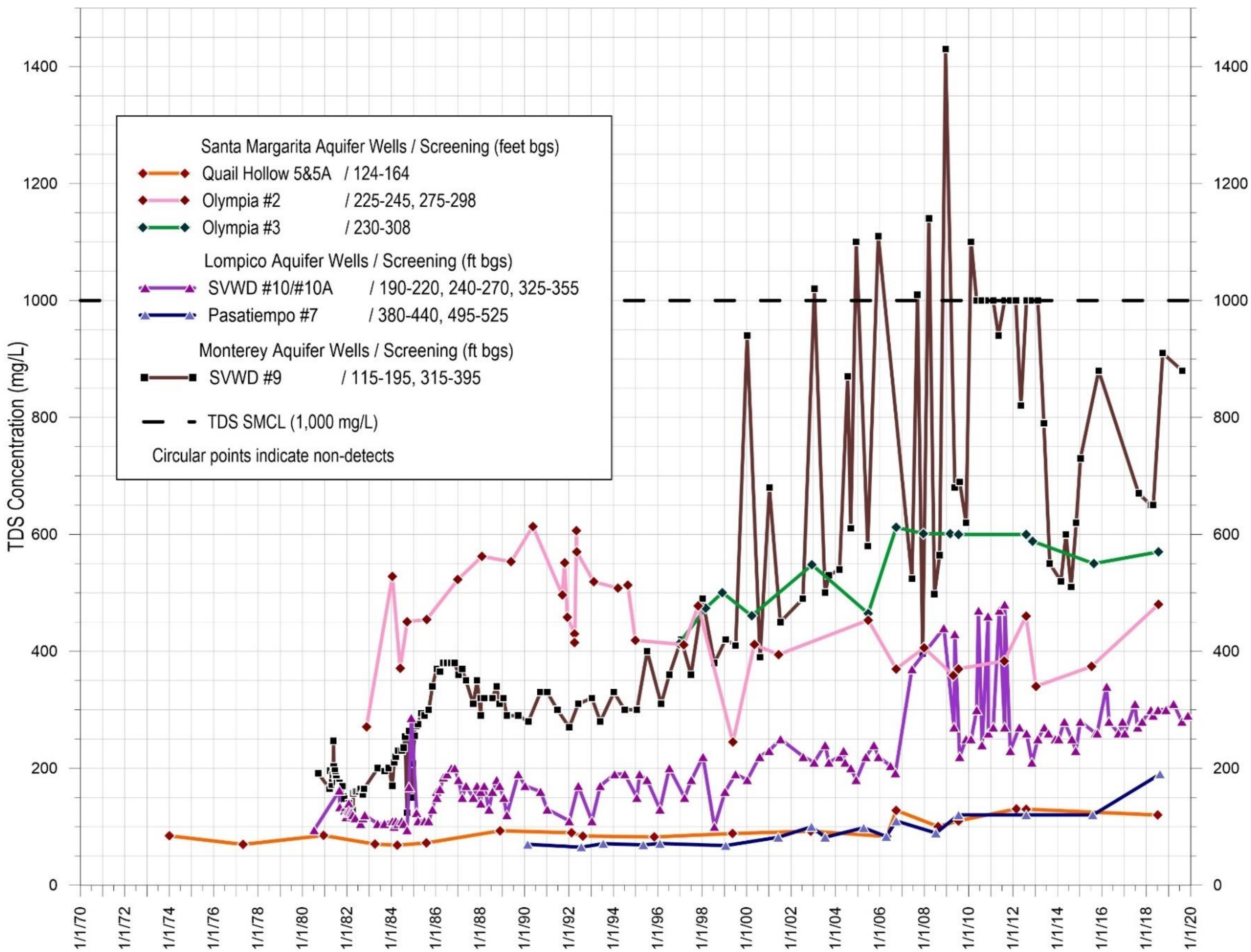


Figure 2-53. Total Dissolved Solids Concentrations in Select Wells from 1970-2019

There are very few wells screened in the Monterey Formation that have groundwater quality data. SVWD's Well #9, the only Monterey Formation well in the Basin with long-term and recent groundwater quality data, has TDS concentrations ranging from 300 to 1,430 mg/L (Figure 2-54). Together with 2 Lompico aquifer wells (SVWD #10A and SLVWD Pasatiempo #7), SVWD's Well #9 has an increasing TDS trend. It is thought its increased TDS concentration is linked to the dewatered Santa Margarita aquifer in the area that has caused reduced leakage of good quality water to the underlying aquifers (Johnson, 2009). High TDS concentrations appear to correspond to periods when the well was being pumped more and thereby extracting a greater proportion of its groundwater from deeper in the Monterey Formation which is known to have elevated TDS because of its marine origin and more limited flushing. This well is no longer used by SVWD for water supply because of its low yield and poor water quality. Further supporting the occurrence of saline water in the Monterey Formation are reports of saline water received by Santa Cruz County from well drillers working in the lower Newell Creek and lower Zayante Creek areas.

Wells screened in the Lompico and Butano aquifers do not exceed TDS secondary drinking water standards and concentrations typically range from 200 to 700 mg/L (Figure 2-53). Municipal extraction wells with increasing TDS trends as described above are SVWD #10A and SLVWD Pasatiempo #7. Similar to increased TDS concentrations in SVWD #9 in the Monterey Formation, increased TDS appears to correspond to declining groundwater elevations (Figure 2-54). However, a corresponding TDS increase and groundwater elevation decrease in the Lompico aquifer does not always occur, as shown on Figure 2-55 where TDS does not increase despite groundwater elevation declines in the SVWD's El Pueblo wellfield (SVWD #11A and 11B). This indicates that the increasing TDS trend associated with declining groundwater elevations in the Lompico aquifer may just be confined to the Pasatiempo/Camp Evers/southern Scotts Valley area.

Of interest, there is a known area of elevated salinity north of the Basin between Kings and Bear Creeks that is likely associated with connate water. Connate water is saltwater water trapped in the pore spaces of marine sediments when it was deposited and subsequently buried by younger sediments. A USGS water resource investigation in 1977 indicated that this area has some saline groundwater and surface water that may be degraded by connate water leaking upward from depth through improperly sealed, abandoned oil test wells (USGS, 1977). Although the source of saline water is outside of the Basin, higher salinity water does impact streams upgradient of the Basin which then flow into the Basin thereby slightly impacting surface water quality in the Basin.

Figure 2-56 summarizes the spatial distribution of TDS and chloride across the Basin by aquifer.

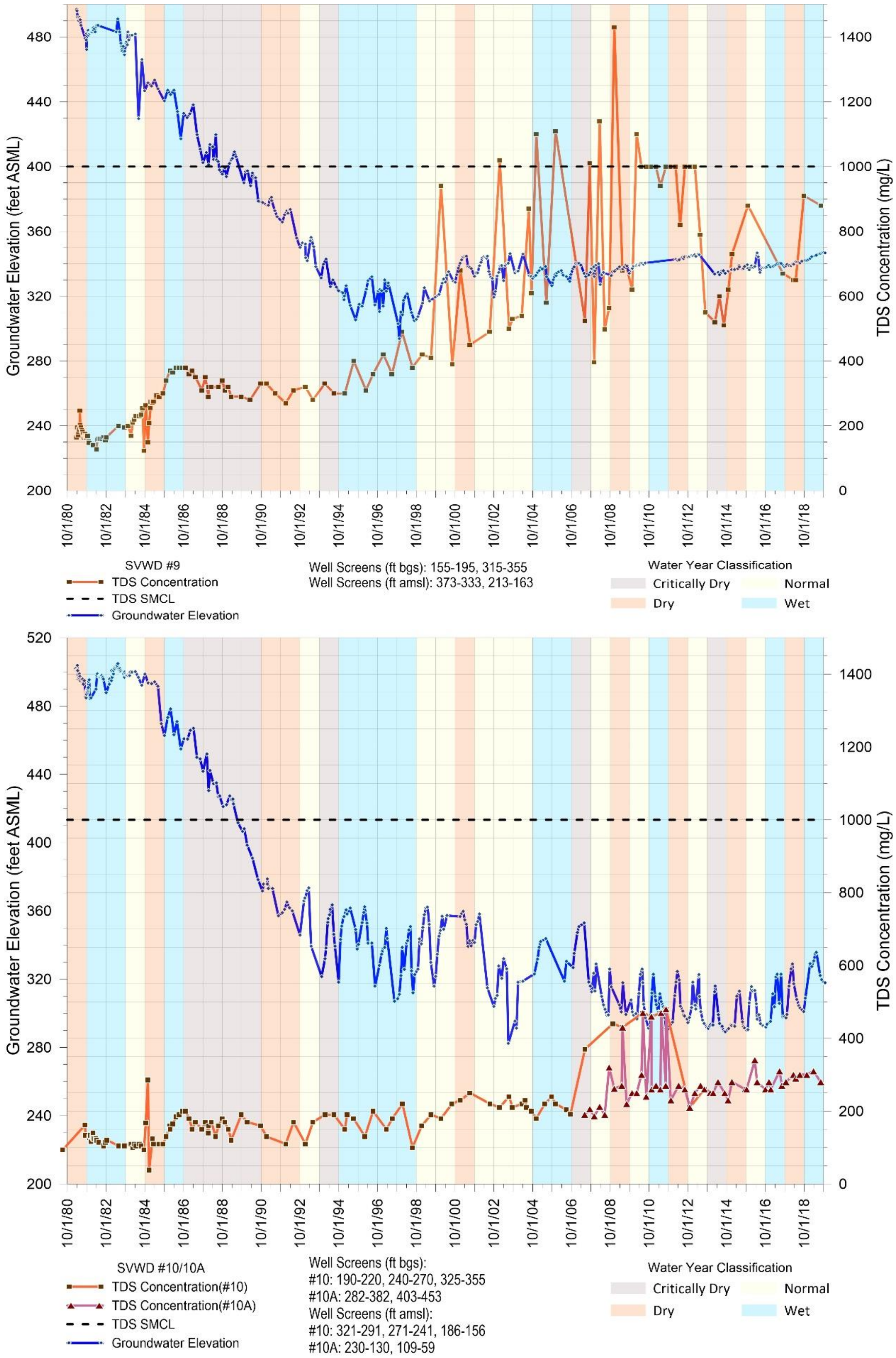
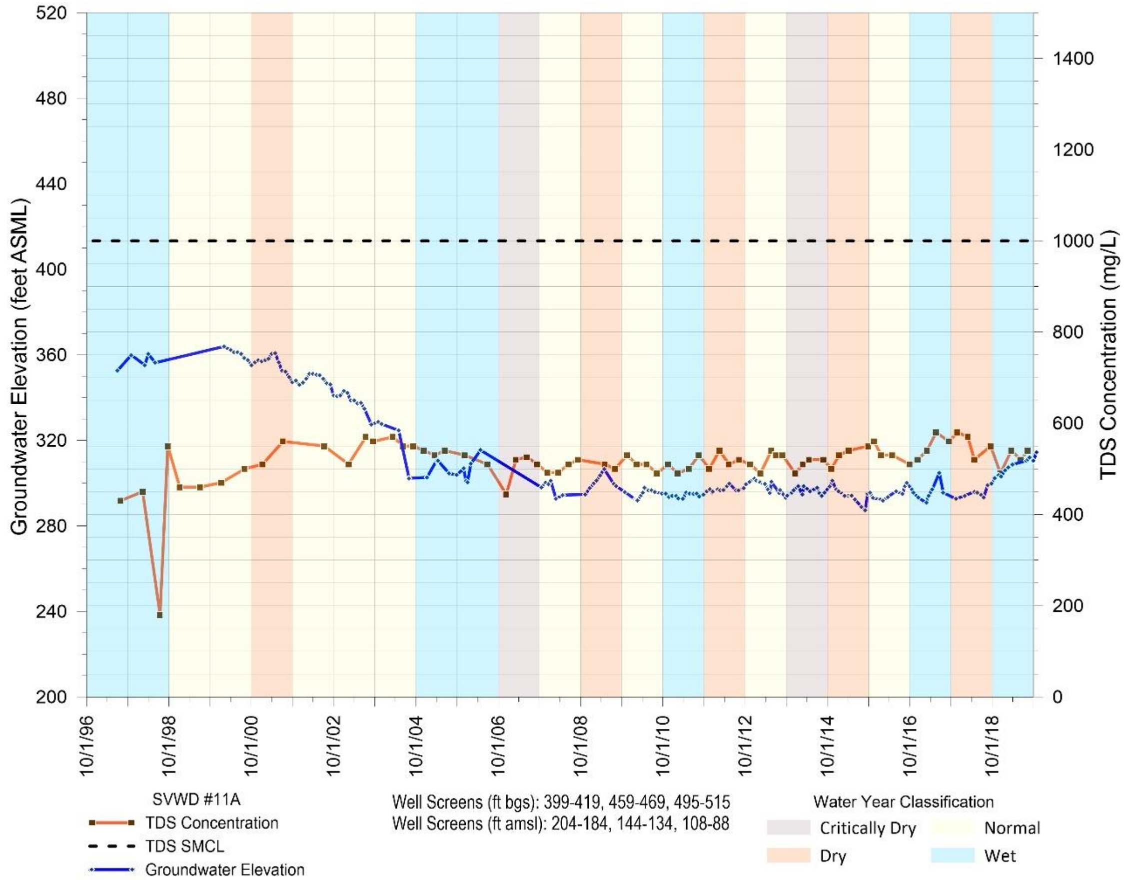


Figure 2-54. Total Dissolved Solids Concentrations and Groundwater Elevations in SVWD Well #9 (Monterey Formation) and SVWD #10/10A (Lompico Aquifer)



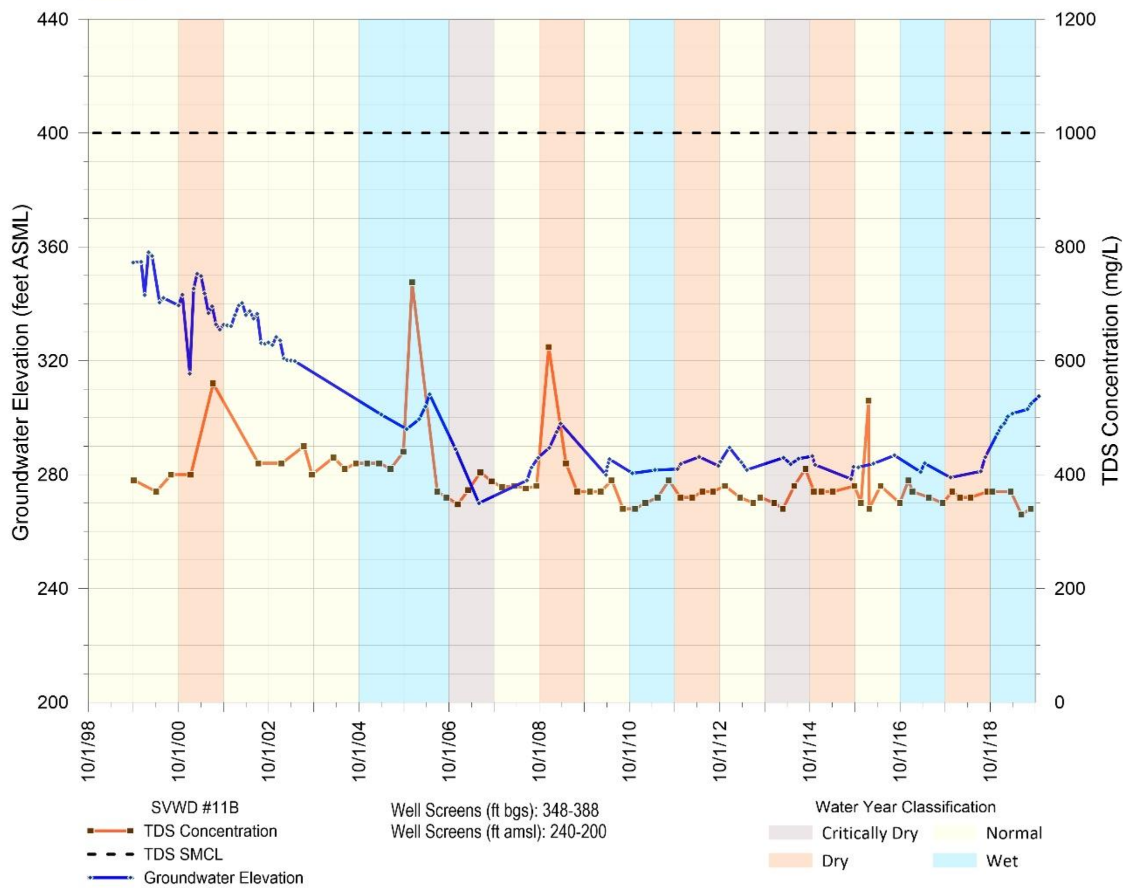


Figure 2-55. Total Dissolved Solids Concentrations and Groundwater Elevations in SVWD Well #11A and SVWD #11B (Lompico Aquifer)

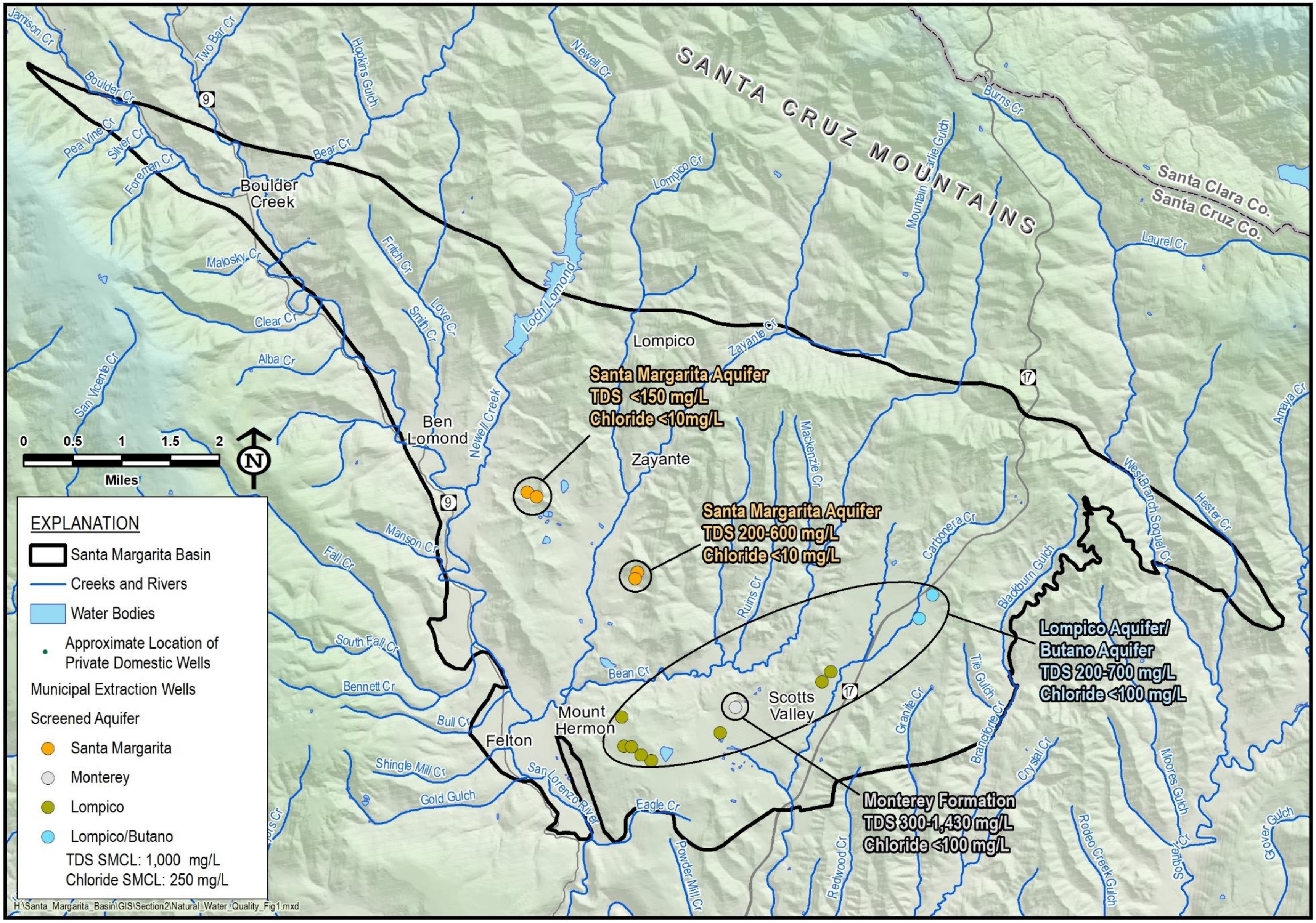


Figure 2-56. Distribution of Total Dissolved Solids and Chloride Across the Santa Margarita Basin

Chloride

Chloride can be a major component of TDS and is also used to determine salinity in groundwater. Chloride concentrations in the Basin are well below chloride's secondary MCL of 250 mg/L and are typically below 100 mg/L. Apart from increasing chloride in the Monterey Formation and Lompico aquifer in the Pasatiempo/Camp Evers/southern Scotts Valley area that mirror TDS trends, chloride concentrations do not have increasing (or decreasing) trends over time. Appendix 2C contains plots of chloride over time for wells with recent groundwater quality data.

2.2.5.4.3.2 Iron and Manganese

Although iron and manganese are required nutrients in the human diet, concentrations above secondary drinking water standards can create aesthetic problems including metallic taste, staining, accumulation of oxides in pipes, and eventually toxicity. Iron and manganese occur naturally in much of the world's groundwater and surface water but can also originate from anthropogenic sources including automobile exhaust and manufacturing (WHO, 2011). The state secondary MCLs for iron and manganese are 0.3 and 0.05 mg/L, respectively.

Iron and manganese concentrations are detected above state secondary MCL in all Basin aquifers, but not in all wells. The widespread occurrence of iron and manganese detections have a naturally occurring origin, associated with the dissolution of metals present in the Basin's geologic formations. There have been no trends in iron or manganese concentrations associated with contaminating activities. All groundwater extracted for municipal purposes with elevated iron and manganese is treated to reduce concentrations below secondary MCLs prior to distribution. Small water systems report iron and manganese concentrations to the County to ensure public health.

As with TDS, previous analysis has noted generally lower iron and manganese in some areas of the Santa Margarita aquifer as a result of high rates of aquifer "flushing" (Johnson, 2009; Johnson, 2016). Concentrations in these areas are consistently below state secondary MCLs including frequent non-detects (Figure 2-57 and Figure 2-58). However, iron and manganese concentrations above respective secondary MCLs do occur in other areas of the Santa Margarita aquifer, such as in the Olympia area, where concentrations of iron and manganese can be as high as 1.5 mg/L and 0.33 mg/L, respectively. Figure 2-59 shows iron and manganese concentrations for extraction well SLVWD Olympia #2 versus its groundwater elevations. Over the period of record, there have been both decreases and increases in manganese concentrations, none of which appear related to changing groundwater elevations. Iron concentrations do not follow the same trend as manganese and generally remain below the secondary MCL, but they do periodically and temporarily increase above the secondary MCL. For the most part, changes in iron concentrations do not appear to be influenced by changing groundwater elevations, although the historically low groundwater elevation for this well in WY2016 did correspond to 2 samples above the secondary MCL during that year (Figure 2-59).

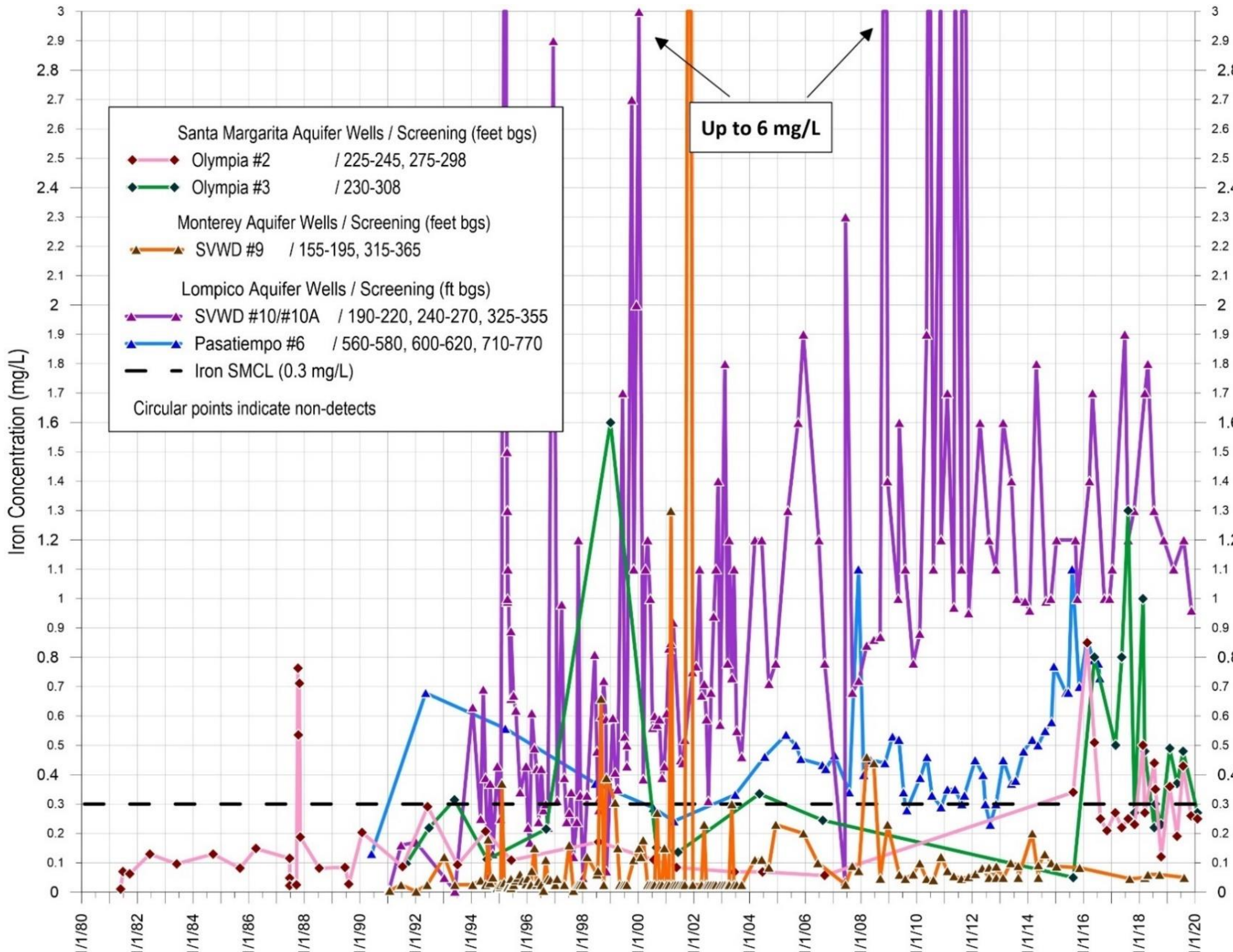


Figure 2-57. Iron Concentrations in Select Wells from 1980-2019

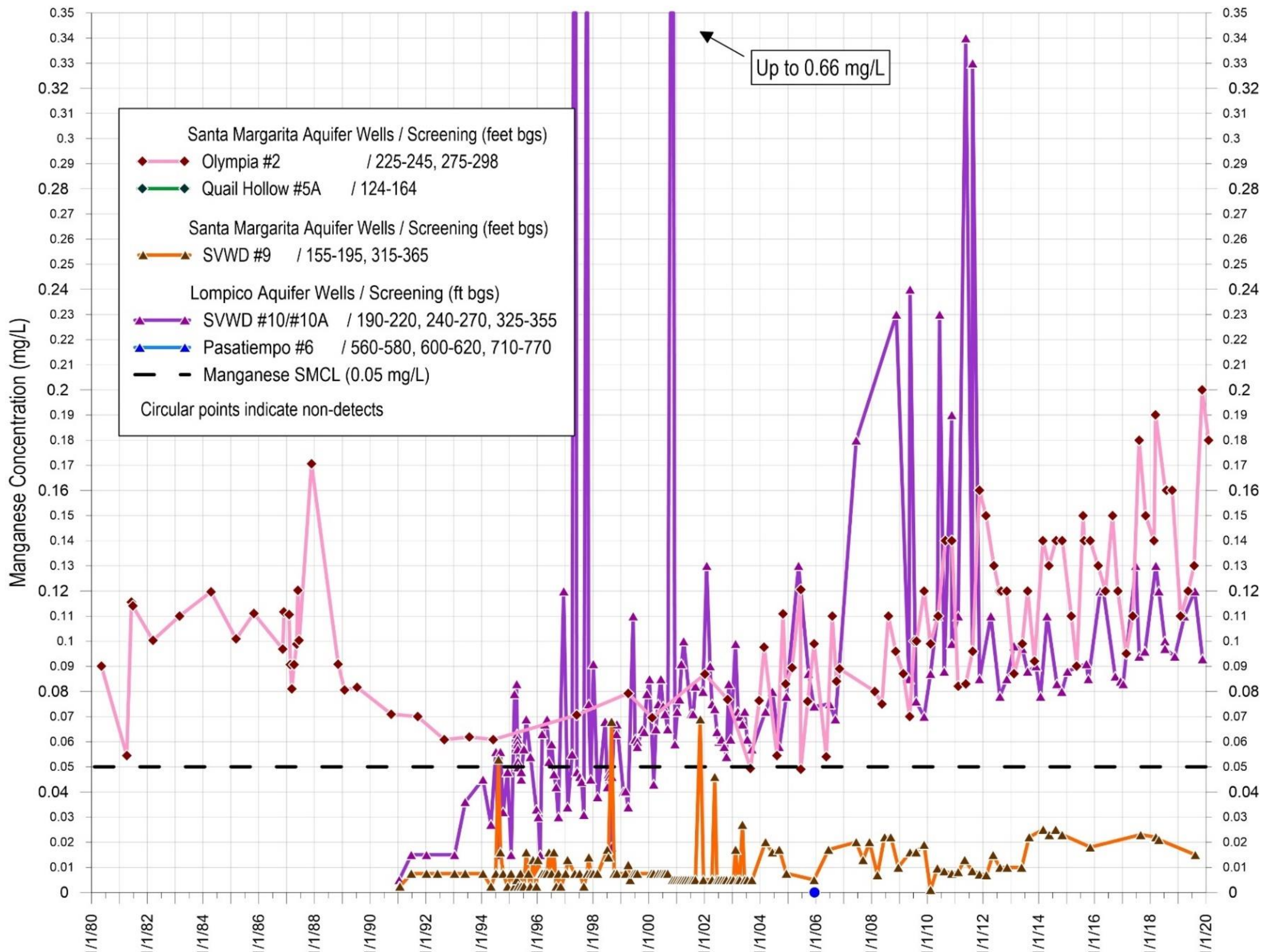
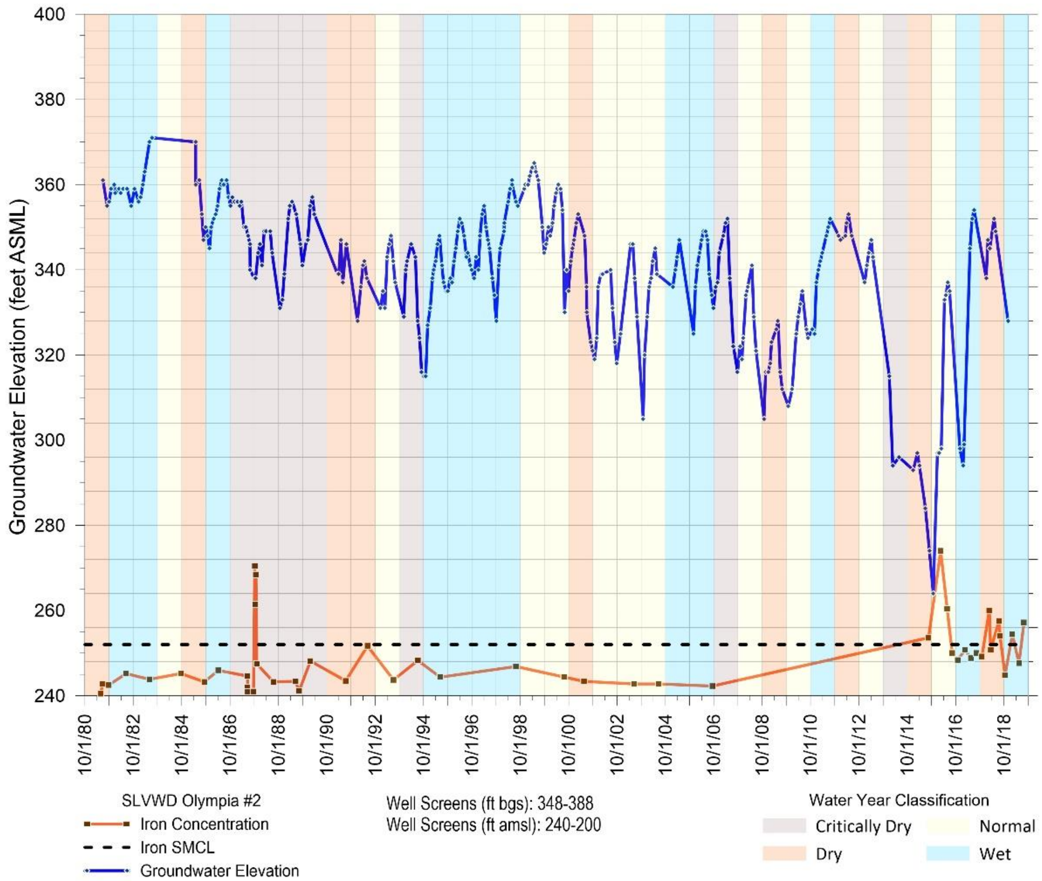


Figure 2-58. Manganese Concentrations in Select Wells from 1980-2019



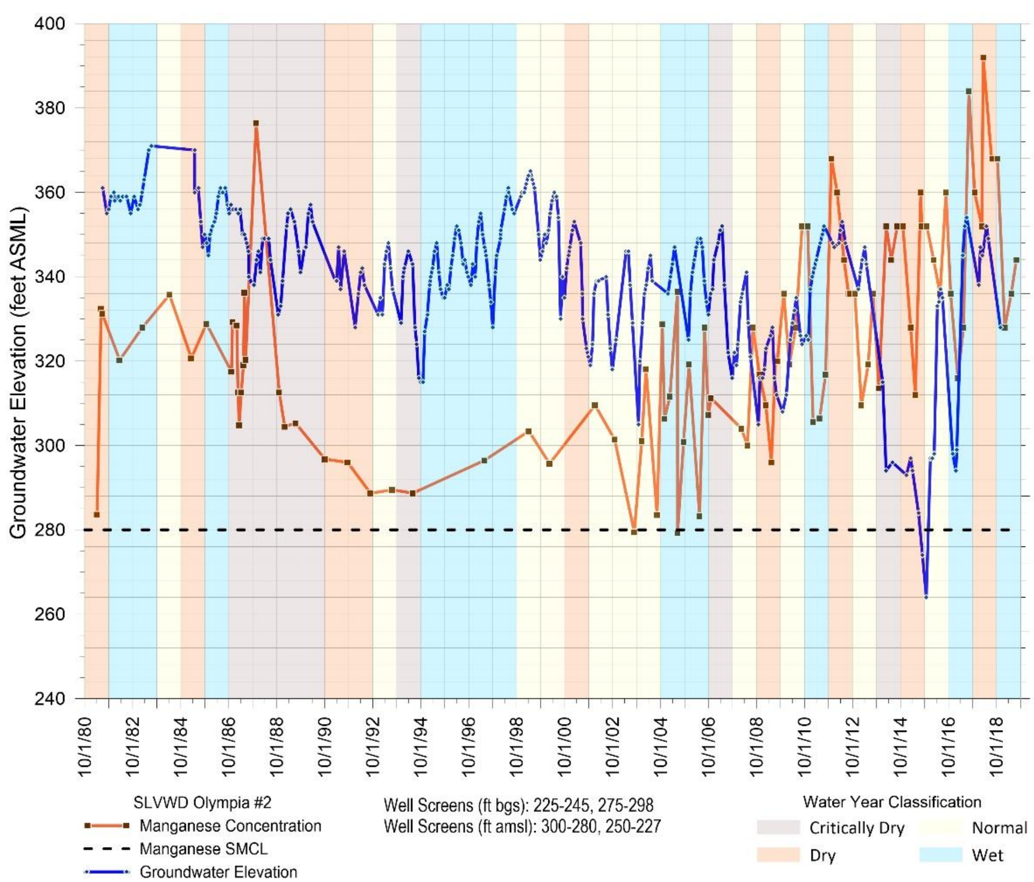


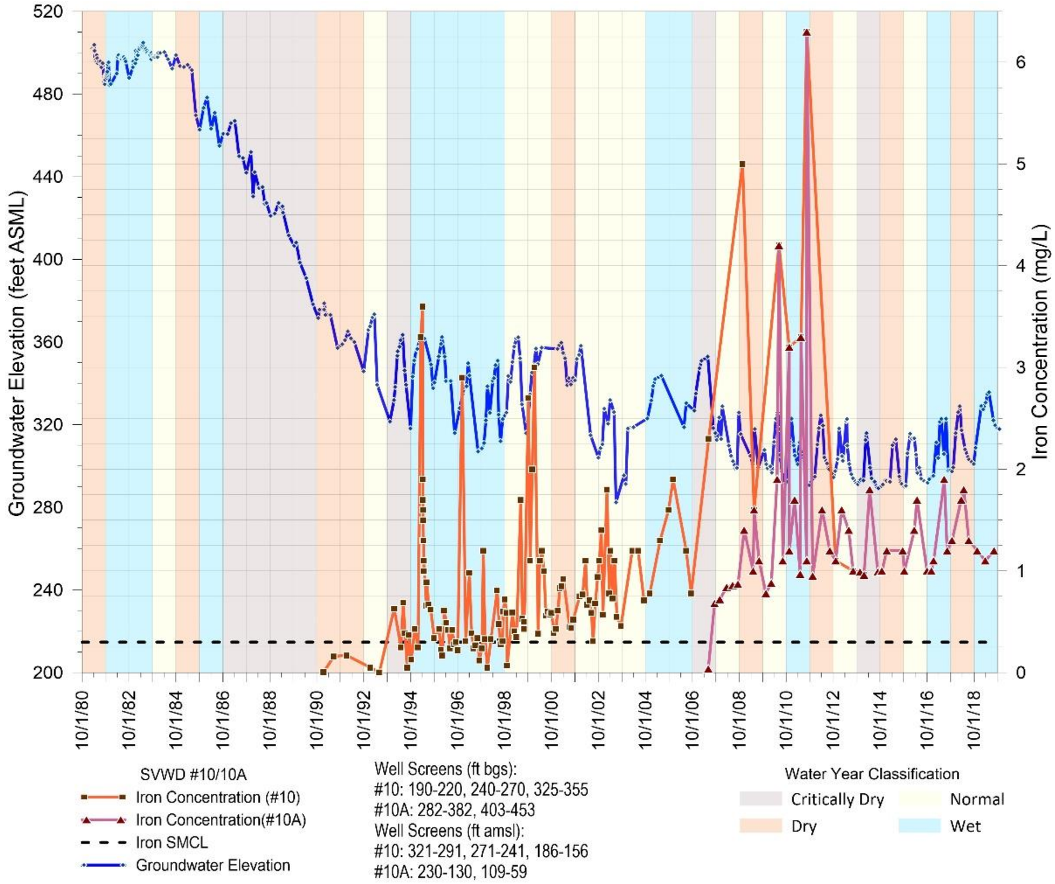
Figure 2-59. Historical Iron and Manganese Concentrations and Groundwater Elevations in SLVWD Olympia #2 (Santa Margarita Aquifer)

Iron and manganese concentrations in the Santa Margarita aquifer are found to be directly correlated with groundwater residence time, and therefore inversely correlated with the rate of aquifer flushing driven by rainfall (Johnson, 2009). Furthermore, where Santa Margarita Sandstone contacts overlying Santa Cruz Mudstone and underlying Monterey Formation, increased iron and manganese concentrations in the Santa Margarita aquifer can occur (Johnson, 2009).

Groundwater in SVWD #9, which is screened in the Monterey Formation, generally has iron and manganese concentrations below secondary MCLs that occasionally spike higher (Figure 2-57 and Figure 2-58). There are no groundwater quality data for other Monterey Formation screened wells.

Iron and manganese concentrations in the Lompico aquifer are typically above state secondary MCLs and can reach concentrations of 6 mg/L and 0.66 mg/L (Figure 2-57 and Figure 2-58), respectively. An increasing trend in iron and manganese has been observed in SVWD Well #10/10A since samples were first analyzed in 1990. There is a possibility the increase corresponds with its declining groundwater elevation (Figure 2-60). However, this is not conclusive as there are no iron and manganese data prior to 1990 for the period when most of the groundwater elevation decline occurred. Lompico aquifer screened extraction well SVWD #11B has different trends in iron and manganese even though it is only 1-mile northeast of SVWD Well #10/10A. This well has no trend in iron and declining manganese concentrations with declining groundwater elevations (Figure 2-61). In contrast, extraction well SVWD #11A near SVWD #11B has a decreasing iron trend and no manganese trend (Figure 2-62). These differences within the same aquifer suggest that differences in how each well is operated and from where in the Lompico aquifer it pumps has an influence on its iron and manganese concentrations.

SVWD wells screened within both the Lompico and Butano aquifers, such as extraction well SVWD Well #3B, generally have iron and manganese concentrations below secondary MCLs with occasional temporary spikes above their secondary MCLs (Figure 2-63). There does not appear to be any iron or manganese concentration correlation with water year type or groundwater elevation.



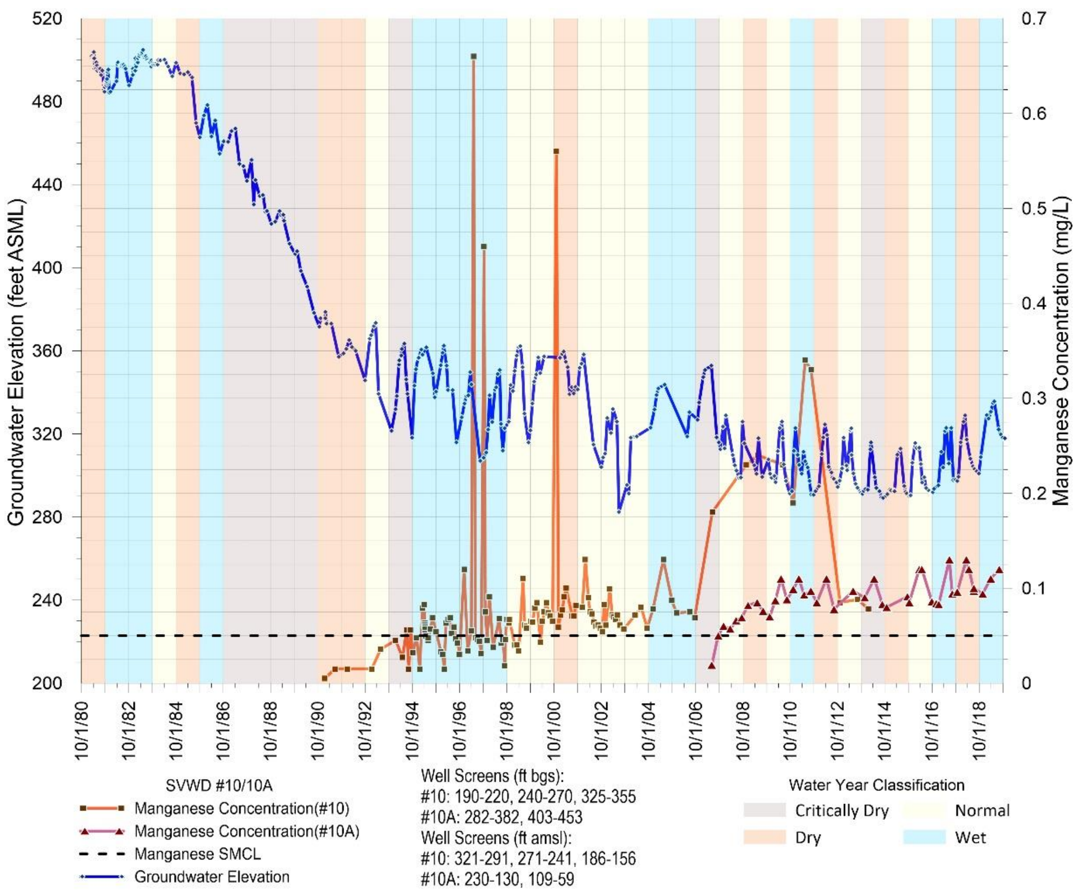


Figure 2-60. Historical Iron and Mangenese Concentrations and Groundwater Elevations in SVWD Well #10/10A (Lompico Aquifer)

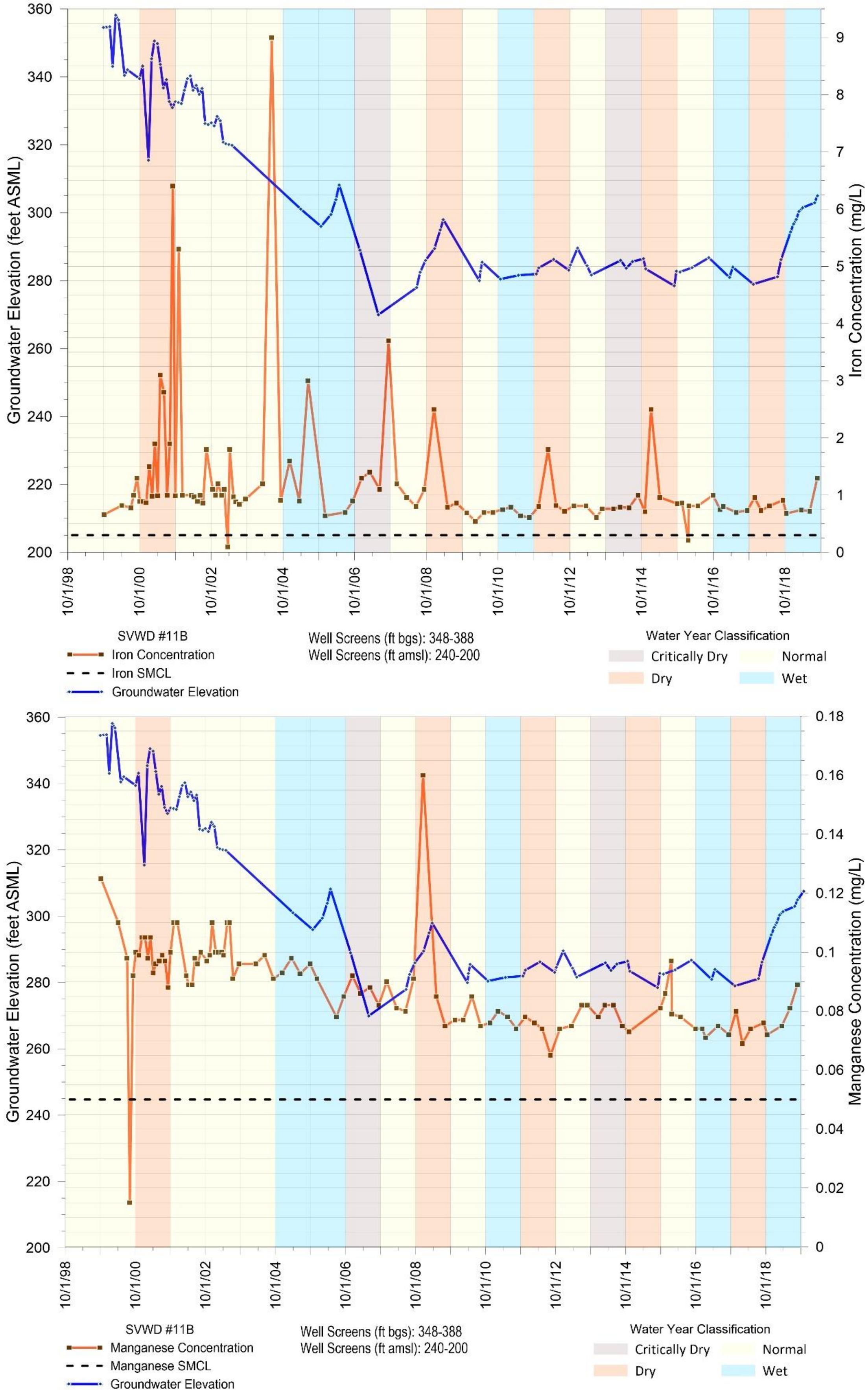
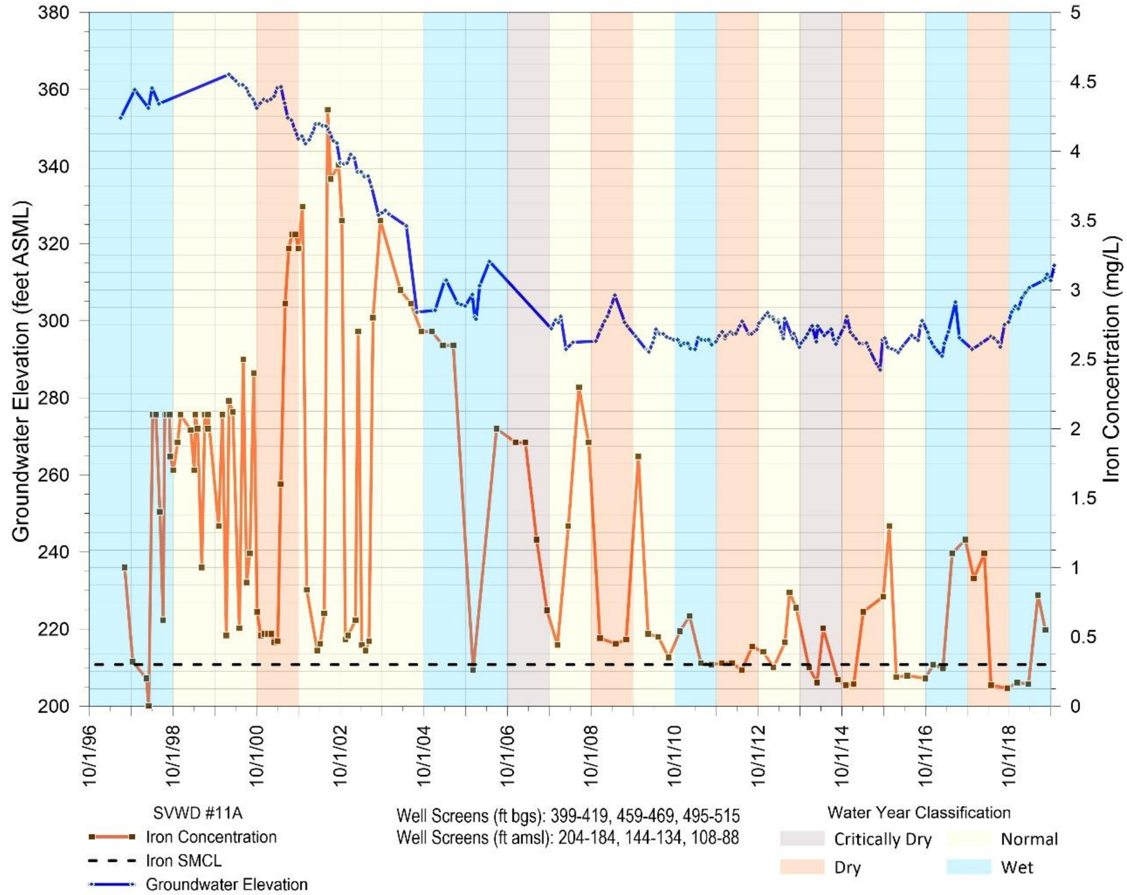


Figure 2-61. Historical Iron and Mangenese Concentrations and Groundwater Elevations in SVWD Well #11B (Lompico Aquifer)



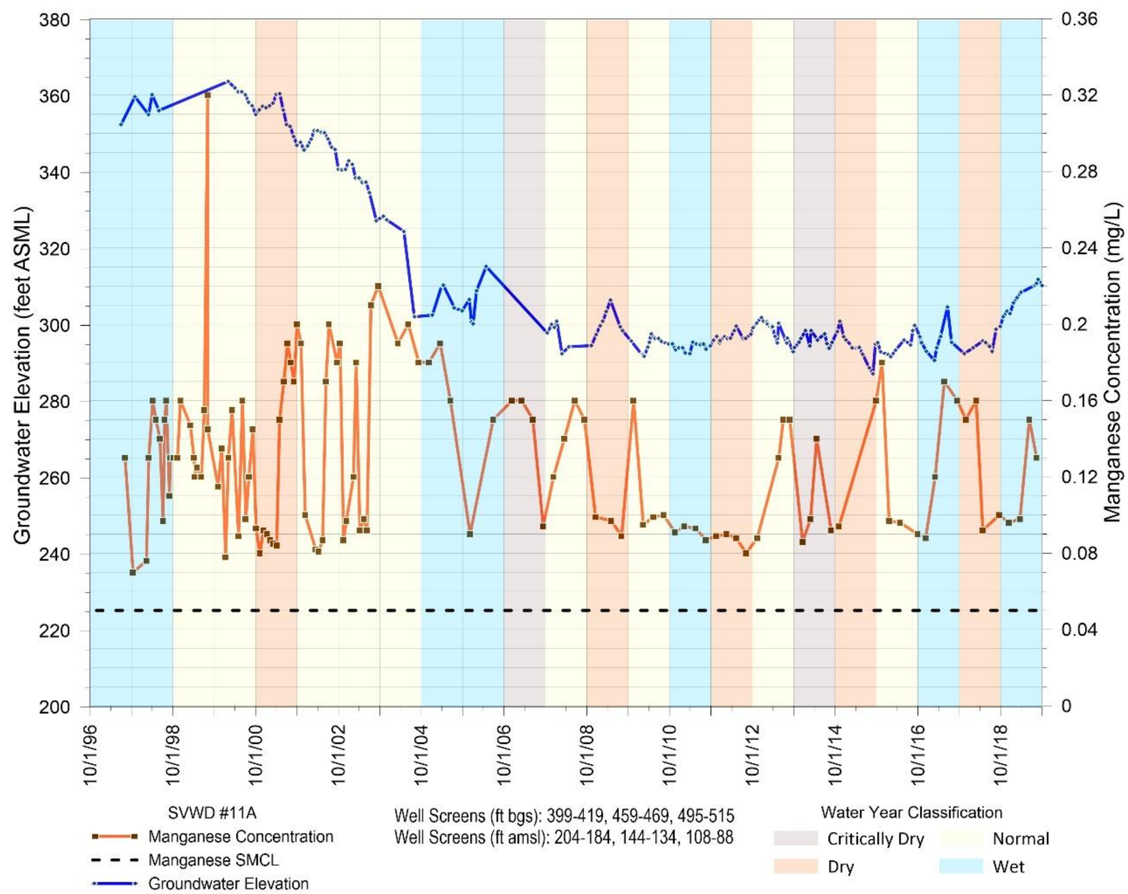


Figure 2-62. . Historical Iron and Mangenese Concentrations and Groundwater Elevations in SVWD Well #11A (Lompico Aquifer)

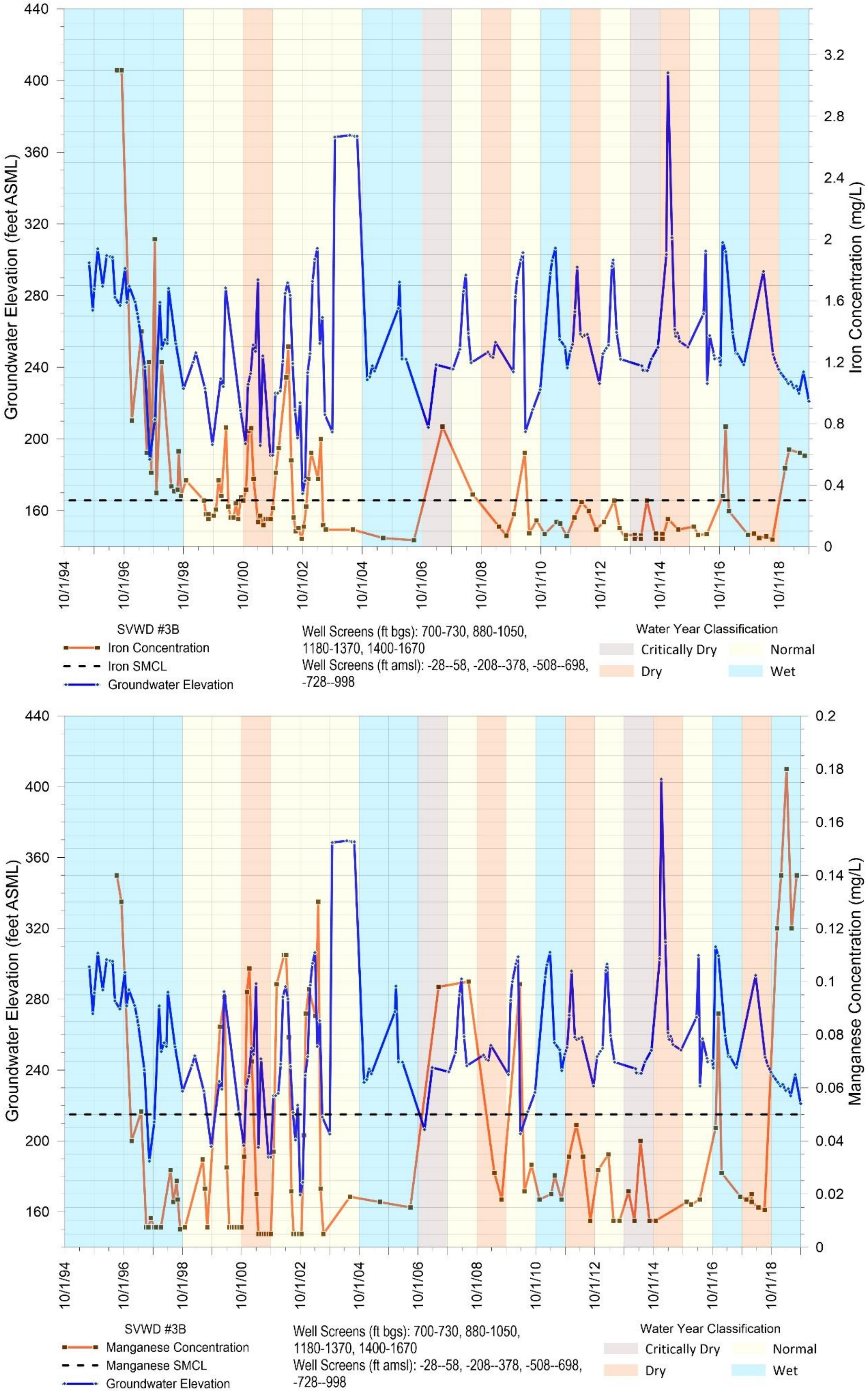


Figure 2-63. Historical Iron and Mangenese Concentrations and Groundwater Elevations in SVWD Well #3B (Lompico/Butano Aquifer)

2.2.5.4.3.3 Arsenic

Arsenic is a trace element often naturally present in groundwater that can negatively impact human health when consumed. Arsenic occurs naturally and is ubiquitous in the environment. It is found in many drinking water sources in California and is commonly associated with deeper portions of sedimentary fill-basins throughout the western United States. (Anning et al, 2012). The primary MCL for arsenic is 0.010 mg/L.

Arsenic concentrations above the MCL (up to 0.025 mg/L) are found periodically in wells pumping from the Lompico aquifer (Figure 2-64). Due to wells with groundwater quality data in the Lompico aquifer being limited to wells in the Pasatiempo and Scotts Valley portions of the Basin (Figure 2-66), there are no arsenic data for the Lompico aquifer in other portions of the Basin. Non-detect or low detections of arsenic in the Basin's other aquifers (all wells with data are included in Appendix 2C), including the Butano aquifer support the observation that elevated arsenic is limited to the Lompico aquifer.

Arsenic is occasionally detected above its MCL in surface waters in the northern and western portions of the Basin, such as near Boulder Creek and south Felton where the Lompico aquifer is exposed at the surface in this area. The iron and manganese treatment process used for groundwater extracted for municipal purposes coincidentally treats arsenic to below MCLs prior to distribution.

Except for the Lompico aquifer extraction well SVWD #11B, there are no increasing arsenic concentration trends in wells with arsenic detections. Increasing arsenic concentrations in SVWD #11B appear to be correlated with groundwater elevation declines and may reflect the well drawing groundwater from a different portion of the aquifer than SVWD #11A (Figure 2-65). SVWD #11A is only 725 feet from SVWD #11B but is screened deeper thereby extracting groundwater from deeper in the Lompico aquifer.

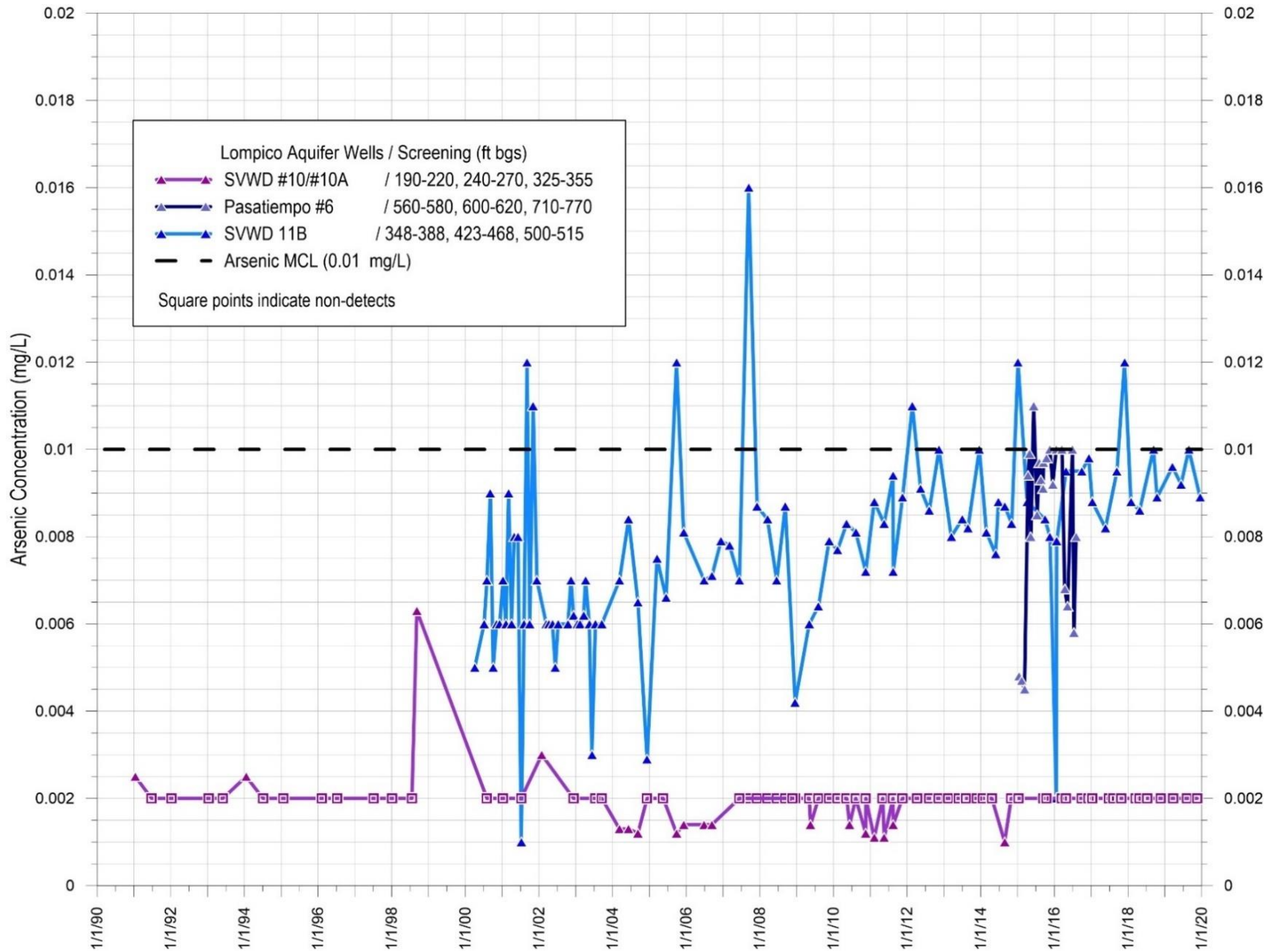


Figure 2-64. Arsenic Concentrations in Select Lompico Aquifer Wells from 1990-2019

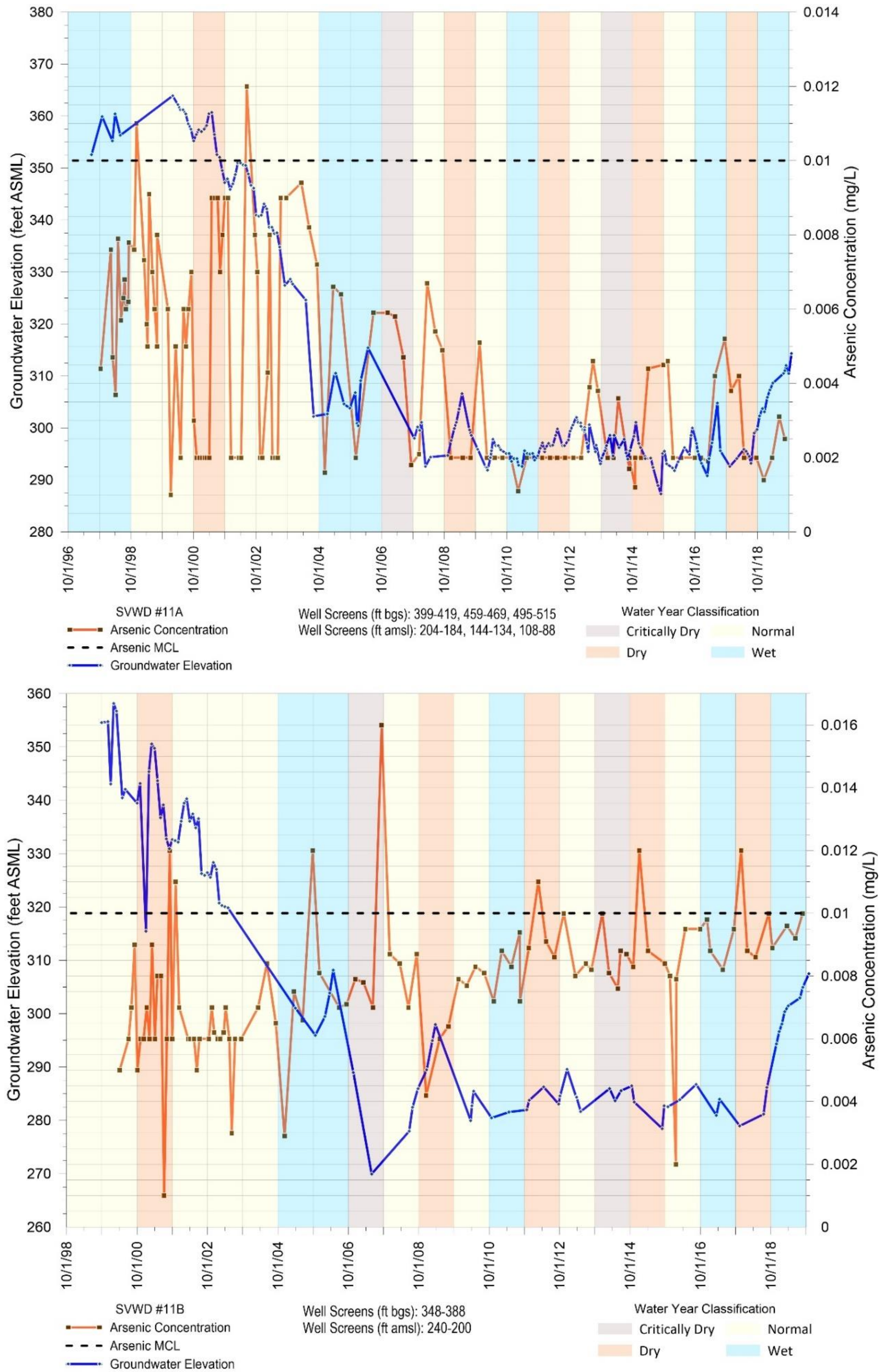


Figure 2-65. Historical Arsenic Concentrations and Groundwater Elevations in SVWD #11A and SVWD #11B

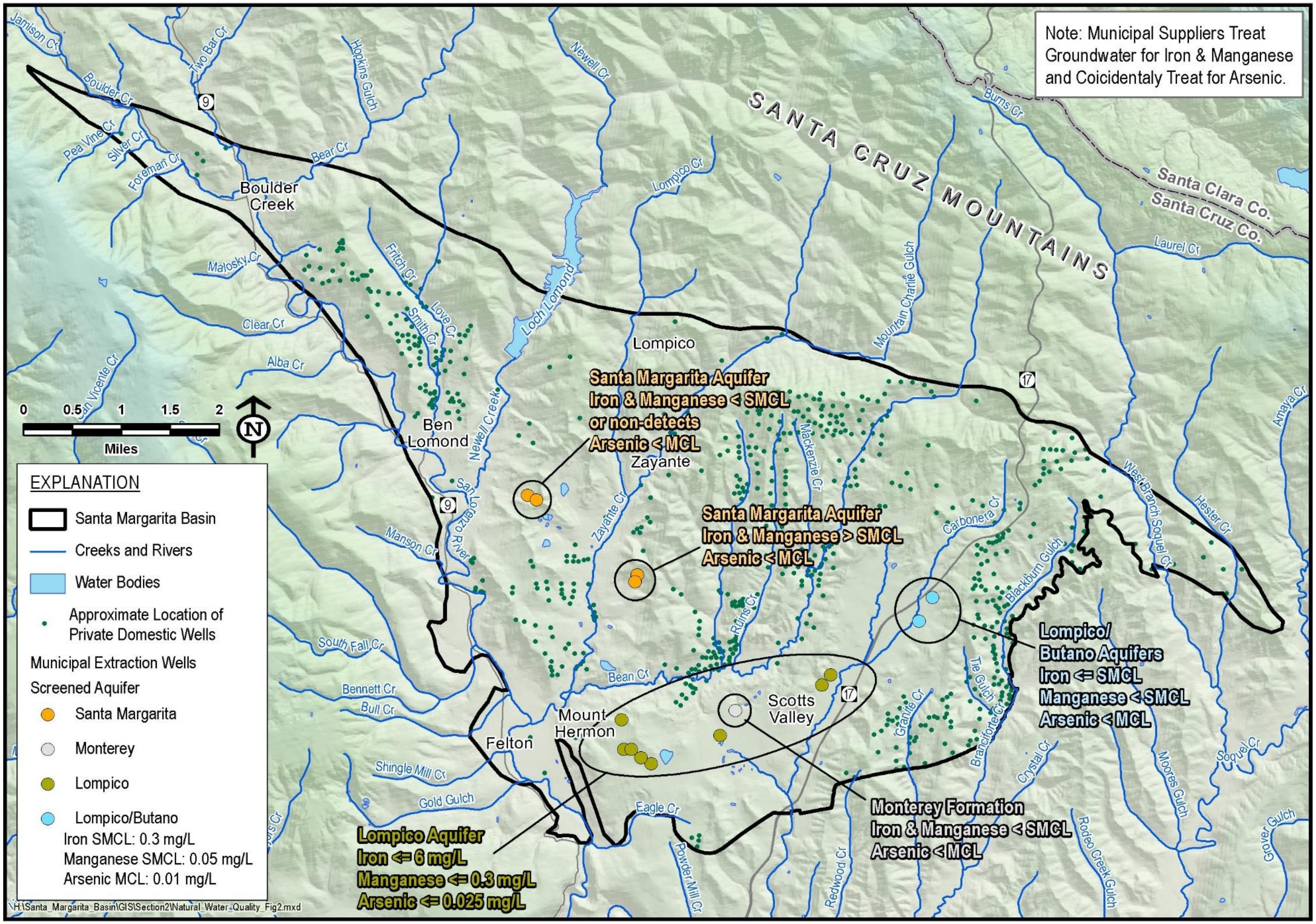


Figure 2-66. Areas of Elevated Naturally Occuring Groundwater Quality

2.2.5.4.4 Anthropogenic Constituents of Concern in Groundwater

2.2.5.4.4.1 Nitrate

Nitrate Sources

Elevated nitrate in groundwater is typically derived from anthropogenic sources such as fertilizer applied to crops and turf, animal operations, such as livestock/stables, and human sources such as wastewater treatment plant effluent and septic tanks. In response to observed increased nitrate concentrations in the San Lorenzo River in the 1980s and 1990s, the County prepared a San Lorenzo Nitrate Management Plan to evaluate the impacts of nitrogen release from septic systems and other sources, and to develop recommendations for reduction of nitrate levels in groundwater and surface water (County of Santa Cruz, 1995). The 1995 Nitrate Management Plan found that 76% of the nitrate load in the San Lorenzo River originated from human waste including septic systems and sewer discharges. The remaining 24% was associated with natural (animal and plant) sources (16%), livestock and stables (6%), and fertilizer use (2%). The Nitrate Management Plan also found that the nitrate concentrations occurring in the San Lorenzo River at that time did not appear to have any adverse impacts on fishery resources, and that impacts on recreation were low.

Historically, the Hansen (also known as Kaiser) quarry in the Pasatiempo area was used to dispose of several thousand gallons per day of primary effluent from the Scotts Valley Water Reclamation Facility constructed in 1964 (USGS, 1977). The City of Scotts Valley is the only area of the Basin that is sewered although there are still approximately 445 operating septic systems (6% of systems in the Basin) within City limits (Figure 2-67). The vast majority of the Basin's residents, as shown on Figure 2-67, use septic systems to treat and dispose of sanitary waste. Using land use data and County septic system inspection records, it is estimated that there are approximately 7,789 septic systems in the Basin. Table 2-18 summarizes the estimated distribution of septic systems, with a major proportion of the Basin's septic systems in areas supplied water by SLVWD.

Table 2-18. Santa Margarita Basin Septic System Distribution

Water Supplier	Estimated Number of Septic Systems (2018)	Percent
SLVWD	5,275	68%
Private domestic wells	784	10%
SVWD	747	10%
Mount Hermon Association	586	7%
Small Water Systems	397	5%
Total	7,789	

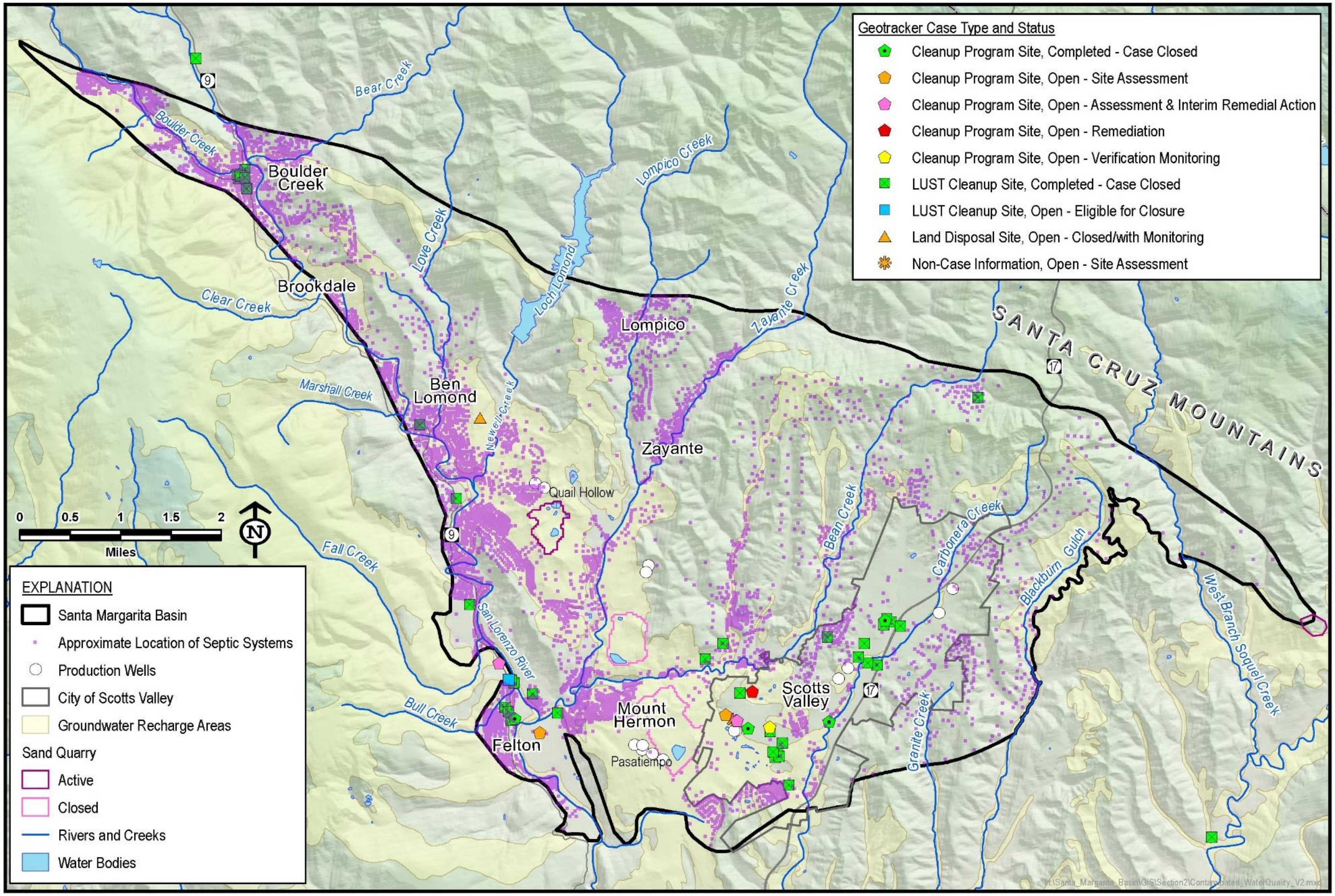


Figure 2-67. Potential Groundwater Contamination Sources

If sited or operated incorrectly, septic systems can be a significant source of groundwater contamination. The USEPA (2001) describes a typical household septic system as:

> A septic tank, a distribution box, and a leachfield. Wastewater flows into the septic tank, where it is held for a period of time to allow suspended solids to separate out. The heavier solids collect in the bottom of the tank and are partially decomposed by microbial activity. Grease, oil, and fat, along with some digested solids, float to the surface to form a scum layer. The partially clarified wastewater that remains between the layers of scum and sludge flows to the distribution box, which distributes it evenly through the leachfield. The leachfield is a network of perforated pipes laid in gravel-filled trenches. Wastewater flows out of the pipes, through the gravel, and into the surrounding soil. As the wastewater effluent percolates down through the soil, chemical and biological processes remove some of the contaminants before they reach groundwater.

Nitrogen, primarily from urine, feces, food waste, and cleaning compounds, is present in sanitary wastewater. Consumption of nitrates can cause methemoglobinemia (blue baby syndrome) in infants, which reduces the ability of the blood to carry oxygen. If left untreated, methemoglobinemia can be fatal for affected infants. Due to this health risk, a drinking water standard of 10 mg/L is set for nitrate measured as nitrogen (N) or 45 mg/L for nitrate as nitrate (NO_3). Even properly functioning conventional septic systems may contribute nitrogen to groundwater exceeding this standard (USEPA, 2001).

The CCRWQCB has historically delegated authority to oversee and regulate the installation of septic systems to SCEH through a memorandum of understanding. The County must comply with the minimum standards contained in the Basin Plan in order to keep the authority to permit septic systems. The County Board of Supervisors has adopted Section 7.38 of the County Code (the Sewage Disposal Ordinance) which specifies the standards for septic system installation in Santa Cruz County. The County is currently in negotiations with the Regional Board for establishment of a Local Area Management Plan (LAMP), which will be in compliance with the California Water Board’s 2012 Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater Treatment Systems.

Nitrate Concentrations in Groundwater

Maximum nitrate (as N) detections in municipal wells from 2010 to 2020 were 3.6 mg/L in the Santa Margarita aquifer, and 0.7 mg/L in the Lompico aquifer which are below the nitrate (as N) MCL of 10 mg/L. Nitrate concentrations are generally higher in the permeable Santa Margarita aquifer due to its widespread exposure at the surface and proximity to potential nitrate contamination sources such as septic tanks and livestock/stables. The description of nitrate concentrations below is limited to areas where groundwater quality data are available.

Figure 2-68 plots nitrate (as N) concentrations in SLVWD Quail Hollow extraction wells from 1970-2020. These wells are screened in the Santa Margarita aquifer at different depths as noted on the chart. Near-surface sources of nitrate have a greater impact on shallower wells (Quail Hollow #5 and #5A) compared to the deeper screened Quail Hollow #4 and #4A wells. There are also more septic systems potentially impacting Quail Hollow #5/5A than Quail Hollow #4/4A. Figure 2-68 shows that from the 1970s to the 1990s, during the County's greatest population growth (Figure 2-35), nitrate concentrations increased in the Santa Margarita aquifer in the Quail Hollow area. Nitrate concentrations peaked in WY1987 which was during the 6-year statewide drought that extended from WY1986 through WY1991. Johnson (1988) demonstrated with a groundwater model that the nitrate peak at Quail Hollow was associated with late-season, drought-year pumping and the number of septic systems within the wells' capture zones. Johnson forewarned that nitrate concentrations had the potential to increase again in the future. Thus far, only a temporary spike that remained below drinking water standards occurred during the WY2012 through WY2015 statewide drought in the Quail Hollow #5A well (Figure 2-69). From Figure 2-69, it does not appear that there is any correlation between nitrate concentrations, water year type, and groundwater elevation. It should be noted, however, that the nitrate data plotted on Figure 2-69 is from groundwater quality samples collected every 3 years per DDW requirements. Comparing nitrate concentrations with water year type and groundwater elevations does not tell a complete story because the 3-year sampling frequency does not allow for comparisons at a seasonal level.

Apart from the temporary increase in WY2015, concentrations in the Quail Hollow wells have been stable or slowly decreasing (Figure 2-68), possibly in response to the County's efforts starting in 1986 to work with property owners to reduce the occurrence of failing septic systems as well as instituting new requirements for the construction and performance of new and existing septic systems, including the requirement for enhanced treatment for effluent nitrogen reduction for new and replacement systems in sandy soils.

Historically, the Santa Margarita aquifer in the Pasatiempo/southern Scotts Valley area was impacted by nitrate (as N) up to 6 mg/L due to septic and sewer waste disposal described above in the section on nitrate sources (Johnson, 2009). Recent nitrate concentration data are not available since the Santa Margarita aquifer is no longer pumped for municipal use.

Included on Figure 2-68 are public water supply wells screened in the Lompico aquifer. Groundwater in the Lompico aquifer generally has lower nitrate concentrations than the Santa Margarita aquifer because of greater travel time nitrate has to reach the deeper aquifer from the surface. The extraction well, SVWD #10/10A, is screened in the Lompico aquifer below the Monterey Formation, which forms a barrier to downward recharge, and has mostly non-detects of nitrate. The SLVWD's Pasatiempo wells, on the other hand, are in an area where the Monterey Formation is absent or very thin. With the barrier between the Santa Margarita aquifer and Lompico aquifer missing, nitrate concentrations are slightly higher than in areas overlain by the Monterey Formation but are lower than in the Santa Margarita aquifer (Figure 2-68). The few public water supply wells screened in the Butano aquifer mostly have no detectable nitrate due to the very deep occurrence of the aquifer.

County well permitting code requires well owners of new private domestic wells to submit a single groundwater quality test result following well installation. Private domestic wells are more vulnerable to nitrate contamination than municipal wells because private wells are typically shallower and are closer to septic systems. The period from 2010 to 2019, only had 1 well with an elevated nitrate (as N) concentration of 4.9 mg/L and the remainder of the nitrate concentrations were less than 1 mg/L.

Figure 2-70 summarizes the Basin's spatial distribution of nitrate concentrations for different aquifers described above.

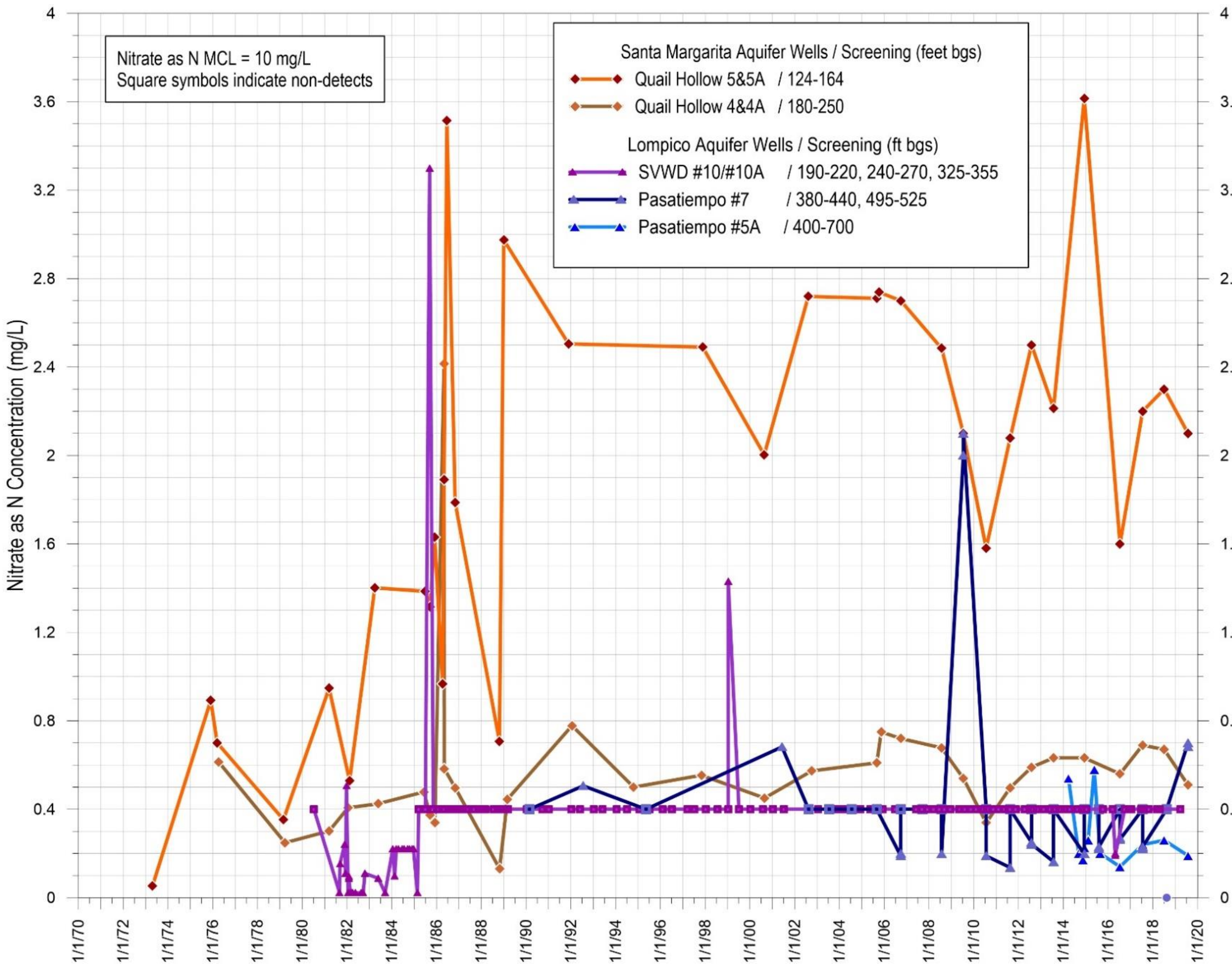
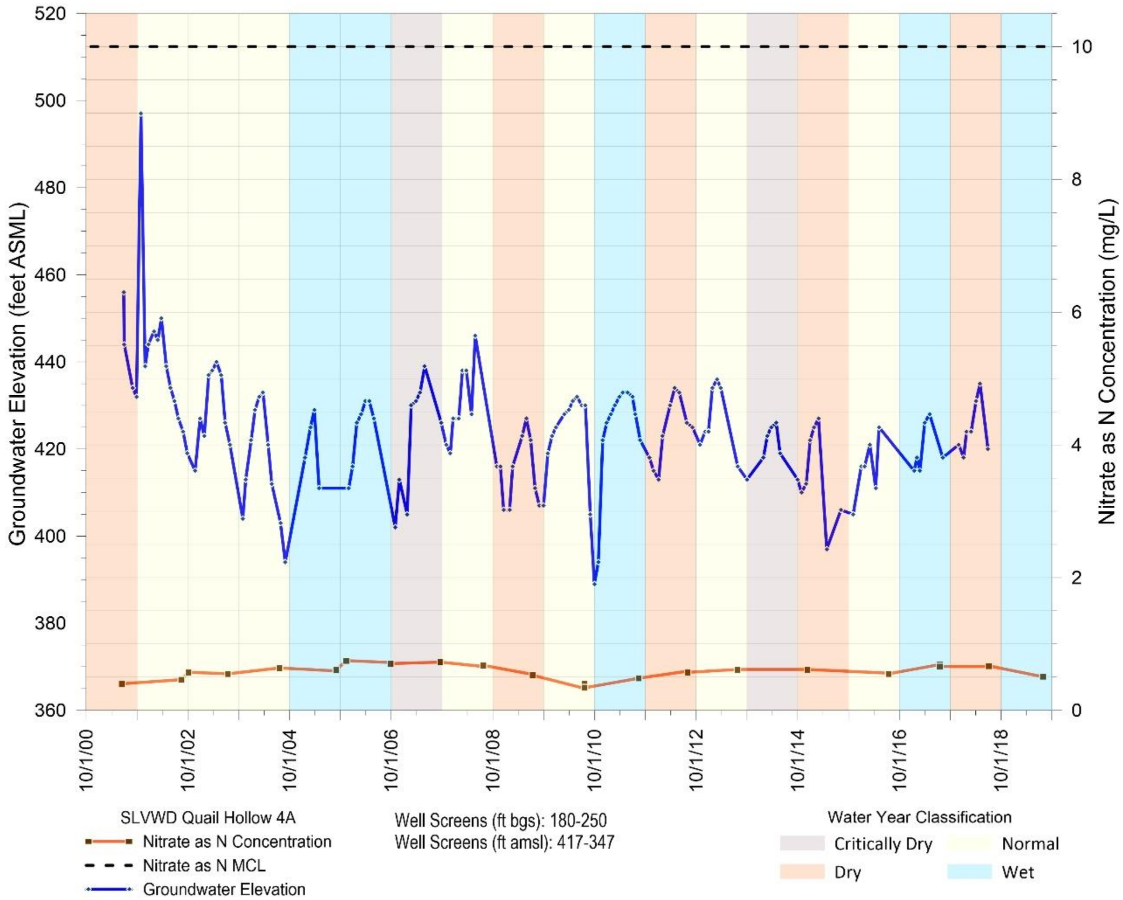


Figure 2-68. Historical Nitrate (as N) Concentrations, 1970-2020



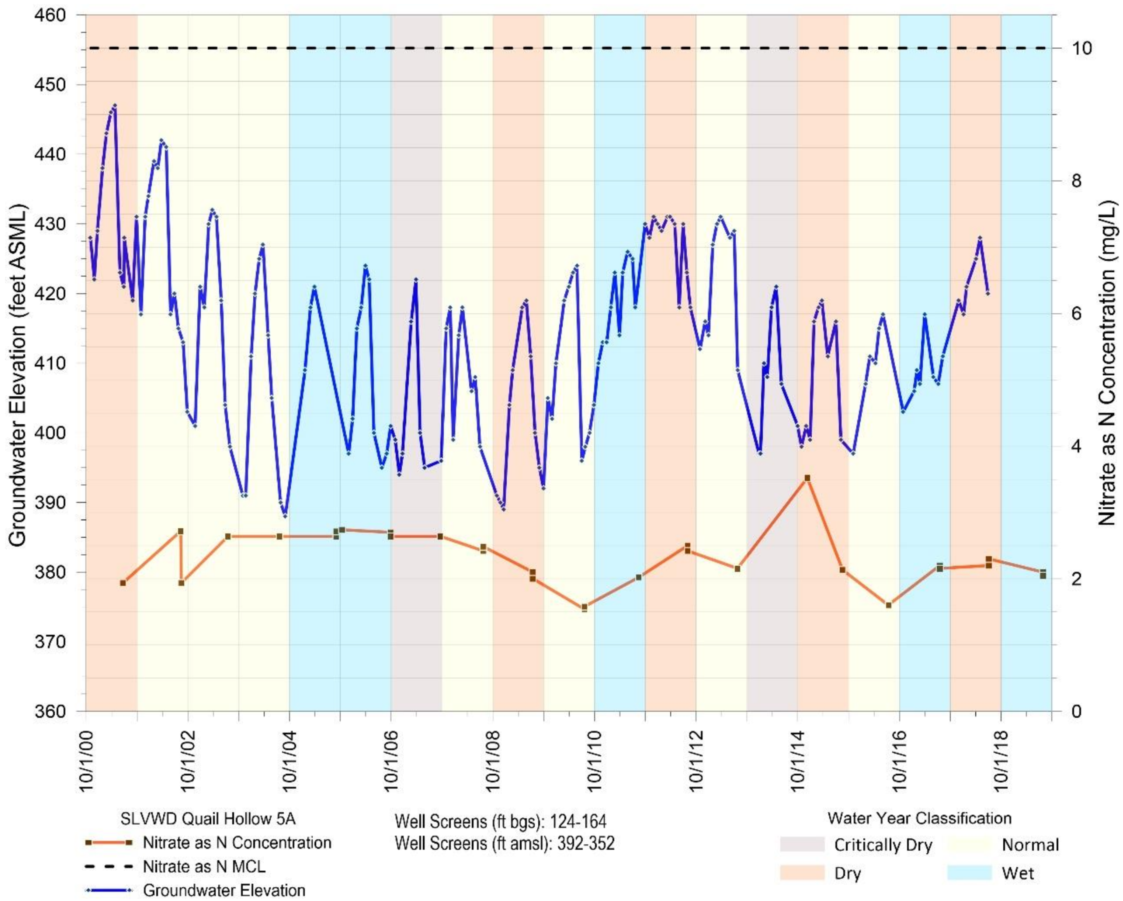


Figure 2-69. Historical Nitrate Concentrations and Groundwater Elevations in SLVWD Quail Hollow #4A and #5A (Santa Margarita Aquifer)

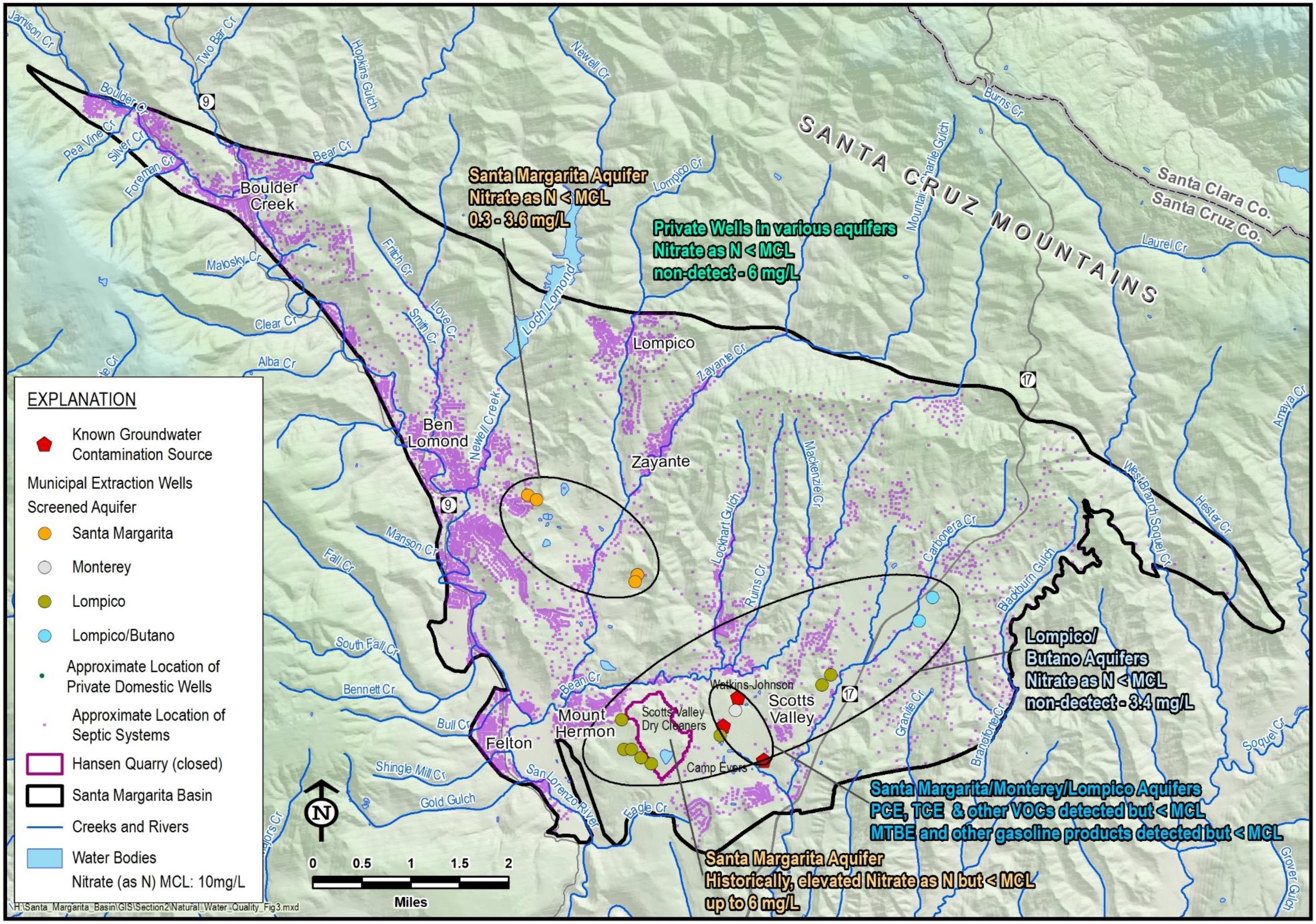


Figure 2-70. Areas of Known Anthropogenic Groundwater Quality Impacts

Nitrate Concentrations in the San Lorenzo River

Water quality in the Basin has a strong influence on water quality in the San Lorenzo River. Nitrate released from septic systems, livestock, fertilizer use, and other sources passes readily through the sandy soil, into the basin groundwater and eventually into tributary streams and the San Lorenzo River. Summer average nitrate (as N) concentrations at the San Lorenzo River at Felton from 1976 to 1993 was 0.42 mg/L (County of Santa Cruz, 1995). More recently, nitrate (as N) concentrations at this same location averaged 0.47 mg/L between September 2011 and September 2018 (converted from nitrate (as NO_3) of 2.1 mg/L; Trussell Technologies Inc., 2019). This indicates that nitrate concentrations in the San Lorenzo River at Felton have increased approximately 11% over the past 30 years.

The San Lorenzo River has been designated as impaired by the State and the USEPA due to elevated levels of nitrate, which stimulates increased algal growth and release of compounds that degrade the quality of drinking water and require increased cost for treatment. Increased nitrate and algal growth also cause impacts in the San Lorenzo lagoon, degrading salmonid habitat and potentially creating harmful algal blooms. Sixty five percent of the nitrate load in the River originates from the Basin, the majority of which is from septic systems.

In order to reduce nitrate levels in the San Lorenzo River, the County developed the San Lorenzo Nitrate Management Plan in 1995, and the CCRWQCB adopted a Nitrate Total Maximum Daily Load (TMDL) of 0.33 mg/L (as N). These plans call for various measures to prevent any increased nitrate discharge and to reduce existing sources, particularly requiring individual enhanced treatment systems as existing septic systems in sandy soils are replaced or upgraded. Additionally, the use of recycled water in the basin requires additional treatment for denitrification before the water can be used.

2.2.5.4.4.2 Contaminants of Emerging Concern

Contaminants of emerging concern (CECs), including pharmaceuticals and personal care products, are detected at low levels in the Basin’s surface water and groundwater. CEC pathways to surface and groundwater resources are similar to nitrate since these constituents are typically found in wastewater. New and emerging contaminants are currently unregulated but may be subject to future regulation. Examples of new and emerging contaminants are N-Nitrosodimethylamine, and 1,4-dioxane, disinfection byproducts, and perfluorinated substances.

The Unregulated Contaminant Monitoring Rule (UCMR) is part of the federal Safe Drinking Water Act Amendments of 1996 and administered by the U.S. Environmental Protection Agency (USEPA). SVWD and SLVWD have had CECs tested in their source waters and treated water in three separate UCMR testing cycles: 2009/2010 (UCMR 2), 2014/2015 (UCMR 3), and 2018/2019 (UCMR 4). Apart from very low levels of brominated haloacetic acid disinfection byproducts in treated water, there have been no CECs detected in groundwater or surface water that are the 2 water districts' sources of water. UCMR data can be accessed from the USEPA (https://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule).

The San Lorenzo River which is a primary source of water for the City of Santa Cruz has detections of CECs at both the Tait and Felton diversions. The Tait diversion is south of the Basin and the Felton diversion is within the Basin. The City's CEC testing was initially undertaken to inform planning for upcoming improvements to the Graham Hill Water Treatment Plant (City of Santa Cruz, 2016b); it is now conducted annually and includes CEC testing of influent and effluent from the treatment plant. The most common CECs detected in raw San Lorenzo River water samples are 2 types of artificial sweeteners, Sucralose (i.e. Splenda) and Acesulfame-K, (i.e. Sunett and Sweet One). Sampling conducted over time and during different seasons found that the most diverse set of CECs were found in the first flush sample that reflects the influence of the first significant rainfall of the season on river flows and is intended to capture the impacts on water quality of both surface runoff and rewetting of the streambed.

Table 2-19 summarizes 1 year of monthly samples tested for CECs, including frequency of detections in either the raw source water blend and/or the treated drinking water at the Graham Hill Water Treatment Plant. In this 1-year water treatment plant study, 59 total detections out of 2,304 CECs measured, which equals a 2.6% rate of CEC detection. Blending of the City's raw water sources prior to treatment was documented to decrease the higher CEC concentrations measured in the San Lorenzo River. Samples collected during the drier months of May through September measured lower concentrations of artificial sugars (universal indictors of wastewater) and a dissimilar variety of CEC compounds compared to those CECs detected during the wetter periods. This occurs because of CECs entering the San Lorenzo River as either surface water runoff or septic system effluent through saturated underground water flow, which are less prevalent during dry season conditions. During these warmest months of the year, weekday, and weekend recreational activities in and around the San Lorenzo River are a probable source of human contamination from swimming and wading, as increased pharmaceutical and personal care products detections.

While there are few regulations for CECs at this time, it is expected there may be more in the future. There is a high likelihood that additional treatment techniques will be used to remove or reduce CECs from the treated drinking water which will be more costly and likely require upgrades to existing water treatment plants.

Table 2-19. Summary of Constituents of Emerging Concern Detections in Raw Source Water Blend and/or Treated Drinking Water at the Graham Hill Water Treatment Plant (2016/2017)

CEC Type	Chemical Type or Use with Common Name if Applicable	Number of CECs detected in the raw source water blend and/or treated drinking water in 2016/2017	Number of Detections
Artificial sweeteners and caffeine	Artificial sweetener (Sunett and Sweet One)	Acesulfame- K (16)	23 detections ranging from 6-320 ng/L, average detection of 70 ng/L
	Artificial sweetener (Splenda)	Sucralose (5)	
	Stimulant (coffee, tea, some energy drinks)	Caffeine (2)	
Pharmaceuticals	Antibiotic	Erythomycin (6)	22 detections ranging from 6-130 ng/L, average detection of 34 ng/L
	Contrast media used for x-ray imaging	Iohexal (4)	
	Organic chemical used in the manufacture of a variety of other products such as dyes, some pharmaceuticals, and niacin (vitamin B3)	Quineline (3)	
	Pain relief medicine	Acetaminophen (2)	
	Veterinary drug for swine	Carbadox (2)	
	Antacid and antihistamine	Cimetidine (2)	
	Anti-inflammatory medicine	Meclofenamic acid (2)	
	High blood pressure medicine	Diltiazem (1)	
Herbicides and insecticides	Insect repellent	DEET (5)	8 detections ranging from 5-60 ng/L, average detection of 23 ng/L
	Herbicide	Chloridazon (2)	
	Herbicide	Chlorotoluron (1)	
Personal care products	Alkylphenols used in manufacturing of antioxidants, lubricating oil additives, and laundry and dish detergents	4-nonylphenol (4)	5 detections ranging from 8-240 ng/L, average detection of 150 ng/L
	Paraben family of preservatives in personal care products found in cosmetics, pharmaceuticals and foods	Propylparaben (1)	
Flame retardant	Flame retardant	Tris(1,3-dichloro-2-propyl) phosphate (1)	1 detection at 1,300 ng/L

2.2.5.4.4.3 Organic Compounds

Organic compounds are those that include VOCs and pesticides. VOCs are chemicals that are carbon-containing and evaporate or vaporize easily into air at normal air temperatures. VOCs are found in a variety of commercial, industrial, and residential products, including gasoline, solvents, cleaners and degreasers, paints, inks and dyes, and pesticides. VOCs in the environment are typically the result of human activity, such as a spill or inappropriate disposal where the chemical has been allowed to infiltrate into the ground. Once released into the environment, VOCs may infiltrate into the ground and migrate into the underlying production aquifers.

Figure 2-67 shows the locations of all historical and current cleanup sites in the Basin sourced from the SWRCB GeoTracker database. GeoTracker is a database and geographic information system (GIS) that provides online access to environmental data. It tracks regulatory data about leaking underground fuel tanks, Department of Defense, Spills-Leaks-Investigations-Cleanups, and landfill sites. Most the Basin's cleanup sites are in the Scotts Valley area and along the San Lorenzo Valley corridor and are impacted with VOCs. These areas correspond with the Basin's developed areas and to detections of anthropogenic contaminants in wells (Figure 2-66). While closed-case cleanup sites (green) are present across a wide range of this area, current open-site cleanup cases are clustered near Felton and the Scotts Valley/Camp Evers area. Section 2.1.3.4.6.1 summarizes the status of the Basin's groundwater cleanup cases based on information available from GeoTracker. The bullets below summarize cleanup sites not included in Section 2.1.3.4.6.1:

- To the southwest of the Watkin-Johnson site there are 2 open-case dry cleaner cleanup sites in the City of Scotts Valley: Scotts Valley Dry Cleaners (orange pentagon on Figure 2-67) and King's Cleaners (yellow pentagon on Figure 2-67). Both sites are located on Mt. Hermon Road between Scotts Valley Drive and Skypark Drive. The Scotts Valley Dry Cleaners site currently operates soil vapor extraction and air sparging systems to remediate PCE and TCE in the unsaturated soils above the groundwater table by extracting soil vapor. A groundwater remediation system was used from 1998-2015. The King's Dry Cleaners Site is operating soil vapor remediation to remove PCE and TCE contamination.
- The Ben Lomond Landfill (orange triangle on Figure 2-67) was closed in 2012 and is now operated as a transfer station. Groundwater monitoring has been ongoing at the now-closed landfill since 1980, as the site is associated with elevated levels of VOCs and heavy metals. Contamination associated with the site is not predicted to expand and is not thought to significantly impact 2 municipal wells operated by SLVWD east of Newell Creek (Johnson, 2009).

In addition to the open-case sites discussed above, there have been many cleanup sites in the Basin which are now closed, indicated in green on Figure 2-67. These include numerous LUST sites, such as the now closed (since November 21, 2017) Camp Evers Combined Site associated with four current and former gasoline stations located at the intersection of Scotts Valley Drive and Mount Hermon Road. Although the Camp Evers site cleanup is complete as described in Section 2.1.3.4.6.1, there are remaining gasoline related chemicals in groundwater below their relevant MCLs.

Several SVWD municipal water supply wells have been impacted by organic compounds originating from some of the sites described above (Montgomery & Associates, 2020). SLVWD's Quail Hollow wells have historically been impacted by organics thought to have originated from spills or septic system disposal of cleaning products by 1 or more of the local residences (Johnson, 2009). Table 2-20 identifies those wells with detections. SVWD and SLVWD use onsite treatment plants to remove certain constituents that are above or approaching primary or secondary drinking water standards.

Table 2-20. Summary of Municipal Water Supply Wells Historical Detections of Organic Compounds

Well	PCE MCL = 0.005 mg/L	TCE MCL = 0.005 mg/L	CISDCE MCL = 0.07 mg/L	Chloro-benzene MCL = 0.1 mg/L	MTBE MCL = 0.013 mg/L
Santa Margarita Aquifer					
SLVWD Quail Hollow #4A	ND	ND	ND	ND	ND
SLVWD Quail Hollow #5A	ND	Below MCL	ND	ND	Below MCL
SLVWD Olympia #2	ND	ND	ND	ND	ND
SLVWD Olympia #3	ND	ND	ND	ND	ND
Monterey Formation					
SVWD #9*	ND	Below MCL	Below MCL	ND	Below MCL
Lompico Aquifer					
SLVWD Pasatiempo #5A	ND	ND	ND	ND	ND
SLVWD Pasatiempo #7	ND	ND	ND	ND	ND
SLVWD Pasatiempo #8	ND	ND	ND	ND	ND
SLVWD Mañana Woods #2*	ND	ND	ND	ND	Above MCL
SVWD #10A	ND	ND	ND	ND	ND
SVWD #11A	ND	ND	ND	Below MCL	ND
SVWD #11B	ND	ND	ND	ND	ND
Lompico/Butano Aquifer					
SVWD #3B	ND	ND	ND	ND	ND
SVWD Orchard Well	ND	ND	ND	ND	ND

MCL = maximum contaminant level or primary drinking water standard
* Well no longer used for water supply

Similar to the fate of nitrate, organic constituents readily migrate through the Santa Margarita Sandstone to the water table. The Lompico aquifer is more protected from contaminants migrating downwards through the Santa Margarita aquifer by the Monterey Formation if it is present above the Lompico aquifer.

2.2.5.5 Land Subsidence

Land subsidence is the gradual or sudden lowering of the land surface. Subsidence can be inelastic or elastic. Elastic subsidence includes short-term land surface elevation changes that are reversible inelastic subsidence is irreversible. Only inelastic subsidence caused by groundwater pumping is subject to SGMA and GSP Regulations. Inelastic subsidence can be caused by the following processes, however only aquifer-compaction related to groundwater pumping is subject to SGMA and GSP Regulations:

- Drainage and decomposition of organic soils
- Underground mining, oil and gas extraction, hydrocompaction, natural compaction, sinkholes, thawing permafrost
- Aquifer-system compaction
- Tectonic forces such as fault uplift and landsliding

There is no known evidence of land subsidence in the Basin. Potential evidence of land subsidence related to lowered groundwater elevations might include damage to roads, bridges, and instances of protruding well casings. None of these conditions have been observed in the Basin.

The only potential cause of subsidence in the Basin that would be subject to SGMA is aquifer-compaction caused by lowered groundwater levels from groundwater pumping. The Monterey Formation and Lompico aquifer have experienced up to 200 feet in groundwater decline in the Scotts Valley area but no known subsidence impacts have been observed.

Pumping-induced subsidence is generally restricted to unconsolidated deposits of clay and fine silt, in which extraction of pore water results in the grains of sediment no longer being subjected to the buoyant support of fluid-saturated pore space. The collapse is inelastic in that, even if pumping were to cease, the deposit is now an aquitard with less pore space to hold water and very limited conductivity.

In contrast, the 3 principal aquifers in the Basin are sandstones that are, to varying degrees, consolidated and cemented. When groundwater is extracted from the pores, the pores do not collapse (as they would in unconsolidated deposits or clay-rich rocks) because the framework of sand and silt grains remains due to grain-on-grain contact and due to lithologic cement that holds the grains in place.

The Monterey Formation, though consisting mostly of siltstone and siliceous shale, has not undergone pumping-induced compaction because the formation is well consolidated and well-cemented. Moreover, the horizons tapped by the pumping are sandy interbeds that are coarser than the bulk of the formation.

As no reports or observations have been made regarding land subsidence due to lowered groundwater elevations in the basin, no local land subsidence monitoring has taken place. There is a continuous global positioning station (CGPS) near Felton about 2.4 miles west of the Basin that is part of the University NAVSTAR Consortium Plate Boundary Observatory network; however, it is located outside the sedimentary basin on granitic basement rock, making it useful for tracking movement of the land surface due to tectonic deformation but of no use for monitoring pumping-induced subsidence in the nearby sedimentary rocks of the Basin.

DWR has made vertical displacement spatial data available as part of its SGMA technical assistance for GSP development and implementation. Vertical displacement estimates are derived from Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency Sentinel-1A and 1B satellites and processed by TRE ALTAMIRA Inc. The InSAR dataset has also been calibrated to best available independent data. The dataset starts in January 2015.

Figure 2-71, derived from the dataset, shows changes in total vertical ground surface displacement between June 2015 and June 2019. During this timeframe, the satellite data showed up to 1.2 inches (0.1 feet) of subsidence within the Basin. Most of areas with subsidence on Figure 2-71 are regional and not co-located with groundwater pumping. It is unlikely that these relatively minor changes in ground surface elevation reflect ongoing trends in inelastic subsidence. Rather, they may be attributed to expected measurement error inherent in the methodology, seasonal fluctuations in soil and vadose zone moisture that cause swelling and recession of the ground surface, or tectonic forces.

An area of approximately 1 square mile to the east of Loch Lomond Reservoir shows a slight increase in land surface elevation of up to 0.035 inches (Figure 2-71). Important to understand is that the DWR InSAR data is subject to potential errors of approximately 0.059 feet (0.7 inch) from error between InSAR data and CGPS data (Towill Inc., 2020) and 2) measurement accuracy when converting from the raw InSAR data to the maps provided by DWR of 0.048 feet (personal communication with Benjamin Breezing - DWR, 2019). A land surface change of less than 0.1 foot (1.2 inches) which is less than the combined error of the dataset is within the noise of the data and is not dispositive of subsidence in the Basin. Additionally, the InSAR data provided by DWR reflects both elastic and inelastic subsidence.

Land subsidence is not an applicable indicator of sustainability in the Basin and land surface elevations within the Basin have not been historically monitored nor are there plans to conduct such monitoring in the future. Consequently, land subsidence is not included in the discussion of applicable sustainability indicators and does not have SMC defined in Section 3. To confirm that subsidence is not occurring in the Basin in the future, the InSAR subsidence dataset (or other available datasets) will be reviewed by the SMGWA as part of its 5-year GSP updates. If future InSAR datasets indicate that subsidence is occurring in portions of the Basin that are being pumped, then additional analysis will be performed to confirm the measurement is not inelastic subsidence related to groundwater pumping. Additional analysis would focus on correlating subsidence observations to groundwater pumping volumes, groundwater elevations, and sources for false positives such as known land sliding and tectonic motion.

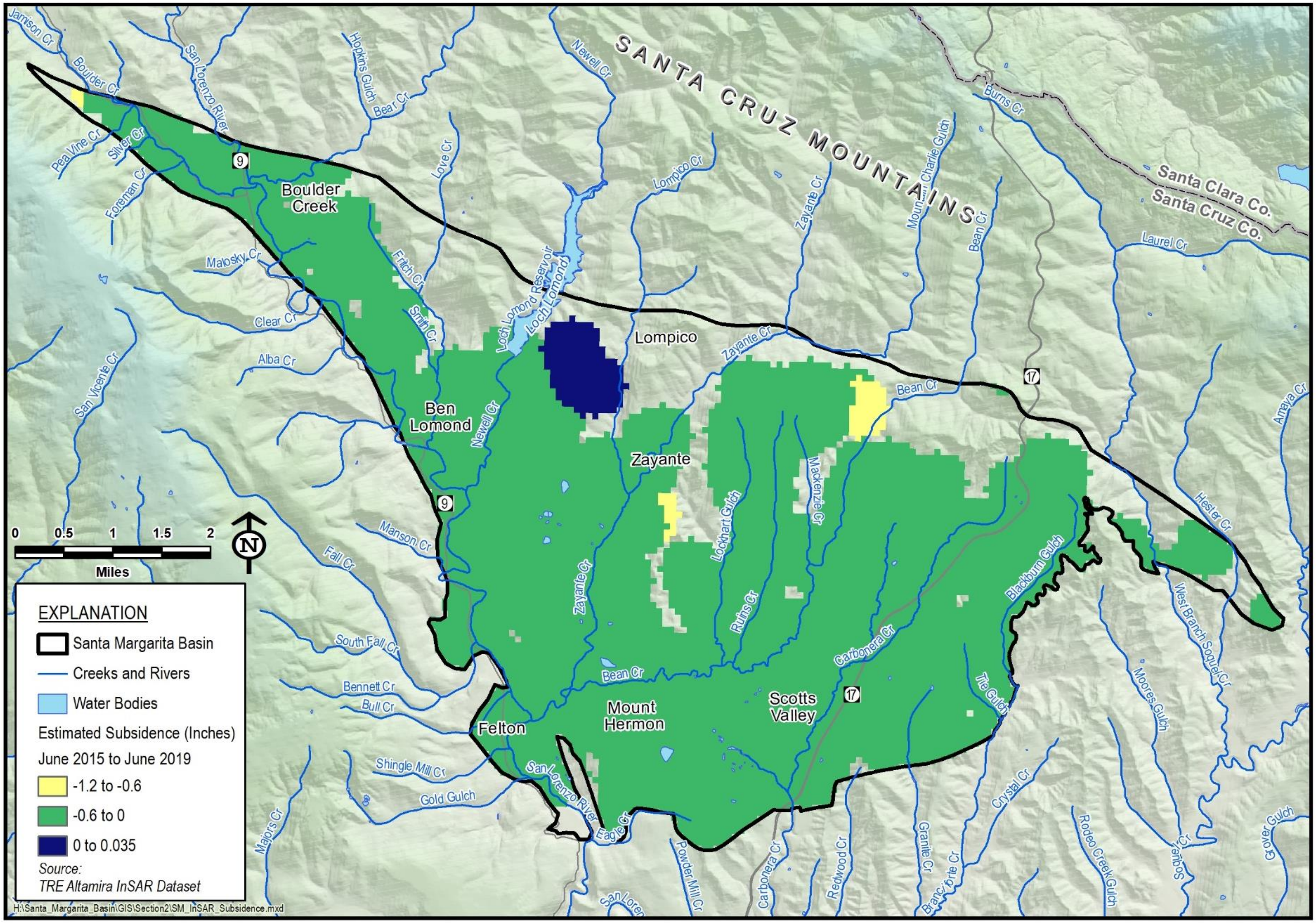


Figure 2-71. Total Vertical Land Surface Displacement in Santa Margarita Basin from June 2015 – June 2019 (based on TRE ALTAMIRA Inc. InSAR)

2.2.5.6 Interconnected Surface Water

Stream gauging, accretion studies, groundwater level monitoring, stream and GDE elevations, field reconnaissance and groundwater modeling have all be used to show that surface water is largely connected to groundwater throughout the Basin. As discussed in Section 2.2.4.8, essentially all of the water flowing in the Basin's streams and creeks is derived from groundwater during the dry season from late May through October (Johnson, 2009).

In 2017, Balance Hydrologics began evaluating interconnected surface water by conducting annual late-season stream observation walks ("accretion runs"), where flow and specific conductance were measured with high precision at select locations along the San Lorenzo River and its tributaries[2]. The accretion runs also include habitat-oriented measurements of localized changes in water temperature, whether stratification of temperature may be present in deep pools, and the presence and height of recent high-water marks, all of which also inform assessments of surface/groundwater exchange. Additionally, measurements of nitrate and sometimes other major ions or forms or organic carbon (Richardson et al., 2020) are also included in many of the 'runs.' Accretion studies tell where the aquifer is adding flow to the stream, and where the stream is replenishing the aquifer. Carefully conducted accretion studies are perhaps the best way of quantifying an understanding of aquifer dynamics and surface-groundwater exchange. Sites along the San Lorenzo River are measured from upstream of downtown Boulder Creek to below the USGS at Big Trees gauge. Much of the emphasis is on areas within the outcrop of the Santa Margarita Sandstone, which contributes water to the river and its tributaries, most notably from Love Creek to downstream of the USGS Big Trees gauge, beneath the Henry Cowell State Park entrance road.

The highly permeable nature of the Santa Margarita aquifer and its proximity to surface water features lends it to being a source of baseflows to the Basin's creeks and the San Lorenzo River. Groundwater in other aquifers is also connected to surface water but the Santa Margarita aquifer is the greatest overall contributor. The water budget in Section 2.2.6 estimates that net groundwater contributions to surface water (i.e., groundwater discharge to creeks less groundwater recharge from creeks) has historically averaged about 12,720 AFY. The Santa Margarita aquifer contributes 40%, the Butano aquifer contributes 32%, and the other formations connected to creeks contributing a combined 28% of net groundwater discharge to creeks. The Butano aquifer contributes a relatively larger amount than expected because it is intersected by numerous creeks along the Basin's northern boundary where these interactions occur. The other formations and aquifers that discharge groundwater to creeks in the Basin, include the small portion of alluvium near Felton, the Monterey Formation, and the Lompico aquifer.

[2] This work grew out of detailed hydrologic studies conducted for the SLVWD during two very dry summers (2014 and 2015), coupled with the effects of a recovery year (2016), and the recommendations of the technical advisory committee reviewing that work.

As part of the on-going GSP processes, sites along Zayante, Lompico and Bean Creeks were added to the accretion runs in the summer of 2019 and 2020, with most of the additional sites along Bean Creek and its tributaries. During the summer and fall of 2019, 3 separate accretion runs (May, July, and September) were conducted on the San Lorenzo River, Lompico, Zayante, Bean, and Eagle Creeks, where measurements were collected at all sites over a period of 1 to 2 days for each run. During the summer and Fall of 2020, 2 separate accretion runs were conducted (July and September) at the same locations as in 2019.

The results of the accretion sampling have shown flow increases downstream along the San Lorenzo River, Bean, and Zayante Creeks, except for 1 dry reach along Bean Creek. The flow increases are independent of surface contributions from other small tributaries along the reaches. The finding suggests that the baseflow in these creeks is supported by groundwater discharge (Parke and Hecht, 2020a; Neill and Hecht, 2020; Neill at al., 2021). Previous studies have shown that streams flowing through the Santa Margarita Sandstone in the San Lorenzo Valley all share common characteristics of elevated baseflows, low solute loads (measured as specific conductance), very low chloride contributions and elevated nitrate loads (Ricker, 1979; Ricker et al., 1994; Sylvester and Covay, 1978; Hecht et al., 1991; Parke and Hecht, 2020a). These characteristics were observed in the accretion runs where streams pass through portions of the Basin influenced by the Santa Margarita aquifer.

Along Bean Creek, the findings of the accretion study are consistent with previous observations: the upper Bean Creek watershed and its tributaries are typically losing reaches that recharge the groundwater, whereas streamflow in the lower watershed is enhanced by groundwater discharge from the Santa Margarita (DWR, 1958 and 1966; Kennedy/Jenks Consultants, 2015b; Neill and Hecht, 2020). It has been noted that Bean Creek, beginning about a mile downstream of Mackenzie Creek, typically goes dry in the summer and has done so since the 1960s, although the extents vary between years (Kennedy/Jenks Consultants, 2015b; personal communication with John Ricker, March 2020). Balance Hydrologics conducted a stream walk along the dry reach to document the conditions and extent during October 2019 and July 2020 (Neill and Hecht, 2020, Neill et al., 2021). The greatest increases in flows were observed downstream of the confluence of Ruins Creek with Bean Creek. This reach, in particular, is the primary gaining reach within the Basin and is characterized by areas where the stream has cut through the Santa Margarita sandstone and into the top of underlying Monterey shale, such that springs in the streambed and along the sides of the stream are contributing groundwater discharge (Figure 2-72). Balance Hydrologics conducted a stream walk along the lower Bean Creek reach in September of 2020 to document the numerous seeps and springs contributing groundwater from the Santa Margarita aquifer (Neill et al., 2021). Similar observations of seeps and springs contributing groundwater along streams within the Basin have been documented along the San Lorenzo River, Zayante Creek, and Eagle Creek (Parke and Hecht, 2020a; Parke and Hecht, 2020b).

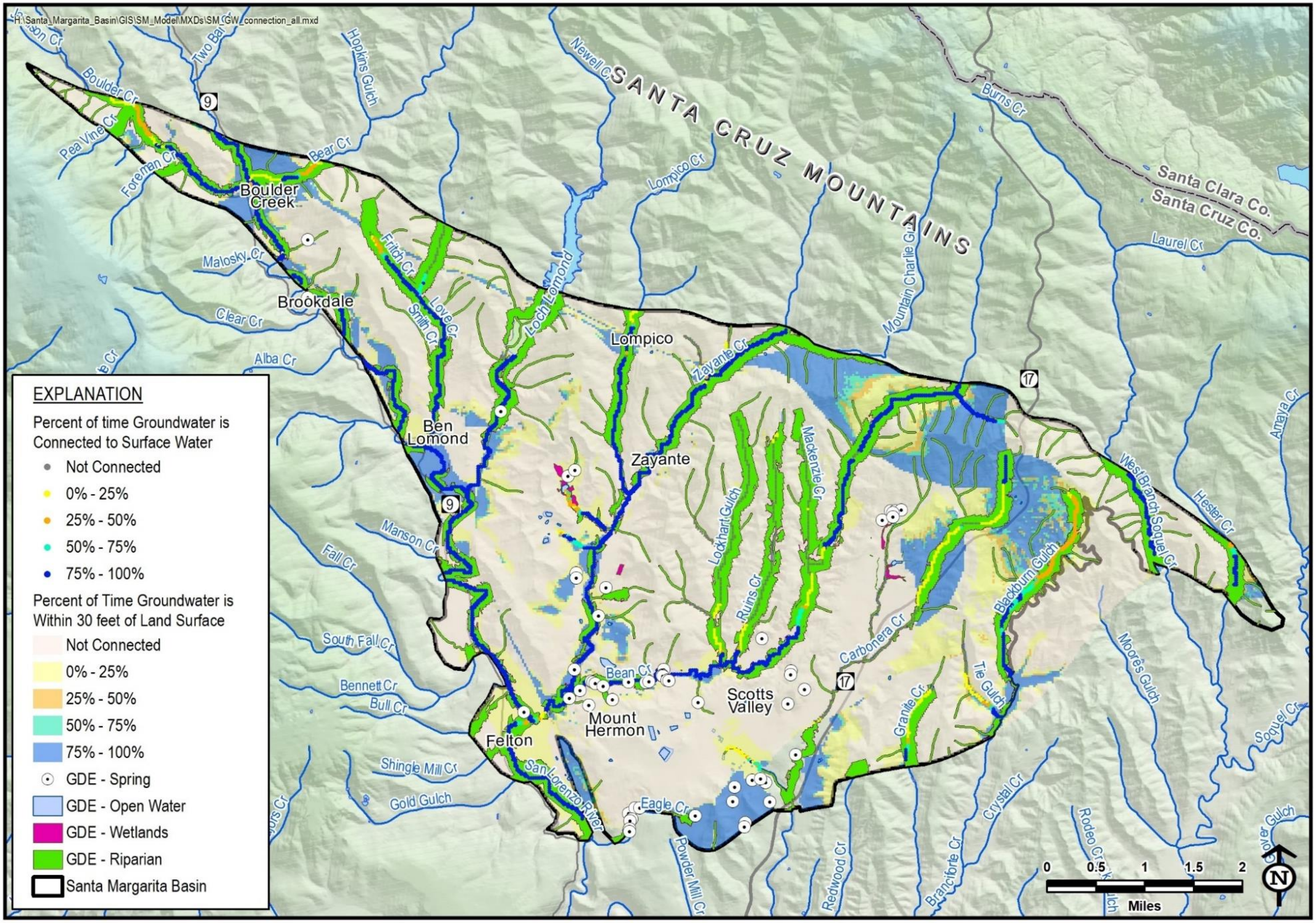


Figure 2-72. Interconnected Surface Water in the Santa Margarita Basin

In addition to accretion studies and field observations, a comparison of groundwater elevations in monitoring wells to nearby streambed elevations shows static groundwater levels consistently higher than the streambed, indicating that groundwater is contributing to streamflow in these locations year-round. For example, Figures 3-8 and 3-9 in Section 3.7.2 compare elevations in monitoring well SLVWD Quail MW-A with nearby streambed elevations in Zayante Creek and in monitoring well SV4-MW with nearby streambed elevations in Bean Creek, respectively.

Findings from these studies and observations are combined with model-simulated groundwater elevations in relation to creeks and land surface to produce a map of where surface water and groundwater are connected (Figure 2-72). The map includes creek connections together with non-riparian areas where depth to groundwater is on average less than 30 feet. A depth of 30 feet is selected because it is generally accepted as being the maximum rooting depth for most plants mapped in the Natural Communities Commonly Associated with Groundwater Dataset are supported by groundwater (TNC, 2019).

Up to 6 shallow monitoring wells will be constructed in 2022 to improve understanding of the interaction of groundwater and surface water in areas lacking groundwater level data. These additional monitoring wells are described in more detail in Section 3.3.4. The reach of Mackenzie Creek that seasonally dries up is 1 of the locations where a new monitoring well and subsurface flow gauge are to be installed.

2.2.6 Water Budget

A water budget is an accounting of the total annual volume of precipitation, surface water, and groundwater entering and leaving the Basin. This section provides an assessment of the historical, current, and projected Santa Margarita Basin water budgets in accordance with the GSP Regulations §354.18 and the Water Budget BMP (DWR, 2016a). Per the GSP Regulations, water budgets are presented in both graphical and tabular formats. Water budgets are developed using groundwater model inputs and outputs described in the Groundwater Model Appendix (Appendix 2D).

2.2.6.1 Water Budget Development

Water budgets are developed for the area and depth bounded by the lateral and vertical boundaries of the Basin. The lateral boundaries are the Basin boundaries described in Section 2.2.2. The water budgets were bounded vertically by the deepest principal aquifer, which in most places is the Butano aquifer. The lateral and vertical boundaries of the aquifers in the groundwater model are discussed in more detail in Appendix 2D: Section 5.2.1.

The water budgets are developed from an inventory of precipitation, surface water, and groundwater inflows (supplies) and outflows (demands) to and from the Basin. Some water budget components are measured, such as streamflow at a gauging station or municipal groundwater pumping from a metered well. Other components of the water budget are simulated by the model, such as recharge from precipitation and change in groundwater storage. The difference between groundwater inflows and outflows equals the change of groundwater in storage. The water budget inputs and outputs from the groundwater model are rounded to the nearest 100 for consistency across all summary tables and text. The larger values are not certain to this precision, but this approach helps summarize the data without introducing rounding errors into summation calculations such as total inflows, outflows, and change in storage.

The change over time in groundwater levels, groundwater and surface water interaction, and groundwater in storage derived from the water budgets will be used to assess Basin sustainability. Water movement in the Basin is driven by precipitation as surface runoff to creeks and groundwater recharge after accounting for evapotranspiration. Creeks flow into and out of the Basin, while interacting with groundwater. Water flows from creeks to groundwater and vice versa, depending on the gradient between creek stage and groundwater levels. Groundwater pumping removes groundwater from aquifers, though a small fraction of pumped water enters the groundwater system as return flows from septic systems, quarry usage, landscape irrigation, and sewer and water distribution system losses. Specific details on these components are described in the groundwater model report contained in in Appendix 2D: Section 5.1.4. Figure 2-73 presents a schematic hydrologic cycle that is included in the Water Budget BMP (DWR, 2016a). This is a generalized graphic and not all the components pictured apply to the Basin.

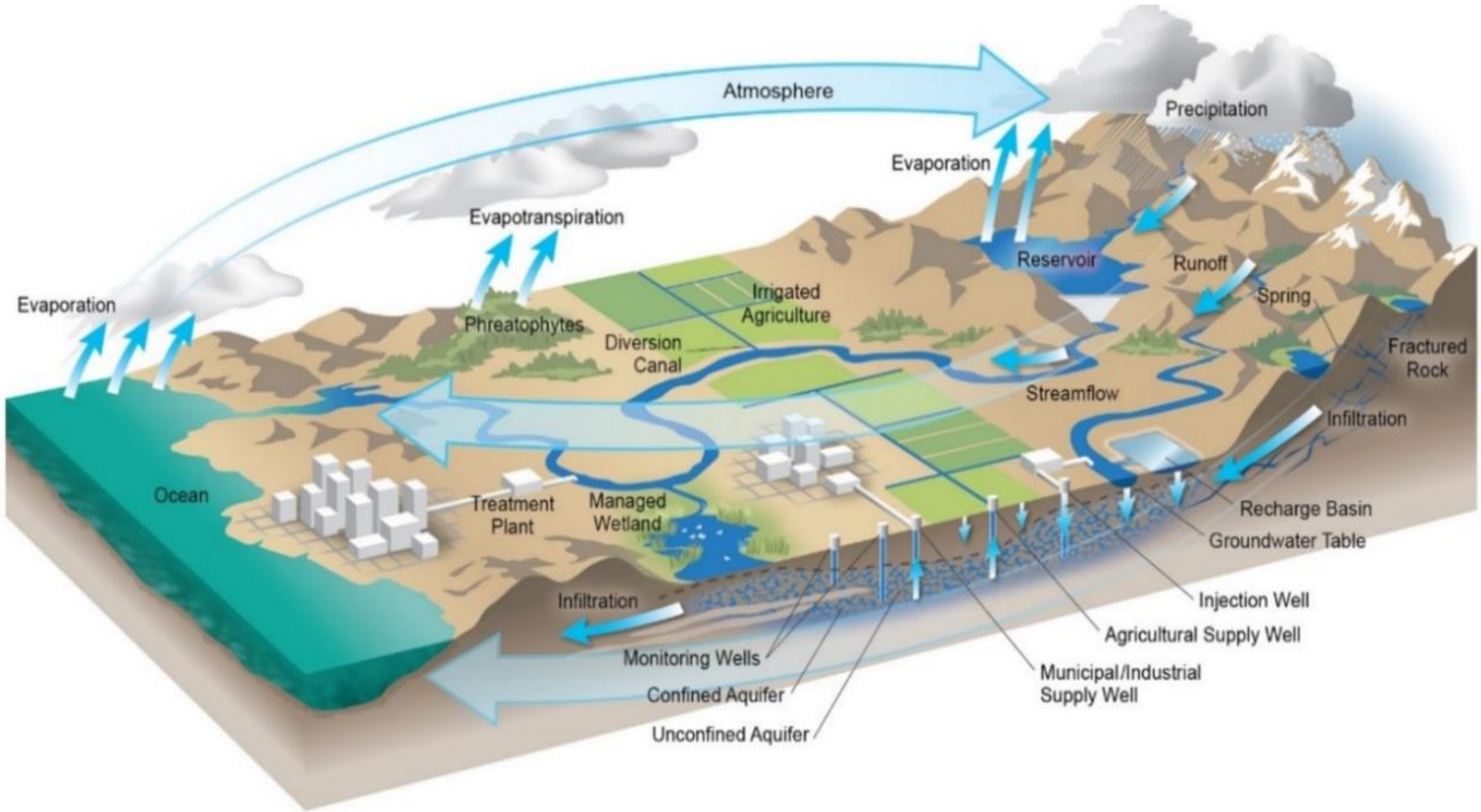


Figure 2-73. Generalized Hydrologic Cycle from Water Budget BMP (DWR, 2016a)

Although not required by GSP Regulations, the groundwater budgets of individual principal aquifers are analyzed to better understand and manage the various sources of groundwater in the Basin. The principal aquifers in the Basin are the Santa Margarita, Lompico, and Butano Sandstones. The Monterey Formation is not considered a principal aquifer but is included in the water budget because there are many private well owners that rely on it as their only source of water. The following describes the general characteristics of the aquifers relevant to water budgets:

- The Santa Margarita aquifer is the primary groundwater source for SLVWD and is also pumped by private well owners. It is the most significant aquifer in terms of groundwater's interactions with surface water.
- The Monterey Formation is primarily pumped to supply shallow private wells where more productive aquifers are not present at or near the surface. It is not currently pumped for municipal supply. Where it is present in the stratigraphic sequence, its low permeability retards recharge of the aquifers in the Lompico and Butano Sandstones below it. The Monterey Formation interacts with surface water where it outcrops in the streambed.
- The Lompico aquifer is pumped extensively for municipal supply in the Scotts Valley area where the formation is thickest. This aquifer has significantly less direct recharge from precipitation than the Santa Margarita aquifer as it outcrops over a much smaller area in the Basin. The area where the Monterey Formation is absent beneath the Santa Margarita aquifer is important for groundwater recharge of the Lompico aquifer in the south Scotts Valley area.
- The Butano aquifer is the deepest of the productive aquifers and is only pumped in northern Scotts Valley. It is recharged by surface water and precipitation where it outcrops along the northern margin of the Basin. In this area, private well owners also pump from it. SVWD pumps water from deep wells that are screened in both the Butano aquifer and the overlying Lompico aquifer.
- Other geologic formations having less of an impact on the water budget still contribute to overall inflows and outflows. The main formation not included in the water budget is the Quaternary alluvium, small deposits that occur widely throughout the Basin, but the most significant are deposits west of the Ben Lomond fault (Figure 2-18 and Figure 2-21).

Additional descriptions of hydrogeologic properties and extents of all aquifer units are provided in 2.2.4.4. The aquifer extents are shown in Appendix 2D: Figure 23 for the Santa Margarita aquifer, Monterey Formation, and Lompico aquifer and in Appendix 2D: Figure 24 for the Butano aquifer.

2.2.6.1.1 Precipitation Budget Components

The precipitation budget is an accounting of how much rain falls on the Basin, and where it is eventually allocated. A simplified schematic showing the precipitation budget components is provided on Figure 2-74. Precipitation budget components and associated data sources and uncertainties are described in the bullets below and in Table 2-21.

Precipitation Budget Inflow

- **Precipitation:** Rain that falls within the Basin.

Precipitation Budget Outflows

- **Evapotranspiration:** Water that evaporates from the land surface and soil or is transpired by plants.
- **Runoff:** Flow that traverses over the land surface into surface water bodies. Also referred to as overland flow.
- **Groundwater Recharge**: Water that percolates through the unsaturated zone and passes through the water table into the saturated zone, becoming groundwater.

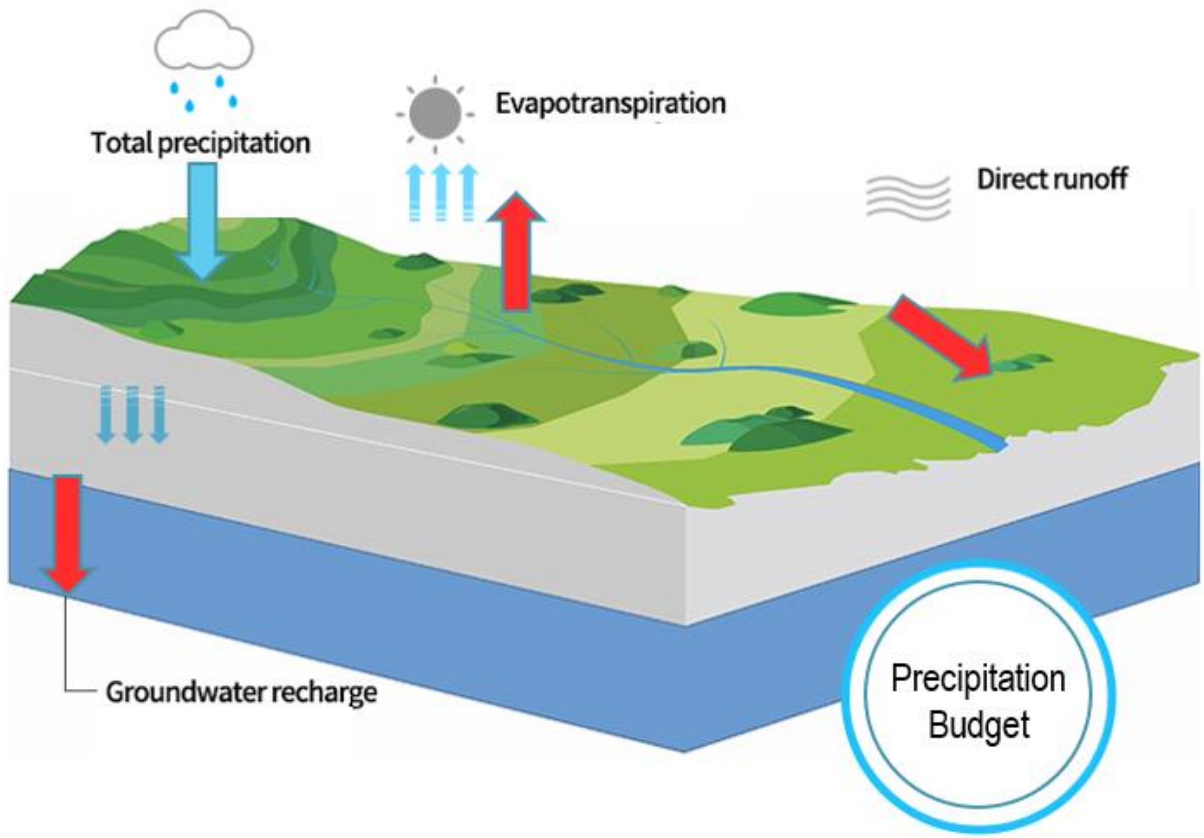


Figure 2-74. Precipitation Budget Components

Table 2-21. Precipitation Budget Components Data Sources and Uncertainty

Budget Component	Source of Model Input Data	Limitations
Inflows		
Precipitation	Monthly precipitation data from PRISM for historical model and Four-model Ensemble for future predictions (Figure 2-12).	Regional precipitation model used to develop model input may not account for local variability
Outflows		
Evapotranspiration	Calculated using the Blaney-Criddle (1962) method with adjusted factors from the Santa Cruz Water Balance Model. Temperature was sourced by PRISM for the historical and the Four-model Ensemble for future predictions. This is discussed in more detail in Appendix 2D: Section 5.1.3.	Regional temperature model used to calculate model input may not account for local variability in temperature
Direct Runoff	Calculated based on land use and geology which controls perviousness of land surface	Estimated, limited data for calibration.
Groundwater Recharge	Calculated from precipitation less evapotranspiration and runoff	Estimated, limited data for calibration.

2.2.6.1.2 Surface Water Budget Components

The surface water budget describes flows into and out of the Basin's surface water system. Evaluation of the surface water budget is important for understanding the groundwater-surface water connection, surface water use, and the responsiveness of the surface water system to historical climatic variation. A simplified schematic showing the surface water budget components is provided on Figure 2-75. Surface water budget components and associated data sources and uncertainties are described in the bullets below and in

Table 2-22.

Surface water diversions within the Basin are small relative to other components of the surface water budget. The only surface water diversion within the Basin is the rarely used City of Santa Cruz San Lorenzo River diversion at Felton that is used to divert to storage at Loch Lomond. SLVWD diversions are all outside of the Basin on upstream tributaries of the San Lorenzo River. The City of Santa Cruz primary surface water diversion occurs on the San Lorenzo River at Tait Street, which is in Santa Cruz and about 5 miles downstream of the Basin.

Despite not being included in the groundwater model simulations, surface water diversions outside of the Basin by SLVWD and the City of Santa Cruz are an important component of the regional water supply system. These diversions made outside of the Basin totaled about 2,300 AF in WY2018 (Table 2-17). In WY2018, SLVWD surface water diversions upstream of the Basin to the west totaled about 1,170 AF, which is about 2.2% of the surface water flow into the Basin that year. That same year, the City of Santa Cruz diverted about 1,230 AF at Tait Street and nothing at the Felton diversion, which is about 1.3% of the surface water budget flowing out of the Basin that year.

Surface Water Budget Inflows

- **Surface Water Inflow:** Streamflow that enters the Basin's surface water system from areas upstream of the Basin. Surface water inflow includes inflow on the San Lorenzo River, Newell Creek (downstream of Loch Lomond Reservoir situated on the northern Basin boundary), Bean Creek, and other smaller tributaries of the San Lorenzo River.
- **Direct Runoff**: Water that runs off the land surface into surface water bodies.
- **Groundwater Discharge to Creeks:** Groundwater that discharges into creeks, also known as gaining stream conditions. This is the component of groundwater-surface water interactions where surface water stage is lower than nearby groundwater levels, allowing groundwater to discharge to surface water.

Surface Water Budget Outflows

- **Surface Water Outflow:** Streamflow that leaves the Basin's surface water system to areas downstream of the Basin.
- **Streambed Recharge:** Water that percolates to groundwater from stream channels, also known as streambed seepage, or losing stream conditions. This is the component of groundwater-surface water interactions where surface water stage is higher than nearby groundwater levels, allowing surface water to recharge the groundwater system.

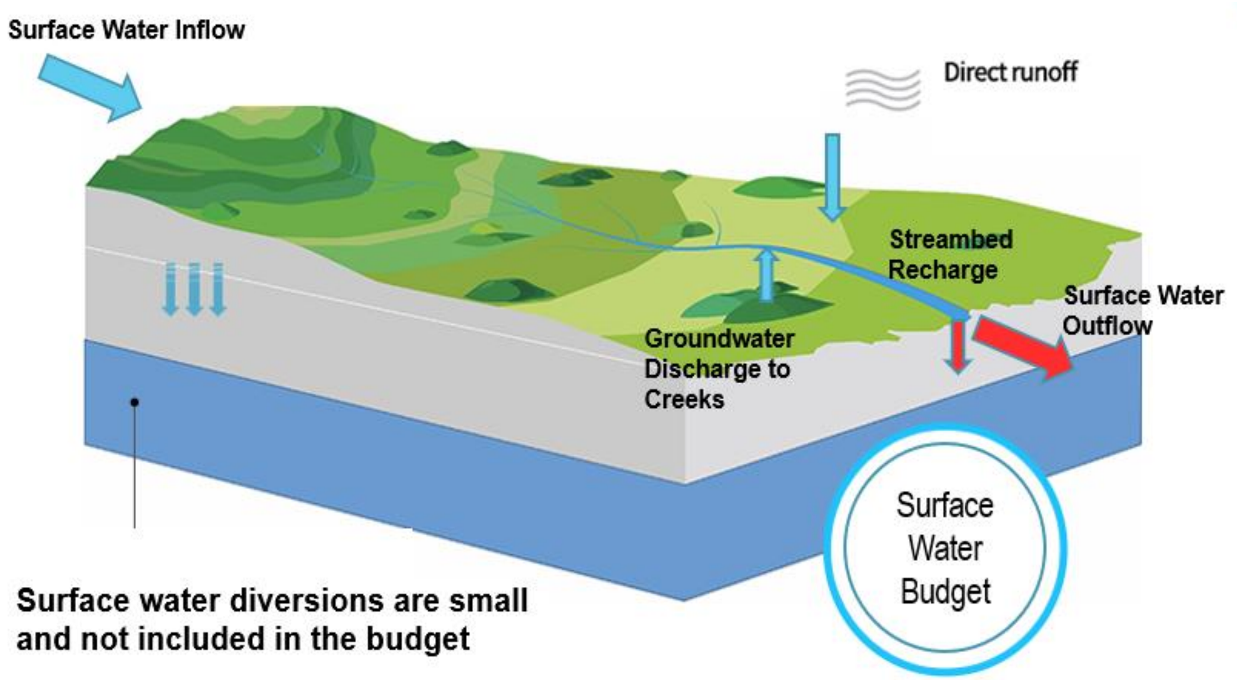


Figure 2-75. Surface Water Budget Components

Table 2-22. Surface Water Budget Components Data Sources and Uncertainty

Budget Component	Source of Model Input Data	Limitations
Inflows		
Surface Water Inflow	Calculated from runoff in areas upstream of the basin	Estimated, limited data for calibration
Direct Runoff	Calculated based on land use and geology which control perviousness of land surface	Estimated, limited data for calibration.
Groundwater Discharge to Creeks	Simulated by model using stream stage and groundwater head.	Calibrated parameter using limited historical stream accretion data; data are not available for every time period or every creek and tributary in the Basin
Outflows		
Surface Water Outflow	Simulated by model.	Calibrated parameter using available historical stream stage and discharge measurements; however, data are not available for every creek and tributary in the Basin.
Streambed Recharge	Simulated by model using stream stage and groundwater head.	Calibrated parameter using limited historical stream accretion data; data are not available for every time period or every creek and tributary in the Basin

2.2.6.1.3 Groundwater Budget Components

The groundwater budget describes flows into and out of the Basin's groundwater system. Evaluation of the groundwater budget is important for understanding trends in climate, groundwater use, and groundwater-surface water interaction. A simplified schematic showing the groundwater budget components is provided on

Figure 2-76. Groundwater budget components and associated data sources and uncertainty are described in the bullets below and in Table 2-23. Change in storage is calculated from model inputs and outputs for all surface water and groundwater budget components. However, change in storage is discussed in the groundwater budget subsections as the majority of storage changes in the Basin occur in groundwater.

Groundwater Budget Inflows

- **Groundwater Recharge:** Water that infiltrates the land surface, percolates through the unsaturated zone, passes through the water table into the saturated zone, thereby becoming groundwater. The term "precipitation recharge" is used interchangeably with groundwater recharge in the water budget section of this GSP.
- **Subsurface Inflow**: Subsurface flow that enters the Basin's aquifers from neighboring areas.

- **Streambed Recharge**: Water that percolates to groundwater from stream channels, also known as streambed seepage, or losing stream conditions. This is the component of groundwater-surface water interactions where surface water stage is higher than nearby groundwater levels, allowing surface water to recharge the groundwater system.
- **Septic Return Flows**: Water originating in domestic septic systems that percolates to groundwater.
- **System Losses:** Water originating from leakage in sewer and water distribution systems that percolates to groundwater.
- **Quarry Return Flows**: Water that originates from usage at quarry sites that percolates to groundwater.
- **Irrigation Return Flows**: Water originating from the inefficient portion of landscape irrigation that percolates to groundwater.

Groundwater Budget Outflows

- **Subsurface Outflow:** Subsurface groundwater that flows out of the Basin's aquifers into adjacent basins or areas.
- **Groundwater Pumping:** Groundwater extracted by wells for municipal, agricultural, domestic, and industrial uses.
- **Discharge to Creeks:** Flow that discharges from groundwater into stream channels, also known as gaining stream conditions. This is the component of groundwater-surface water interactions where surface water stage is lower than nearby groundwater levels, allowing groundwater to discharge to surface water.

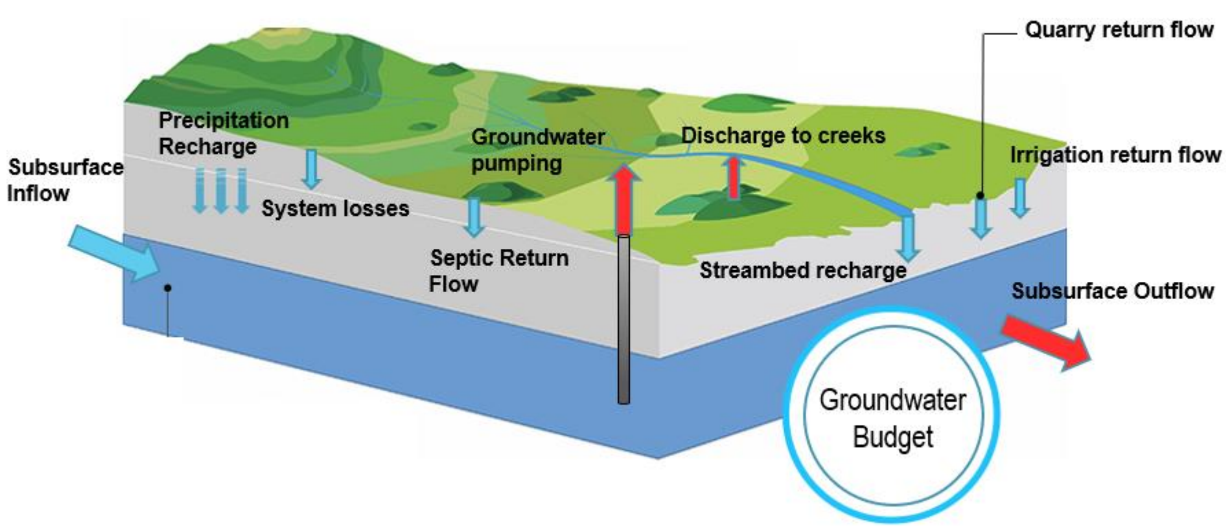


Figure 2-76. Groundwater Budget Components

Table 2-23. Groundwater Budget Components Data Sources and Uncertainty

Budget Component	Source of Model Input Data	Limitations
Inflows		
Precipitation (Groundwater) Recharge	Calculated from precipitation less evapotranspiration and runoff depending on land use and geology	Estimated, limited data for calibration.
Subsurface Inflow	Simulated by model.	Subject to uncertainty in simulated heads and aquifer hydraulic properties
Streambed Recharge	Simulated by model using stream stage and groundwater head.	Calibrated parameter using limited historical stream accretion data; data are not available for every time period or every creek and tributary in the Basin
System Losses	Estimated based on reported water demand or pumping and loss assumptions	Estimated, limited data for calibration.
Quarry Return Flows	Estimated based on reported pumping and loss assumptions	Estimated, limited data for calibration.
Irrigation Return Flows	Estimated based on assumed outdoor portion of reported water use for municipal users, and estimated for private domestic users and loss assumptions	Estimated, limited data for calibration.
Outflows		
Subsurface Outflow	Simulated by model.	Estimated, limited data for calibration.
Groundwater Pumping	Reported by providers for public supply use. Estimated for private well owner domestic use using number of domestic parcels and local estimate of water use coefficients. Estimated for industrial, pond-filling, and landscape uses.	Unmetered data subject to estimation errors.
Discharge to Creeks	Simulated by model using stream stage and groundwater head.	Calibrated parameter using limited historical stream accretion data; data are not available for every time period or every creek and tributary in the Basin

2.2.6.2 Historical Water Budget

Per GSP Regulations (§ 354.18), the historical water budget is developed to show past water supplies and demands. The historical water budget time frame for this GSP starts in WY1985 and ends in WY2018. This period encompasses multiple droughts and wet periods to represent historical variation in water budget components. The model period starts in 1985 because groundwater pumping and groundwater level data are only available for the majority of the Basin from 1985 on.

2.2.6.2.1 Historical Precipitation Budget

The historical precipitation budget provides an accounting of how much precipitation fell in the Basin and how much of it was lost to evapotranspiration, became surface water, or recharged groundwater. The historical precipitation budget is summarized in Table 2-24 and presented in a time series chart on Figure 2-77.

Table 2-24. Summary of Historical Precipitation Budget

Water Budget Components Average Total for Historical Water Budget (AF)		Historical Water Budget 1985-2018 Annual Average (AF)	Historical Water Budget 1985-2018 Percent of Total Inflow or Outflow	Annual Average by Water Year Type (AF) Critically Dry	Dry	Normal	Wet
Inflows (82,400)*	Precipitation	82,400	100%	49,400	65,600	83,400	122,000
Outflows (82,500)*	Evapotranspiration	38,000	46%	25,500	32,700	37,000	53,400
	Direct Runoff	30,800	37%	16,600	23,000	31,800	47,700
	Groundwater Recharge	13,700	17%	7,300	9,900	14,600	20,900

*Small discrepancies between total inflow and outflow may occur due to rounding.

On average, about 82,400 AFY of precipitation falls within the Basin boundaries, with critically dry years averaging about 49,400 AF and wet years averaging about 122,000 AF. On average, about 46% of precipitation is evaporated or transpired by plants, 37% runs off the land surface into creeks, and 17% percolates through the soil vadose zone and recharges groundwater.

Total outflow in the precipitation budget to evaporation, groundwater, and surface water is dependent on climate and land use/cover. As expected, evapotranspiration, runoff, and groundwater recharge are greater during dry years than wet years. In general, runoff and recharge are more responsive to climate variation than evapotranspiration because vegetation cover is relatively constant, dry soil in dry years absorbs soil moisture, and saturated soil moisture in wet years promotes runoff and infiltration. During critically dry years, a greater percentage of precipitation (about 52%) is lost from the system due to evapotranspiration than in wet years when only about 44% of precipitation is lost to evapotranspiration. As a result, a smaller percentage of precipitation enters the surface water and groundwater systems during critically dry years, and a greater percentage of precipitation enters the surface water and groundwater systems in wet years.

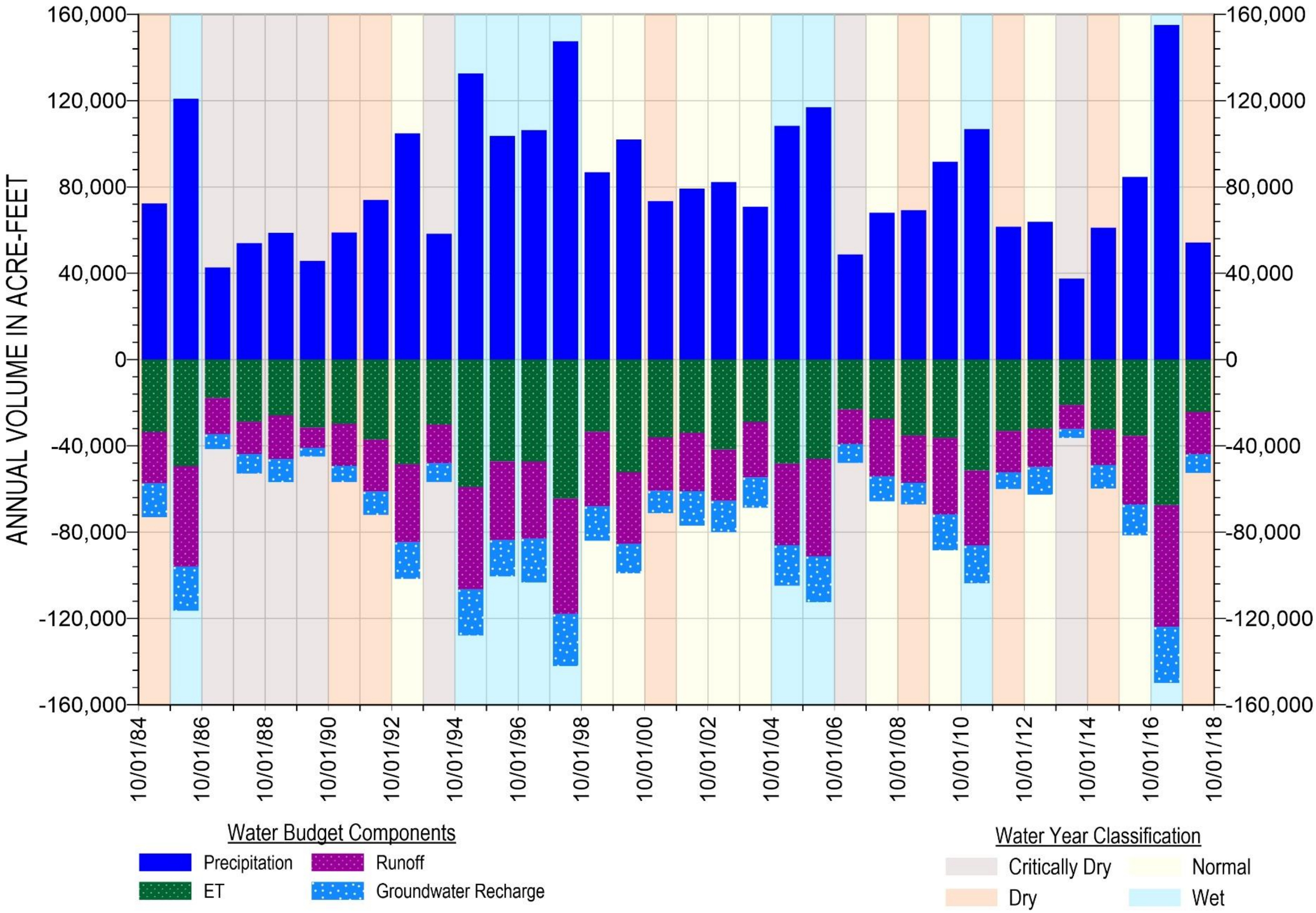


Figure 2-77. Historical Precipitation Budget

2.2.6.2.2 Historical Surface Water Budget

The historical surface water budget provides information on historical surface water and groundwater interactions, and how much surface water has flowed through the Basin. The historical surface water budget is summarized in Table 2-25, and is presented in a time series chart on Figure 2-78.

Table 2-25. Summary of Historical Surface Water Budget

Water Budget Components Average Total for Historical Water Budget (AF)		Historical Water Budget 1985-2018		Annual Average by Water Year Type (AF)			
		Annual Average (AF)	Percent of Total Inflow or Outflow	Critically Dry	Dry	Normal	Wet
Inflows (120,300)	**Surface Water Inflow**	70,800	59%	37,900	54,100	72,500	109,500
	Runoff	28,300	23%	15,200	21,100	29,200	43,800
	Groundwater Discharge to Creeks	21,200	18%	18,000	19,400	21,500	25,100
Outflows (120,300)	**Surface Water Outflow**	111,700	93%	63,800	86,600	114,400	168,400
	Streambed Recharge	8,600	7%	7,400	8,200	8,800	9,800

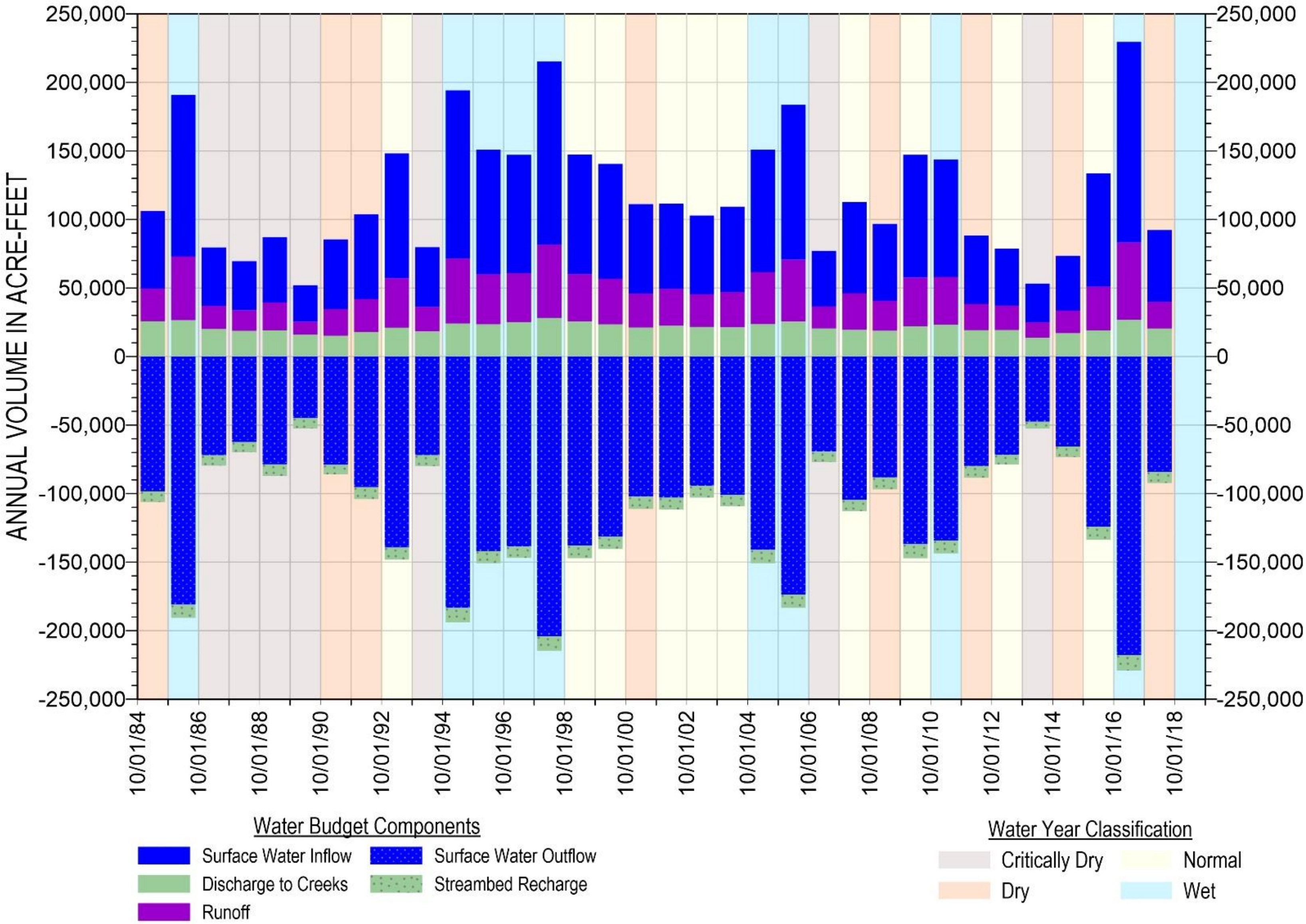


Figure 2-78. Historical Surface Water Budget

Average historical surface water inflow in the Basin is about 120,300 AFY. Water year type strongly influences the surface water inflows, averaging about 71,100 AF in critically dry years and 178,400 AF in wet years. Surface water inflows are mostly from the San Lorenzo River, Newell Creek, Bean Creek, and a few other smaller streams and tributaries originating outside of the Basin. Creeks originating outside the Basin make up 59% of the surface water inflow to the Basin during an average year. Runoff from precipitation to surface water comprises 23% of total precipitation during an average year. Groundwater discharge to creeks makes the smallest contribution to surface water budget inflow, with an average of only 18% of the total inflow.

Outflow from the surface water system is approximately balanced with inflow over time across all water year types. Like inflow, surface water outflow is strongly correlated with water year type. Nearly all (93%) of surface water flows out of the Basin, mostly in the San Lorenzo River and Carbonera Creek. Recharge of aquifers underlying the surface water system accounts for only 7% of surface water outflow from the system.

Although groundwater discharge to creeks and streambed recharge to groundwater make up the smallest percentages of the surface water inflow and outflow budgets, surface water and groundwater interaction is important for maintaining volumes of surface water baseflows in the summer and fall months and for providing some groundwater recharge. Although there are months where there are losing reaches, creeks in the Basin consistently have a net annual gain from groundwater contributions regardless of water year type. Overall, there is about 2.5 times more groundwater discharge to creeks than creek recharge of groundwater. This results in widespread gaining stream conditions and contributes to greater surface water outflow than inflow. Annual precipitation and lowered groundwater levels influence groundwater and surface water interactions. Groundwater discharge to creeks during average wet years is about 7,100 AF more than in average critically dry years. Similarly, streambed groundwater recharge is about 2,400 AF more in average wet years than critically dry years. The impact of surface water interaction and precipitation on groundwater is discussed further in Section 2.2.6.2.3 and 2.2.6.2.4.

2.2.6.2.3 Historical Groundwater Budget

The historical groundwater budget provides information on how groundwater is replenished and used. Groundwater pumping, groundwater and surface water interaction, and changes of groundwater in storage are particularly relevant to groundwater management. The historical groundwater budget is summarized in Table 2-26 and presented in a time series chart on Figure 2-79.

Table 2-26. Historical Groundwater Budget

Water Budget Components Average Total for Historical Water Budget (AF)		Historical Water Budget 1985-2018		Annual Average by Water Year Type (AF)			
		Annual Average (AF)	Percent of Total Inflow or Outflow	Critically Dry	Dry	Normal	Wet
Inflows (24,000)*	Precipitation Recharge	13,700	57%	7,300	10,200	14,600	20,700
	Subsurface Inflow	100	1%	100	100	100	100
	System Losses	200	1%	200	200	200	200
	Septic Return Flow	1,100	5%	1,100	1,100	1,100	1,200
	Quarry Return Flow	200	1%	300	200	200	200
	Streambed Recharge	8,700	36%	7,400	8,300	8,900	9,900
	Irrigation Return Flow	<100	<1%	<100	<100	100	<100
Outflows (25,200)*	Groundwater Pumping	3,700	15%	3,800	3,500	3,900	3,700
	Subsurface Outflow	100	<1%	100	100	100	100
	Discharge to Creeks	21,400	85%	18,200	19,600	21,600	25,300
Storage*	Average Annual Change in Storage	-1,100	--	-5,600	-3,000	-500	3,200
	Cumulative Change in Storage	-39,300	--	--	--	--	--

*Small discrepancies between total inflow and outflow may occur due to rounding.

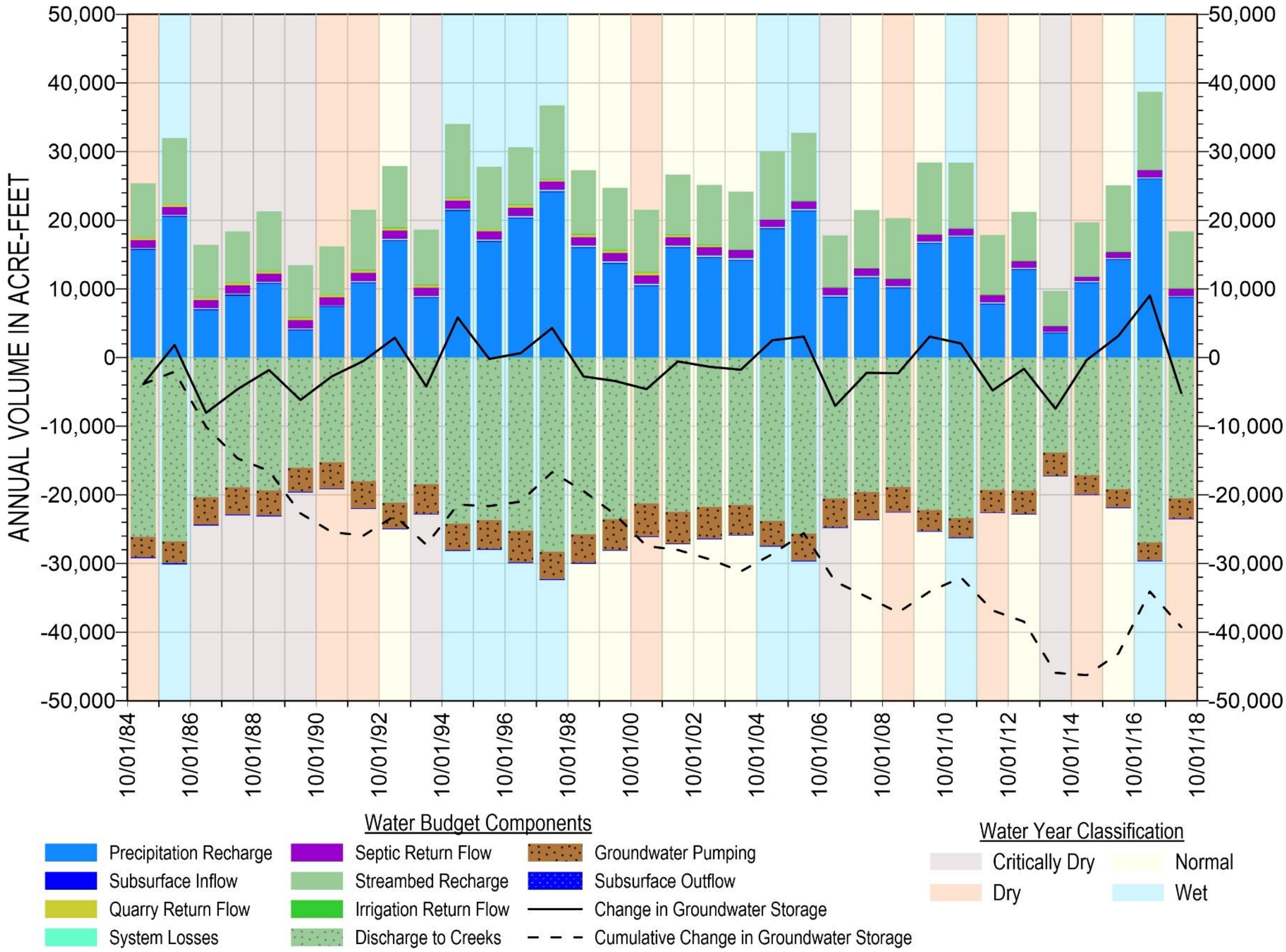


Figure 2-79. Historical Groundwater Budget

Groundwater inflow totals about 24,000 AFY on average and range from about 16,400 AF in average critically dry years to 32,300 AF in average wet years. Inflow to the groundwater system is dominated by precipitation and streambed recharge, which on average comprise 57% and 36% of total groundwater inflow, respectively. These 2 inflow components vary with climate, with significantly larger recharge volumes from both precipitation and creeks occurring during wet periods. Groundwater recharge from precipitation and streams combined ranges from about 14,700 AF in average critically dry years to 30,600 AF in average wet years.

Recharge to groundwater from septic systems, quarries, landscape irrigation, and other system losses make up only 7% of total annual inflow to groundwater. Groundwater return flows do not vary substantially with water year type but are correlated to population growth because more than half of the return flows are from septic systems. Septic return flows increased with population growth during the 1980s and early 1990s but decreased since the 2000s. due to expansion of wastewater treatment systems, and replacement of older septic systems with systems that have less discharge in part to mitigate increasing nitrate concentrations due to septic impacts.

The Basin is hydrogeologically isolated by the bounding faults and relatively impermeable basement rock beneath the Basin; therefore, subsurface inflow and outflow constitute only a very small fraction of the total groundwater budget.

Total outflow from the Basin's groundwater system is approximately 25,200 AFY on average and ranges between 22,100 AF in average critically dry years to 29,100 AF in average wet years. Outflow is dominated by groundwater discharge to creeks and groundwater pumping, which comprise roughly 85% and 15% of total groundwater outflow, respectively.

As discussed in the historical surface water budget section, groundwater discharge to creeks is controlled by climate. Average groundwater discharge to creeks in critically dry years was 18,200 AF and average discharge in wet years was 25,300 AF. In contrast to predominantly agricultural groundwater basins in the state, groundwater pumping in the Basin does not increase greatly in dry years as groundwater is mainly for municipal and private domestic purposes, which have more consistent year-round demands than agriculture. Municipal pumping in the Basin reached a high during a period of relatively rapid population growth in the 1980s and 1990s. Groundwater management adjustments particularly from around 2010 on have reduced total groundwater pumping. More details on changes in groundwater pumping and its impact on groundwater levels are provided in Section 2.2.5.1: Groundwater Elevations.

Given that the Basin is a relatively closed groundwater system, groundwater discharge to creeks comprises a major component of groundwater outflow, and the Basin's creeks are dependent on groundwater discharge to maintain baseflows in the summer and early fall months. As discussed in the surface water budget section, creeks consistently gain more water from groundwater than they lose to groundwater from streambed recharge, regardless of climate or anthropogenic factors.

The historical groundwater budget is indicative of a Basin not operating within its sustainable groundwater yield. Overall, historical groundwater outflow has been greater than inflow, resulting in a cumulative net decrease in groundwater in storage, which translates to falling groundwater levels. Between 1985 and 2018 the Basin cumulatively lost about 39,300 AF of groundwater in storage, or on average 1,100 AFY. While cumulative change in storage historically recovered during extended wet periods (notably WY1995 to WY1998 and WY2016 to WY2018), dry and normal years have historically resulted in large decreases in storage (notably WY1987 to WY1992 and the recent drought from WY2012 to WY2015). Improvements in groundwater supply management from 2010 onward appear to have slowed the decline in groundwater storage.

2.2.6.2.4 Historical Groundwater Budget by Aquifer

The historical groundwater budget was analyzed by aquifer to demonstrate how groundwater was used and recharged in the various formations. The historical groundwater budget by aquifer is summarized in Table 2-27 and in more detailed tables in Appendix 2E.

In general, groundwater inflows are mostly into the Santa Margarita and Butano aquifers as they are conductive sandstones with large outcrop areas in the Basin. They are recharged by direct percolation of precipitation and streambed recharge. The Quaternary alluvium also receives substantial streambed recharge where it is thickest along the Basin’s southern boundary, west of the Ben Lomond Fault near Felton. The alluvium is generally shallow across most of the Basin, but it is highly permeable and located in an area with relatively high streamflow where the San Lorenzo River flows out of the Basin.

In contrast to the other primary aquifers, the Lompico aquifer is recharged primarily from flow from overlying aquifers as it has limited surface outcrop in the Basin. It is readily recharged where Santa Margarita Sandstone directly overlies Lompico Formation in the Pasatiempo and Camp Evers areas. Elsewhere in the Basin, however, the presence of intervening Monterey Formation, an aquitard, limits the recharge of the Lompico aquifer.

Table 2-27. Summary of Historical Groundwater Budget by Aquifer

Groundwater Budget Components		Historical Water Budget: 1985- 2018 Annual Average (AF)				
		Santa Margarita Aquifer	Monterey Formation	Lompico Aquifer	Butano Aquifer	Other Formations
Inflows	**Precipitation Recharge**	6,500	1,500	1000	4,100	700
	Subsurface Inflow	0	0	0	100	<100
	Return Flows	800	200	200	200	200
	Streambed Recharge	1,700	800	400	3,400	2,500
	Flow from Other Aquifers	<100	300	1,900	700	Not calculated
	Total Inflow*	***9,000***	***2,800***	***3,700***	***8,500***	***3,400***
Outflows	**Groundwater Pumping**	1,100	300	1,800	500	<100
	Subsurface Outflow	0	0	0	100	<100
	Discharge to Creeks	6,800	2,300	1,500	7,400	3,400
	Flow to Other Aquifers	1,300	400	700	700	Not calculated
	Total Outflow*	***9,200***	***3,000***	***4,000***	***8,700***	***3,400***
Storage	**Average Annual Change in Storage***	-100	-100	-600	-200	-100
	Cumulative Change in Storage*	-3,600	-4,000	-20,400	-7,700	-3,600

*Small discrepancies between total inflow and outflow may occur due to rounding

Like the basin-wide groundwater inflow budget, groundwater outflow by aquifer is dominated by groundwater discharge to creeks, primarily from the Santa Margarita and Butano aquifers. There is also substantial flow between aquifers, with most of the flow being from the Santa Margarita aquifer to the deeper aquifers. The Lompico aquifer has smaller inflows than other aquifers, yet it supports almost half of the groundwater pumping in the Basin; the result is that about half the decline in storage in the Basin is in the Lompico aquifer.

2.2.6.2.5 Historical Groundwater Change in Storage by Subarea

To evaluate historical changes of groundwater in storage in different areas of the Basin and identify specific areas and aquifers that require projects and management actions, the Basin is divided into subareas as depicted on Figure 2-37 and Figure 2-38. The subareas do not represent management areas and are only used in this GSP to describe aquifer conditions for different parts of the Basin.

Santa Margarita aquifer subareas are 1) Quail Hollow, 2) Olympia/Mission Springs, 3) Mount Hermon/South Scotts Valley, and 4) North Scotts Valley (Figure 2-37). These subareas are described in Section 2.2.5.1.2.2: Santa Margarita Aquifer Groundwater Elevation Contours and Flow Directions. Unlike the Santa Margarita aquifer, the Basin's confined aquifers are more continuous throughout the Basin. The Monterey Formation and Lompico and Butano aquifers share the same subareas: 1) North of Bean Creek, 2) Mount Hermon/South Scotts Valley, and 3) North Scotts Valley (Figure 2-38).

Plots of change in aquifer storage by subarea on Figure 2-80 through Figure 2-83 show that the largest loss of groundwater storage in the Lompico aquifer in the Mount Hermon/South Scotts Valley subarea. The Monterey Formation and Butano aquifers in the Mount Hermon/South Scotts Valley subarea also have storage losses, but they are an order of magnitude smaller than in the Lompico aquifer. Depletions of groundwater in storage in this subarea correspond to lowered groundwater levels measured in wells screened in the Monterey Formation and Lompico aquifer as described in Sections 2.2.5.1.3 and 2.2.5.1.4. The Butano aquifer has storage losses in subareas where it outcrops along the Basin's northern boundary in the North of Bean Creek and North Scotts Valley subareas. In comparison, the Lompico aquifer in those same subareas has smaller storage losses than the Butano aquifer. Storage losses in the Butano aquifer appear due to groundwater discharge to creeks since pumping is much smaller than creek discharges (Table 2-27). Conclusions concerning the Butano aquifer cannot be made with confidence because there are only 2 Butano aquifer specific monitoring wells in the Basin. The Butano aquifer is not as well-calibrated in the groundwater model as the shallower aquifers for which there are more data, as described in Section 2.2.4.11 on hydrogeologic conceptual model data gaps.

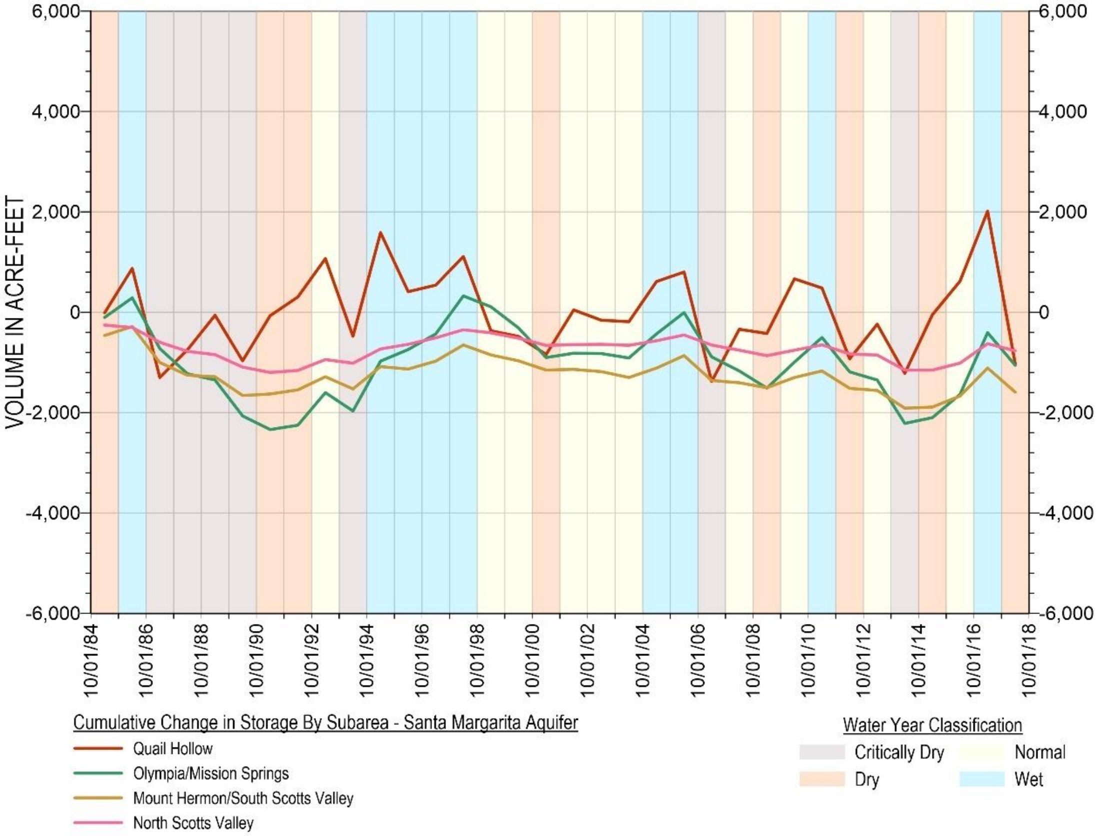


Figure 2-80. Historical Cumulative Change of Groundwater in Storage in the Santa Margarita Aquifer

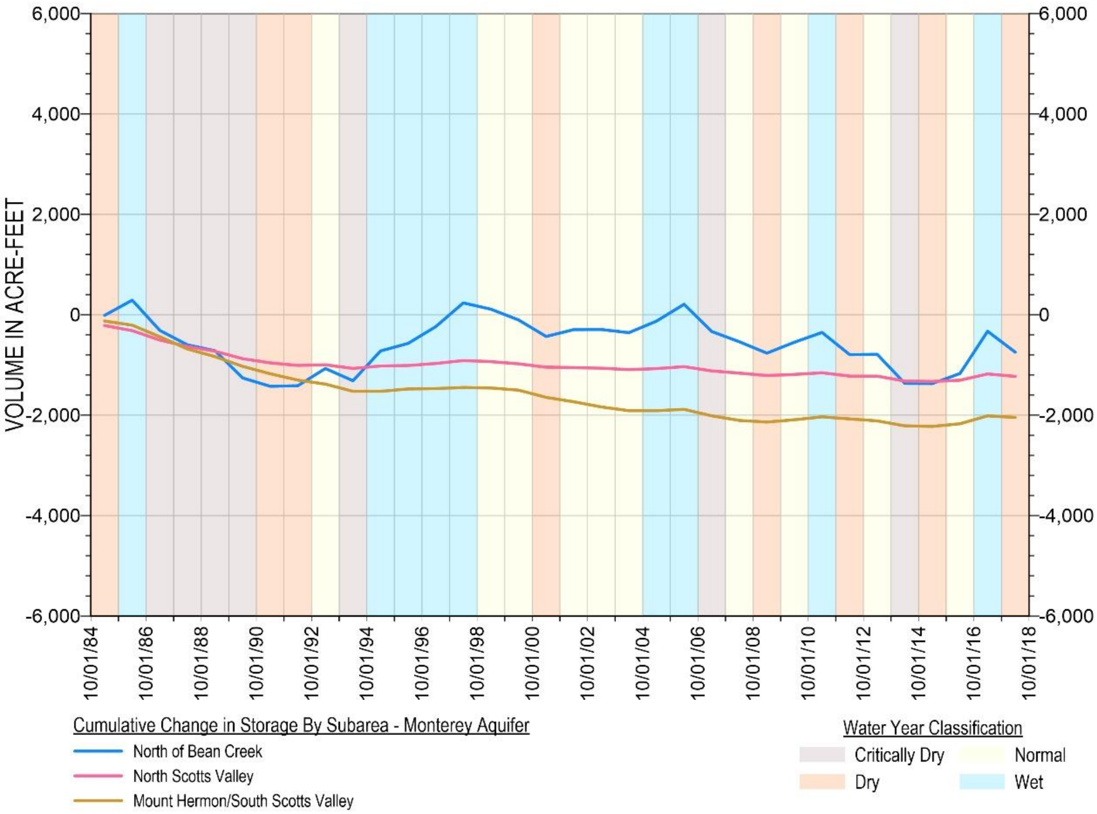


Figure 2-81. Historical Cumulative Change of Groundwater in Storage in the Monterey Formation

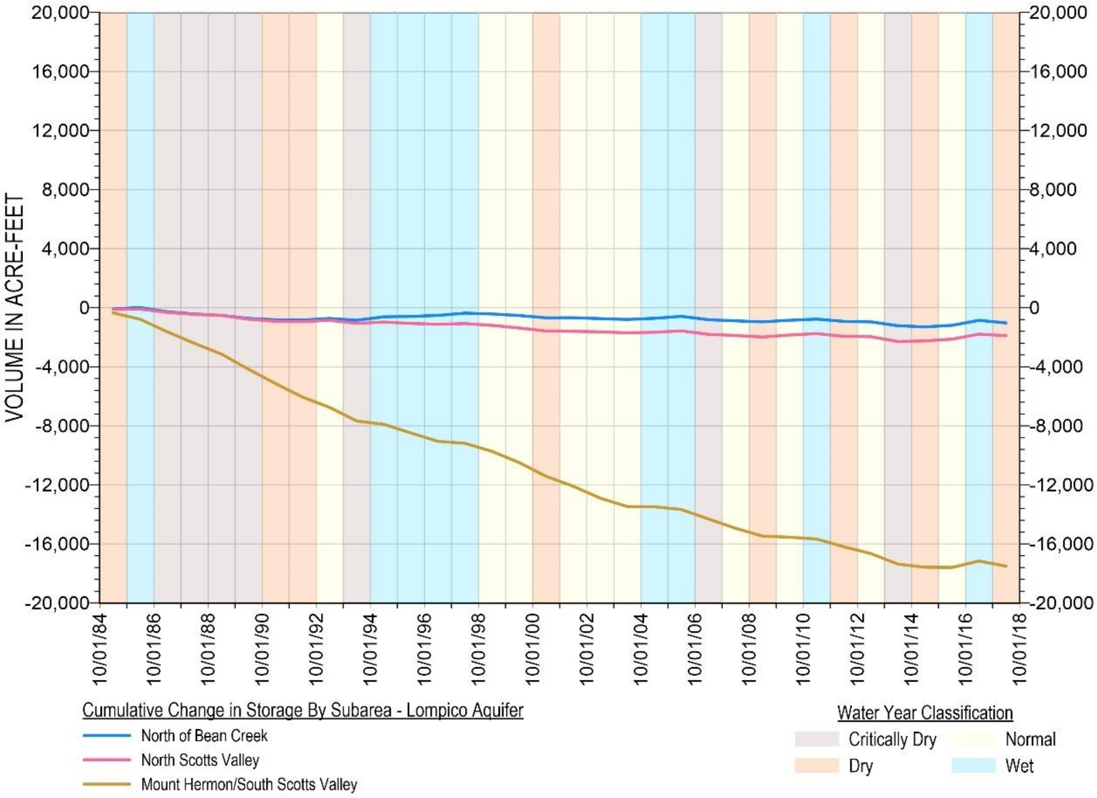


Figure 2-82. Historical Cumulative Change of Groundwater in Storage in the Lompico Aquifer

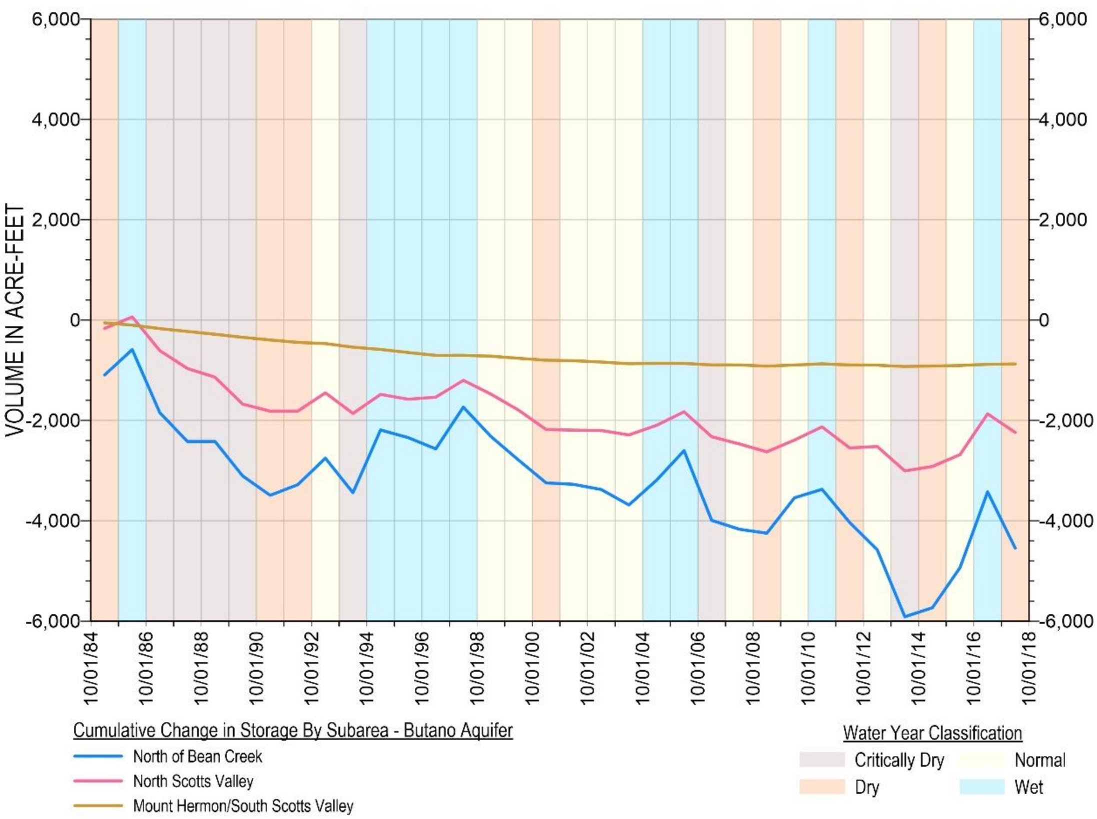


Figure 2-83. Historical Cumulative Change of Groundwater in Storage in the Butano Aquifer

2.2.6.3 Current Water Budget

Per GSP Regulations (§ 354.18), a current water budget is developed for the Basin based on the most recent land use, water use, and hydrologic conditions. The current water budget allows the SMGWA to assess the most recent water supply, demand, groundwater and surface water interaction, and aquifer conditions for implementing the GSP. What constitutes current conditions is not prescribed by DWR in the GSP Regulations. For this Basin's GSP, the current water budget period from WY2010 to WY2018 adopted is selected as it encompasses some extreme climatic conditions that are anticipated to become more typical in the future due to climate change: extended dry conditions from WY2012 to WY2015, normal conditions in WY2016, and historically wet conditions in WY2017. In addition, the current period starts in WY2010 to reflect reduced municipal water demands due to water use efficiency measures, and much reduced quarry and remediation extractions than in prior years.

2.2.6.3.1 Current Precipitation Budget

The current precipitation budget provides a recent record of precipitation inflow and outflow in the Basin. The current precipitation budget is summarized in Table 2-28 and presented as part of the time series chart on Figure 2-77.

Table 2-28. Summary of Current Precipitation Budget

Water Budget Components Average Total for Current Water Budget (AF)		Current Water Budget 2010-2018		Historical Water Budget 1985-2018	
		Annual Average (AF)	Percent of Total Inflow or Outflow	Annual Average (AF)	Percent of Total Inflow or Outflow
Inflows (79,600)*	**Precipitation**	79,600	100%	82,400	100%
Outflows (79,700)*	**Evapotranspiration**	37,100	47%	38,000	46%
	Direct Runoff	29,400	37%	30,800	37%
	Groundwater Recharge	13,200	16%	13,700	17%

*Small discrepancies between total inflow and outflow may occur due to rounding

Overall, total precipitation during the current period is slightly less than during the historical period and is more variable. On average, approximately 79,600 AFY of precipitation fell in the Basin during the current timeframe, which is about 2,500 AF less per year than the historical period. During the current period, average evapotranspiration, runoff, and groundwater recharge has similar modest overall reductions due to slightly lower precipitation and greater variability compared to the historical period. As with the historical period, evapotranspiration during the current period is relatively less responsive to extremes in climate than runoff and groundwater recharge. As a result, proportionally less precipitation enters the surface water and groundwater systems during critically dry years, and proportionally more precipitation enters the surface water and groundwater systems in wet years.

2.2.6.3.2 Current Surface Water Budget

The current surface water budget provides a recent record of surface water inflow and outflow in the Basin. The current surface water budget is summarized in Table 2-29 and presented as part of the time series chart on Figure 2-78.

Table 2-29.Summary of Current Surface Water Budget

Water Budget Components Average Total for Current Water Budget (AF)		Current Water Budget 2010-2018		Historical Water Budget 1985-2018	
		Annual Average (AF)	Percent of Total Inflow or Outflow	Annual Average (AF)	Percent of Total Inflow or Outflow
Inflows (115,600)*	Surface Water Inflow	68,500	59%	70,800	59%
	Runoff	27,000	23%	28,300	23%
	Groundwater Discharge to Creeks	20,100	18%	21,200	18%
Outflows (115,500)*	Surface Water Outflow	106,900	93%	111,700	93%
	Streambed Recharge	8,600	7%	8,600	7%

*Small discrepancies between total inflow and outflow may occur due to rounding

During the current period, average overall inflow and outflow is approximately 115,600 AFY, which is about 4,700 AF less per year than the historical period. Overall drier conditions during the current period compared to the historical period result in less surface water inflow and outflow. Groundwater discharge to creeks and streambed recharge to groundwater decreased proportionally with decreased inflow and outflow, especially during the drought from 2012 to 2015.

2.2.6.3.3 Current Groundwater Budget

The current groundwater budget provides a recent record of groundwater inflow and outflow in the Basin. The current groundwater budget is summarized in Table 2-30 and presented as part of the time series chart on Figure 2-79.

The inflows and outflows to the groundwater budget are similar in the historical and current periods. The total inflow is about 22,900 AF, which is about 1,100 AFY less than the historical period. The total outflow is about 23,300 AF, which is about 1,900 AFY less than the historical period.

Table 2-30. Current Groundwater Budget

Water Budget Components Average Total for Current Water Budget (AF)		Current Water Budget 2010-2018		Historical Water Budget 1985-2018	
		Annual Average (AF)	Percent of Total Inflow or Outflow	Annual Average (AF)	Percent of Total Inflow or Outflow
Inflows (22,900)*	Precipitation Recharge	13,100	54%	13,700	57%
	Subsurface Inflow	100	1%	100	1%
	System Losses	200	1%	200	1%
	Septic Return Flow	900	4%	1,100	5%
	Quarry Return Flow	<100	<1%	200	1%
	Streambed Recharge	8,600	36%	8,700	36%
	Irrigation Return Flow	<100	<1%	<100	<1%
Outflows (23,300)*	Groundwater Pumping	3,000	13%	3,700	15%
	Subsurface Outflow	100	<1%	100	<1%
	Discharge to Creeks	20,200	87%	21,400	85%
Storage*	Average Annual Change in Storage	-200	--	-1,200	--
	Cumulative Change in Storage	-2,100	--	-39,300	--

*Small discrepancies between total inflow and outflow may occur due to rounding

The main difference between the current and historical periods is that municipal pumping decreased. During the current period, outflow from groundwater pumping is 3,000 AFY on average, which is about 700 AF less than during the historical period. This reflects a reduction of average annual groundwater pumping of about 20% between the historical and current period. More details on groundwater pumping reductions are provided in Section 2.2.5.1: Groundwater Elevations.

During the current period groundwater discharge to streams decreased by about 1,200 AFY in comparison to the historical period. Less net groundwater discharge to streams is likely related to less precipitation and lower groundwater levels in the Santa Margarita aquifer between 2012 and 2015.

Change of groundwater in storage fluctuated over the current period, with a cumulative loss of 2,100 AF, and an average annual loss of 200 AF. The small overall change in storage during the current period indicates that groundwater inflow and outflow balanced since 2010. This is an improvement from the historical period during which average annual storage losses are about 1,200 AF. Groundwater in storage declines in dry and critically dry water years suggest that net groundwater recharge of the Basin’s aquifers is possible only in normal and wet years.

2.2.6.3.4 Current Groundwater Budget by Aquifer

The current groundwater budget is analyzed by aquifer to demonstrate changes in groundwater flows in the various aquifers relative to the historical period. The current groundwater budget by aquifer is summarized in Table 2-31 and in more detailed tables in Appendix 2E.

Table 2-31. Summary of Current Groundwater Budget by Aquifer

Groundwater Budget Components		Current Water Budget: 2010-2018 Annual Average (AF)				
		Santa Margarita Aquifer	Monterey Formation	Lompico Aquifer	Butano Aquifer	Other Formations
Inflows	**Precipitation Recharge**	6,200	1,400	900	3,900	700
	Subsurface Inflow	0	0	0	100	<100
	Return Flows	600	200	200	200	100
	Streambed Recharge	1,700	800	400	3,300	2,500
	Flow from Other Aquifers	<100	300	1,700	600	Not calculated
	Inflow*	**8,500**	**2,700**	**3,200**	**8,100**	**3,300**
Outflows	**Groundwater Pumping**	800	200	1,500	500	<100
	Subsurface Outflow	0	0	0	<100	<100
	Discharge to Creeks	6,400	2,100	1,300	7,100	3,400
	Flow to Other Aquifers	1,200	400	600	400	Not calculated
	Total Outflow*	**8,400**	**2,700**	**3,400**	**8,000**	**3,400**
Storage	**Average Annual Change in Storage***	<100	<100	-200	<100	-100
	Cumulative Change in Storage*	800	100	-2,000	100	-1,100

*Small discrepancies between total inflow and outflow may occur due to rounding

There are a few notable differences between the aquifer-specific water budgets for current and historical periods. As noted in Section 2.2.5.1: Groundwater Elevations less groundwater is pumped now than prior to 2010. Despite less overall precipitation recharge during the current period, streambed recharge has remained approximately the same. Current groundwater discharge to creeks is about 1,200 AFY less than the historical budget. Like the historical budget, most of the surface water and groundwater interactions are in the Santa Margarita and Butano aquifers.

During the current period, inflows and outflows for each aquifer are close to balanced. This is an improvement from the historical period, when each aquifer underwent comparatively larger storage losses annually of 1,100 AFY for the entire Basin. Each principal aquifer, except the

Lompico aquifer, has a slight increase of groundwater in storage during the current period. The average annual loss in storage from the Lompico aquifer is about 200 AFY, which improves on the historical period where the average annual loss was about 600 AFY.

2.2.6.3.5 Current Groundwater Change in Storage by Subarea

The current groundwater change in storage is analyzed by subarea to assess where storage changes are occurring. Figure 2-80 through Figure 2-83 illustrate that cumulative change in storage has ceased declining in the current period with fluctuations in some aquifer subareas.

The amounts of groundwater in storage in the Santa Margarita aquifer subareas has remained approximately constant in the current period, although they are subject to large annual fluctuations as a function of precipitation, particularly in the Quail Hollow subarea. Similar results were found for the Santa Margarita aquifer as a whole for the current time frame. The relative constancy of the groundwater in storage is a result of the elevated conductivity in this unconfined aquifer allowing for rapid storage recovery during wet years.

Historical declines in groundwater in storage in the deeper, semi-confined, and confined aquifers stabilized during the current timeframe. The Lompico aquifer in the Mount Hermon/South Scotts Valley subarea, which had the greatest groundwater in storage losses during the historical timeframe, lost only about 2,000 AF of groundwater in storage during the eight most recent years. Where the Butano aquifer outcrops along the Basin's northern boundary, i.e., North of Bean Creek and North Scotts Valley subareas, groundwater in storage declined during the WY2012 to WY2015 drought.

2.2.6.4 Projected Water Budget

The GSP Regulations (§ 354.18) require the development of a projected water budget baseline to assess how water supply, surface water and groundwater interactions, and aquifer conditions will be impacted by future changes in climate and water demands if projects and management actions are not implemented. The projected baseline water budget presented in this subsection fulfills those requirements of the GSP. The projected water budget is developed for the period WY2020 to WY2072 per the GSP Regulations requirement that the projected period include a 50-year planning and implementation horizon over which the GSP and measures will be implemented to ensure that the Basin is operated within its sustainable yield.

Section 2.2.3.2 describes the climate projection used by the groundwater model to simulate and estimate water budget components. In addition to the climate projection, the projected baseline simulation assumes a small increase in urban growth. Water demands are projected to increase 8% for SLVWD and 7% for SVWD from 2020 through 2045 that continues linearly through the projected model period ending in 2072. Although it is not simulated in the projected groundwater model, the urban footprint in the service areas is projected to expand slightly, resulting in slightly more runoff and less recharge. As shown in the sections below, climate change is predicted to have a larger impact on the projected water budget than changes in water demand and runoff due to urban and residential development.

2.2.6.4.1 Projected Precipitation Budget

The projected precipitation budget provides a simulated outlook of precipitation inflow and outflow in the Basin. The projected precipitation budget is summarized in Table 2-32 and presented in a time series chart on Figure 2-84.

Table 2-32. Summary of Projected Precipitation Budget

Water Budget Components Average Total for Projected Water Budget (AF)		Projected Water Budget 2020-2072		Current Water Budget 2010-2018	Historical Water Budget 1985-2018
		Annual Average (AF)	Percent of Total Inflow or Outflow	Annual Average (AF)	Annual Average (AF)
Inflows (77,400)*	**Precipitation**	77,400	100%	79,600	82,400
Outflows (77,500)*	**Evapotranspiration**	37,600	48%	37,100	38,00
	Direct Runoff	27,700	36%	29,400	30,800
	Groundwater Recharge	12,200	16%	13,200	13,700

*Small discrepancies between total inflow and outflow may occur due to rounding

Projected precipitation in the Basin is on average about 3% less than the current period and 6% less than the historical period. Annual precipitation is predicted to average about 5,000 AF less than in the historical period. Future precipitation is predicted to be more variable year-to-year than in the historical period, with more wet and critically dry years, and extended periods of wet or dry conditions. The 4-model ensemble climate projection has 53% of the water years classified as critically dry, 11% are normal, and 36% are wet. There are no water years classified as dry in the projection. In comparison, historical precipitation is less variable with only 21% of water years classified as critically dry and 26% as wet, with the remainder classified as dry or normal.

Evapotranspiration over the projected period is similar to current and historical evapotranspiration. Evapotranspiration projections are stable despite lower precipitation mainly because temperature is anticipated to increase during the projected period. Higher temperature causes more vegetative growth and evaporation. The more or less constant evaporation, combined with a decrease in precipitation, result in simulated overland flow and groundwater recharge being about 10% less than in the historical period.

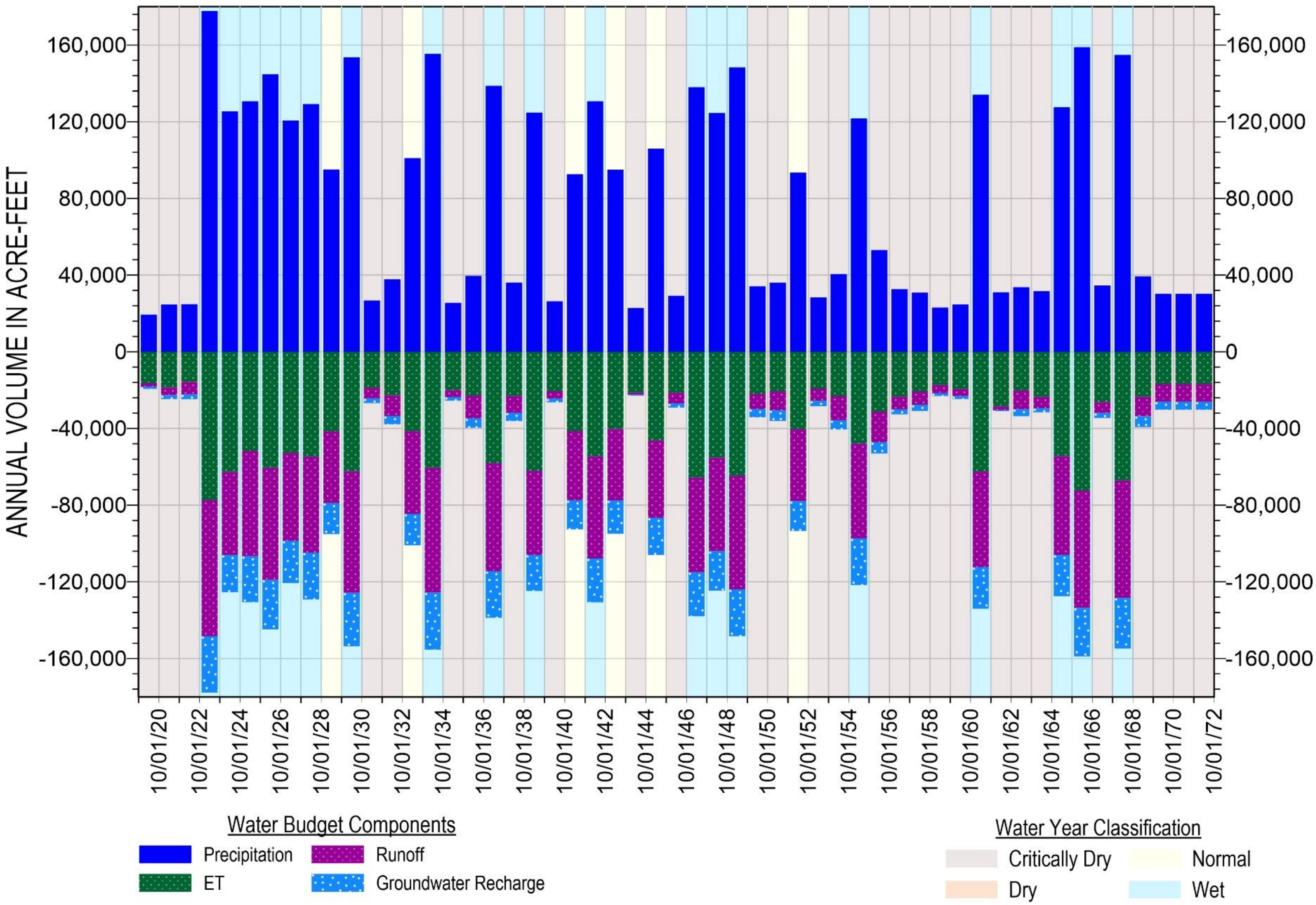


Figure 2-84. Projected Precipitation Budget

2.2.6.4.2 Projected Surface Water Budget

The projected surface water budget provides a simulated outlook for surface water inflow and outflow in the Basin in the future. The projected surface water budget is summarized in Table 2-33 and presented in a time series chart on Figure 2-85.

Table 2-33. Summary of Projected Surface Water Budget

Water Budget Components Average Total for Projected Water Budget (AF)		Projected 2020-2072 Annual Average (AF)	Projected 2020-2072 Percent of Total Inflow or Outflow	Current 2010-2018 Annual Average (AF)	Historical 1985-2018 Annual Average (AF)
Inflows (109,600)	Surface Water Inflow	64,800	59%	68,500	70,800
	Runoff	25,400	23%	27,000	28,300
	Groundwater Discharge to Creeks	19,400	18%	20,100	21,200
Outflows (109,600)	Surface Water Outflow	101,200	92%	106,900	111,700
	Streambed Recharge	8,400	8%	8,600	8,600

During the projected period, average groundwater total inflow and outflow is approximately 109,600 AFY, which is about 10,700 AFY less than the historical period. Surface water inflows and outflows during the projected period decrease by about 9%, in comparison to the historical period, which reflects drier climatic conditions predicted in the future. Surface water and groundwater interaction reflected as discharge to creeks and streambed recharge to groundwater fluctuates proportionally with precipitation and surface water inflow, especially during periods of extended drought. Consequently, the amount of surface water and groundwater interaction decreases during the projected period.

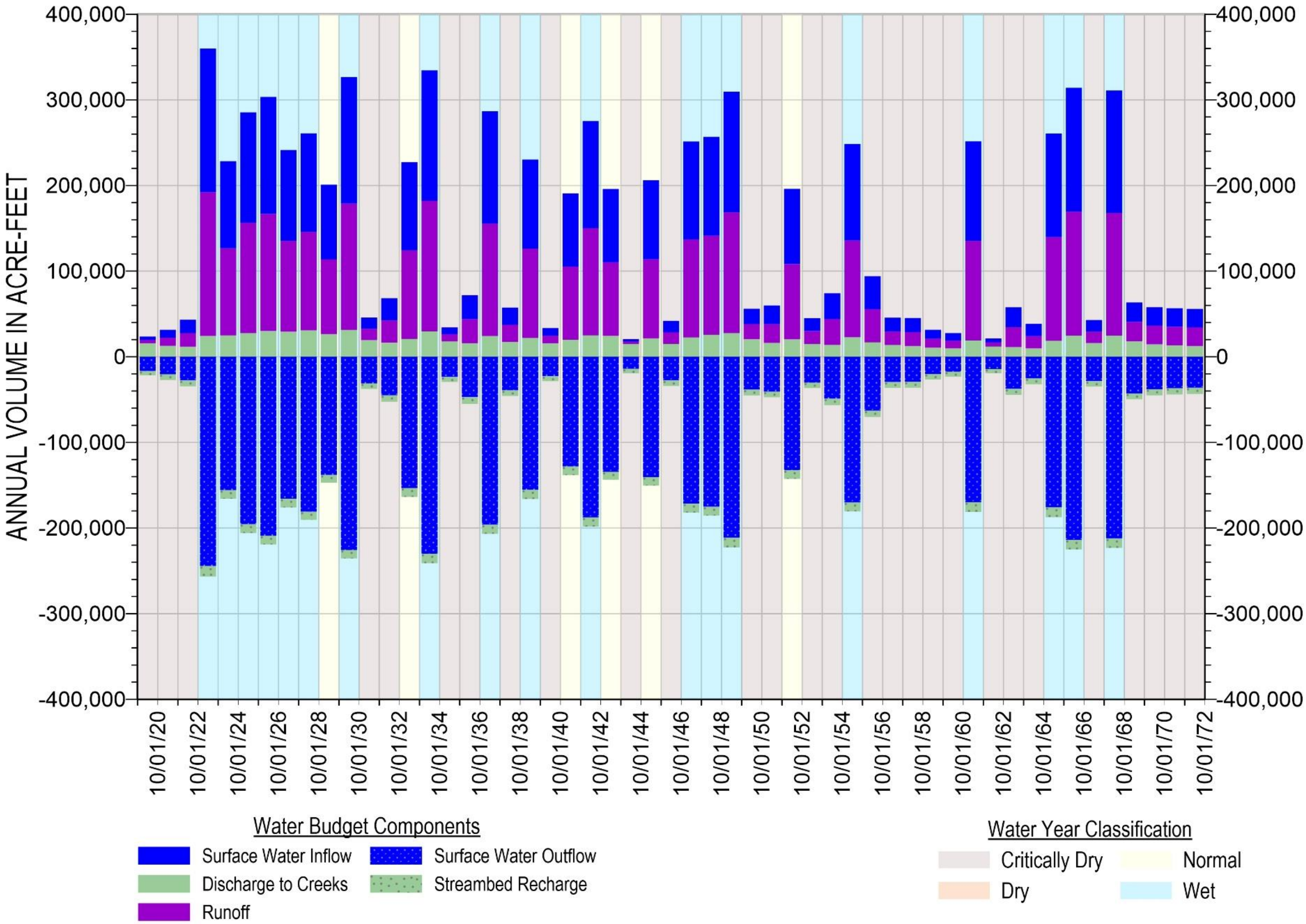


Figure 2-85. Projected Surface Water Budget

2.2.6.4.3 Projected Groundwater Budget

The projected groundwater budget provides a simulated outlook for groundwater inflow and outflow in the Basin. The projected groundwater budget is summarized in Table 2-34 and presented in a time series chart on Figure 2-86.

Table 2-34. Summary of Projected Groundwater Budget

Water Budget Components		Projected 2020-2072		Current 2010-2018	Historical 1985-2018
Average Total for Projected Water Budget (AF)		Annual Average (AF)	Percent of Total Inflow or Outflow	Annual Average (AF)	Annual Average (AF)
Inflows (21,700)*	**Precipitation Recharge**	12,100	56%	13,100	13,700
	Subsurface Inflow	100	<1%	100	100
	System Losses	300	1%	200	200
	Septic Return Flow	800	4%	900	1,100
	Quarry Return Flow	<100	<1%	<100	200
	Streambed Recharge	8,400	39%	8,600	8,700
	Irrigation Return Flow	<100	<1%	<100	<100
Outflows (22,300)*	**Groundwater Pumping**	2,800	12%	3,000	3,700
	Subsurface Outflow	100	1%	100	100
	Discharge to Creeks	19,400	87%	20,200	21,400
Storage*	**Average Annual Change in Storage**	-500	-	-200	-1,200
	Cumulative Change in Storage	-24,000	-	-2,100	-39,300

*Small discrepancies between total inflow and outflow may occur due to rounding

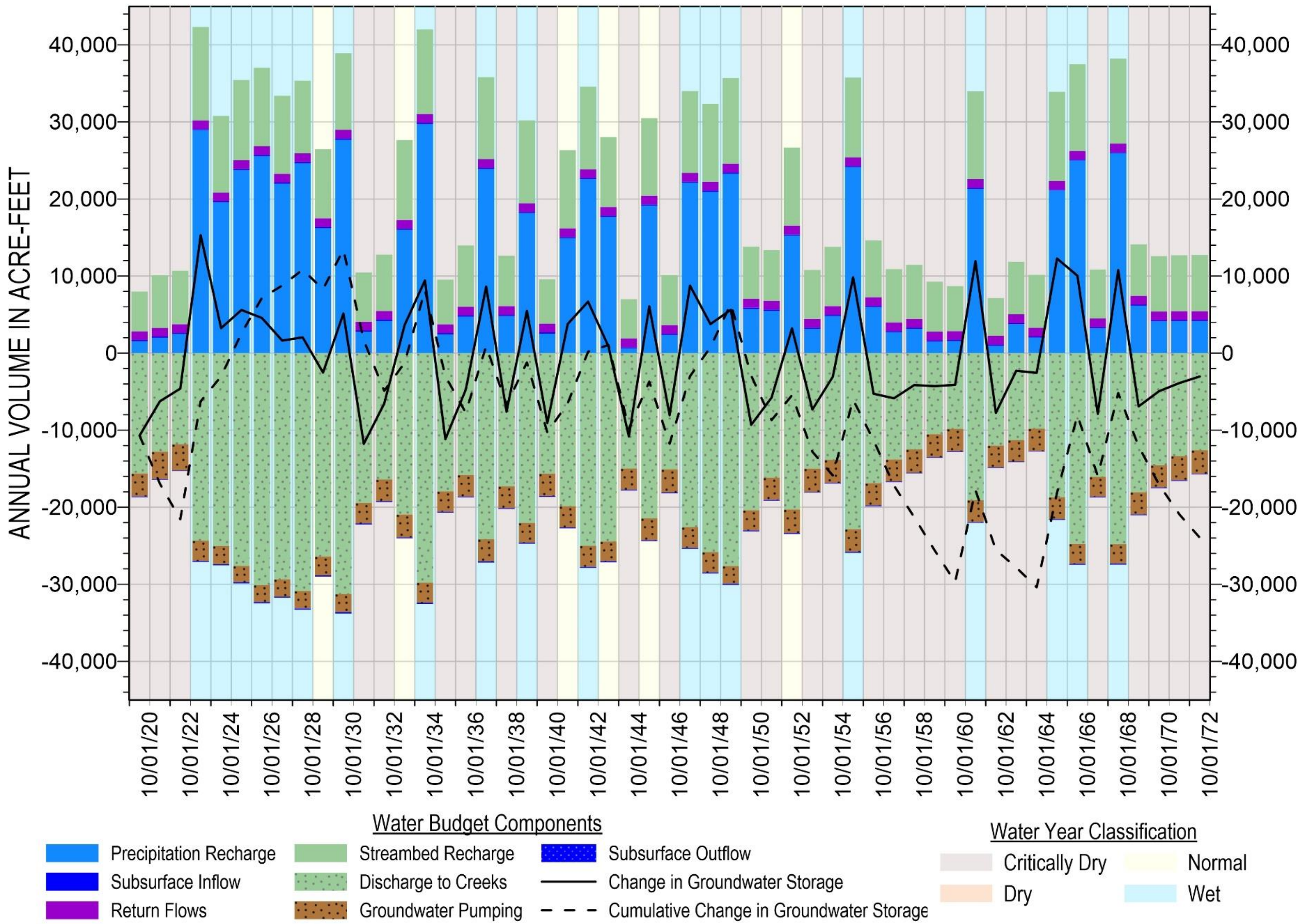


Figure 2-86. Projected Groundwater Budget

Total inflows and outflows to the groundwater budget are both smaller in the projected period than in the historical and current periods. Compared to the historical period, predicted total inflows and outflows are approximately 2,300 AFY and 2,900 AFY smaller, respectively.

Reduced recharge by precipitation is the largest source of the predicted decline in total groundwater inflows. Direct groundwater recharge from precipitation is projected to be about 1,600 AF less per year than the historical period; in comparison, streambed recharge is predicted to be about 300 AF less. Septic return flows to groundwater are expected to decrease about 28% with improved water efficiency as water fixtures are replaced, resulting in about 800 AFY of septic return flows compared to about 1,110 AF per over the historical period. Other components of projected groundwater inflow are expected to be similar to historical inflows.

Reduced projected groundwater outflow is mostly a result of less groundwater pumping and groundwater discharge to creeks. In the future, groundwater pumping is estimated to average about 2,800 AFY, which is about 200 AFY less than average current conditions and about 900 AFY less than average historical conditions. The reduced groundwater use is based on the assumption that SLVWD will use surface water more in wet years in place of groundwater. Future population growth is expected to be moderate and is expected to be offset with continued efficiency improvements in public water supply. It is projected that groundwater discharge to creeks will be about 19,400 AFY on average, which is 2,000 AF less than the historical annual average. The projected reduction in groundwater and surface water interactions is primarily due to overall drier conditions, which will reduce groundwater recharge and lower groundwater levels.

Under the 4-model ensemble climate projection used to simulate future groundwater conditions, the Basin will experience slightly less overall precipitation and greater precipitation variability resulting in longer periods of drought. Together, this causes losses of groundwater in storage and lower groundwater levels. Prolonged drought stresses the water supply in the Basin and requires greater groundwater banking and/or conjunctive use strategies to increase groundwater in storage in wetter years when water is available. The projected baseline simulation without implementing new projects or management actions results in a cumulative loss of groundwater in storage of about 24,000 AF between 2020 and 2072. The annual average decline in storage in this timeframe is about 500 AFY.

Given these results, projects and management actions will need to be implemented to achieve sustainability of groundwater conditions, as discussed further in Section 4. It is, however, important to recognize that the model projections are highly dependent on estimates of future precipitation. To the degree that actual future precipitation deviates from that predicted by the four-model ensemble, groundwater conditions could be better or worse than simulated.

2.2.6.4.4 Projected Groundwater Budget by Aquifer

The projected groundwater budget is analyzed by aquifer to demonstrate changes in groundwater flows in the various aquifers if no additional projects or management actions are implemented. The projected groundwater budget by aquifer is summarized in Table 2-35 and in more detailed tables in Appendix 2E.

Table 2-35. Projected Groundwater Budget by Aquifer

Groundwater Budget Components		Projected Water Budget: 2020-2072 Annual Average (AF)				
		Santa Margarita Aquifer	Monterey Formation	Lompico Aquifer	Butano Aquifer	Other Formations
Inflows	**Precipitation Recharge**	5,700	1,300	900	3,600	600
	Subsurface Inflow	0	0	0	100	<100
	Return Flows	500	200	200	200	100
	Streambed Recharge	1,600	800	400	3,300	2,300
	Flow from Other Aquifers	<100	300	1,600	600	Not calculated
	Total Inflow*	***7,800***	***2,600***	***3,100***	***7,800***	***3,100***
Outflows	**Groundwater Pumping**	900	100	1,200	500	<100
	Subsurface Outflow	0	0	0	100	<100
	Discharge to Creeks	6,100	2,100	1,300	6,900	3,000
	Flow to Other Aquifers	1,100	400	600	400	Not calculated
	Total Outflow*	***8,100***	***2,600***	***3,100***	***7,900***	***3,000***
Storage	**Average Annual Change in Storage***	-200	-100	-100	-100	<100
	Cumulative Change in Storage*	-9,600	-2,900	-7,000	-5,100	600

*Small discrepancies between total inflow and outflow may occur due to rounding

There are a few notable differences between the aquifer-specific change in storage for the projected, current, and historical periods. The most notable difference between the water budget timeframes is changes to precipitation patterns due to climate change. Simulated precipitation in the projected timeframe is more variable and less than current and historical precipitation, translating to less recharge available for the Basin's aquifers. This change is anticipated to impact future recharge patterns in all aquifers, but especially the Santa Margarita and Butano aquifers which rely directly on recharge from precipitation and from streambeds. The Lompico aquifer is also impacted by reduced overall recharge, although to reach the Lompico aquifer, recharge water typically percolates through the overlying Santa Margarita aquifer and/or Monterey Formation, so the response to climatic patterns is muted. Recharge of the Lompico aquifer from the Santa Margarita aquifer is unimpeded in the Camp Evers area in south Scotts Valley where shale of the Monterey Formation is absent between the permeable Santa Margarita and Lompico aquifers. The result of more variable and less overall precipitation is that groundwater in storage is projected to decrease in each of the principal aquifers and the Monterey Formation.

The projected water budget assumes groundwater pumping will be on average 200 AFY less than current pumping (Table 2-31). This is because in the projection's very wet years, there will be more surface water available for municipal water supply. Slight increases in pumping are projected in the Santa Margarita and Butano aquifers, while slight decreases in groundwater pumping are projected in the Lompico aquifer in comparison to current pumping.

The average long-term annual change in storage is projected to be slightly negative for each of the principal aquifers. The greatest amounts of storage loss are projected for the Santa Margarita and Lompico aquifers. Storage is lost during dry periods and gained during wet periods. Since more dry years are projected than wet years, the result is a net overall loss of groundwater in storage.

2.2.6.4.5 Projected Groundwater Change in Storage by Subarea

Based on the projected baseline simulation the principal aquifers will all be affected by the drier projected climate simulated by the 4-model ensemble climate projection. This is especially the case in the multiple critically dry years towards the end of the projected period. Figure 2-87 through Figure 2-90 show each aquifer's projected cumulative change of groundwater in storage.

The Santa Margarita aquifer is the most sensitive to climatic changes and loses almost 6,000 AF from storage in the Quail Hollow subarea during the longest projected drought period from 2050 to 2064 (Figure 2-87). However, it recovers very quickly after several wet years. The same pattern of groundwater depletion and recovery occur in the other subareas, but at a lesser scale. The Quail Hollow and Olympia/Mission Springs subareas have the greatest losses and gains in storage because they contain municipal supply wells that pump most of the groundwater extracted from the Santa Margarita aquifer.

Monterey Formation projected change of groundwater in storage is shown on Figure 2-88. The Monterey Formation is not pumped by many wells in the area south of Bean Creek (North Scotts Valley and Mount Hermon/South Scotts Valley subareas) and even in the driest years, little change in storage is predicted. Figure 2-88 shows that there is more change in stored groundwater in the subarea north of Bean Creek where only *de minimis* users pump from the Monterey Formation. The very low rainfall predicted from 2050 onwards results in an overall loss of about 2,000 AF at the end of the projected period.

Up until 2048, groundwater in storage in the Lompico aquifer is generally consistent (Figure 2-89). This indicates that pumping from the Lompico aquifer is roughly in balance with its recharge. The extended drought projected after this period causes a significant loss of groundwater in storage, especially in the Mount Hermon/South Scotts Valley subarea where the majority of Lompico aquifer pumping occurs by Mount Hermon Association, SLVWD, and SVWD. Recovery from significant losses such as this, even in wet years, is not possible without projects or management actions because of the aquifer's limited recharge area and confined nature. Section 4 described potential projects that target the Lompico aquifer to both provide for some recovery from past losses of storage and to provide resiliency against prolonged future droughts.

The Butano aquifer is pumped only in the northern portions of the Basin, where it outcrops south of the Zayante-Vergeles fault and slightly farther south from the boundary where SVWD has 2 deep wells in Scotts Valley that extend down more than 1,000 feet. The projected modeled changes in storage depicted on Figure 2-90 reflect effects of recharge in wet years. This pattern is more like the Santa Margarita aquifer response to recharge events and less like the similarly confined Lompico aquifer responds. The 2 Butano aquifer monitoring wells in northern Scotts Valley do not appear to respond to wet years in the same way the model predicts (hydrographs are included on Figure 2-47). It is acknowledged in Section 2.2.4.11 that because of so few monitoring wells in the Butano aquifer, our current understanding of it is limited and assumptions made in the model may not be correct. Existing plans to install new Butano monitoring wells may increase hydrogeologic understanding, in turn informing the groundwater model.

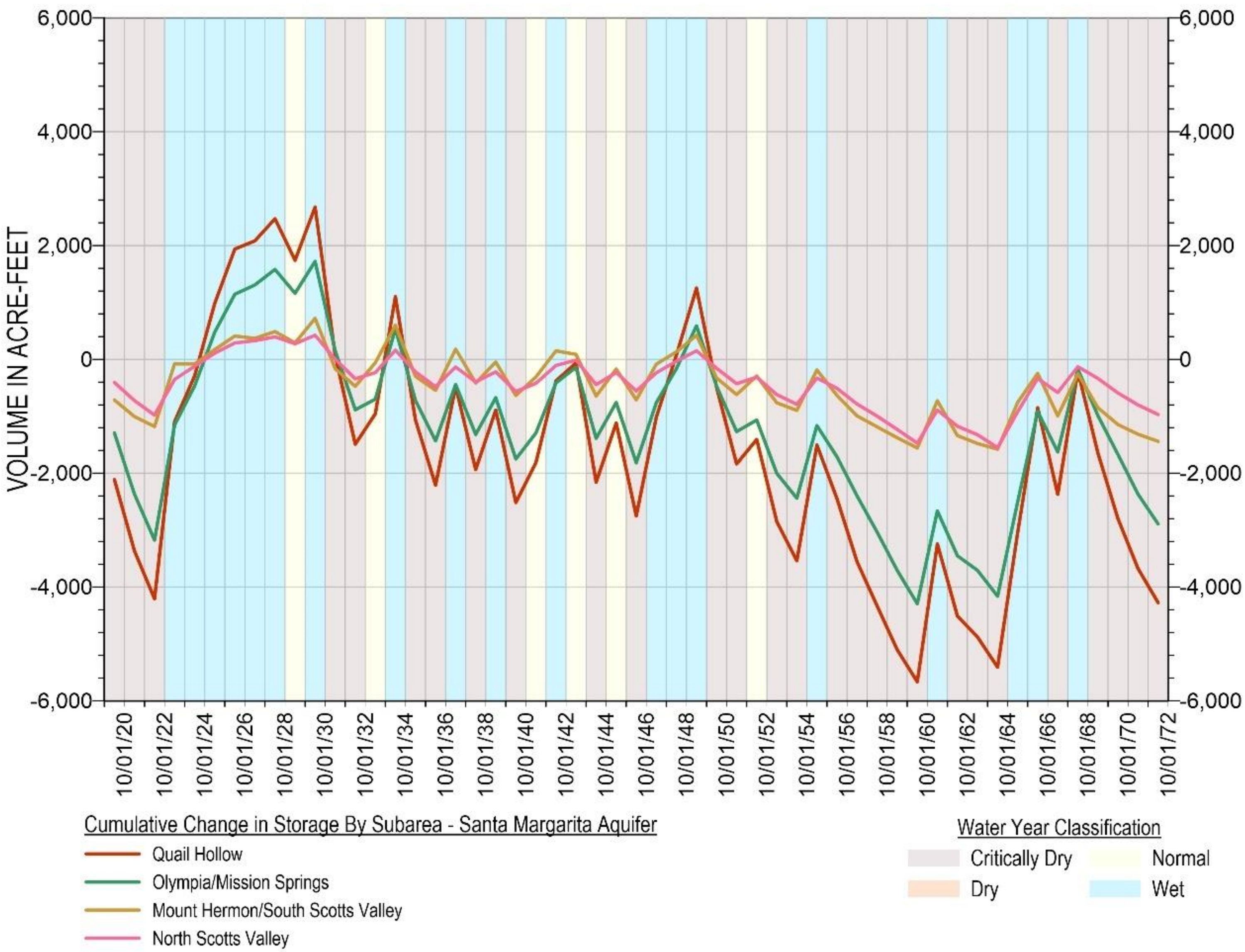


Figure 2-87. Projected Cumulative Change of Groundwater in Storage in the Santa Margarita Aquifer

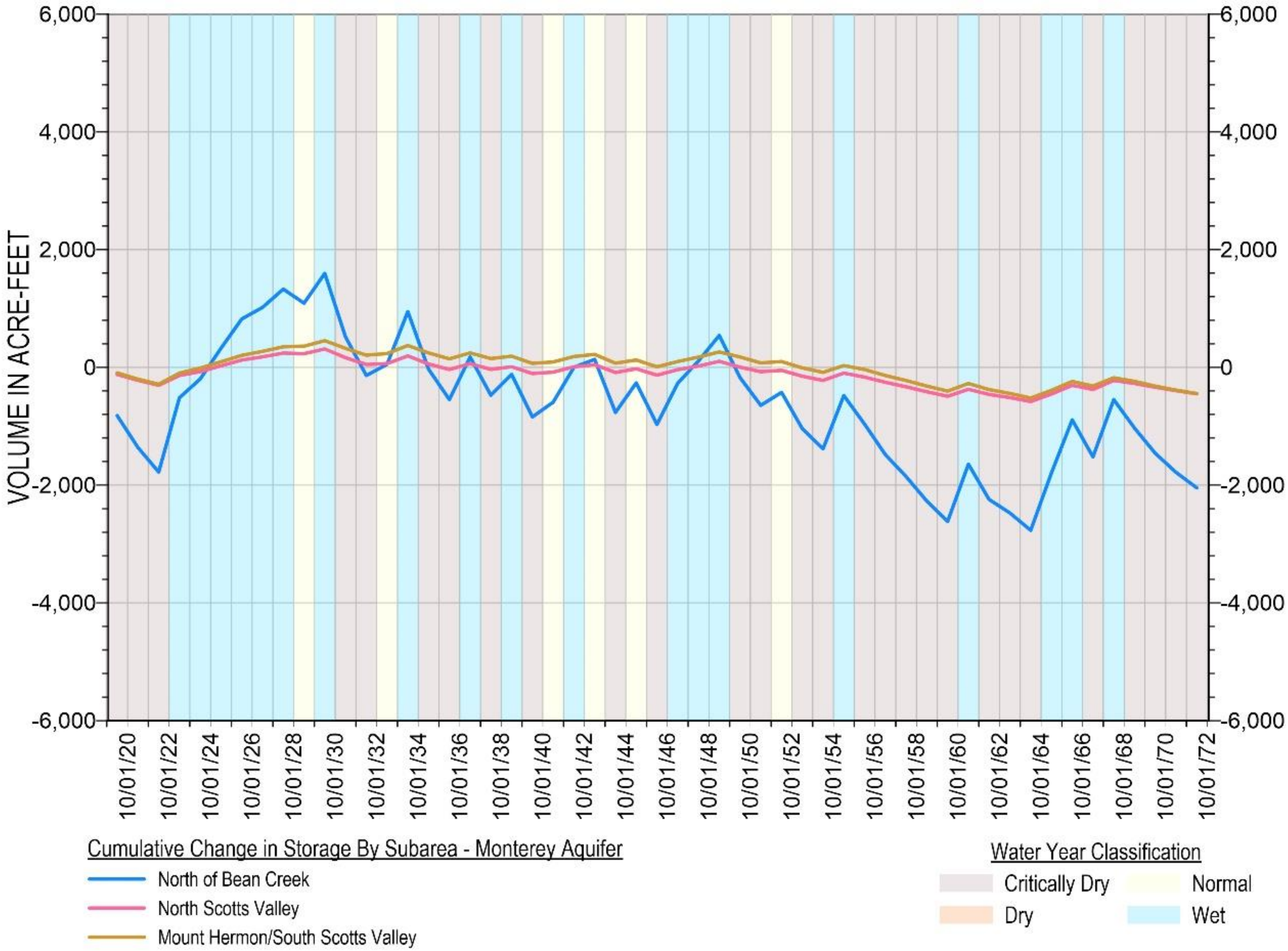


Figure 2-88. Projected Cumulative Change of Groundwater in Storage in the Monterey Formation

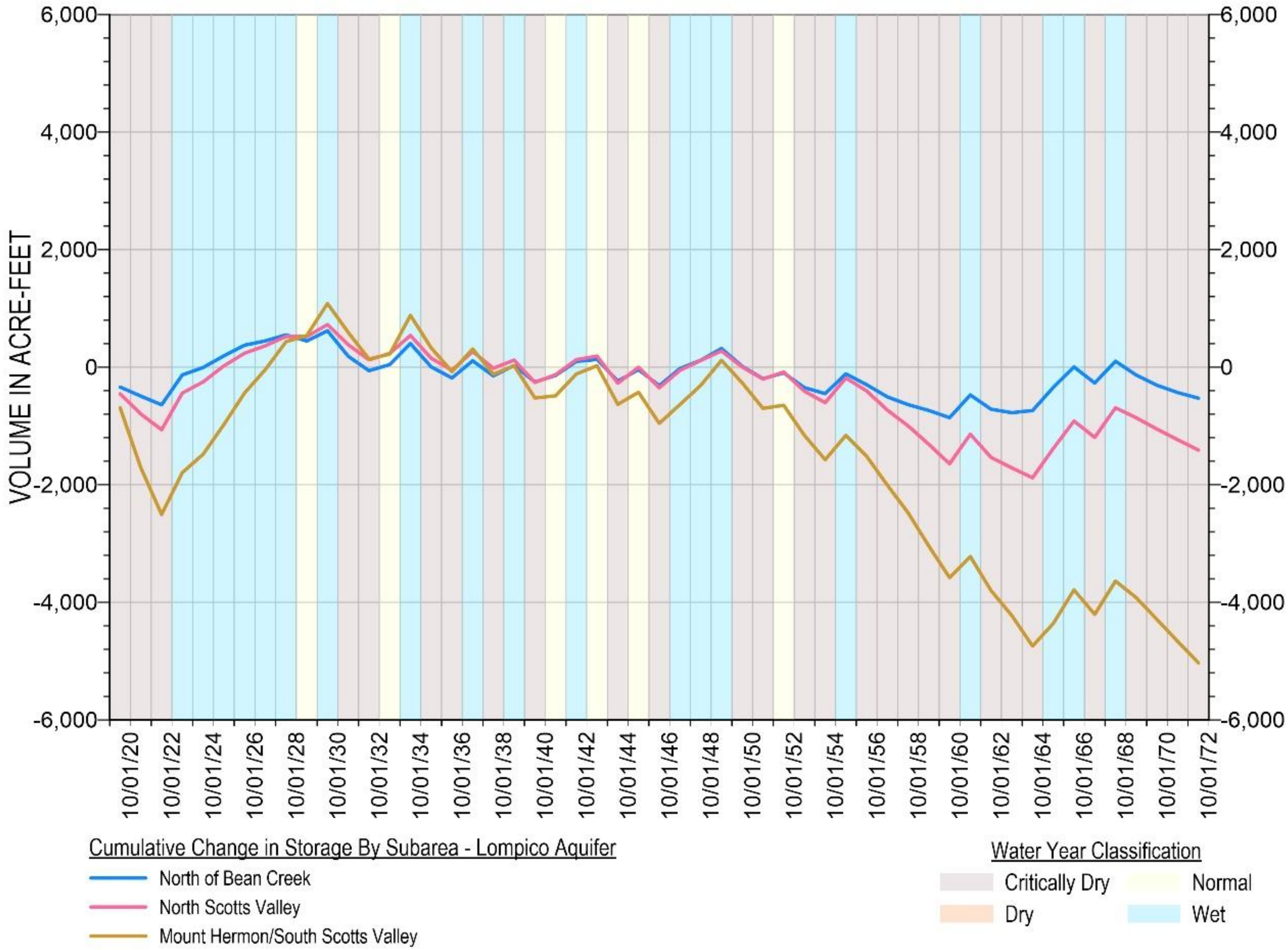


Figure 2-89. Projected Cumulative Change of Groundwater in Storage in the Lompico Aquifer

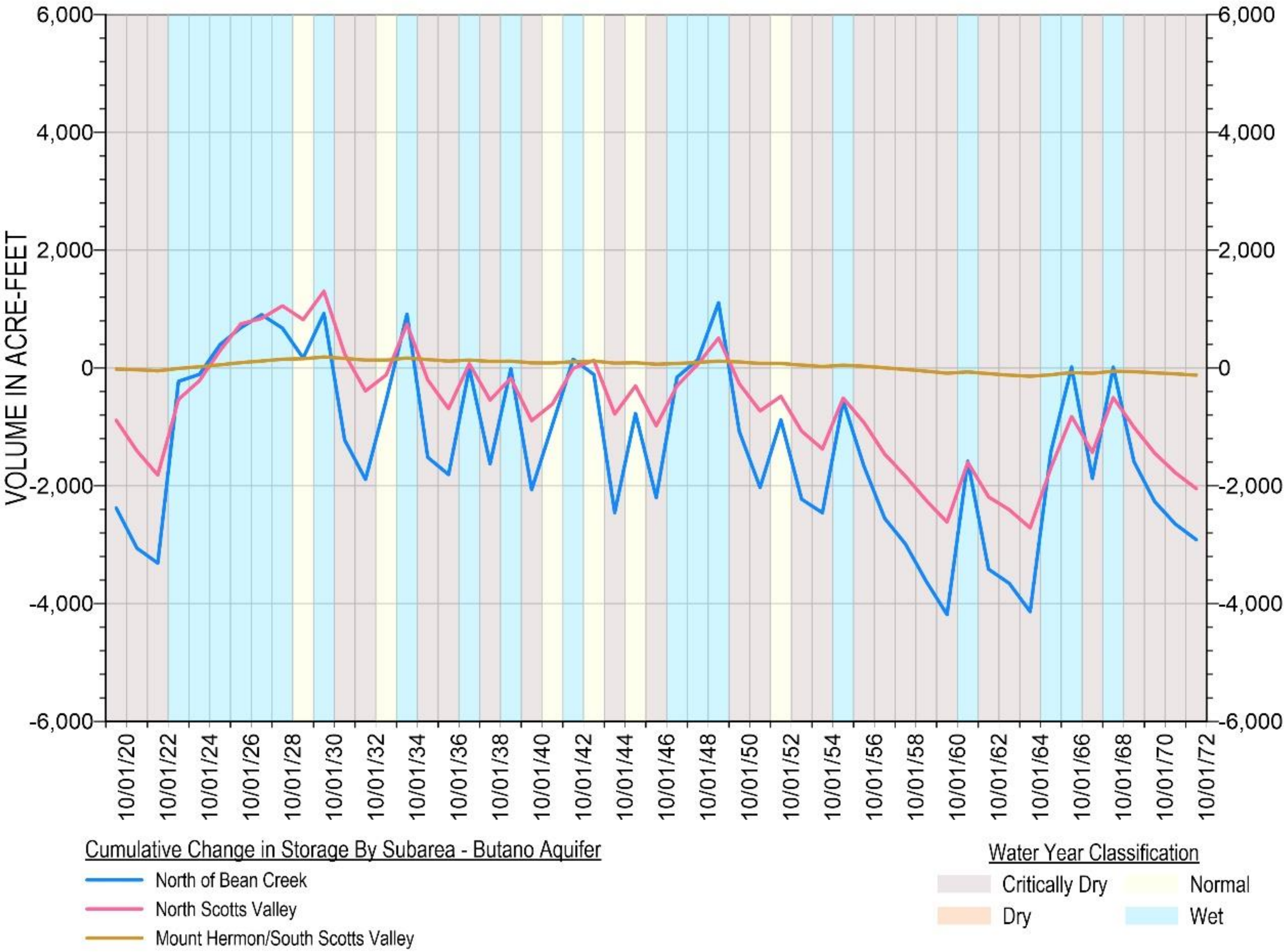


Figure 2-90. Projected Cumulative Change of Groundwater in Storage in the Butano Aquifer

2.2.6.5 Sustainable Yield

The Basin's sustainable yield is an estimated volume of groundwater that can be pumped on a long-term average annual basis without causing undesirable results. The role of sustainable yield estimates in SGMA as described in the Sustainable Management Criteria (SMC) BMP (DWR, 2016a) are as follows:

> *"In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. Sustainable yield is referenced in SGMA as part of the estimated basinwide water budget and as the outcome of avoiding undesirable results.*
>
> *Sustainable yield estimates are part of SGMA's required basinwide water budget. Section 354.18(b)(7) of the GSP Regulations requires that an estimate of the basin's sustainable yield be provided in the GSP (or in the coordination agreement for basins with multiple GSPs). A single value of sustainable yield must be calculated basinwide. This sustainable yield estimate can be helpful for estimating the projects and programs needed to achieve sustainability."*

Basin-wide groundwater pumping within the sustainable yield does not constitute proof of sustainability. Sustainability under SGMA is only demonstrated by avoiding undesirable results for the sustainability indicators applicable to the Basin. Specific undesirable results for the chronic lowering of groundwater levels, reduction in groundwater storage, and depletion of interconnected surface water sustainability indicators are presented in Section 3. While GSP Regulations only require 1 sustainable yield volume for the entire basin, pumping within the sustainable yield may affect groundwater elevations in different aquifers and aquifer subareas differently depending on how pumping is distributed spatially. Therefore, sustainable yield volumes are estimated for each aquifer based on predictive model simulations that do not produce undesirable results.

The future baseline model simulation incorporating climate change and projected water use predicts undesirable results will not occur within the modeled 50-year interval. This means that groundwater pumping volumes used in the baseline simulation can be used to estimate sustainable yield. Given that groundwater pumping in the model is not specifically optimized to avoid undesirable results, it is possible that slightly more pumping than the estimated sustainable yield could avoid future undesirable results. Groundwater pumping in the projected baseline simulation, shown on Figure 2-91, is generally consistent after WY2022 in the Monterey Formation, and Lompico and Butano aquifers. The sustainable yield for those aquifers is therefore set as the average pumping after 2022 plus a 5% buffer to allow for pumping optimization during GSP implementation.

The amount of municipal groundwater pumped in the Santa Margarita aquifer is related to water year type and increases considerably during dry periods. When surface water supply is limited (Figure 2-89), SLVWD augments it with groundwater pumped from the Santa Margarita aquifer at the Quail Hollow and Olympia wellfields. For example, a substantial modeled increase in pumping during an extended simulated drought after WY2050 results in considerable loss of groundwater in storage in the Santa Margarita aquifer, and minimum thresholds to be exceeded (Figure 2-92). These exceedances are not considered undesirable results because they occur during an extended drought. In contrast, from WY2030-2049 the simulation shows in a non-drought period that the Santa Margarita aquifer does not have undesirable results. During this relatively wetter period, the Santa Margarita aquifer experiences almost no cumulative groundwater in storage losses, indicating sustainable groundwater conditions. Therefore, the sustainable yield for the Santa Margarita aquifer is set as the average pumping from 2030-2049 plus a 5% buffer to allow for pumping optimization during GSP implementation.

Historical pumping and estimate of sustainable yield for each aquifer is presented in Table 2-36. The estimates of sustainable yield for each aquifer are used as minimum thresholds for the reduction of groundwater storage sustainability indicator, described further in Section 3.

Five-year averages of historical pumping are compared with sustainable yield values on Figure 2-93. While pumping in all aquifers has declined over the historical period, current period pumping remains above sustainable yield in the Monterey and Lompico aquifers.

Table 2-36. Sustainable Yield by Aquifer Compared to Historical and Current Pumping

Aquifer	Historical Pumping 1985 – 2018 (AFY)	Current Pumping 2010 – 2018 (AFY)	Sustainable Yield (AFY)	Sustainable Yield Based on
Santa Margarita	1,070	770	850	Average pumping between 2030-2049 plus 5% buffer
Monterey	320	180	140	Average pumping after 2022 plus 5% buffer
Lompico	1,770	1,520	1,290	Average pumping after 2022 plus 5% buffer
Butano	530	480	540	Average pumping after 2022 plus 5% buffer

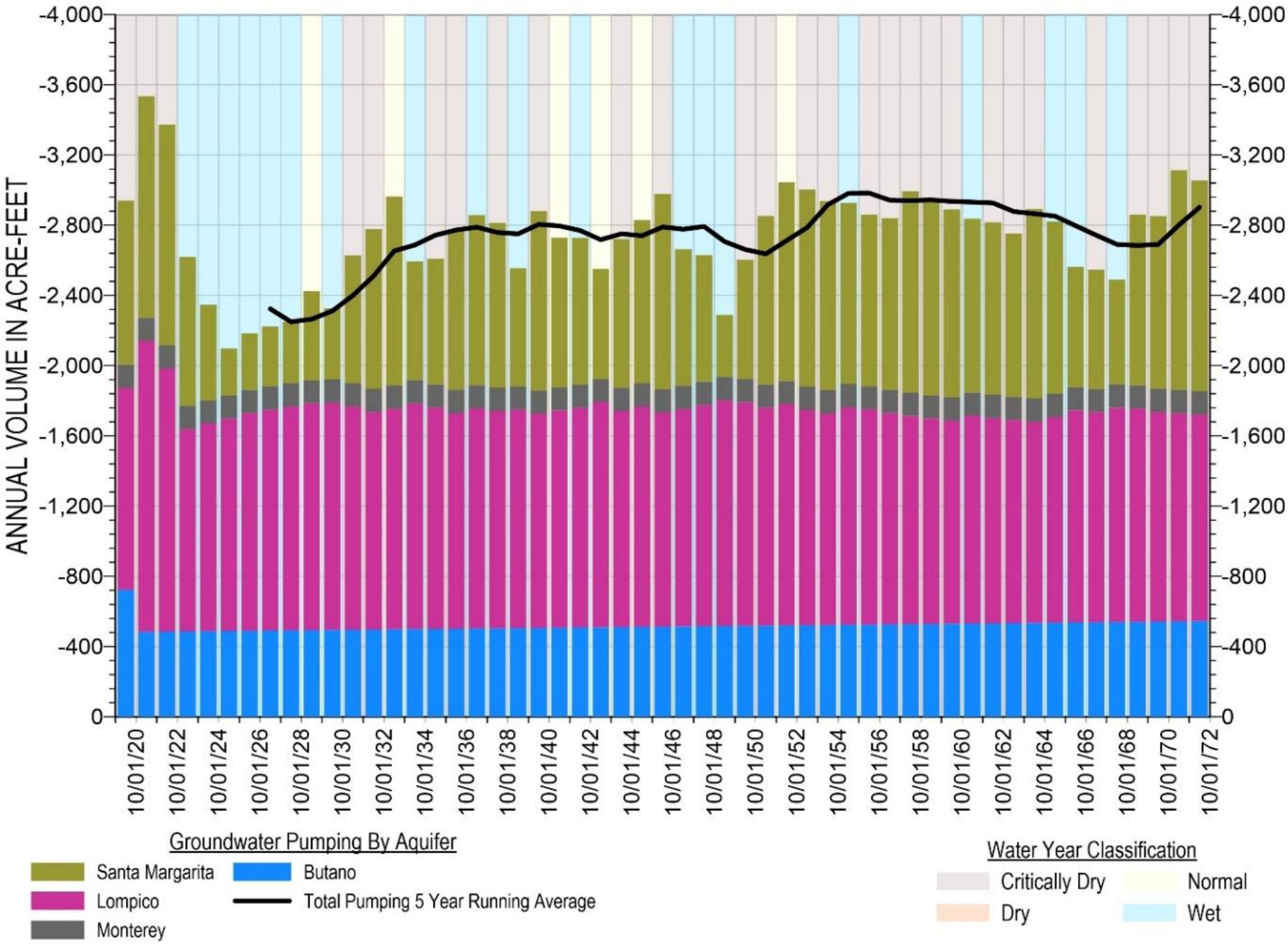


Figure 2-91. Projcted Baseline Simulation Groundwater Pumping by Aquifer

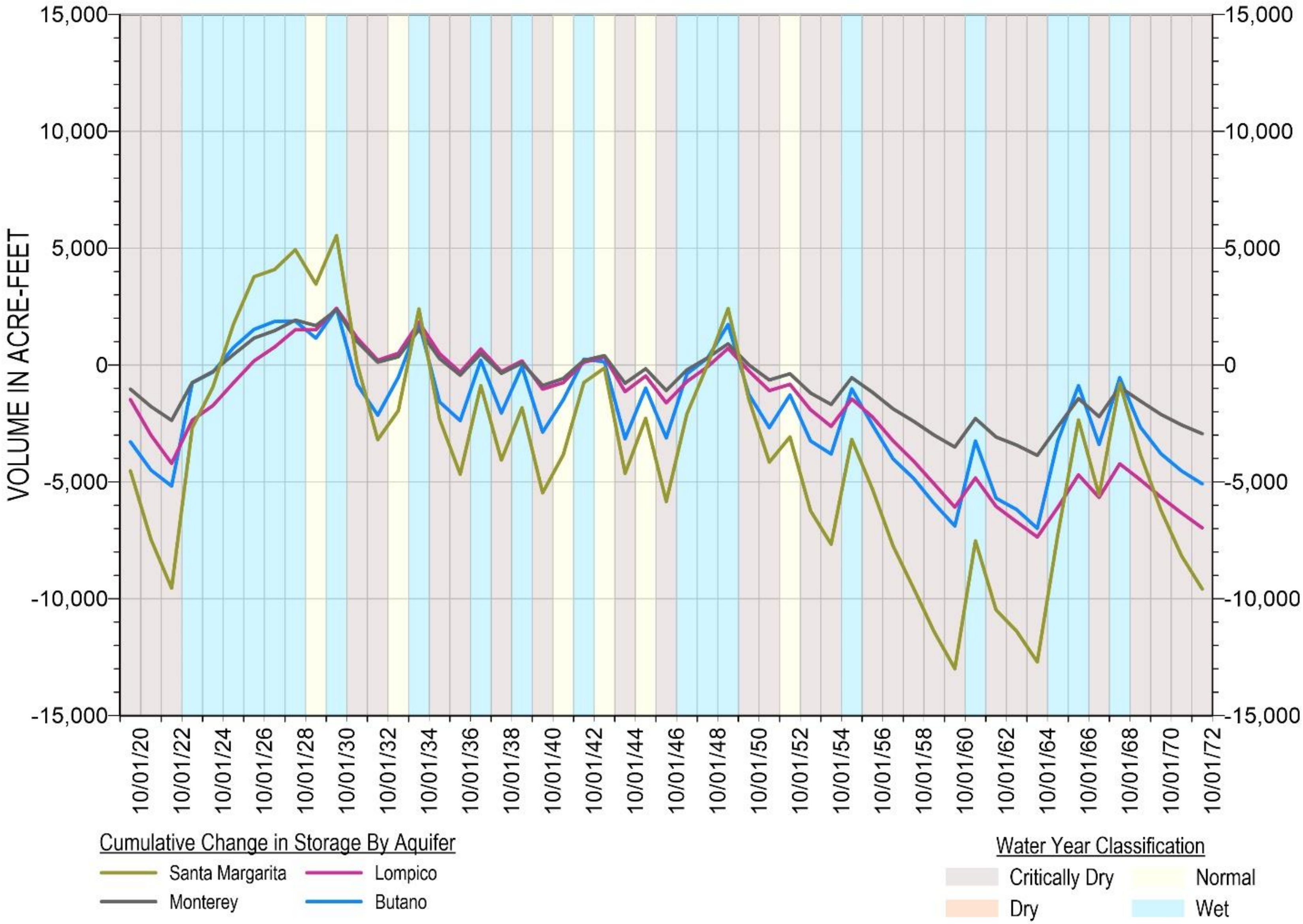


Figure 2-92. Projected Baseline Simulation Cumulative Change in Groundwater in Storage by Aquifer

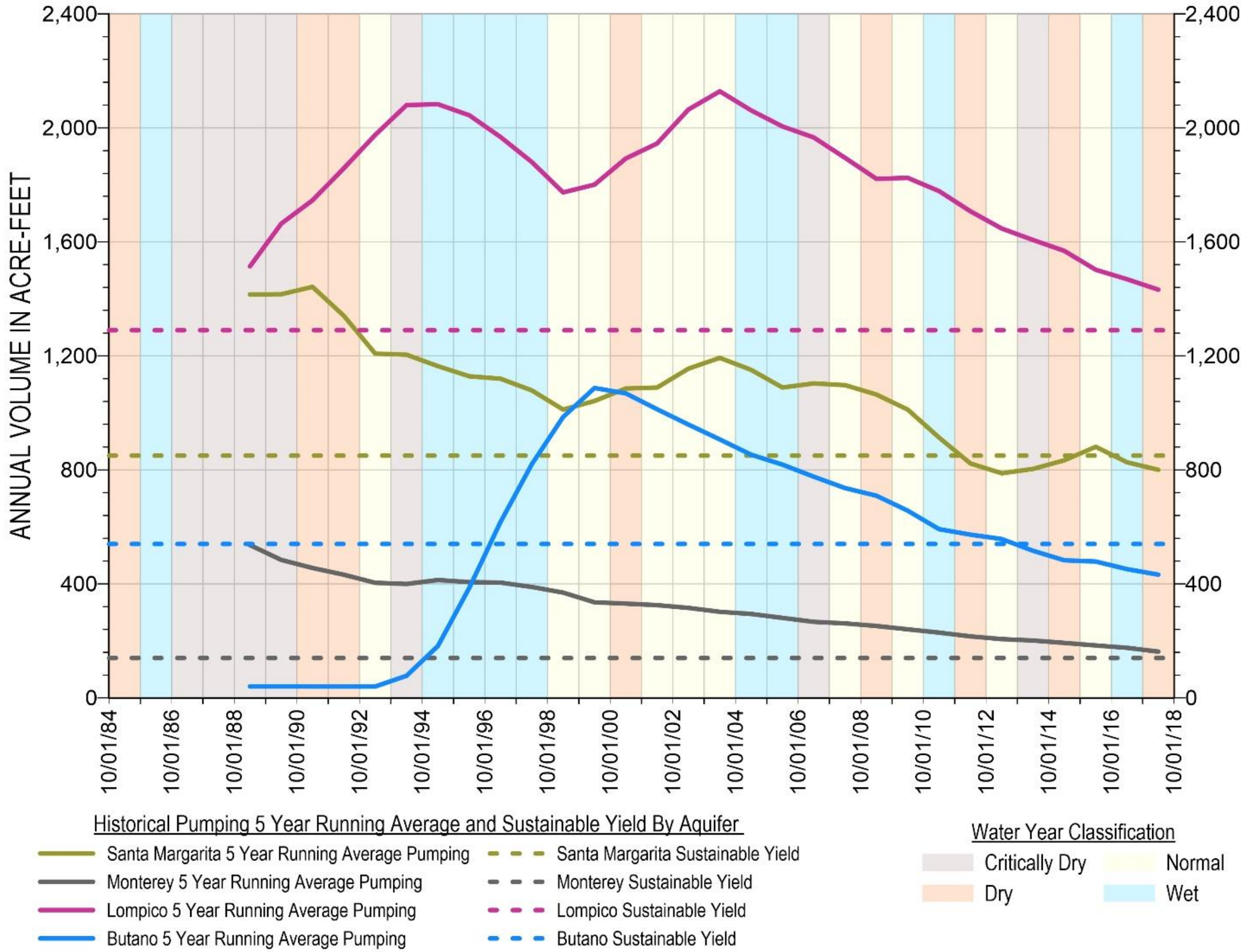


Figure 2-93. Historical Pumping 5-Year Running Average and Sustainable Yield by Aquifer

2.2.6.6 Description of Surface Water Supply for Groundwater Recharge or In-Lieu Supply

The sources of water supply in the Basin are discussed in Section 2.2.4.10: Sources and Points of Water Supply. Almost all water supply within the Basin is derived from surface water and groundwater, which is fed by precipitation in the Basin and the surrounding watershed. A very small amount (between 160 to 200 AFY) of recycled water is used by SVWD to supplement their water supply.

SLVWD has rights to divert water from tributaries of the San Lorenzo River located outside of the Basin. When surface water is available, SLVWD uses it in lieu of pumping its wells. This conjunctive use of surface water and groundwater is described in more detail in the baseline projects in Section 4. If SLVWD's water rights and place of use restrictions are revised per current requests to the State Water Resources Control Board, in wet years there will be more surface water available for conjunctive use by SLVWD and potentially SVWD.

SVWD has provided recycled water to its irrigation customers in lieu of pumping groundwater since 2002. Larger volumes of treated wastewater from outside of the Basin is another source of water that could be used for groundwater recharge in the future. Section 4 describes potential projects that would use treated wastewater for indirect potable reuse.

Currently, the City of Santa Cruz has water rights to divert water from the San Lorenzo River. Between October 1 and May 31, the San Lorenzo River and its tributaries are not fully appropriated, and at times have streamflow in excess of minimum bypass flows; these excess flows could be used for groundwater recharge and conjunctive use projects. Appendix 2D: Section 7.3.3 describes an estimated total of 540 AFY for excess flows within the water rights of SLVWD and City of Santa Cruz. This potential source and volume of water is used for an expanded conjunctive use project described in Section 4 on projects and management actions. The 540 AFY estimate may change subject to applications by the City of Santa Cruz and SLVWD to change their water rights.

2.2.7 Management Areas

SGMA allows GSAs to define 1 or more management areas within a groundwater basin if the agency determines that the creation of management areas will facilitate implementation of its GSP. Management areas may have different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin. The SMGWA found no additional benefit to establishing separate management areas within the Basin at this time, although management areas may be needed in the future.

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