Groundwater Management Plan Goleta Groundwater Basin

2022 Update

April 2023

Prepared for:

Goleta Water District

Prepared by:

GSI Water Solutions, Inc.

418 Chapala Street, Suite H, Santa Barbara, CA 93101

Mission

To provide a reliable supply of quality water at the most reasonable cost to the present and future customers within the Goleta Water District.

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Abbreviations and Acronyms

AF	acre-feet
AFY	acre-feet per year
ASR	aquifer storage and recovery
Basin	Goleta Groundwater Basin
BMO	Basin Management Objective
CCWB	Central Coast Regional Water Quality Control Board
County	County of Santa Barbara
Court	Superior Court of California, County of Santa Barbara
DDW	Division of Drinking Water
District	Goleta Water District
DWR	California Department of Water Resources
GIS	geographic information system
Goleta Basin	Goleta Groundwater Basin
GSA	Groundwater Sustainability Agency
GSI	GSI Water Solutions, Inc.
GSP	Groundwater Sustainability Plan
GWD	Goleta Water District
GWMP	Groundwater Management Plan
InSAR	Interferometric Synthetic Aperture Radar
La Cumbre	La Cumbre Mutual Water Company
mg/L	milligrams per liter
Model	Goleta Groundwater Basin Numerical Model
Plan	Groundwater Management Plan
SAFE Ordinance	Safe Water Supplies Ordinance
SCADA	supervisory control and data acquisition
SGMA	Sustainable Groundwater Management Act
SNMP	Salt and Nutrient Management Plan
SWP	State Water Project
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
Wright Judgment	Goleta North-Central Groundwater Basin adjudication
WY	Water Year

1 Introduction

This document presents an update to the Goleta Groundwater Basin (Basin or Goleta Basin) Groundwater Management Plan (GWMP or Plan) originally adopted in 2010 by the Goleta Water District (GWD or District) and La Cumbre Mutual Water Company (La Cumbre) and updated in 2016 (GSI, 2016a). **Figure 1-1** shows the basin boundaries and the GWD and La Cumbre water service areas. The GWMP describes the physical and legal context of groundwater management in the Basin, addresses groundwater quantity and quality issues, reviews and updates previously adopted Basin Management Objectives (BMOs), and describes current and recommended future strategies.

The GWMP encourages continued implementation of existing groundwater management strategies, including:

- Aquifer Storage and Recovery (ASR) (drought buffer)
- Groundwater Monitoring
- The Goleta North-Central Groundwater Basin adjudication (Wright Judgment) and Safe Water Supplies Ordinance (SAFE Ordinance) Implementation
- Groundwater Modeling
- Wellhead Protection
- Cooperation with Other Agencies

The GWMP also recommends a number of additional "future" groundwater management strategies designed to improve overall management of the Basin and address potential undesirable results that could occur.

The remainder of this section summarizes the purpose and scope of the GWMP update and the existing legal and statutory groundwater management framework. Sections 2 through 6 present the various plan elements:

- **Section 2:** Groundwater Basin and Hydrogeology
- **Section 3:** Groundwater Pumping and Injection
- **Section 4:** Basin Yield and Storage
- **Section 5:** Basin Management
- **Section 6:** Recommended Future Strategies
- **Section 7:** References
- **Appendix A** includes the Salt and Nutrient Management Plan (SNMP) for the Basin.

FIGURE 1-1

Goleta Groundwater Basin with Service Areas of Goleta Water District and La Cumbre Mutual Water Company

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

GWD Service Area
La Cumbre MWC Service Area

Goleta Groundwater Subbasins

Central Subbasin
North Subbasin
West Subbasin

All Other Features

City Boundary
Major Road
Watercourse
Waterbody

NOTES

GWD: Goleta Water District
MWC: Mutal Water Company

N

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Miles

GSI Water Solutions, Inc.

Date: December 7, 2022
Data Sources: USGS, ESRI, Maxar Imagery (2021)

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1.1 Purpose and Scope

GWD and La Cumbre initially adopted the GWMP in 2010 under the authority provided in California Water Code Section 10750 et seq. The process of preparing and adopting the Plan included public meetings with input from stakeholders, public drafts circulated for comments, and adoption by both water purveyors. The original GWMP:

- Describes the Wright Judgment
- Describes the hydrogeology of the Central, North, and West subbasins
- Includes GWD's SAFE Ordinance (Section 1.2.3)
- Addresses groundwater issues
- Establishes the BMOs
- Outlines recommended management strategies for the Basin
- Recommends beneficial future tasks and associated timelines

As described in the 2010 GWMP, 5-year updates are both prudent for capturing changes to groundwater conditions and management strategies, and are also required for state-funded groundwater grants. The 2016 GWMP update (GSI, 2016a) and this 2022 update have been prepared to fulfill the 5-year update recommendation, and includes updates on:

- Current groundwater levels
- Groundwater quality
- Groundwater pumping
- Groundwater storage
- Modifications to groundwater management strategies and operating plans

Since the 2010 GWMP was developed, the groundwater management planning context has changed considerably. The original 2010 GWMP was developed at a time when there had been no drought in the Basin for approximately 20 years, and groundwater levels had been at or above the SAFE Ordinance Elevation for nearly a decade. Between publication of the 2010 GWMP and the 2016 update (GSI, 2016a), record-breaking drought conditions developed, and new regulatory requirements were put in place, affecting management of local and imported surface water supplies and groundwater. Since 2016, only 3 years have received above-average rainfall (2017, 2019, and 2023). In the winter of 2023, the Cachuma Project spilled for the first time since 2011.

GWD provides water service to a population of approximately 84,500 using a combination of surface water and groundwater supplies. Local surface water from the Cachuma Reservoir, operated by the U.S. Bureau of Reclamation (USBR), has historically been the principal source of supply with the exception of drought years when surface supply availability is reduced, particularly during the recent dry years from 2014 through 2018. From 2011 through 2020, average annual delivery of water from Cachuma Reservoir was 6,488 acre-feet per year (AFY), which represents approximately 70 percent of GWD's entitlement. At the height of the last drought in Water Year (WY) 2015 to 2016, GWD received a zero percent (0%) allocation of Cachuma water for the first time in history. In 2019, the State Water Resources Control Board (SWRCB) adopted Water Rights Order 2019-0148, which modified two USBR water right permits for the Cachuma Project with the purpose of protecting fishery flows and water right holders below Bradbury Dam. Although the Order requires the USBR to increase flows on the Santa Ynez River below Bradbury Dam, these releases are required only during wetter years, minimizing the impact on local water users.

A combination of regulatory requirements and drought conditions have affected imported water supplies from the State Water Project (SWP) since the original GWMP was developed. Table A[1] allocations from 2010 to 2015 averaged 43 percent, while allocations from 2016 through 2021 averaged 47 percent (60, 85, 35, 75, 20, and 5 percent, respectively) (DWR, 2023). During the drought years when surface water deliveries were reduced or unavailable, GWD was able to meet customer demand by increasing its groundwater production. This groundwater pumping drew from the drought buffer to meet existing customer demand established pursuant to the SAFE Ordinance because there was no additional SWP water available. The California Department of Water Resources (DWR) most recently updated its Table A projections in the SWP Final Delivery Capability Report 2021 (DWR, 2022). The final Table A allocation in 2022 was 5 percent. The initial Table A allocation for 2023 was 5 percent, and increased to 30 percent in February 2023 and again to 75% in March 2023, with a final allocation of 100% announced in April 2023 as a result of impoved water supply conditions. The long-term average projected Table A allocation moving forward is 56 percent, with allocations during a 2- to 6-year drought ranging from 17 to 28 percent.

Appendix A of this GWMP update presents an SNMP that was prepared to comply with the SWRCB's Recycled Water Policy. The Recycled Water Policy requires stakeholders to develop an implementation plan to meet basin-wide goals for management of salts and nutrients from all sources in a manner that optimizes recycled water use while ensuring protection of groundwater supply and beneficial uses, agricultural beneficial uses, and human health. The SNMP was developed at the level of specificity necessary to consider the potential impacts of existing and planned recycled water use and support the ongoing effective management of salts and nutrients in the Goleta Basin. The level of detail presented reflects the existing and planned conditions, and the SNMP provides a simplified analysis of salt and nutrient assimilative capacity, loading, fate and transport, and antidegradation, as well as laying out a process for evaluating potential future recycled water projects. No update of the SNMP has been required since it was originally developed in 2016, because there has been no substantially increased use of recycled water in the Basin or development of new projects that would potentially alter the plan implementation or impact groundwater quality. The SNMP may be updated at a future date if there is substantially more use of recycled water.

[1] Table A is used to define each SWP contractor's proportion of the available water supply that the California Department of Water Resources (DWR) will allocate and deliver to that contractor.

1.2 Groundwater Management Framework

The following subsections present the legal and statutory framework for management of the basin groundwater resources. A timeline of the legal and statutory actions affecting management of the Basin is presented as **Figure 1-2**.

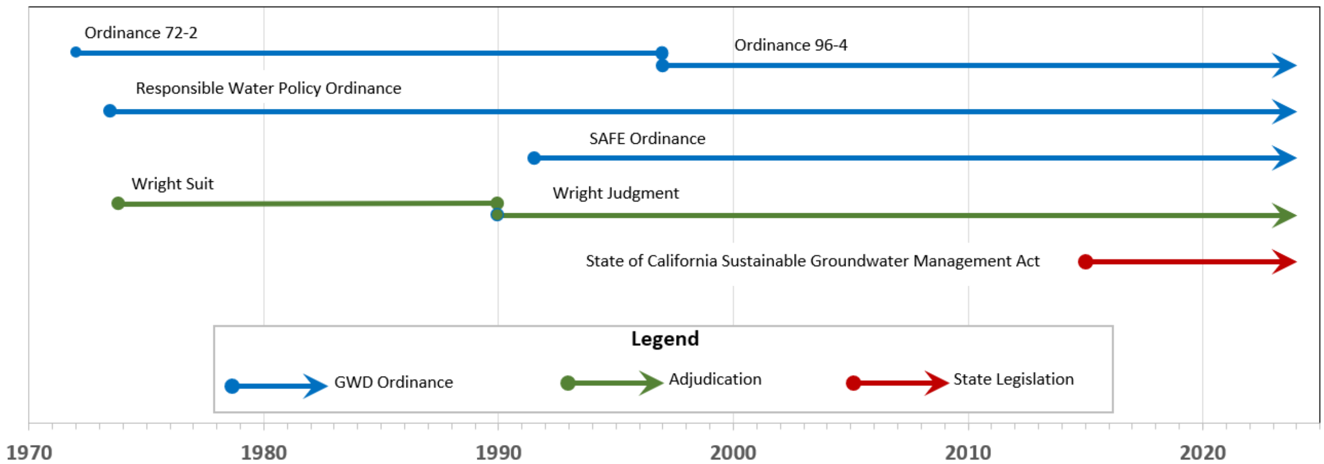

Figure 1-2. Timeline of Legal and Statutory Actions Affecting Management of the Goleta Basin

1.2.1 Pre-Wright Judgment

As the result of a long period of drier-than-average years from the 1940s to the 1970s, combined with population growth in the area, water supplies in the Basin began to fall short of demand by the 1970s. As a result, GWD adopted various ordinances to restrict the use of water. First, GWD adopted Ordinance 72-2, which imposed a moratorium on new water service connections. (The moratorium was eventually rescinded by Ordinance 96-4 in December 1996.) Over time, Ordinance 72-2 was modified to make exceptions for fire hydrant flow and service connections that would result in water savings to GWD. In May 1973, the Responsible Water Policy Ordinance was adopted by voter initiative to ban the importation of water from outside the County without voter approval, which was largely aimed at preventing GWD from connecting to the SWP. Because of these limitations, GWD relied on groundwater to serve customers, and significant pumping occurred in the Basin.

1.2.2 Wright Judgment

In 1973, a group of landowners filed suit for the adjudication of water rights in the Goleta North-Central Groundwater Basin (Wright v. Goleta Water District).[2] Including cross complaints and an appeal, the case took 2 decades to be decided; the decision was finalized in 1989 ("Wright Judgment") by the Superior Court of California, County of Santa Barbara (Court). The major elements of the Wright Judgment dealing with groundwater management include:

- Overlying landowners were assured of superior rights to groundwater pumping; overlying pumping was determined to be 351 AFY, which can increase without Court approval as long as there is no change in

[2] Martha H. Wright et al. v. Goleta Water District et al., 1989, Amended Judgment, Superior Court of Santa Barbara County Case No. SM57969.

how the pumped groundwater would be used (e.g., change of use would be conversion of agricultural to urban use).

- La Cumbre was given a senior appropriative right to extract 1,000 AFY from the Basin (calculated on a 10-year running average), plus any Temporary Surplus.[3]
- GWD was given an appropriative right to extract 2,000 AFY from the Basin, plus any Temporary Surplus.
- The total safe yield of the Basin was determined to be 3,410 AFY.
- Perennial yield, which included 350 AFY for GWD injection well system and 100 AFY of return flow (applied water that percolates back to the aquifer), was determined to be 3,700 AFY.
- GWD was required to submit a Water Plan to the Court, including plans for the development of supplemental supplies; the Water Plan's objective was to bring the Basin into hydrologic balance by 1998.
- A status report on the Basin is to be filed with the Court on an annual basis.
- Overlying pumpers may transfer their water right and well(s) to GWD in return for service from GWD. Such exchanges have added 357 AFY of water rights to GWD as of 2022 (**Table 1-1**).
- GWD may inject water into the Basin using La Cumbre wells until 1998; after 1998, La Cumbre and GWD have the sole right to store water in the Basin.
- The Court assumes continuing jurisdiction in the Basin.
- In 1992, the Court reaffirmed the continuing right of GWD to store up to 2,000 AFY in the Basin.[4]
- In 1998, the Court found that the Basin was in Hydrologic Balance[5] and that summary annual reports to litigation parties could replace annual reports to the Court.[6] It also confirmed GWD's storage of 18,084 acre-feet (AF) as of 1998.

[3] Temporary Surplus is defined in the Wright Judgment as "The amount of water that can be extracted from the Basin in any Water Year in excess of the Basin's Safe Yield."
[4] Martha H. Wright et al. v. Goleta Water District et al., 1992, Order Regarding Goleta's Right to Store Water in the North Central Basin, Superior Court of Santa Barbara County Case No. SM57969.
[5] As it pertains to the Basin as a whole, Hydrologic Balance exists when the perennial recharge exceeds the perennial extractions from the Basin.
[6] Martha H. Wright et al. v. Goleta Water District et al., 1998, Order Regarding Goleta Water District's Tenth Annual Report, Superior Court of Santa Barbara County Case No. SM57969.

Table 1-1. Goleta Water District Water Rights under the Wright Judgment, as Filed in the Goleta Water District Annual Reports

Year	Base Water Right (AFY)	Exchanges To-Date (AFY)	Total Water Right (AFY)
1992	2,000	23	2,023
1993	2,000	37	2,037
1994	2,000	51	2,051
1995	2,000	51	2,051
1996	2,000	175	2,175
1997	2,000	224	2,224
1998	2,000	226	2,226
1999	2,000	226	2,226
2000	2,000	226	2,226
2001	2,000	226	2,226
2002	2,000	226	2,226
2003	2,000	350	2,350
2004	2,000	350	2,350
2005	2,000	350	2,350
2006	2,000	350	2,350
2007	2,000	350	2,350
2008	2,000	350	2,350
2009	2,000	357	2,357
2010	2,000	357	2,357
2011	2,000	357	2,357
2012	2,000	357	2,357
2013	2,000	357	2,357
2014	2,000	357	2,357
2015	2,000	357	2,357
2016	2,000	357	2,357
2017	2,000	357	2,357
2018	2,000	357	2,357
2019	2,000	357	2,357
2020	2,000	357	2,357
2021	2,000	357	2,357
2022	2,000	357	2,357

Notes

AFY = acre-feet per year

As a result of the Wright Judgment, GWD was initially required to file a report annually to the Court. In 1998, the Court determined that GWD had achieved Hydrologic Balance as that term is defined in the Wright Judgment, and that GWD had successfully complied with the Wright Judgment. The Court allowed GWD to simplify its annual report and streamline the information reported to the Court and the parties to the litigation. The annual report in its present form itemizes extractions from the Basin, groundwater storage, and changes in groundwater elevations from key index wells. GWD has in the past stored water in the Basin by direct injection, and by taking Cachuma water and its SWP water allocation in lieu of pumping its groundwater right, resulting in 46,014 AF of stored water at the end of 2021 (Section 4.2). From a planning perspective, it is important to note that the amount of groundwater physically stored in the Basin likely differs from the volume listed in the annual reports, and physical limitations prevent GWD from recovering the full amount of groundwater that is actually in storage at any given time. These concepts are developed further in Section 4.2 together with estimates of recoverable groundwater storage.

1.2.3 Goleta Water District's SAFE Ordinance

During the 1987 to 1992 drought, it became clear that water deliveries from Lake Cachuma would likely be insufficient to meet demand during a prolonged drought, and GWD customers voted to authorize the importation of SWP water. As part of the authorization for acquiring SWP water, the SAFE Ordinance was approved by GWD voters in 1991 and amended in 1994.[7] The SAFE Ordinance amended and partially superseded its predecessor, the Responsible Water Policy Ordinance. The key elements of the SAFE Ordinance include:

- The SAFE Ordinance established a "Drought Buffer" based on 1972 groundwater levels. The 1972 groundwater levels were evaluated in detail during development of the original GWMP, and seven wells were recommended for use in implementing the SAFE Ordinance, which are referred to as the "Index Wells." (Details about the Index Wells are provided in **Table 5-7** and the wells are shown in **Figure 2-4**. Information concerning the selection of the Index Wells is presented in Section 5.2.4.)
- GWD is authorized to acquire an additional entitlement to the SWP in an amount of up to 2,500 AFY to supplement its allocation of 4,500 AFY.
- GWD will plan for the delivery of 3,800 AFY of SWP water as the amount of firm average long-term yield (this was based on the then-current availability calculations by the State Water Contractors), which includes the basic allocation of 4,500 AFY, the 2,500 AFY supplement, and GWD's share of the drought buffer held by the Central Coast Water Authority.
- After serving existing customers, any excess water actually delivered over 3,800 AFY will be stored in the Central subbasin until the Basin is replenished to its 1972 level. This "drought buffer" is designated for use during drought conditions. An "Annual Storage Commitment" of at least 2,000 AFY is required for replenishment to 1972 levels (first instituted in 1997). Through 2021, 46,025 AF of water was added to basin storage through direct injection and using other water supplies in lieu of pumping groundwater.
- The drought buffer can only be used for delivery to existing customers when a drought on the South Coast causes a reduction in GWD's annual deliveries from Lake Cachuma, and it cannot be used as a supplemental supply for new or additional water demands.
- After the Basin has recovered to 1972 levels, GWD can again use the yield of the Basin to provide water service to existing customers. Previously, it was estimated in 2008 that groundwater storage in the Central subbasin was 6,000 to 12,000 AF above 1972 levels (this was at a time when water levels were at nearly historical high levels [GWD, 2008]). More recently, results from the Goleta Groundwater Basin Numerical Model (the Model) suggested that the volume of groundwater storage between historical high

[7] GWD Ordinances No. 91-01 and 94-03.

groundwater levels and 1972 levels is approximately 10,000 AF, and the recoverable storage volume for the GWD drought buffer defined between 1972 and historical low water levels is approximately 23,000 AF, depending on pumping rates. Storage is discussed further in this Plan (Section 4).

- For each year that all other obligations for water delivery have been met, GWD is authorized to release 1 percent of its total potable water supply to new or additional service connections. When new or additional service connections are issued, the Annual Storage Commitment for the drought buffer must permanently increase by ⅔ of the new demand. The requirements for allowing new service connections were met between 1997 and October 1, 2014, with new service connections adding 713 AFY of demand, resulting in an increase of the Annual Storage Commitment to 2,477 AFY from the original Annual Storage Commitment of 2,000 AFY. In accordance with the SAFE Ordinance, a moratorium on new service connections was implemented in October 2014 because of reduced Cachuma Project allocations (GWD, 2014). Although the USBR issued a 100 percent allocation of Cachuma Project water for WY 2018 to 2019, the District determined that all of its available water supplies were needed to serve existing customers and it did not have additional supplies to meet its Annual Storage Commitment under the SAFE Ordinance. Therefore, the moratorium on additional service connections remains in place as of this GWMP update.

1.2.4 Interaction of Wright Judgment and the SAFE Ordinance

The Wright Judgment (which applies to GWD and La Cumbre) and the SAFE Ordinance (which applies to GWD only) work together, with the Wright Judgment quantifying and defining the amount of groundwater production and drought storage, and the SAFE Ordinance specifying both the quantity and timing of storage and the rules for extracting water from the drought buffer. Groundwater storage under the Wright Judgment is intended to augment the basin yield assigned to La Cumbre and GWD. The water can be stored at any time using both in lieu recharge (groundwater pumping reduced by using other sources of water) and direct injection methods. There are no restrictions in the Wright Judgment as to the timing and rate of extraction of the stored water. An annual accounting of water stored under the Wright Judgment is maintained by GWD.

As indicated in **Table 1-2**, groundwater storage under the Wright Judgment is simple: an entity is entitled to extract the amount that it has previously stored. It is similar to having a bank account. However, the amount of groundwater physically stored in the Basin likely differs from that which is assumed in the Wright Judgment, and physical limitations prevent GWD from recovering the full amount groundwater that is actually in storage at any given time.

The SAFE Ordinance for GWD is quite different. It is not a bank account, but an operational plan that sets rules to augment the storage quantified in the Wright Judgment. The rules for the SAFE Ordinance are based on two criteria: (1) whether groundwater elevations are below 1972 levels and (2) whether Cachuma deliveries have been curtailed. The SAFE Ordinance creates a drought buffer by filling the Basin up to 1972 levels; thus, the buffer is defined not by the amount of water that was stored, but by the increase in groundwater elevations that was achieved. Although the SAFE Ordinance does not refer to storage volumes, it is important to know from a water supply planning and operations perspective how much water is recoverable using GWD wells during a drought. These concepts are developed further in Section 4.2 together with estimates of recoverable groundwater storage.

Table 1-2. Differences between Storage Requirements for the Wright Judgment and the SAFE Ordinance

	Wright Judgment (GWD and La Cumbre)	SAFE Ordinance (GWD only)
Annual Storage Commitment	None	Requirement when groundwater elevations are below 1972 levels
Limit on When Stored Water Can Be Pumped	None	In years when groundwater elevations are above 1972 levels or when drought reduces annual deliveries from Lake Cachuma
Annual Limit on Quantity of Stored Water That Can Be Pumped	None	None
Limit on Total Amount of Stored Water That Can Be Pumped	Cannot exceed the amount stored by GWD or La Cumbre	None

Notes

GWD = Goleta Water District SAFE Ordinance = Safe Water Supplies Ordinance

The SAFE Ordinance has worked well during the storage phase of the drought buffer. Groundwater elevations in the Basin rose for almost 20 years and were above 1972 levels for 13 years between 2002 and 2015 (**Figure 6-3**). As planned, GWD used the drought buffer for its intended purpose during the 2012 to 2018 drought. Groundwater levels fell below 1972 levels after approximately 2 years of drought pumping that began in 2013 and have remained below 1972 levels since 2015.

Additionally, in December 2015, GWD acquired 2,500 AF of supplemental water from another SWP contractor through the Central Coast Water Authority's Supplemental Water Purchase Program and began taking delivery of the supplemental water in 2016. This includes 1,000 AF from the City of Santa Maria, and 1,500 AF from Santa Clarita Valley Water Agency. Since 2016, GWD has not acquired additional supplemental water.

Future reliability of all of GWD's water sources is examined in GWD's *Water Supply Management Plan, 2017 Update* (Bachman and BGC, 2017), and additional recommendations are provided in GWD's 2020 *Urban Water Management Plan*. These plans explore the probability and consequences of various scenarios to ensure that GWD will continue to be able to meet demand under a range of drought conditions and potential reductions in surface water supplies. The scenarios investigated underscore the importance of maximizing injection capacity to help refill the Basin as quickly as possible after any use of the drought buffer.

1.2.5 Sustainable Groundwater Management Act

In 2015, the Sustainable Groundwater Management Act (SGMA) was enacted to provide for the sustainable management of groundwater basins in California. SGMA planning requirements are mandatory for the high- and medium-priority groundwater basins identified by DWR. In these basins, qualifying local agencies are required to create a Groundwater Sustainability Agency (GSA) and adopt a SGMA-compliant Groundwater Sustainability Plan (GSP). DWR Bulletin 118 identifies the groundwater basin boundaries (DWR, 2004).

The Goleta Basin (DWR Basin No. 3-16) was initially considered a medium-priority basin; however, the SGMA 2019 Basin Prioritization process reassessed the priority of the groundwater basins following the 2016 basin boundary modifications, and the Goleta Basin was subsequently reclassified as a very low-priority basin. This reclassification was based on DWR's determination that the Basin is a "Basin with Adjudication and Non-Adjudicated Groundwater Use <9,500 AF." Therefore, the Basin is not required to form a GSA or adopt a GSP. GWD, the County, and the City of Goleta all made decisions not to form a GSA for portions of the Basin not subject to the adjudication, which would be allowable but not required under SGMA. As a very low-priority basin, GWD is permitted to update this Plan pursuant to California Water Code Section 10750.1(b).

2 Groundwater Basin and Hydrogeology

2.1 Basin Boundaries

The Basin is divided into three subbasins: the Central subbasin, where the majority of the extractions occur; the West subbasin, which is generally shallower and has the least extractions; and the North subbasin (**Figure 2-1**). The boundaries of these subbasins, and of the Basin as a whole, vary among investigators. Some of the boundaries coincide with faults that are mapped at the surface or are inferred from hydrogeologic evidence, such as large differences in groundwater elevations on each side of the "fault." Other boundaries are defined by the thinning edges of water-bearing strata against bedrock highs and upstream valleys. Because of the differences in interpretations of this evidence, Basin and subbasin boundaries have been drawn differently.

The DWR Bulletin 118 groundwater basin boundaries (DWR, 2004) to be used for management purposes under SGMA do not necessarily coincide with the basin boundaries described by local investigators or established by the Wright Judgment. As described above, the Goleta Basin is classified as a very low-priority basin under SGMA and is not required to develop a GSP, so GWD has continued to manage its groundwater resources in the Basin using its GWMP in conjunction with other planning documents, such as its *Urban Water Management Plan* and *Water Supply Management Plan, 2017 Update* (Bachman and BGC, 2017).

2.1.1 Boundary of Overall Basin

The boundaries of the overall Basin have been mapped differently by local investigators and DWR. As described in the following sections, there are several areas where the DWR Bulletin 118 basin boundary (DWR, 2004) does not coincide with the boundary established pursuant the Wright Judgment for the North-Central subbasins and the extent of the Basin as understood by local investigators and GWD.

2.1.1.1 Southern Basin Boundary – Wright Judgment Area

The southern boundary of the Basin is defined by the trace of the More Ranch Fault (**Figure 2-1**), where consolidated rocks of Tertiary age are uplifted along the south side of the fault and form a hydrologic barrier between the ocean and the water-bearing deposits of the groundwater basin (Upson, 1951). The location of the More Ranch Fault has varied slightly among investigators and was most recently updated by the U.S. Geological Survey (USGS) in 2009 (Minor et al., 2009). As shown in **Figure 2-1**, the updated location of the More Ranch Fault lies north of the Wright Judgment boundary in some areas and south of it in others. DWR's Bulletin 118 basin boundary lies north of both the USGS More Ranch Fault location and the Wright Judgment boundary (DWR, 2004). A small portion of the Basin near the Santa Barbara Municipal Airport lies south of both the Wright Judgment and DWR Bulletin 118 boundaries.

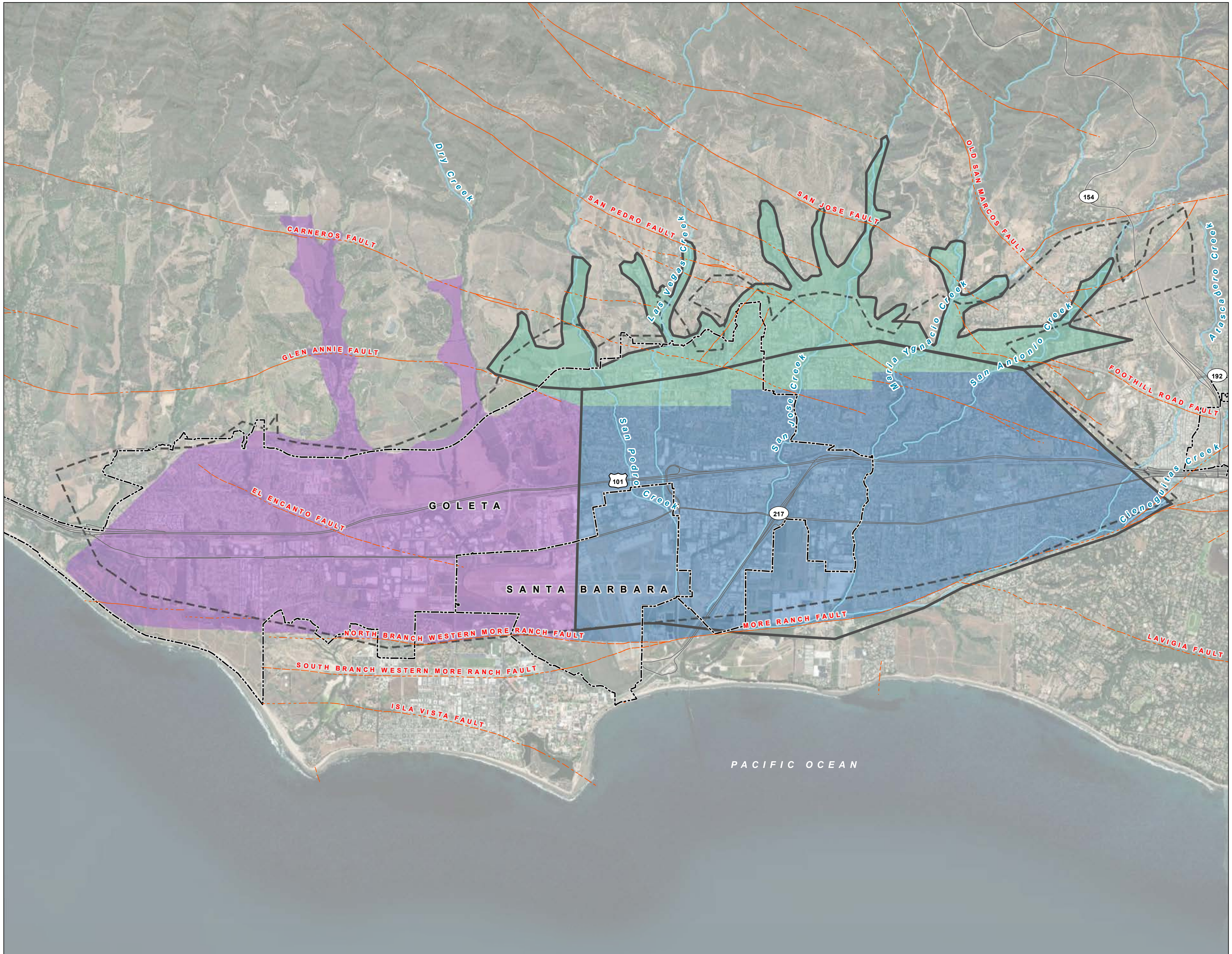

FIGURE 2-1

Basin and Subbasin Boundaries

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Wright Adjudication Judgement Boundary

DWR Bulletin 118 Groundwater Basin Boundary

Goleta Groundwater Subbasins

Central Subbasin

North Subbasin

West Subbasin

Fault

Fault

Fault (Inferred)

Fault (Approximate)

All Other Features

City Boundary

Major Road

Watercourse

NOTE

DWR: California Department of Water Resources

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Feet

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

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2.1.1.2 Eastern Basin Boundary – Wright Judgment Area

The eastern boundary of the Basin historically has been defined as the location of the Modoc Fault. The Modoc Fault has been considered to be a hydrologic barrier, although USGS suggested that along the eastern boundary near its southern juncture with the More Ranch Fault, groundwater discharges freely from the adjacent Foothill Groundwater Basin on the east into the Goleta Basin (Freckleton, 1989).

Upson (1951) determined the location of the barrier based on differences in water-level elevations and the lack of transmission of pumping effects across the fault. Upson (1951), Evenson et al. (1962), and Mann (1976) indicated that the quantity of groundwater moving across the boundary historically has been small. USGS also considered the eastern boundary of the Basin as the Modoc Fault in a water resources paper (Kaehler et al., 1997). A more recent surface geology map by USGS (Minor et al., 2009) did not identify the Modoc Fault; instead, it identified faults and folds across a half-mile-wide deformation zone that encompasses the various locations of the boundary by a number of investigators (**Figure 2-1**). There are no known groundwater wells within this zone of deformation. The eastern basin boundary in the Wright Judgment is within this zone of faulting and folding. DWR's Bulletin 118 (DWR, 2004) also maps the basin boundary within the zone of deformation, but several hundred feet to the east of the Wright Judgment boundary. Further, the northern extent of the eastern basin boundary differs notably between DWR Bulletin 118 and the Wright Judgment. DWR Bulletin 118 places an approximate 0.15-square-mile portion of the Wright Judgment area in the Foothill Basin.

2.1.1.3 Northern Basin Boundary – Wright Judgment Area

The northern boundary of the Basin has been defined by the northern edge of water-bearing sediments as they abut or thin out against older more-consolidated sediments. The exact location of the boundary varies with the investigator. DWR's Bulletin 118 boundary does not include portions of the alluvial canyons that extend to the north, which are included in the Wright Judgment boundary. These alluvial canyons could be interpreted as part of the Goleta Basin. Another difference is that the DWR Bulletin 118 basin boundary (DWR, 2004) includes areas north of the Wright Judgment in between the alluvial canyons. These areas are not considered by local investigators to be part of the Basin, and there are no known water wells in these areas that draw from basin sediments.

2.1.1.4 Basin Boundary – West Subbasin Area

As shown in **Figure 2-1**, the DWR Bulletin 118 boundary and the West subbasin boundary historically mapped by GWD differ notably along the northern, western, and southern reaches. The technical basis of the basin boundary for the West subbasin may be reviewed in detail to determine if it supports the DWR Bulletin 118 boundary, in which case GWD may adopt it moving forward. The West subbasin is only partially adjudicated, and it is considered separate from the adjudicated North and Central subbasins in the Wright Judgment. GWD does not pump any groundwater from the West subbasin.

2.1.2 Subbasin Boundaries

The boundaries between subbasins within the Basin have been defined either by the location of suspected faulting or by changes in hydrologic properties across the boundary (**Figure 2-1**). None of the subbasin boundaries coincides with surface traces of faults mapped by USGS (Minor et al., 2009).

Upson (1951) stated that the "Goleta Fault" and extensions of the Carneros and Glen Annie faults all inhibit the movement of groundwater in the main aquifers in the Basin. Upson (1951) located the east-west trending boundary-based differences in water levels and lack of transmission of pumping effects across the inferred trace at several sites. Evenson et al. (1962) proposed a slightly different location for the North subbasin boundary and stated that groundwater moves across this hydrologic barrier in the upper part of the groundwater system. The subbasin boundaries in the Wright Judgment largely follow Evenson et al. (1962). The North subbasin's southern boundary was subsequently moved about 1,000 feet farther south in reports to the GWD (CH2M HILL, 2006). For this Plan, the North subbasin boundary approximately follows this interpretation by CH2M HILL (2006)and the Glen Annie fault outside of the groundwater model domain. However, for discussion of water rights issues, the Wright Judgment boundary must be used; differences between the two will be called out in the Plan when necessary.

The north-south-trending boundary between the Central and West subbasins is characterized by significant changes in water quality and hydraulic characteristics thought to be related to different sediment types and thicknesses (GWD, 2008). Evenson et al. (1962) believed that there were differences in water levels in wells and in water level trends across the boundary. Mann (1976) documented water quality differences on opposite sides of the boundary. Evenson et al. (1962) attributed the boundary to a lateral change in permeability caused by a facies change[8] in the sediments or by faulting in the unconsolidated sediments. The location of the subbasin boundary varies among investigators by 2,500 feet in an east-west direction. The boundary used in this Plan is from the Wright Judgment due to its water rights implications and is generally consistent with the subbasin boundary in the Model (CH2M HILL, 2010).

2.2 Basin Aquifers

The Basin is bounded by consolidated rocks of Tertiary age. The principal water-bearing units are younger alluvium of Holocene age, terrace deposits and older alluvium of Pleistocene age, and the Santa Barbara Formation of Pleistocene age (Kaehler et al., 1997). The younger and older alluvium are generally less than 250 feet thick, and the Santa Barbara Formation is as much as 2,000 feet thick.

The Santa Barbara Formation is the primary water-bearing unit in the Basin and is composed primarily of marine sand, silt, and clay. The hydrostratigraphy of the Basin has been divided into hydrostratigraphic zones based on geologic and geophysical logs (CH2M HILL, 2006). From youngest to oldest, the zones that produce meaningful amounts of groundwater include:

- An Upper Producing Zone consisting of alternating sequences of sands, silts, and sandy clays that attain a maximum thickness of up to 600 feet. In the Central subbasin, most wells produce from this zone.
- A Lower Producing Zone consisting of clean fine sands and silt about 200 feet thick in the Central subbasin. This zone is separated from the Upper Producing Zone by a clay-rich aquitard. Some GWD and La Cumbre wells produce from this zone in addition to the Upper Producing Zone.

The hydraulic connection between the Upper and Lower Producing Zones is not well understood. Groundwater elevations measured from wells in each zone have generally been combined when water level contours have been constructed.

2.3 Sources of Recharge and Recharge Areas

California Assembly Bill 359 (2011) requires that GWMPs identify and map groundwater recharge areas. The recharge areas within the Basin are depicted in **Figure 2-2**. The major sources of recharge (other than artificial recharge by the water agencies) to the Basin are likely infiltration from rainfall, percolation from streambeds draining upland areas, subsurface inflow from alluvial canyons underlying the streambeds along the northern boundary of the Basin, deep percolation of irrigation waters, and underflow from the adjacent (largely upslope) consolidated bedrock units. Rainwater falling on the consolidated bedrock in the upland areas percolates along fractures and bedding plains in the bedrock. A portion of that groundwater

[8] The term "facies change" refers to a spatial transition in the depositional characteristics of a rock unit; for example, the transition from near shore, sandy deposits to fine-grained shelf deposits.

discharges to nearby springs and stream channels and flows as surface water and alluvial groundwater present in the stream channels, which then flows into the basin sediments. A portion of this groundwater also discharges from the bedrock directly into the basin sediments. This is commonly referred to as mountain front recharge. Downward leakage from streams draining upland and bedrock areas in the unconfined portion of the North subbasin provides recharge to the Central subbasin. Throughout the Central subbasin and much of the West subbasin, there is a clay layer or other less-transmissive layer above the basin aquifers (a “confining layer”), that limits downward percolation of water from the surface. In these areas, the aquifers that are below the confining layers must receive their recharge by horizontal flow within the aquifer from other areas where confining layers are absent (i.e., groundwater flow from the North subbasin and western portion of the West subbasin). For the Central subbasin to receive recharge from the adjacent North subbasin (which is largely unconfined), the proposed fault(s) that separates the subbasins must be “leaky” (i.e., it is only a partial barrier to groundwater flow), allowing some groundwater to flow through the fault plane into the Central subbasin.

Confining layers occur in the seaward portion of the Basin. One of the areas where there is little or no connection of surface waters and aquifer waters is around the tidal channels that comprise much of the seaward portion of the Basin. If there were vertical communication between the tidal waters and the aquifers, groundwater would be as salty as the tidal waters. There has been disagreement among researchers as to how far the coastal confining layers extend inland. Upson (1951) considered much of the area south of Cathedral Oaks Boulevard to the ocean as having confined conditions. This effectively eliminates much of the central area of the Basin from recharge by percolation from overlying sources. Upson estimated that an average of about 3,100 AFY of rainfall and stream infiltration reach the aquifer. In contrast, Evenson et al. (1962) considered the confined area to be much smaller, increasing the area for direct recharge from surface sources.

FIGURE 2-2

Recharge Areas, Streams, and USGS Gauge Locations within the Goleta Groundwater Basin

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

- USGS Gauge - Active
- USGS Gauge - Inactive
- Recharge Area

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTE

USGS: United States Geological Survey

N

0 1,900 3,800 5,700
Feet

GSI Water Solutions, Inc.

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-2_RechargeAreas.mxd, abarry

2.4 Groundwater Elevations

Groundwater elevations have been collected from wells in the Basin since at least the 1940s. These records have now been compiled in digital databases for easy analysis. In 2008, GWD contracted a land survey of all wells used for monitoring groundwater elevations, so both the location and the elevation of the wells are known with some accuracy.

Contours of water level elevations above mean sea level from the April 2021 measurements are shown in **Figure 2-3**. The regional groundwater gradient is generally from north to south, with localized depressions near pumping wells. This gradient reflects the movement of recharge water from the recharge area in the northern portion of the Basin toward the areas where pumping is highest in the Central subbasin. The groundwater elevations change approximately 50 feet across the boundary between the North and Central subbasins, suggesting that the boundary is a partial barrier to groundwater flow. Groundwater elevations are lowest in the southeastern portion of the Central subbasin (deeper than 100 feet below sea level in 2021), which is the result of focused pumping in this area and limited groundwater flow from the south and east. The overall groundwater flow pattern is consistent with historical conditions and reflects additional pumping beginning in 2013 because of drought conditions.

The analysis of groundwater elevations is divided into the three subbasins because each subbasin shows a different historical trend. The locations of the wells used in the hydrograph displays are presented in **Figure 2-4**.

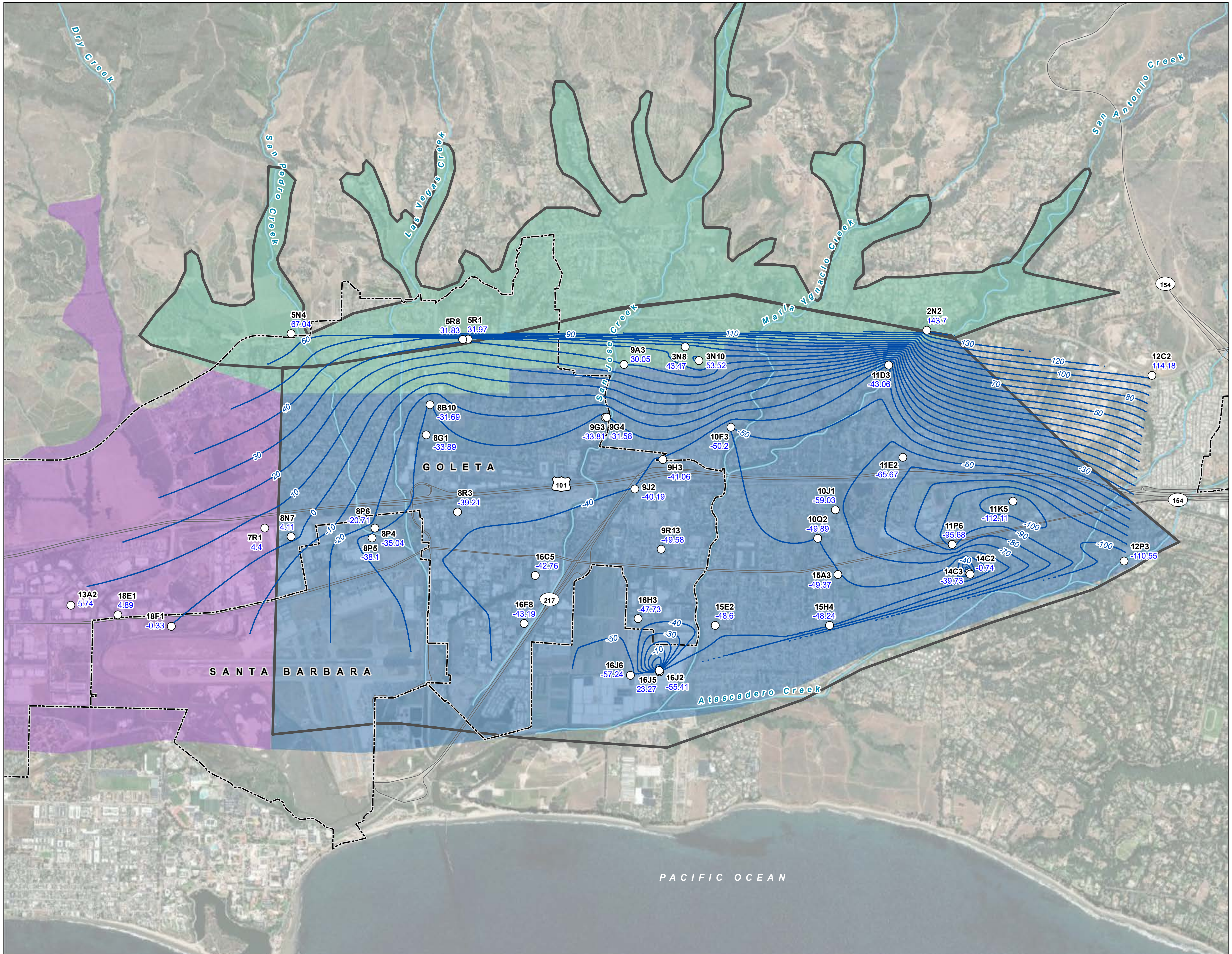

FIGURE 2-3

Groundwater Contour Map - April 2021 Water Levels

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

- Monitoring Well
  Water Level Elevation (feet above MSL)
- Water Level Elevation Contour (feet above MSL, 10 foot interval)
- Wright Adjudication Judgement Boundary

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTE

MSL: mean sea level

N

0 1,250 2,500 3,750
Feet

Date: December 7, 2022
Data Sources: USGS, ESRI, Maxar Imagery (2021)

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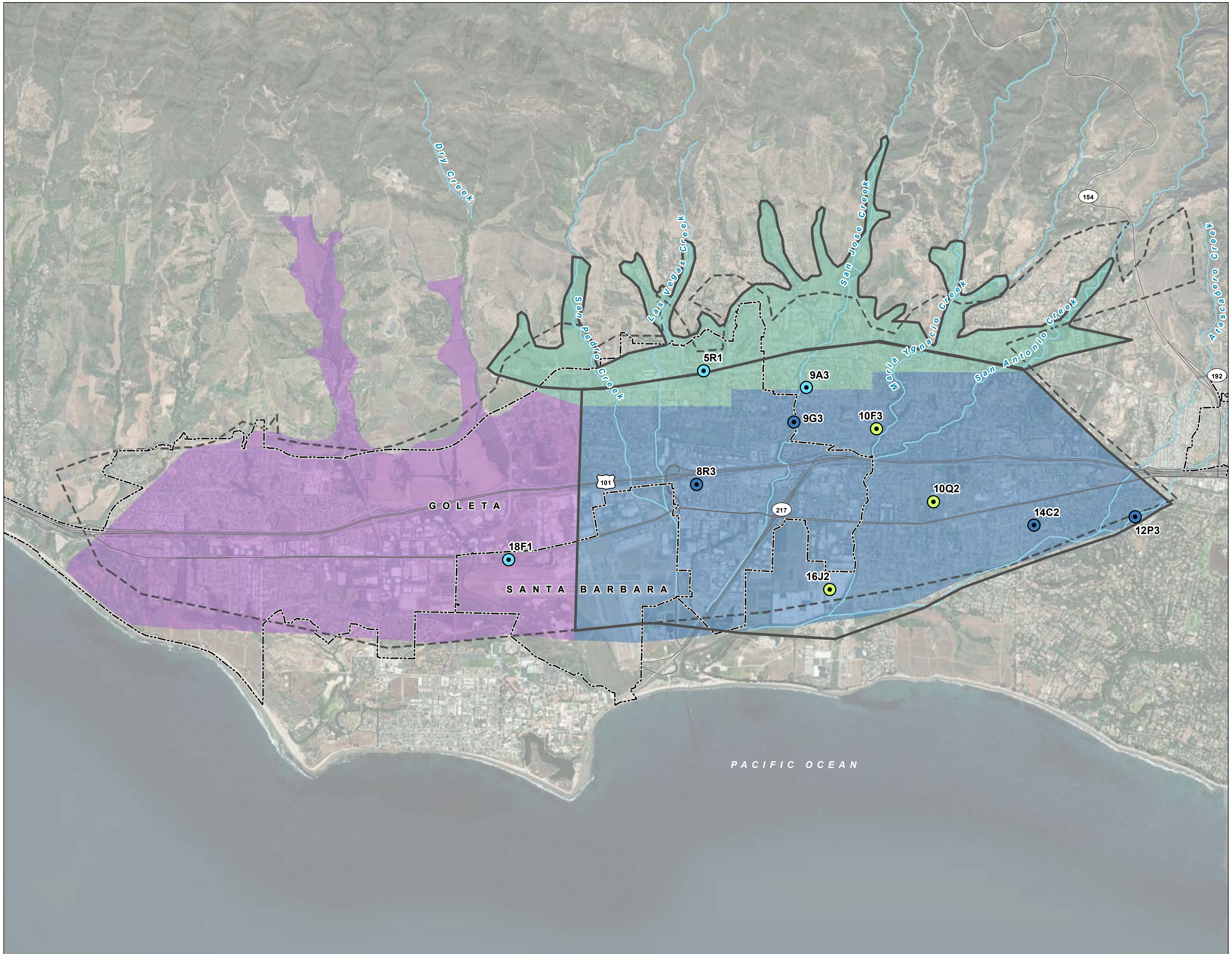
Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Figure2-3_GW_Contours_April2021.mxd, abarry

FIGURE 2-4

Location of Index and Hydrograph Wells

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update



LEGEND

- Index Well with Hydrographs
- Index Well without Hydrographs
- Hydrograph Well
- Wright Adjudication Judgement Boundary
- Groundwater Basin Boundary

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

N

0 1,900 3,800 5,700
Feet

Date: December 7, 2022
Data Sources: USGS, ESRI, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Figure2-4_Index_Hydrograph_Wells.mxd, abarry

2.4.1 Central Subbasin

Groundwater elevations in the Central subbasin have fluctuated by almost 150 feet during the last 80 years. The wet climatic cycle ending in the 1940s is commonly the high historical groundwater elevation in many coastal basins of California; however, in the Central subbasin, high groundwater elevations in the 1940s were matched in many wells during subsequent wet periods in the early 1970s and again in the early 2010s. Drought conditions beginning in 2012 and increased groundwater pumping by GWD beginning in 2013 caused water levels to decline through 2017. These declining trends generally leveled off and even reversed in some wells since 2017 following above average rainfall and reduced groundwater pumping (**Figures 2-6** through **2-10**).

When groundwater basins are being pumped within the yield of the basin and the primary sources of recharge to the basin are dependent on rainfall and runoff (as is the case in the Goleta Basin), hydrographs commonly reflect the local climatic patterns. Precipitation patterns can be represented by a cumulative departure curve, such as shown in **Figure 2-5**, where downward sloping line segments indicate periods of less rainfall (dry or drought conditions), and the upward sloping line segments indicate wet periods. For the Basin, the lowest cumulative departure from mean precipitation occurred in the late 1960s and early 1970s.

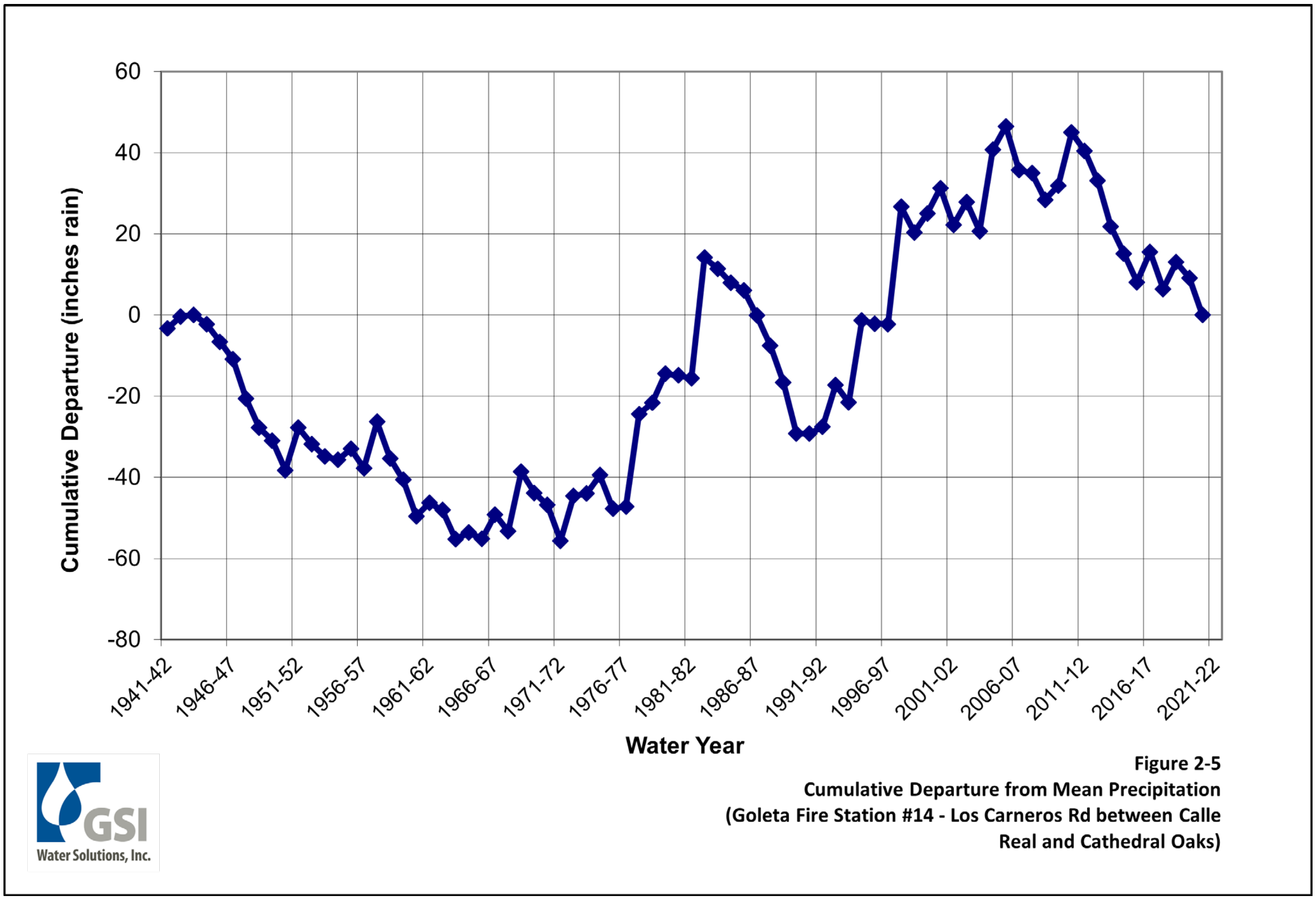


Figure 2-5. Cumulative Departure from Mean Precipitation (Goleta Fire Station #14 - Los Carneros Rd between Calle Real and Cathedral Oaks)

However, hydrographs for the Central subbasin do not consistently track that pattern (**Figures 2-6** through **2-10**). In **Figure 2-7**, the cumulative departure curve is superimposed on the hydrograph for Well 14C2. As indicated, the water level elevations tracked the cumulative departure into the late 1950s, but then diverged. During the late 1950s to the early 1970s, groundwater elevations were rising during drier-than-normal conditions. However, as rainfall increased during the 1970s to 1983, groundwater elevations dropped. The climatic trend and the groundwater level trend were mostly synchronous from the 1990s through the early 2010s before diverging again. The fact that the water level patterns do not always follow the cumulative departure curve suggests that basin groundwater levels are heavily influenced by pumping.

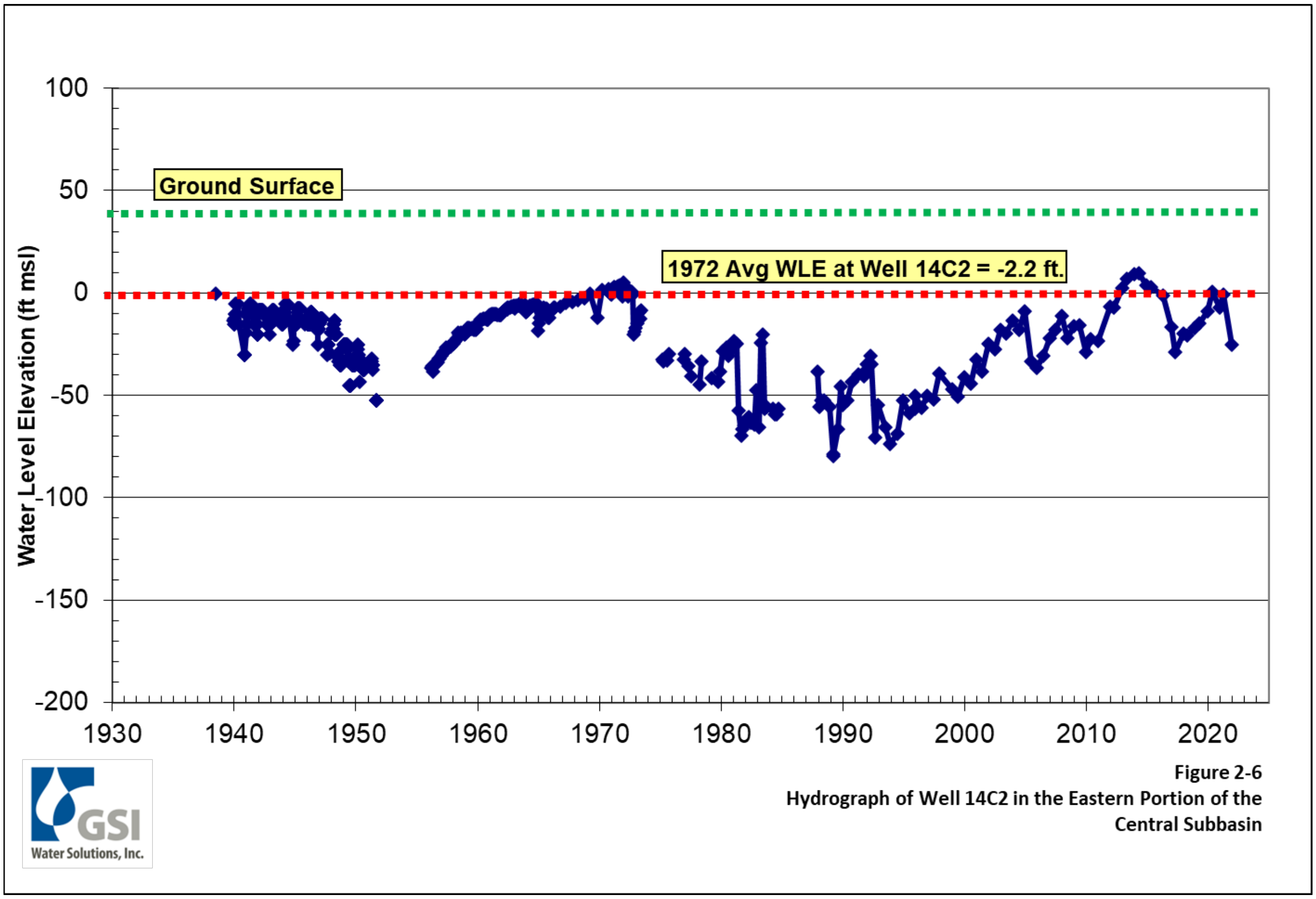


Figure 2-6. Hydrograph of Well 14C2 in the Eastern Portion of the Central Subbasin

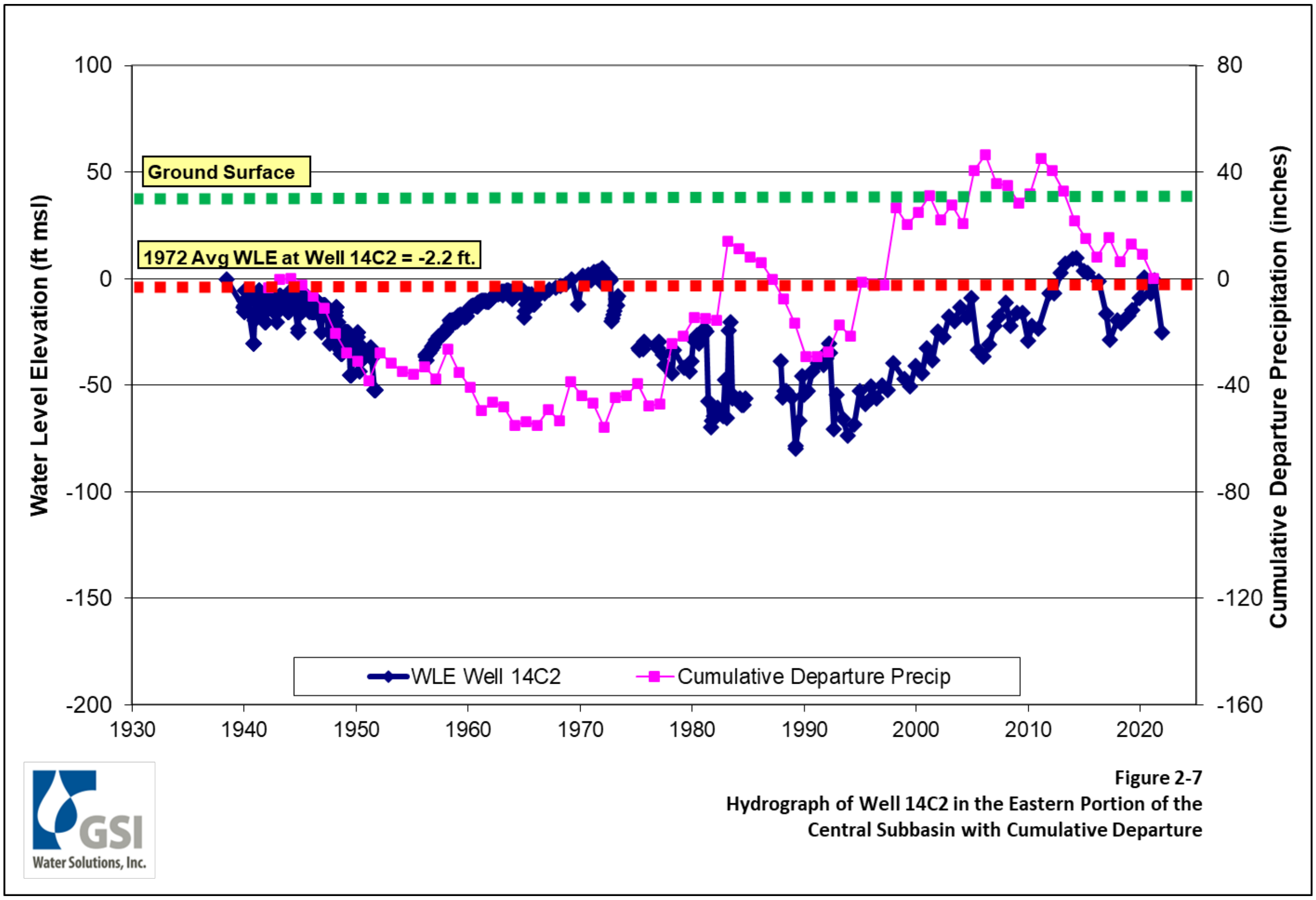


Figure 2-7. Hydrograph of Well 14C2 in the Eastern Portion of the Central Subbasin with Cumulative Departure

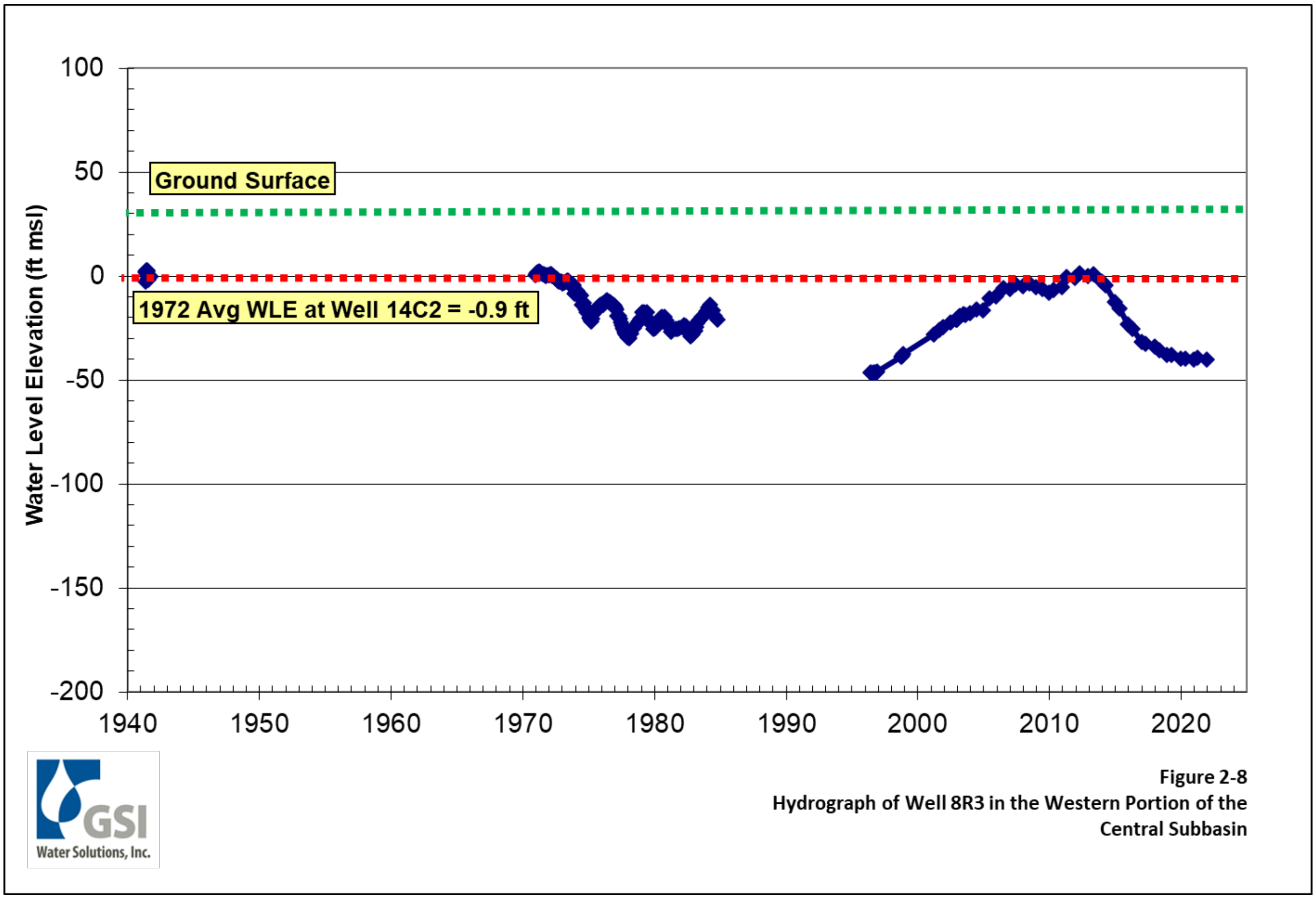


Figure 2-8. Hydrograph of Well 8R3 in the Western Portion of the Central Subbasin

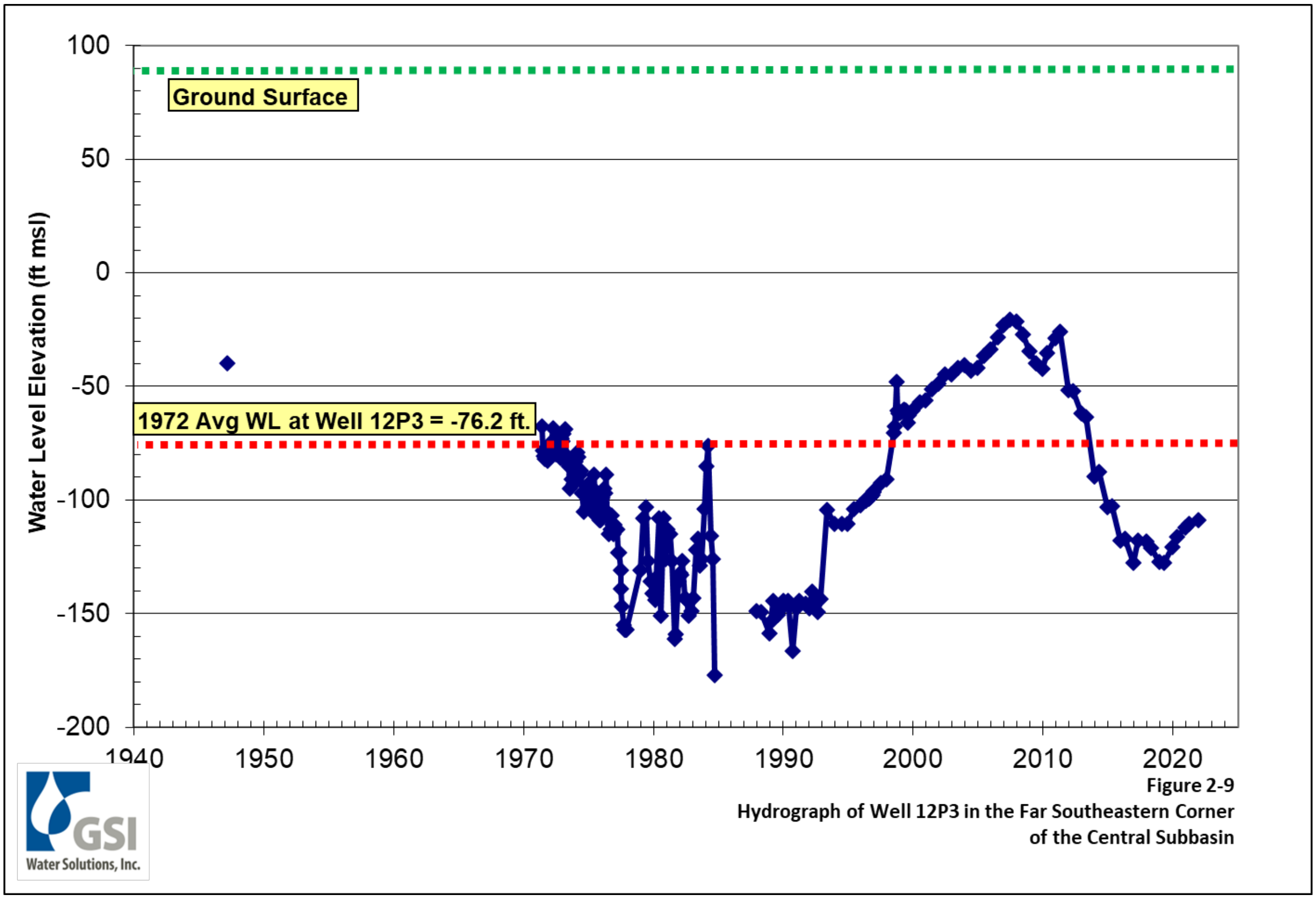


Figure 2-9. Hydrograph of Well 12P3 in the Far Southeastern Corner of the Central Subbasin

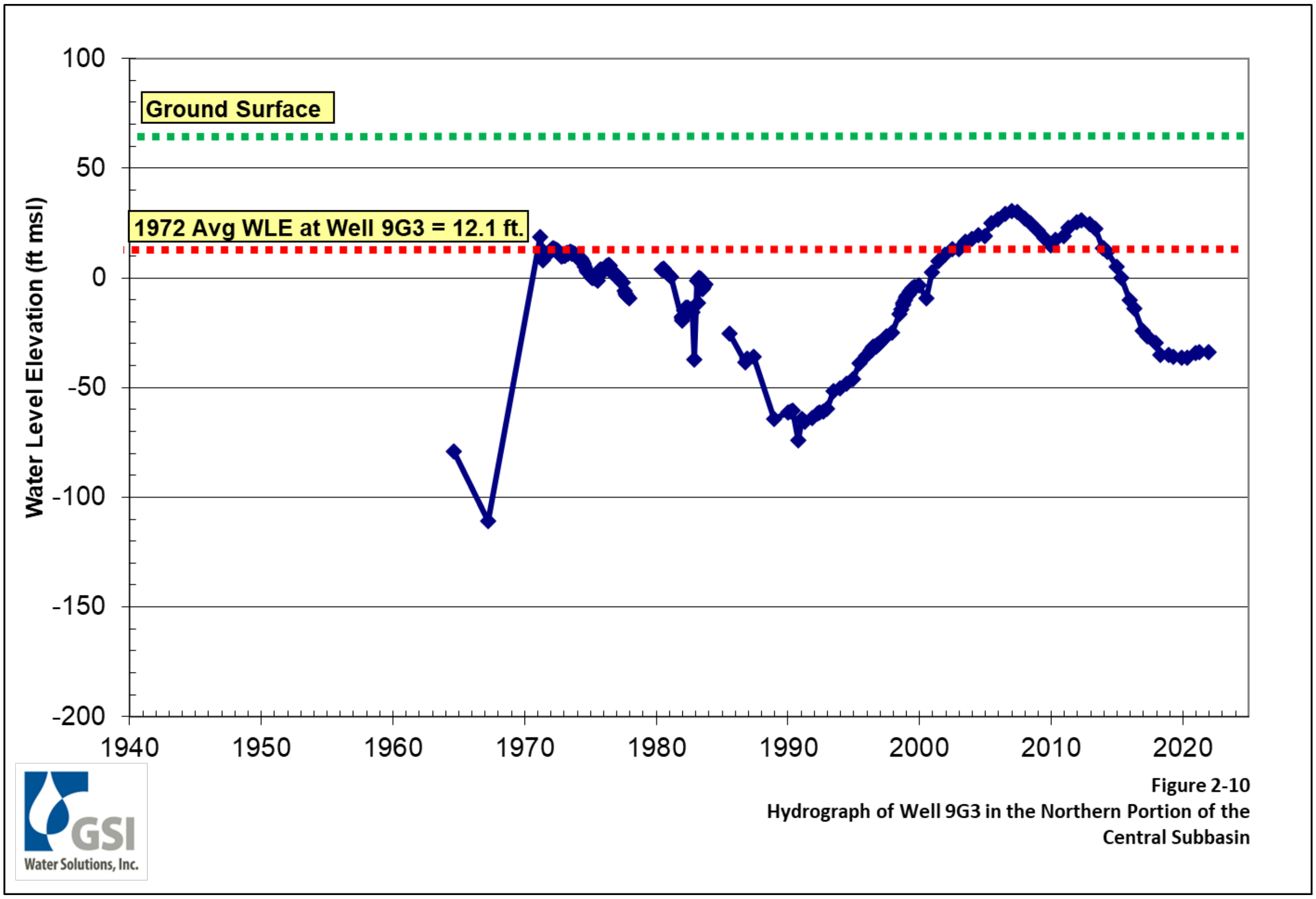


Figure 2-10. Hydrograph of Well 9G3 in the Northern Portion of the Central Subbasin

Even when groundwater elevations are near historical highs in the Central subbasin, they are typically below sea level. Groundwater elevations below sea level in coastal basins are always a concern because of the risk of seawater intrusion into the aquifer. Areas of seawater intrusion caused by low groundwater elevations have been found in Orange, Los Angeles, Ventura, San Luis Obispo, and Monterey Counties. As discussed in Section 2.1, the More Ranch Fault provides protection from seawater intrusion to the Goleta Basin by uplifting a block of older geologic units across what could otherwise be a pathway for seawater to move inland in the aquifer. This is not unprecedented in coastal basins; the Newport-Inglewood Fault provides similar protection along the Orange and Los Angeles Counties' coastline, except in areas where buried canyons cut through the older sediments in the uplifted fault block.

2.4.2 North Subbasin

Groundwater elevations generally have fluctuated within a narrower range in the North subbasin than in the Central subbasin (**Figures 2-11** and **2-12**). The overall trend in groundwater elevations is similar to the Central subbasin, with groundwater highs in the 1970s and early 2010s, and a groundwater low in the early 1990s. Groundwater elevations are generally above sea level and have approached the ground surface in some wells.

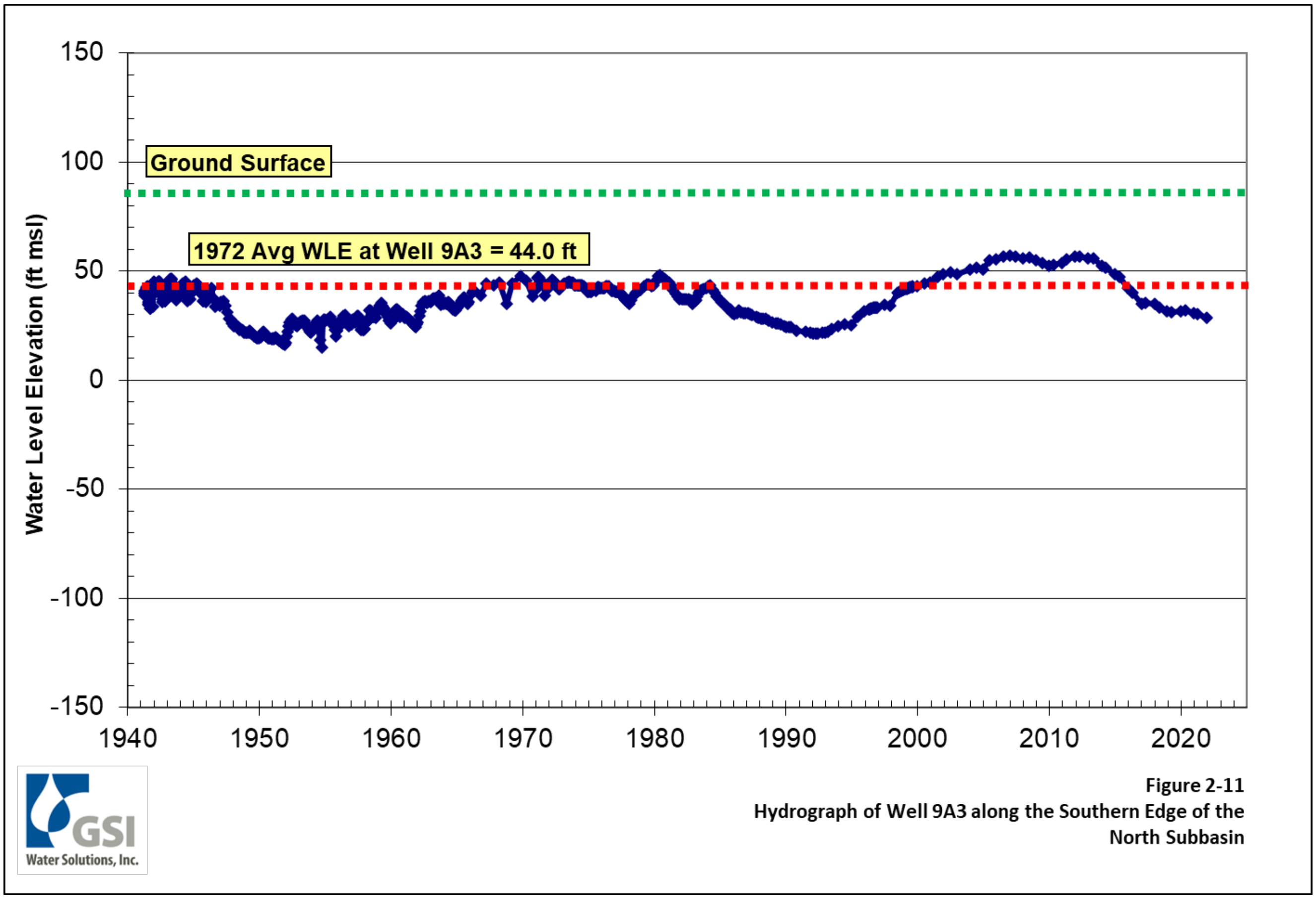


Figure 2-11. Hydrograph of Well 9A3 along the Southern Edge of the North Subbasin

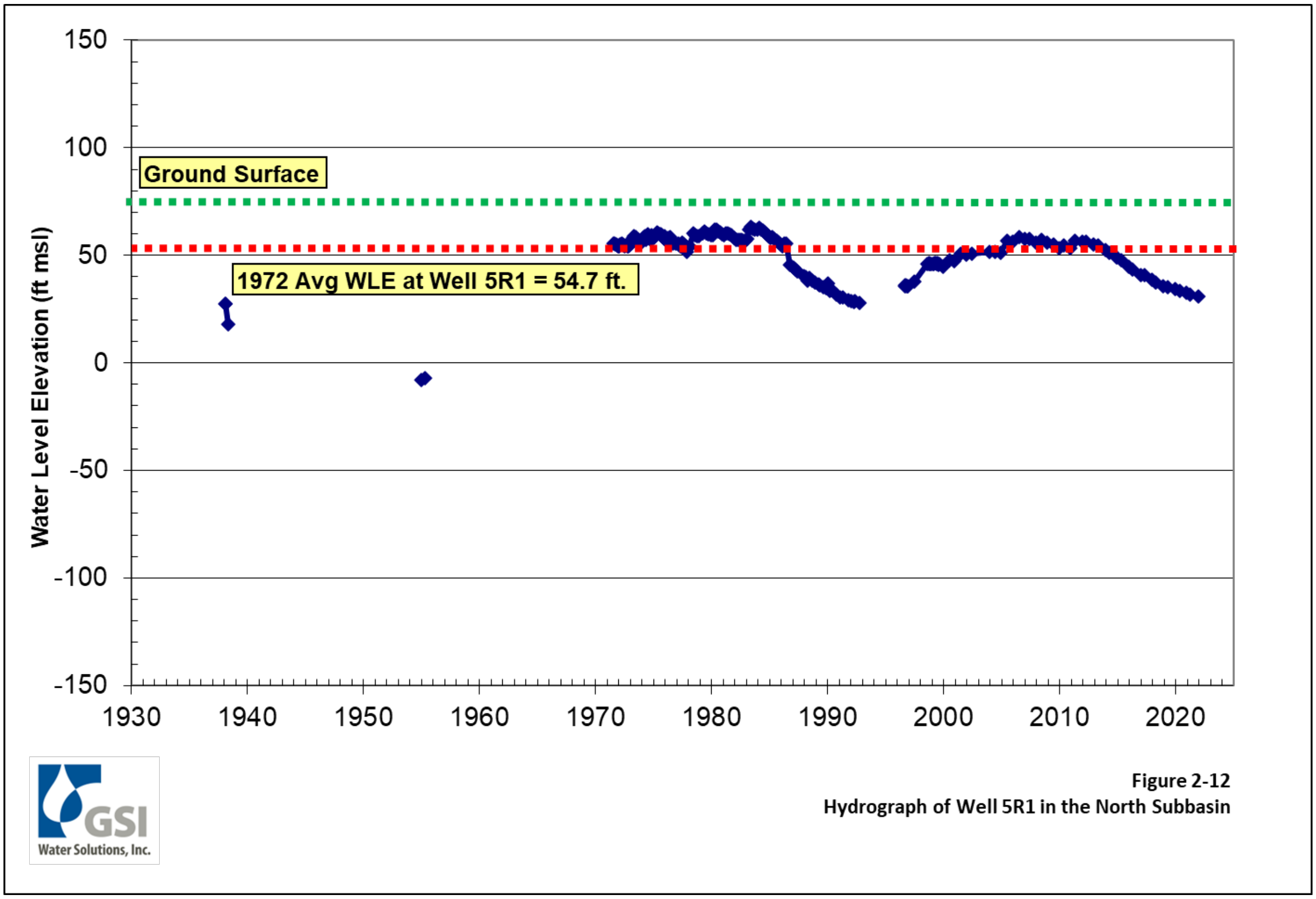


Figure 2-12. Hydrograph of Well 5R1 in the North Subbasin

2.4.3 West Subbasin

Although groundwater elevations for wells in the West subbasin have dropped below ground surface in historical records, groundwater elevations were near the surface from the 1990s through about 2013 (**Figure 2-13**). High groundwater elevations can create springs and boggy areas, as well as causing problems for the foundations of buildings. CH2M HILL (2009) reported local problems caused by the high groundwater elevations. Groundwater levels declined slightly from 2013 to 2016 and have remained stable below ground surface since that time.

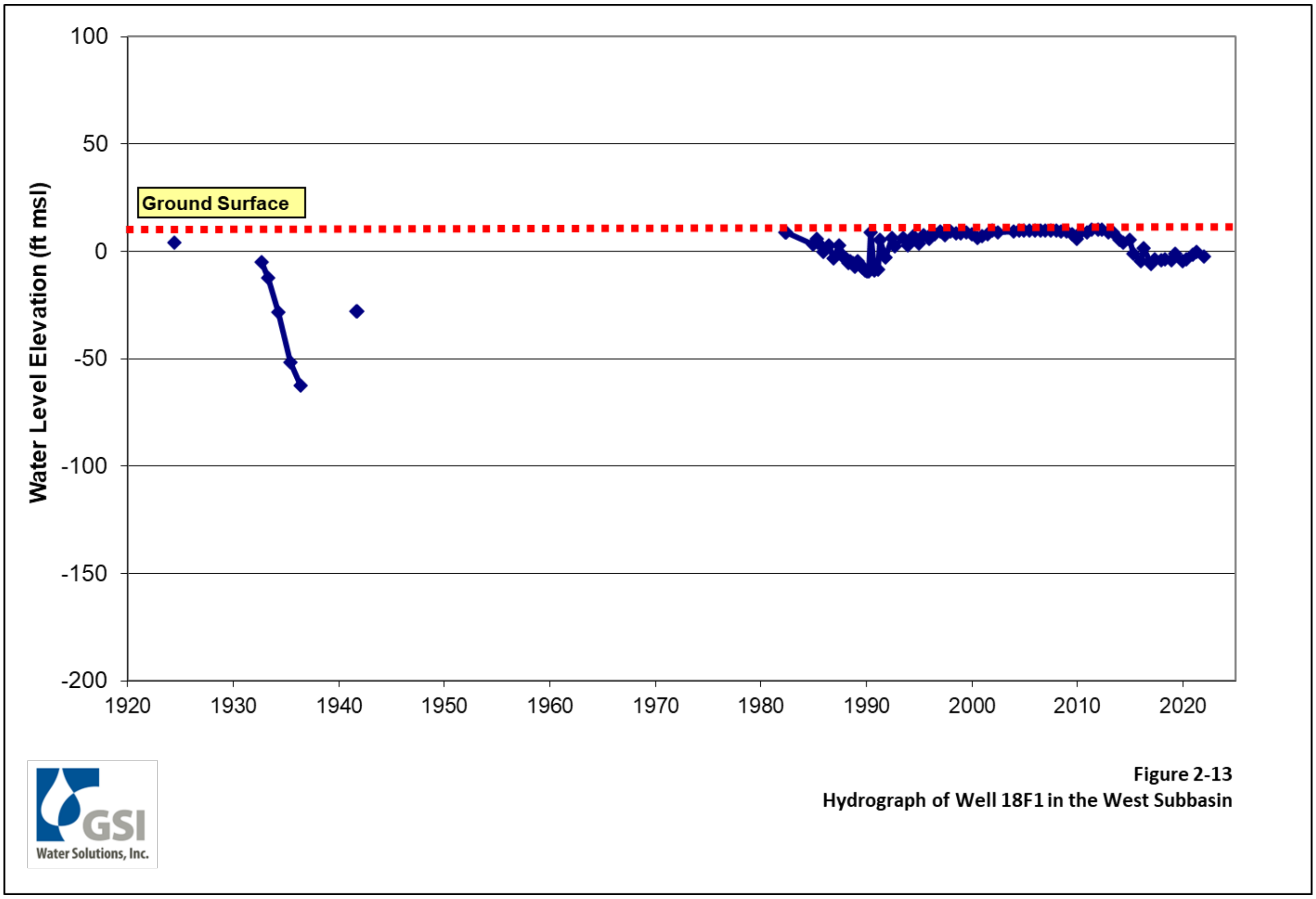


Figure 2-13. Hydrograph of Well 18F1 in the West Subbasin

2.5 Groundwater Quality

Managing groundwater quality in a basin involves several considerations:

1. Existing poor-quality water in parts of the basin that must be prevented from spreading across the basin (e.g., areas of saline water or high nitrates)
2. Potential degradation of water quality via poor-quality water being pulled in from areas outside the aquifers (e.g., intrusion of seawater or high salts being pulled from surrounding sediments)
3. Dissolution of naturally occurring elements, such as iron, manganese, arsenic, or chromium, which have primary or secondary drinking water standards
4. Overlying sources of contamination that could leak into the aquifers (e.g., leaking underground tanks)

All of these considerations are important for the Basin. Groundwater in the Basin is of a calcium bicarbonate nature (DWR, 2004). Water quality is similar in nature to other coastal groundwater basins, where groundwater typically flows through geologically young marine sediments (Santa Barbara Formation) and becomes relatively mineralized. Chloride is an issue in some of the coastal basins, especially when there is a connection with the ocean allowing for potential seawater intrusion.

2.5.1 Historical Groundwater Quality

Figures 2-14 through **2-19** present historical water quality data for constituents that affect drinking water quality or are important for agricultural production. Data from the years 1980 through 2000 are assumed to be representative of historical conditions and include a variety of wells in and around the Basin, including irrigation wells, domestic supply wells, and municipal supply wells. Historical data showed somewhat elevated chloride concentrations in portions of the West and North subbasins (typically up to about 200 milligrams per liter [mg/L]) (Upson, 1951). Although below the drinking water standard of 500 mg/L, irrigation water with chloride above approximately 150 mg/L can harm salt-sensitive crops. However, some portions of the North and West subbasins had chloride concentrations above the drinking water standard. During the historical period of 1980 to 2000, chloride concentrations in the Central subbasin were well below these levels (**Figure 2-14**).

Historical nitrate levels were significantly below the drinking water standard of 45 mg/L except in three wells (**Figure 2-15**); this is somewhat surprising, given the rural agricultural heritage of the Basin (agricultural fertilizers, concentrations of livestock, and septic systems are the largest sources of nitrate in many basins). Both sulfate and total dissolved solids (TDS) concentrations were above the secondary drinking water standards in many wells in the North and West subbasins (**Figures 2-16** and **2-17**, respectively).

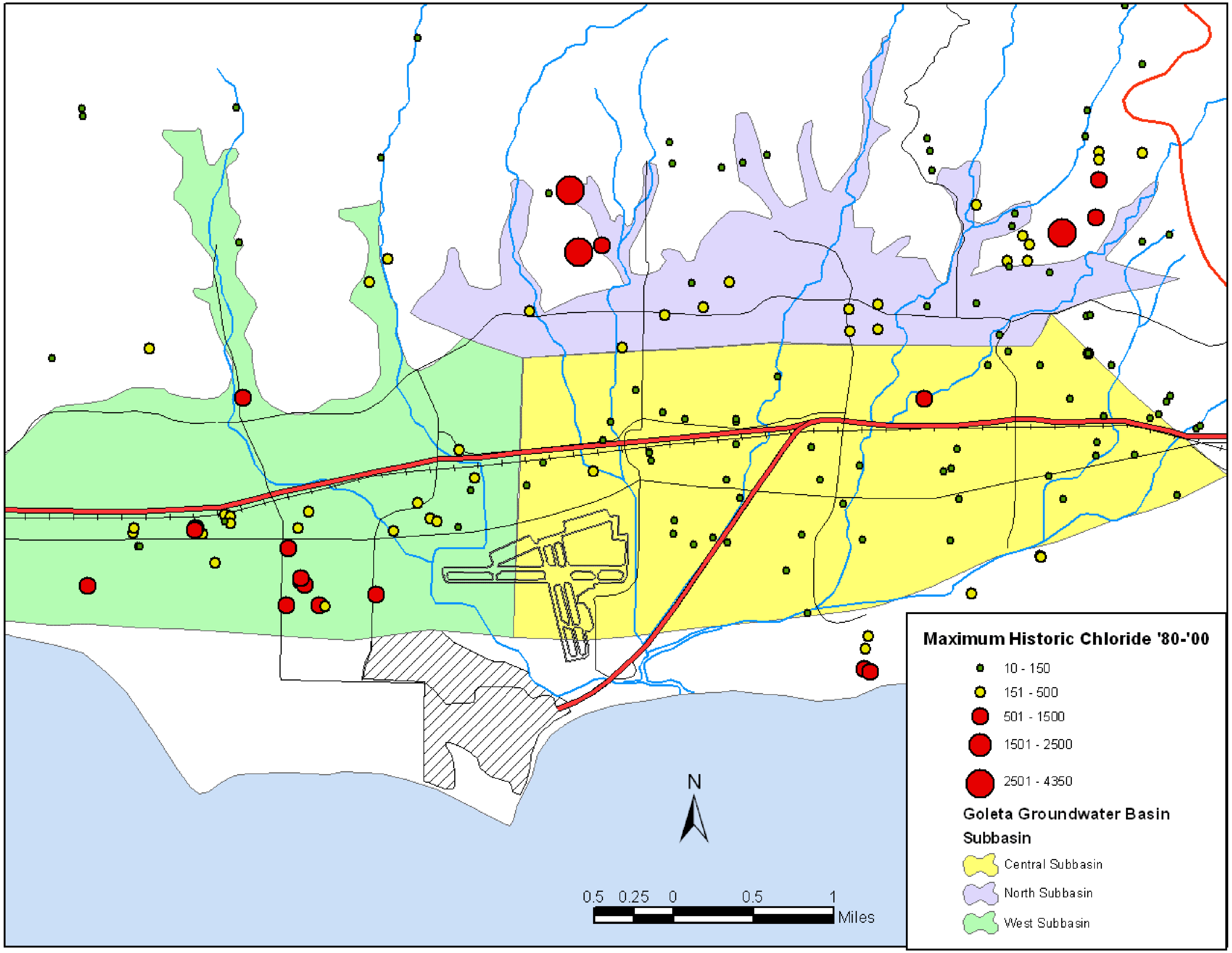
Iron and manganese have historically been elevated in the Basin, with most wells in all subbasins having recorded maximum concentrations above the secondary drinking water standards of 0.3 mg/L and 0.05 mg/L, respectively (**Figures 2-18** and **2-19**, respectively).

In general, concentrations of chloride, nitrate, sulfate, and TDS were historically higher in the recharge areas in the northern part of the North and Central subbasins, and lower in the southern confined portion of the subbasins. Nitrate concentrations generally remained low across all three subbasins (Central, North, and West), with a few outliers. In the West subbasin, concentrations of chloride and sulfate typically increased from north to south. Nitrate concentrations were low across the entire West subbasin, while TDS is generally elevated across much of the West subbasin. Historical data for the recharge area of the West subbasin (the portion of the Basin located north of Highway 101) are limited.

FIGURE 2-14

Maximum Historical Chloride Concentrations in Wells 1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update



Date: December 7, 2022
Data Sources: ESRI

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-14_Max_Cl_80_2010.mxd, abarry

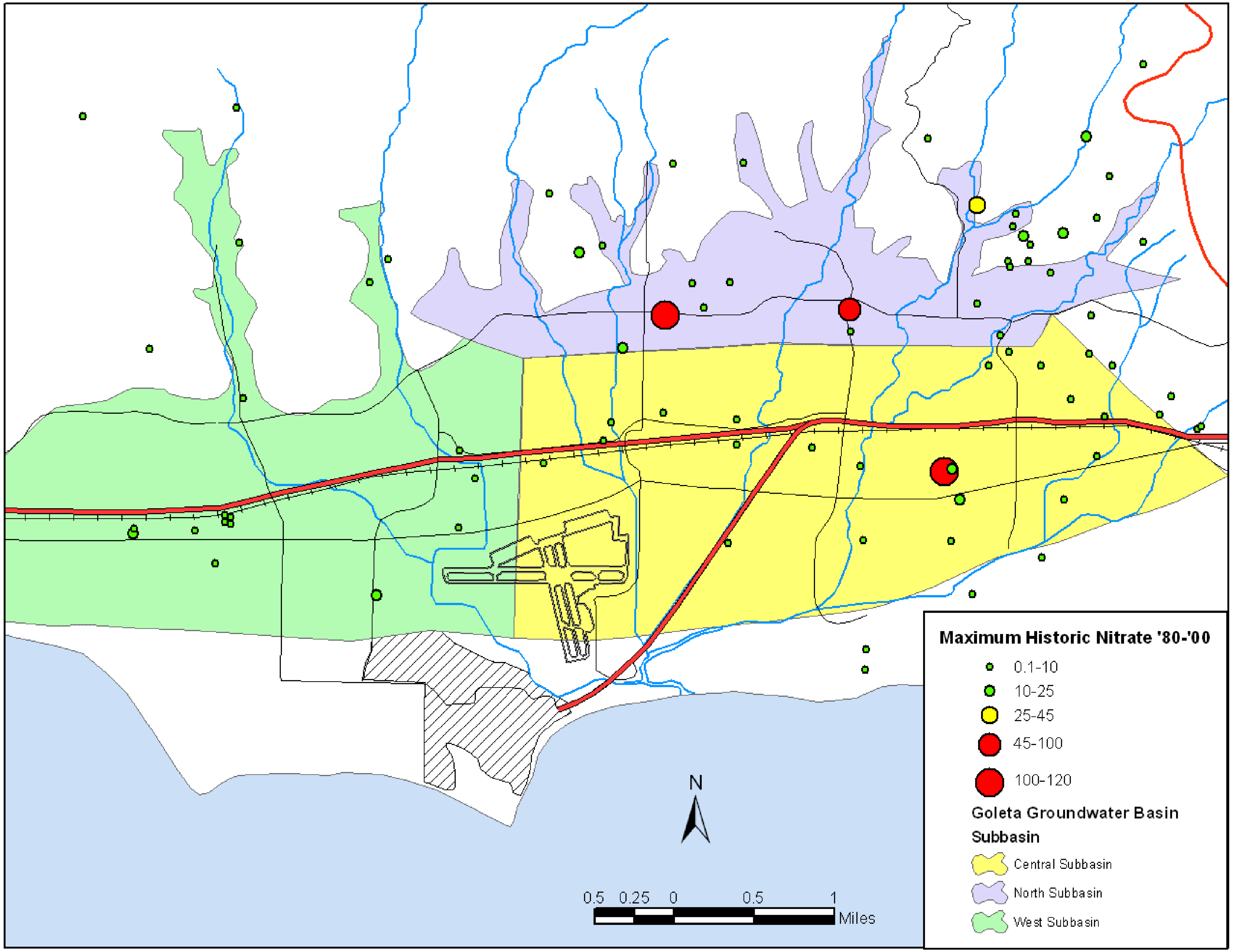


FIGURE 2-15

Maximum Historical Nitrate Concentrations in Wells 1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

Date: December 7, 2022
Data Sources: ESRI

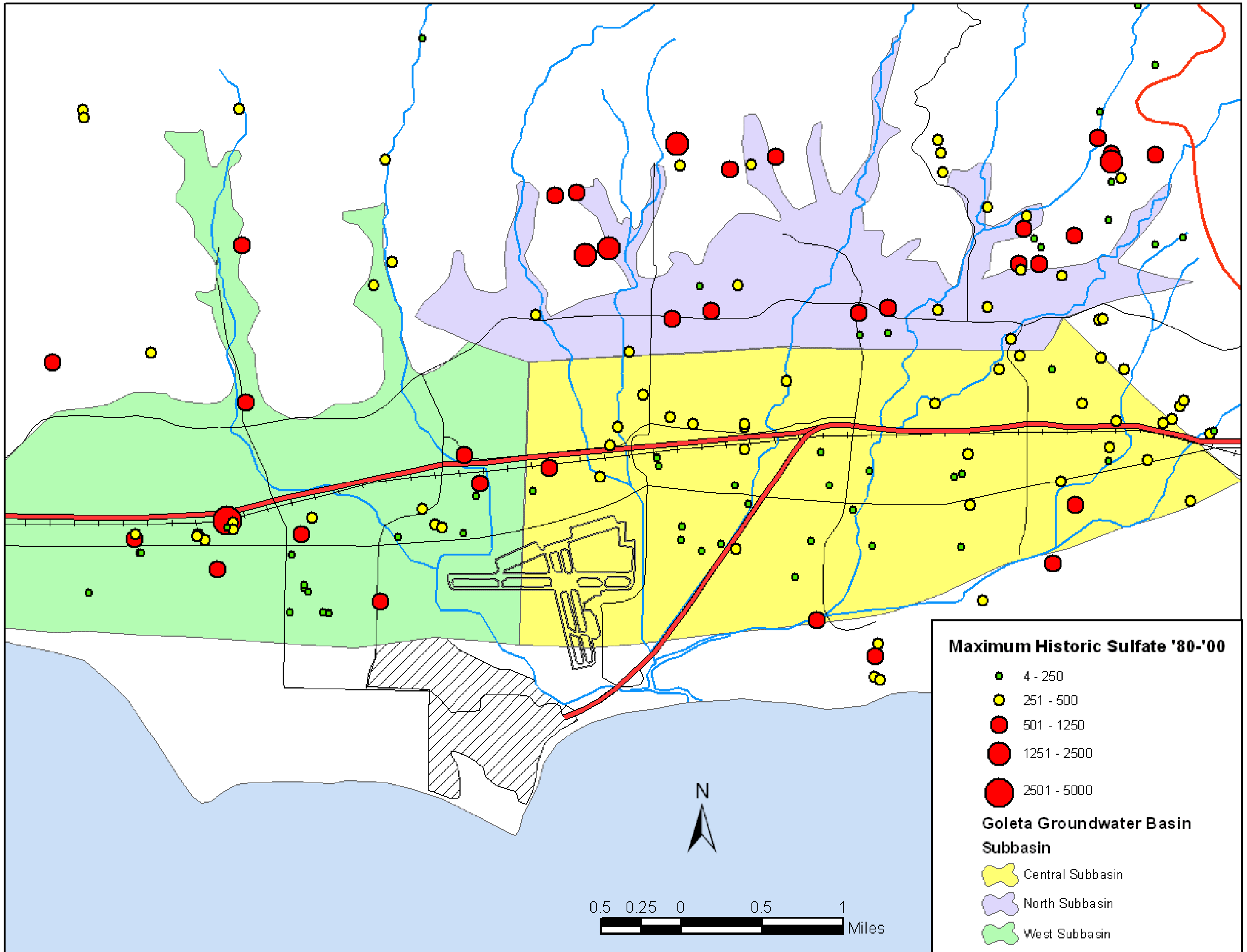
GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-15_Max_NO3_80_2010.mxd, abarry

FIGURE 2-16

Maximum Historical Sulfate Concentrations in Wells 1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update



Date: December 7, 2022
Data Sources: ESRI

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-16_Max_SO4_80_2010.mxd, abarry

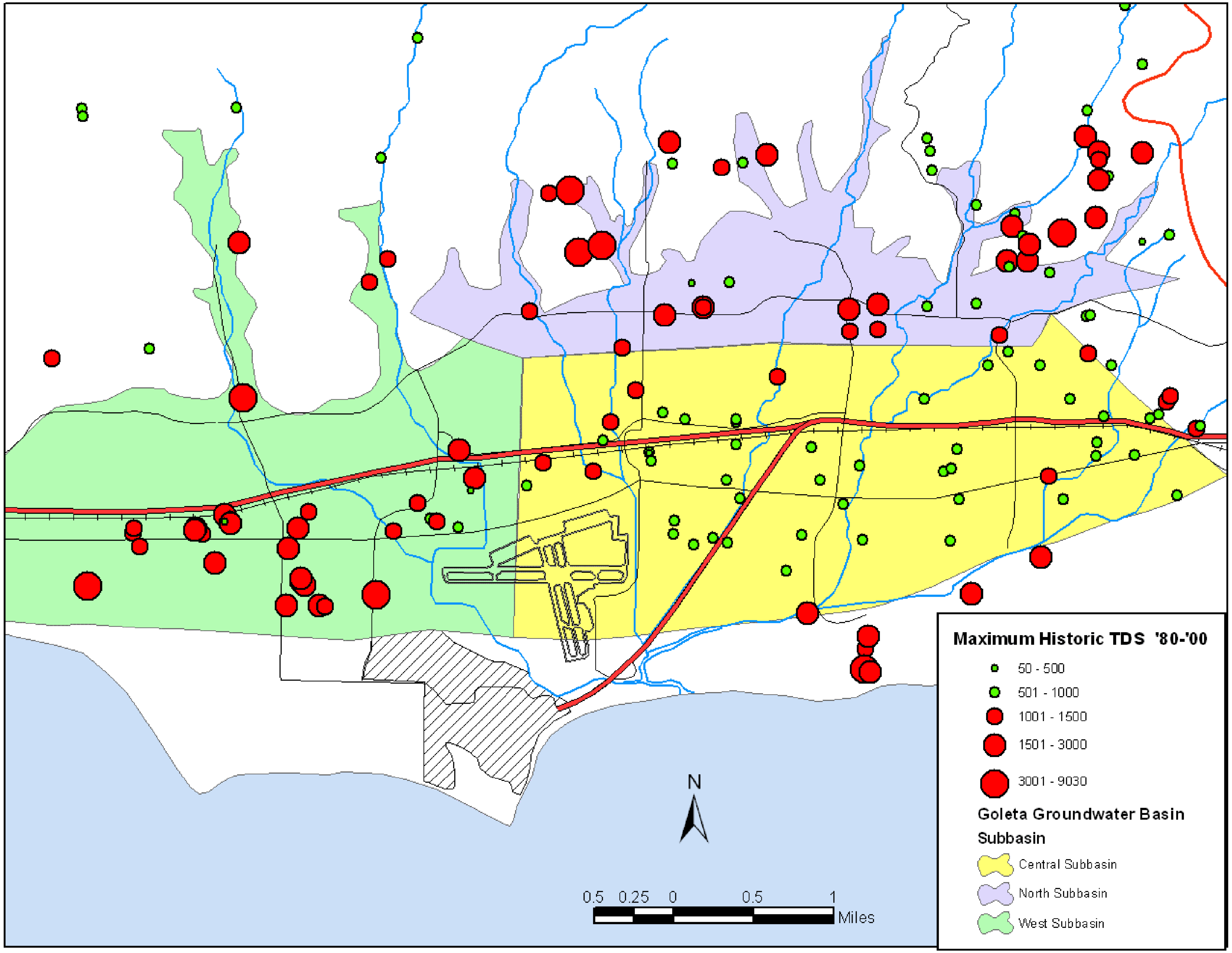


FIGURE 2-17

Maximum Historical TDS Concentrations in Wells 1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

NOTE
TDS: total dissolved solids

Date: February 22, 2023
Data Sources: ESRI

GSI Water Solutions, Inc.

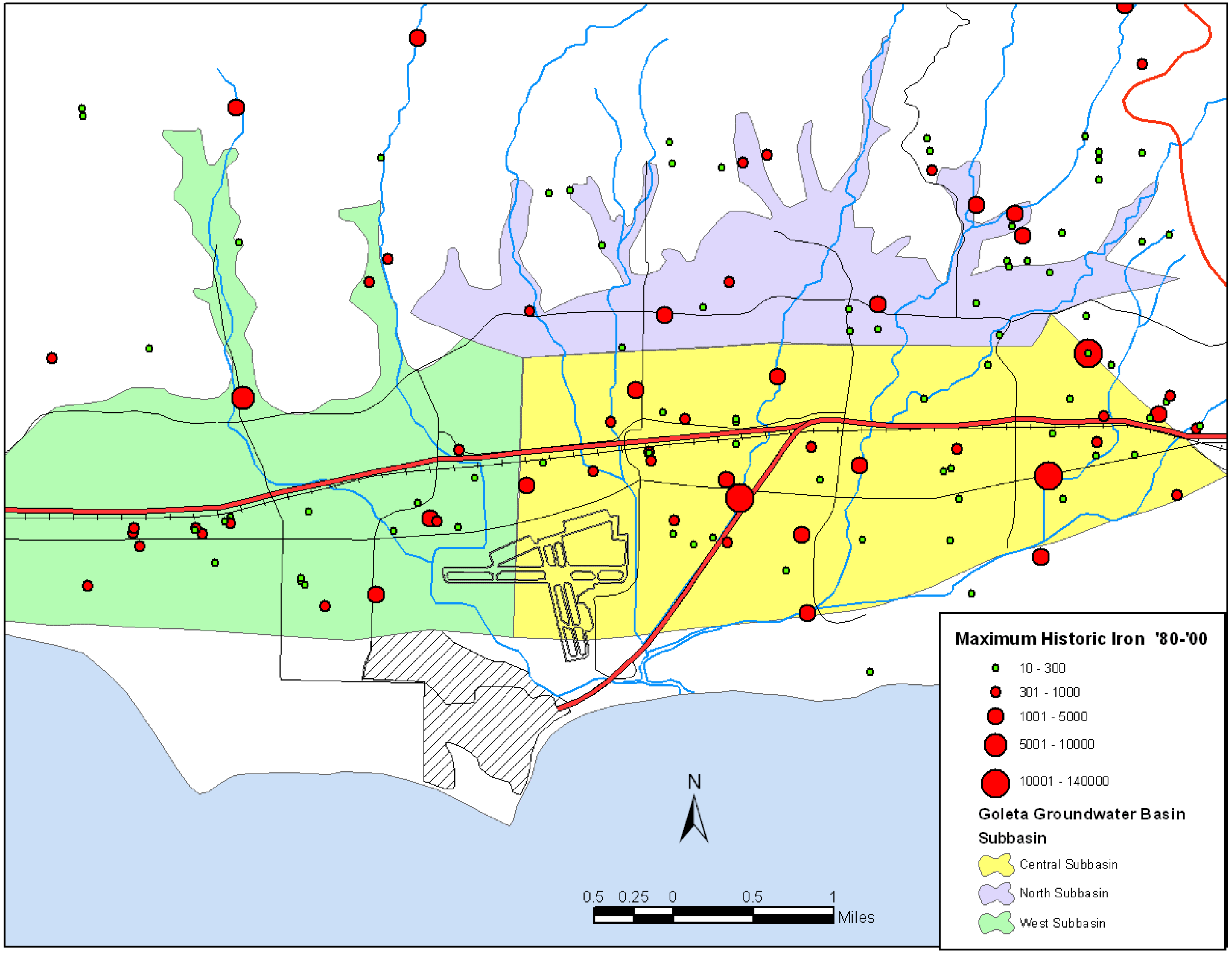


FIGURE 2-18

Maximum Historical Iron Concentrations in Wells 1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

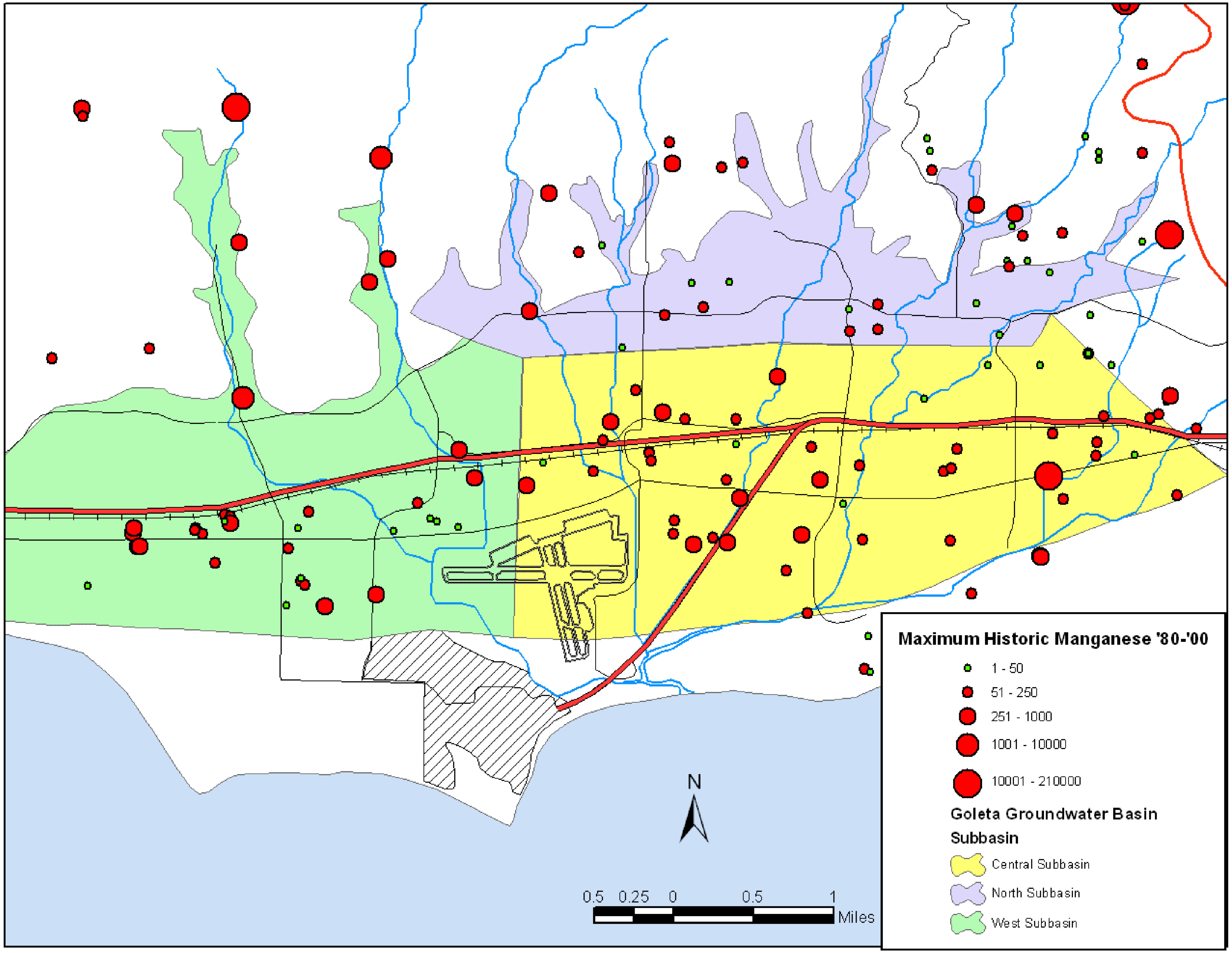
Date: December 7, 2022
Data Sources: ESRI

GSI Water Solutions, Inc.

FIGURE 2-19

Maximum Historical Manganese Concentrations in Wells 1980 - 2000

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update



Date: December 7, 2022
Data Sources: ESRI

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-19_Max_Mn_80_2010.mxd, abarry

2.5.2 Current Groundwater Quality

Water quality data for the current management period (2016 to 2021) were obtained from the SWRCB Division of Drinking Water (DDW) and the District for this GWMP update. Unlike the historical data set, these data are limited to water supply wells and represent a narrower dataset. **Figures 2-20** through **2-25** present maps of the average concentrations of key water quality constituents from 2016 through 2021 and are assumed to represent current conditions. As shown in **Figure 2-20**, none of the wells sampled had chloride concentrations above the secondary maximum contaminant level (recommended level) during the last 6 years. Similarly, **Figure 2-21** shows that none of the reporting wells had nitrate concentrations above the primary maximum contaminant level during this timeframe.

Sulfate concentrations exceeded the secondary maximum contaminant level (recommended level) in two of ten wells sampled (**Figure 2-22**). Elevated sulfate levels may cause a bitter or astringent taste in the water and can have laxative effects. Elevated sulfate is common in the region and appears to be related to the geologic materials that make up the aquifer. TDS, which is reflective of dissolved inorganic salts, exceeded the secondary maximum contaminant level (1,000 mg/L) in two wells in the northern portion of the Central subbasin during the current period (**Figure 2-23**). High levels of TDS produce “hard water,” which can leave deposits and films on plumbing fixtures but is not considered a health hazard. Elevated TDS in some wells also appears to be related to the geologic setting.

Iron and manganese are naturally occurring metals found in rocks in the Basin. High levels of these constituents may impart a strong metallic taste to water and may cause water to appear orange-brown when exposed to oxygen, which may cause staining. Drinking water is treated for iron and manganese prior to delivery to customers. Most of the groundwater in the Central subbasin has concentrations of iron that are above the secondary drinking water standards, and all ten wells sampled showed concentrations of manganese above the secondary drinking water standards during the recent period (**Figures 2-24** and **2-25**, respectively).

Figure 2-26 displays the locations of wells used to track trends in water quality over time. **Figures 2-27** to **2-32** present graphs of various water quality constituents in these wells over the last five decades. Constituent concentrations have generally been stable over time, with some wells showing increasing concentrations of chloride, sulfate, and TDS during the drought of the late 1980s and early 1990s and decreasing concentrations following the drought. Similar increases in concentrations have been noted in recent years because of drought conditions, including one well with a substantial increase in nitrate concentration and two different wells showing increased concentrations of sulfate and TDS. Increases in concentration of these constituents during drought periods are not attributed to salt loading at land surface. Reduced infiltration of low TDS rainwater during droughts tends to result in higher salt concentrations in the aquifer. It should be noted that since the last GWMP update, nitrate concentration data has been reported as “nitrate as N” as opposed to previous reported values in “nitrate as NO_3” in the 2016 GWMP (GSI, 2016a). Nitrate data collected since 2016 has been converted to “nitrate as NO_3” for consistency with previous reporting by applying a correction factor of 4.43, as recommended by the University of California, Agriculture and Natural Resources.[9]

[9] See https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=7744 for more information.

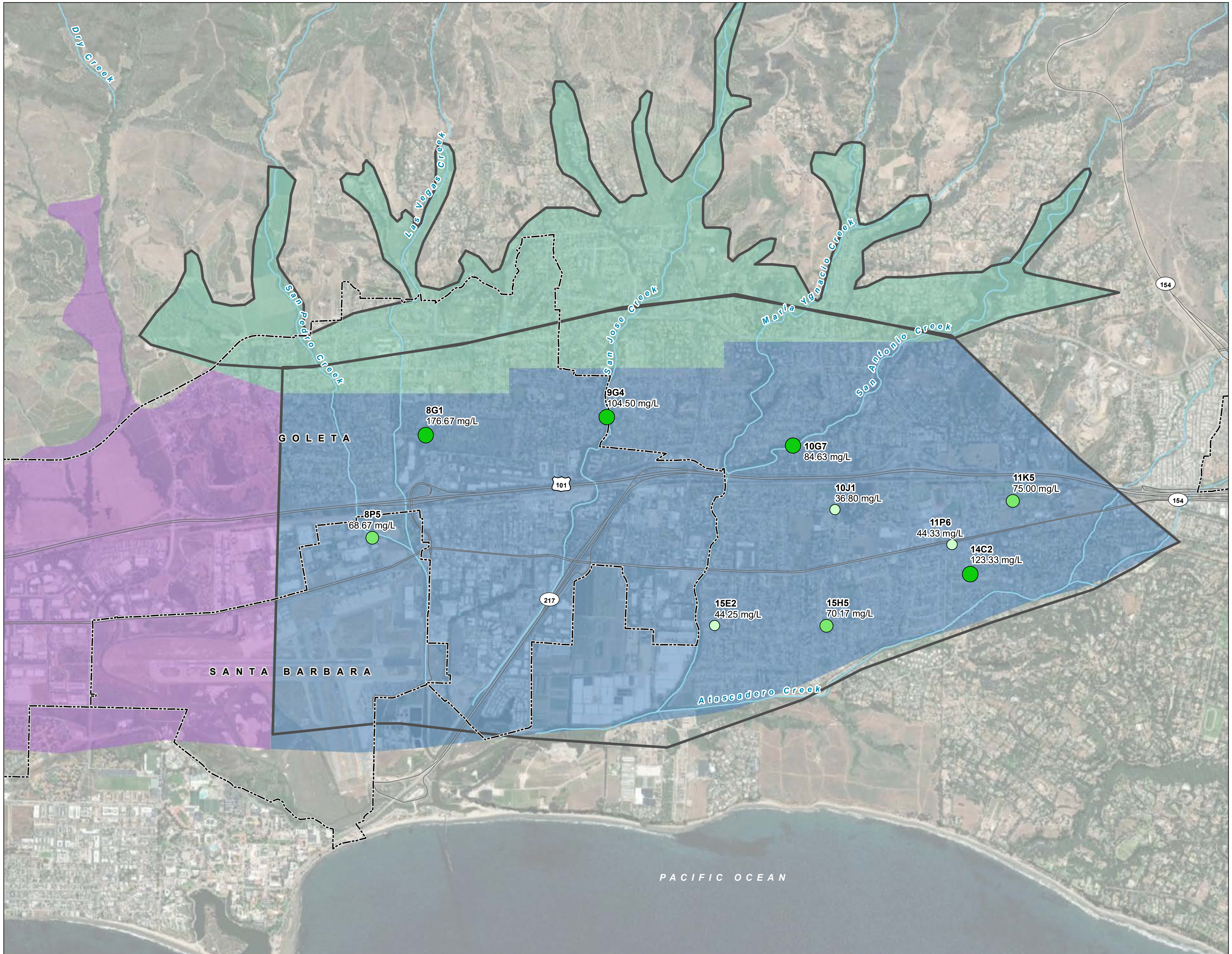


FIGURE 2-20

Average Chloride Concentrations in Wells 2016 - 2021

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Wright Adjudication Judgement Boundary

Average Chloride Concentrations (mg/L) - 2016-2021

- 37 - 50
- 51 - 75
- 76 - 177

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

The drinking water upper SMCL for Chloride is 500 mg/L.

mg/L: milligrams per liter
SMCL: secondary maximum contaminant levels

N

0 1,250 2,500 3,750
Feet

GSI Water Solutions, Inc.

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-20_Cl_2016_2021.mxd, abarry

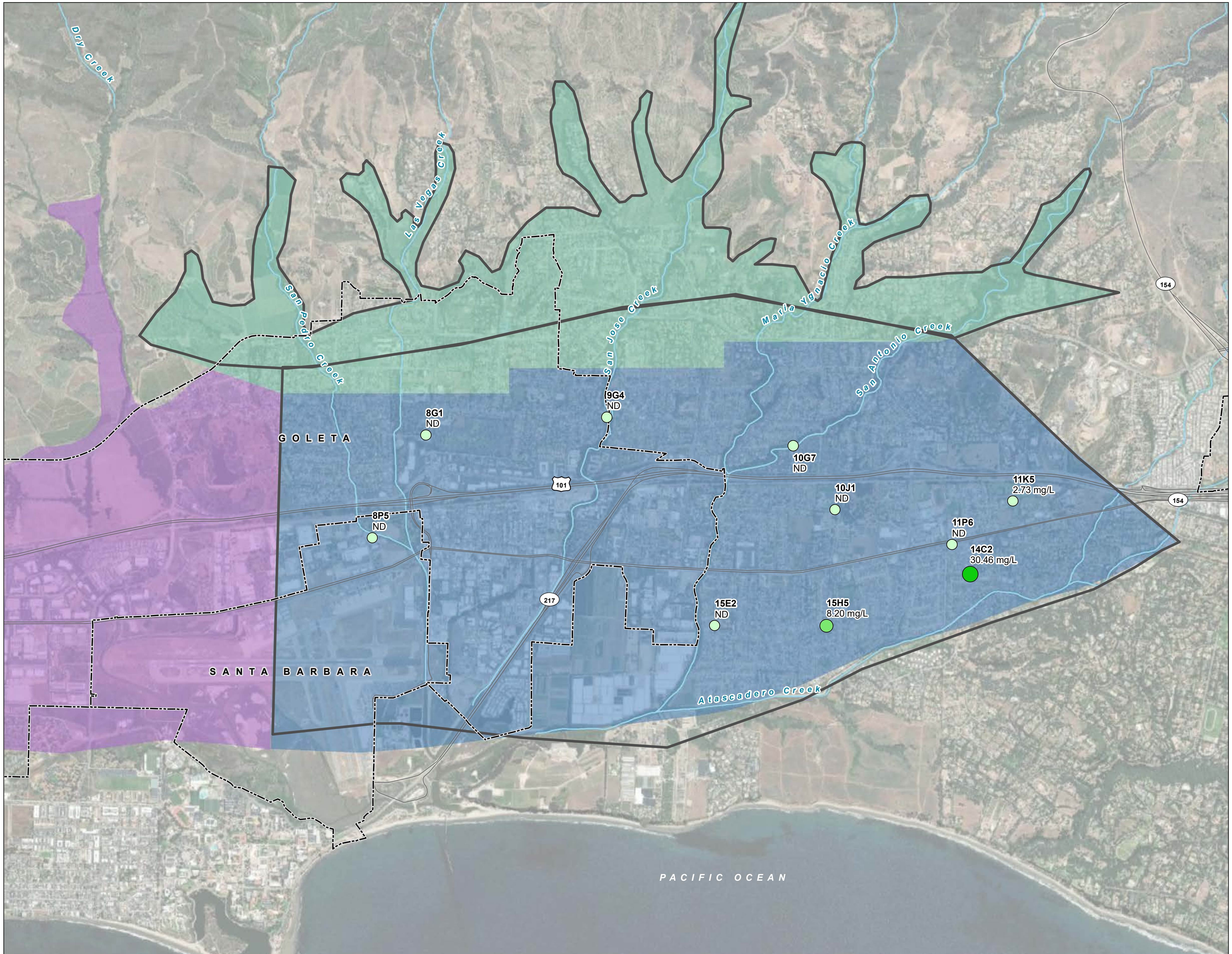


FIGURE 2-21

Average Nitrate Concentrations in Wells 2016 - 2021

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Wright Adjudication Judgement Boundary

Average Nitrate as NO3 Concentrations (mg/L) - 2016-2021

- 0 - 5
- 6 - 10
- 11 - 30

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

The drinking water MCL for Nitrate as NO3 is 45 mg/L.

MCL: maximum contaminant levels
mg/L: milligrams per liter
ND: non-detect

N

0 1,250 2,500 3,750
Feet

GSI Water Solutions, Inc.

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-21_NO3_2016_2021.mxd, abarry

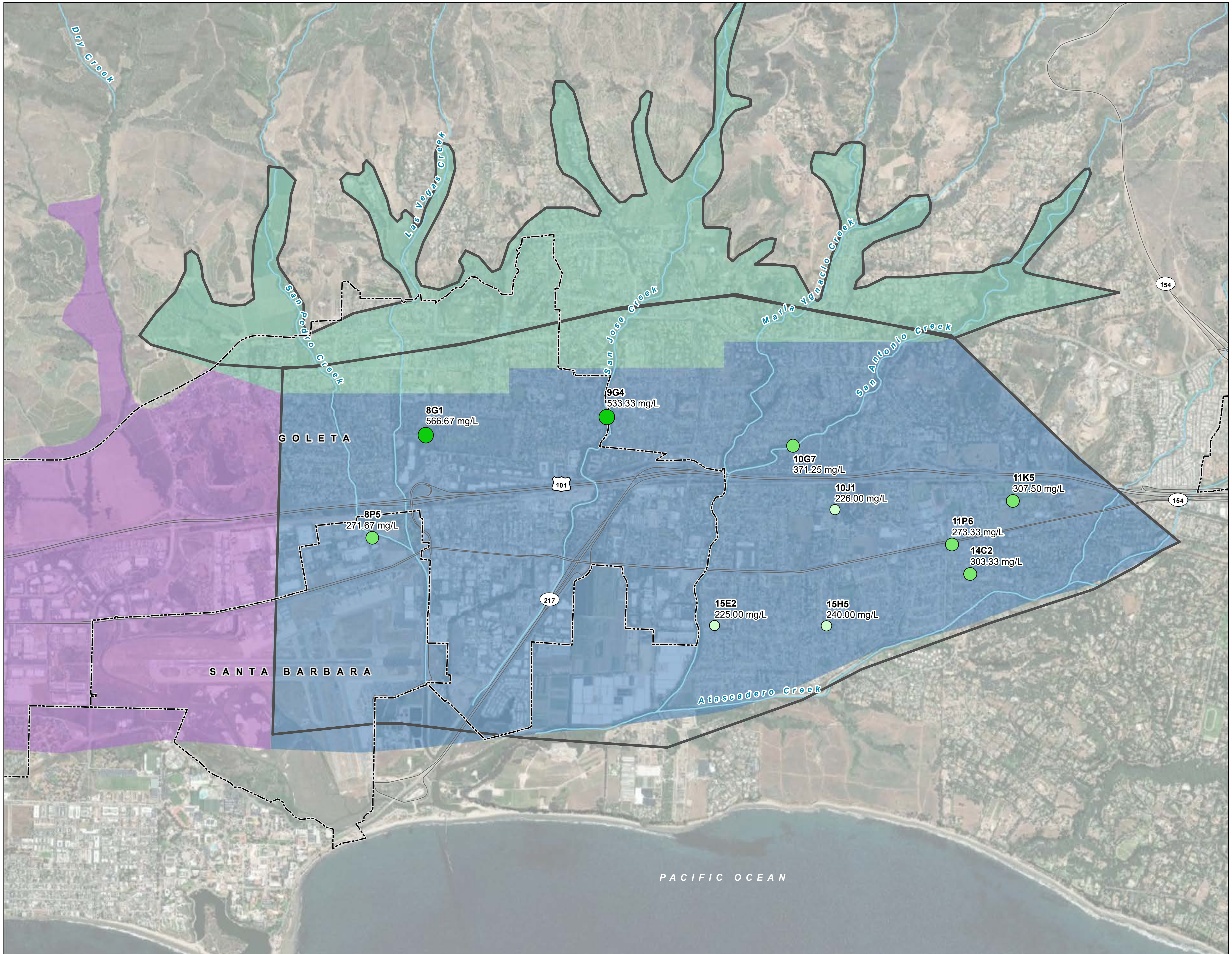


FIGURE 2-22

Average Sulfate Concentrations in Wells 2016 - 2021

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Wright Adjudication Judgement Boundary

Average Sulfate Concentrations (mg/L) - 2016-2021

- 225 - 250
- 251 - 500
- 501 - 567

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

The drinking water upper SMCL for Sulfate is 500 mg/L.

mg/L: milligrams per liter
SMCL: secondary maximum contaminant levels

N

0 1,250 2,500 3,750
Feet

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-22_SO4_2016_2021.mxd, abarry

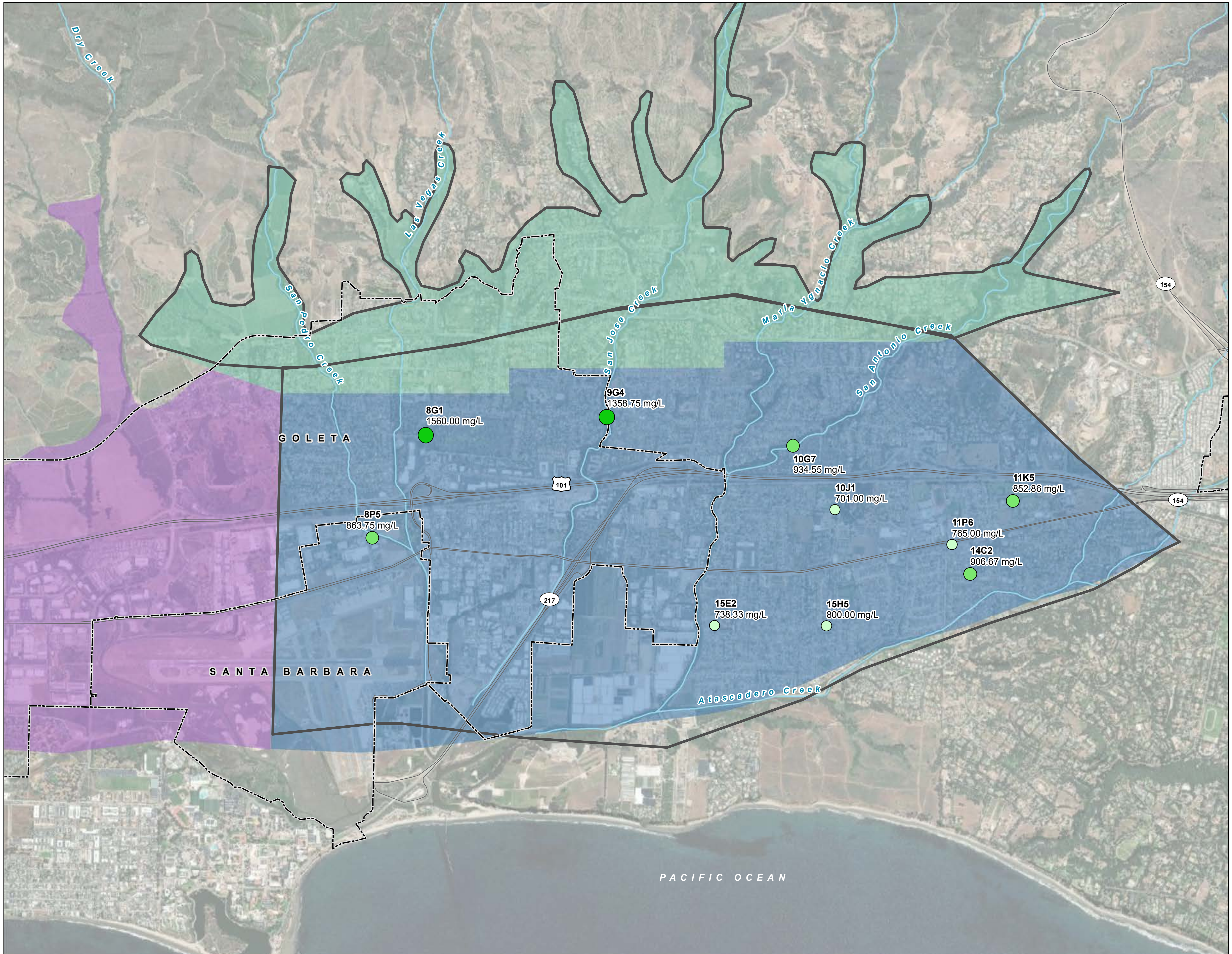


FIGURE 2-23

Average TDS Concentrations in Wells 2016 - 2021

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Wright Adjudication Judgement Boundary

Average TDS Concentrations (mg/L) - 2016-2021

- 701 - 800
- 801 - 1000
- 1001 - 1560

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

The drinking water upper SMCL for TDS is 1,000 mg/L.

mg/L: milligrams per liter
SMCL: secondary maximum contaminant levels
TDS: total dissolved solids

N

0 1,250 2,500 3,750
Feet

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-23_TDS_2016_2021.mxd, abarry

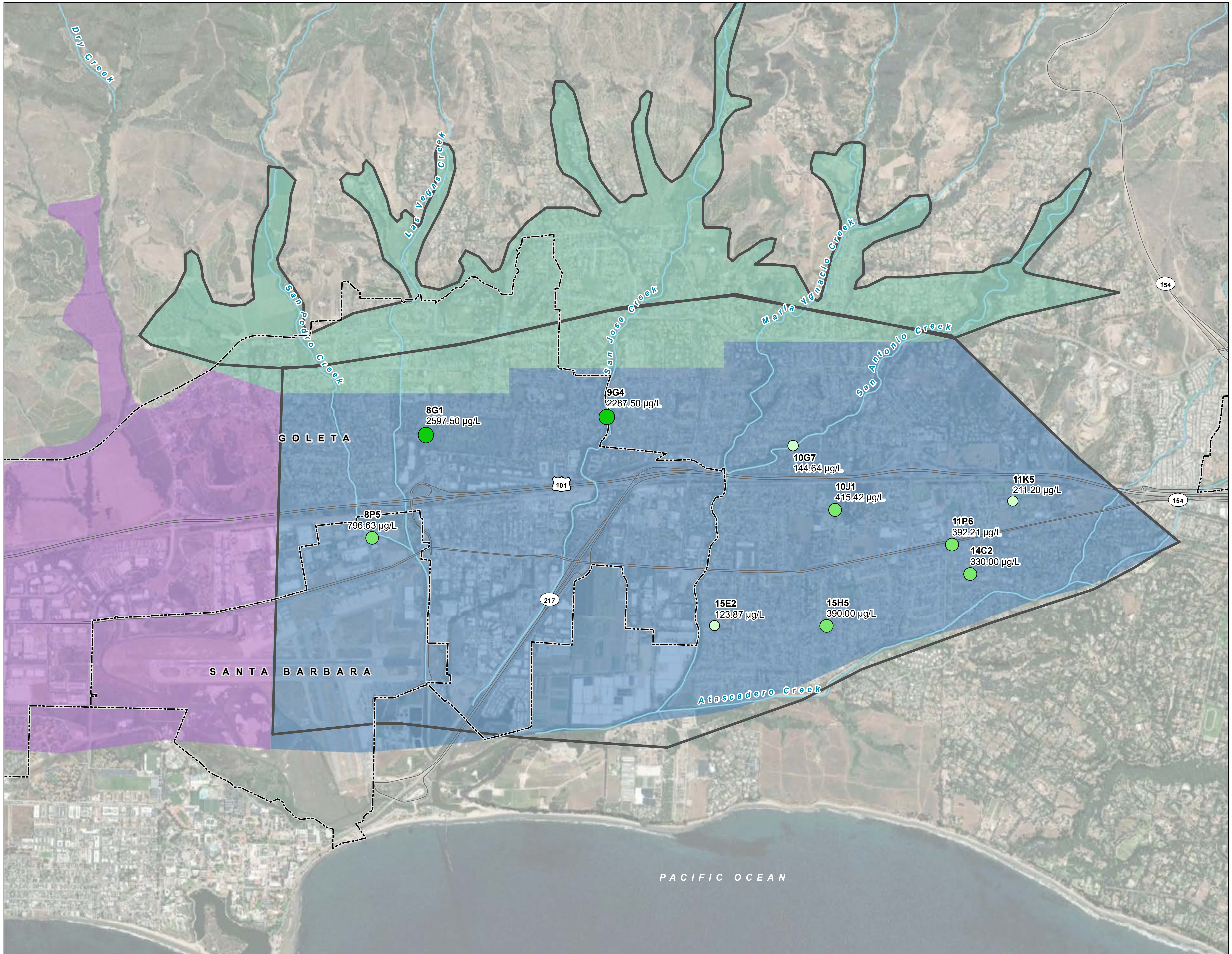


FIGURE 2-24

Average Iron Concentrations in Wells 2016 - 2021

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Wright Adjudication Judgement Boundary

Average Iron Concentrations (µg/L) - 2016-2021

- 124 - 300
- 301 - 1000
- 1001 - 2598

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

The drinking water SMCL for Iron is 300 µg/L.

SMCL: secondary maximum contaminant levels
µg/L: micrograms per liter

N

0 1,250 2,500 3,750
Feet

GSI Water Solutions, Inc.

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-24_Fe_2016_2021.mxd, abarry

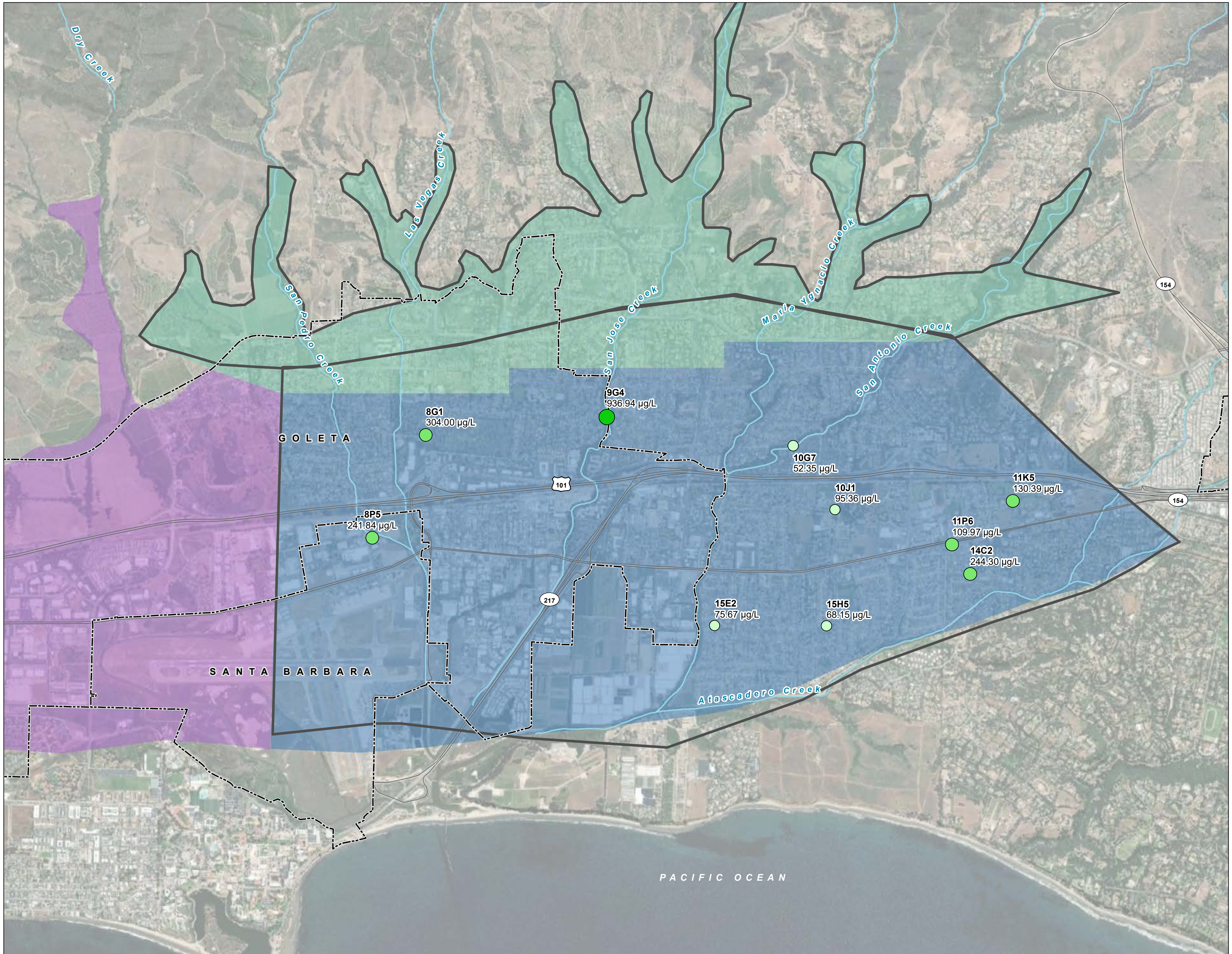


FIGURE 2-25

Average Manganese Concentrations in Wells 2016 - 2021

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Wright Adjudication Judgement Boundary

Average Manganese Concentrations (µg/L) - 2016-2021

- 52 - 100
- 101 - 500
- 501 - 937

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

The drinking water SMCL Manganese is 50 µg/L.

µg/L: micrograms per liter

N

0 1,250 2,500 3,750
Feet

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-25_Mn_2016_2021.mxd, abarry

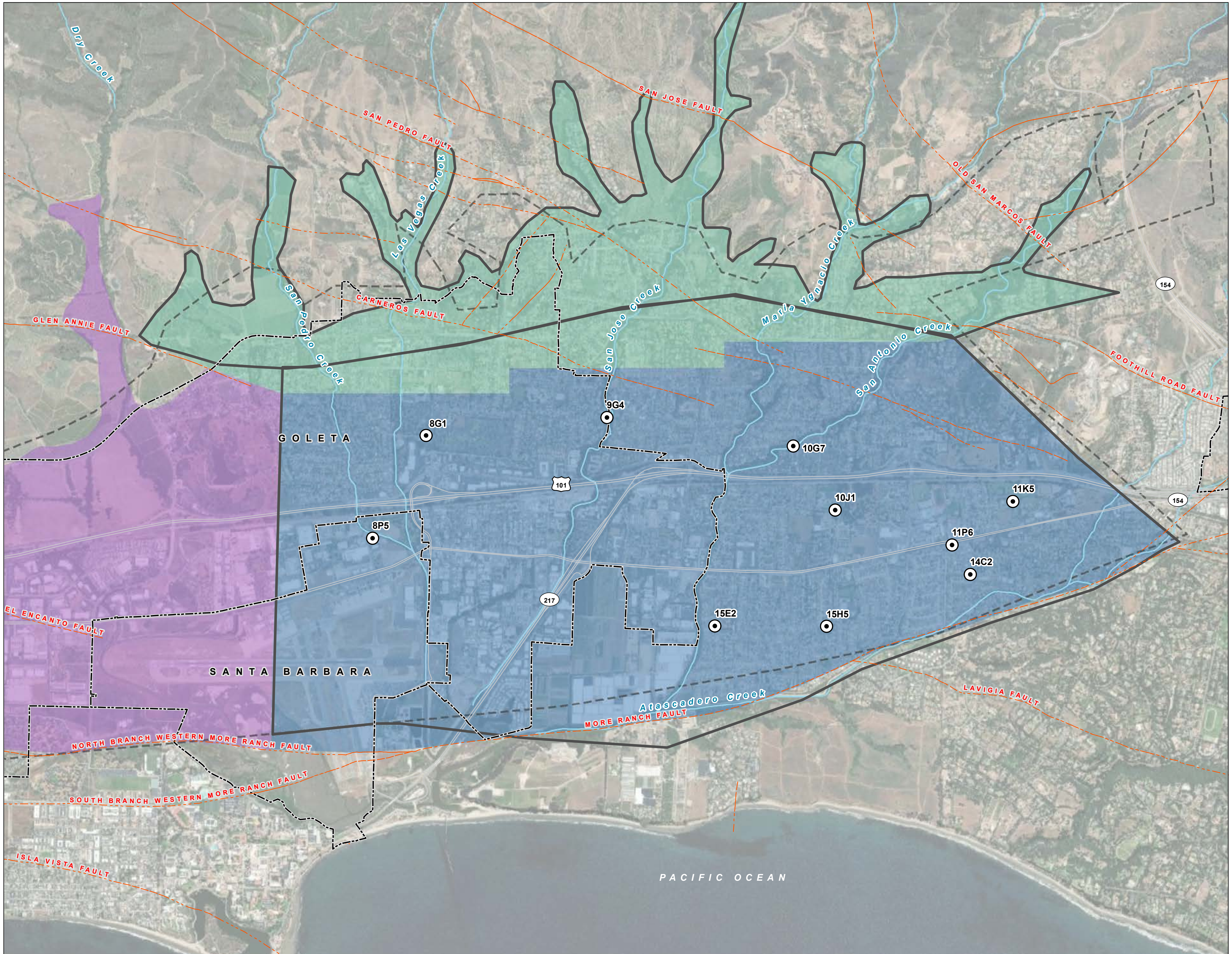


FIGURE 2-26

Location of Wells Used in Water Quality Charts

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

- Water Quality Display Well
- Wright Adjudication Judgement Boundary
- Groundwater Basin Boundary

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

Faults

- Fault
- Fault (Inferred)
- Fault (Approximate)

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

The drinking water SMCL Manganese is 50 µg/L.

µg/L: micrograms per liter

N

0 1,250 2,500 3,750
Feet

GSI Water Solutions, Inc.

Date: December 7, 2022
Data Sources: USGS, ESRI, Maxar Imagery (2021)

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-26_WQ_Wells.mxd, abarry

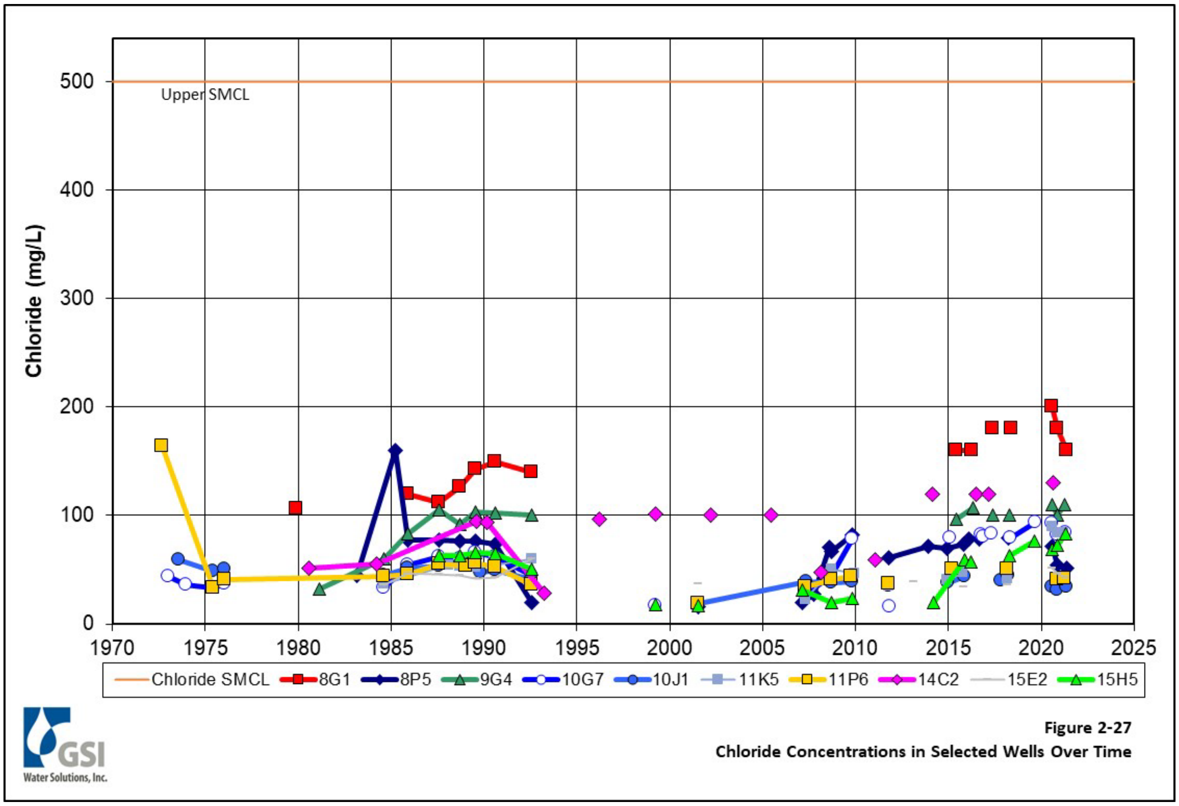


Figure 2-27. Chloride Concentrations in Selected Wells Over Time

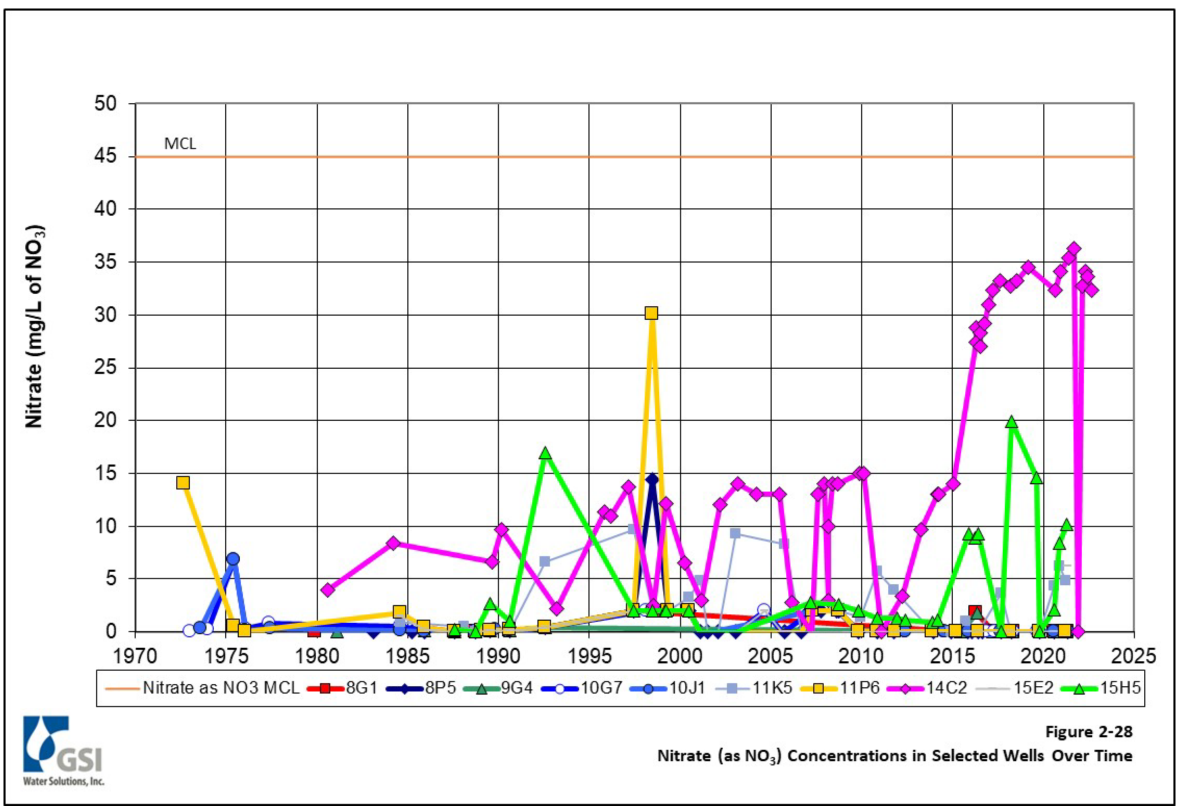


Figure 2-28. Nitrate (as NO_3) Concentrations in Selected Wells Over Time

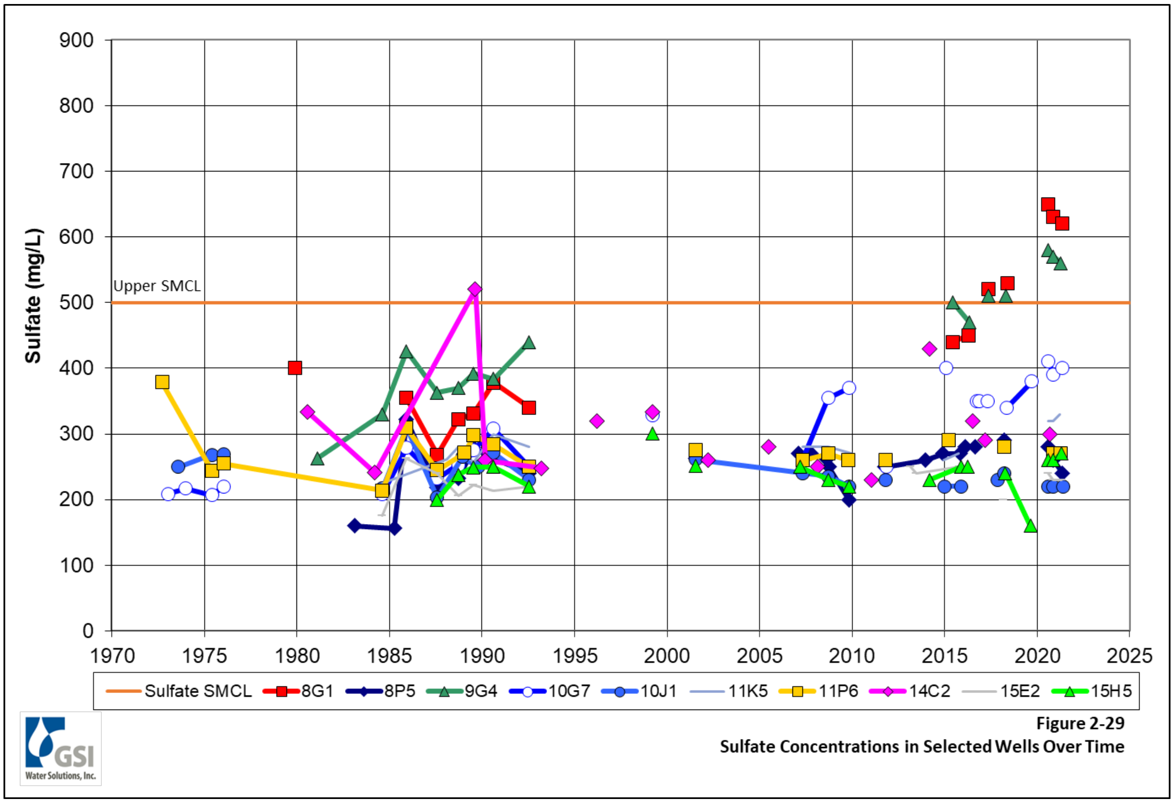


Figure 2-29. Sulfate Concentrations in Selected Wells Over Time

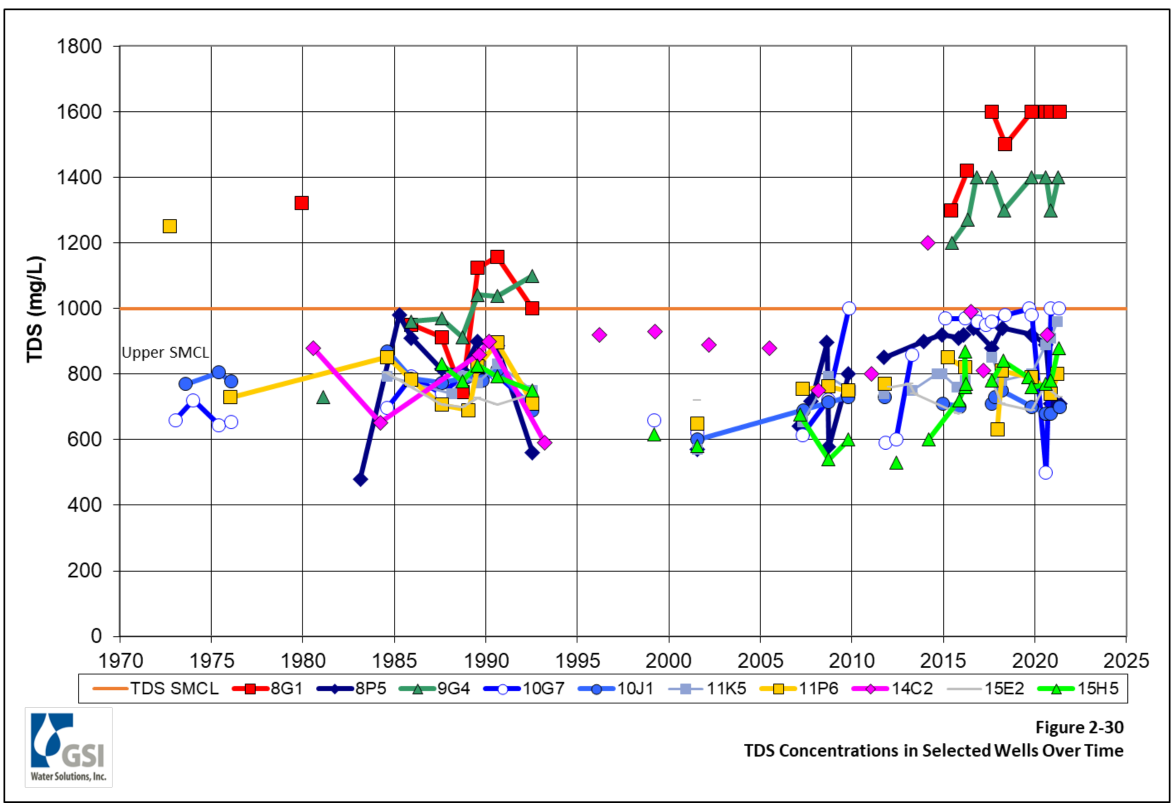


Figure 2-30. TDS Concentrations in Selected Wells Over Time

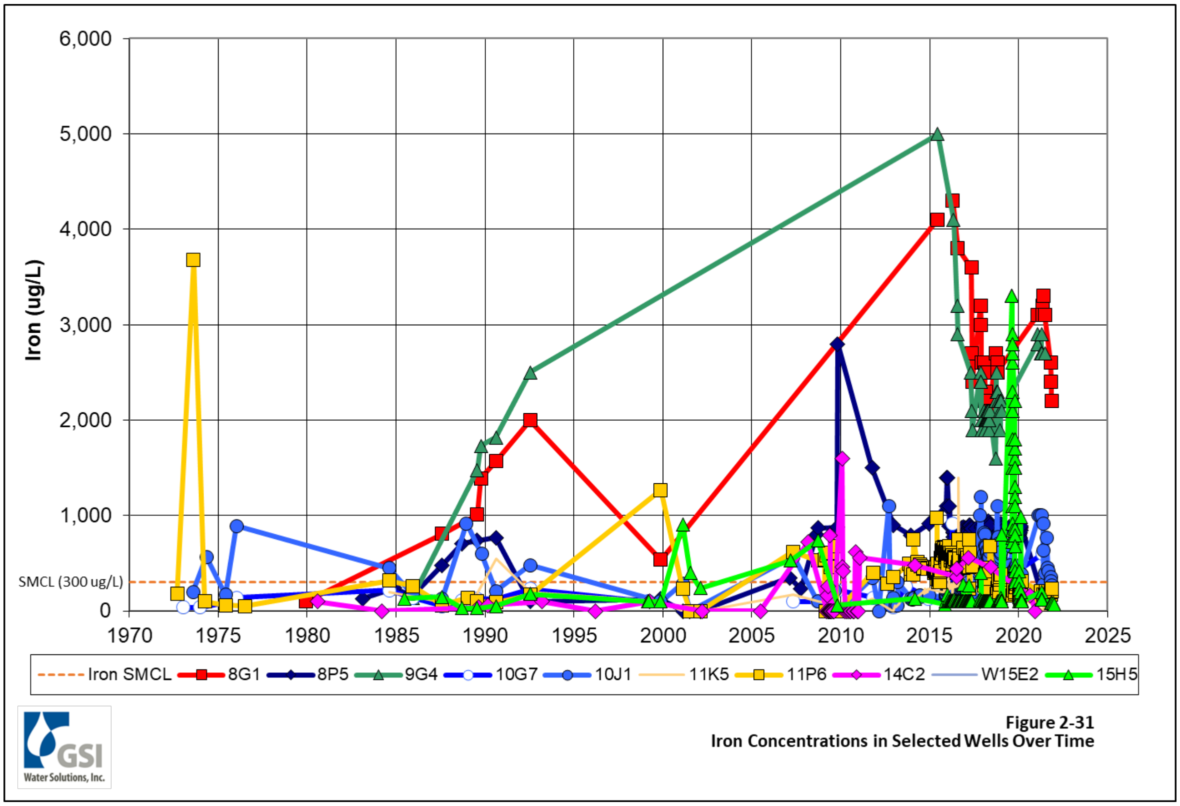


Figure 2-31. Iron Concentrations in Selected Wells Over Time

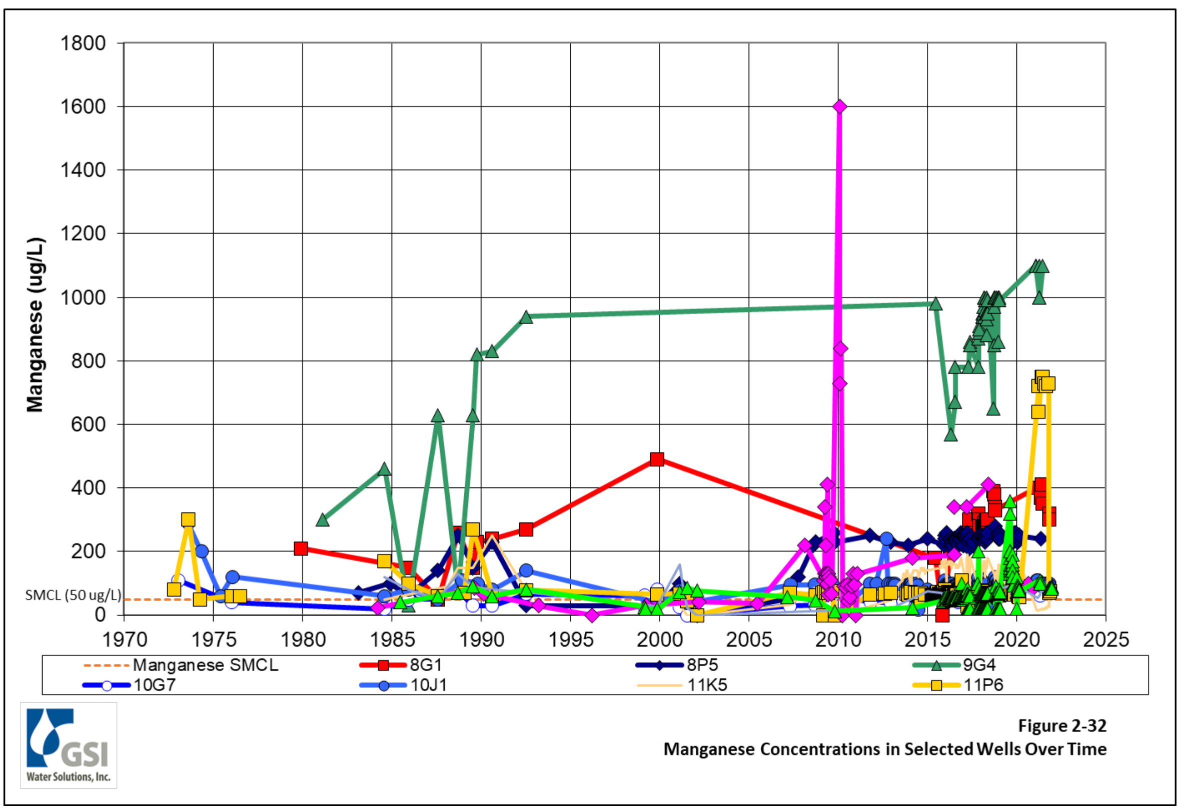


Figure 2-32. Manganese Concentrations in Selected Wells Over Time

Historically, there have been several reported spills and leaks of contaminants at the ground surface overlying the Basin (**Figure 2-33**). The spilled or leaked contaminants range from gasoline (the most common) to volatile organic compounds. Most active well sites in the Central subbasin are located near a source of potential groundwater contamination; however, the extent of the contamination is generally confined to the shallow water-bearing zones above the primary producing zones in part because of clay layers that impede downward migration of contaminants into the deeper producing zones. The agency responsible for enforcing the cleanup of most of these sites is the SWRCB, through the Regional Water Quality Control Board (RWQCB). The RWQCB tracks each of these sites, approves remediation plans, and eventually determines when the site is remediated and the case is closed.

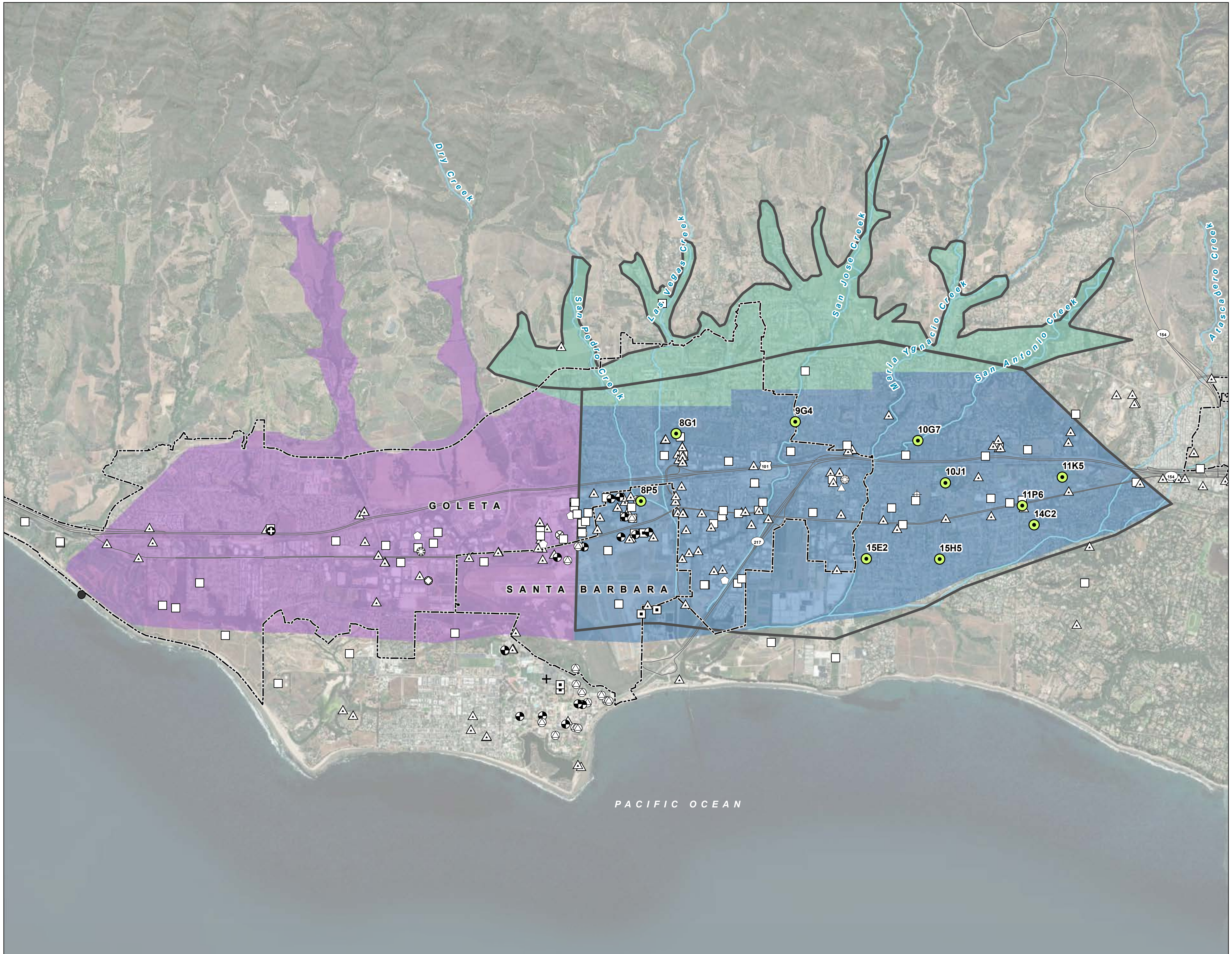
These spills and leaks pose a potential problem to the aquifers in areas of the Basin where there are no confining layers that separate the aquifers from the surface soils; specifically, the risk is present in the recharge areas where contaminants may move freely from the ground surface to the deeper aquifer. These recharge areas, which are discussed in Section 2.3 and shown in **Figure 2-2**, are generally in the foothills that lie to the north of the majority of the recorded spills. Periodically reviewing the status of contamination sites near public water supply wells is a recommendation discussed in Section 6.

Groundwater management in the Basin may need to account for the interaction of regional groundwater gradients with the remediation of contaminated sites. This is particularly likely in the West subbasin, where high groundwater elevations and lack of significant water supply pumping may hamper site remediation efforts in areas of known contamination in the vicinity of the airport. For example, GWD's best producing well, Airport Well (Well ID 04N28W08P05), in the western portion of the Central subbasin is located near several known surface contamination sites. Accordingly, water quality is closely monitored at this well. GWD removed this well from service because water quality did not meet new drinking water standards. This circumstance has had an adverse effect on the District's water supply and the District is working with the RWQCB to address the issue.

FIGURE 2-33

Location of Surface Contamination Sites in Goleta Groundwater Basin

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update



LEGEND

- Well
- Wright Adjudication Judgement Boundary

Potential Contaminant Source

- RCRA
- CALMORTGAGE
- CLEANUP PROGRAM SITE
- CORRECTIVE ACTION
- EVALUATION
- FUDS
- INSPECTION
- LUST CLEANUP SITE
- MILITARY CLEANUP SITE
- MILITARY PRIVATIZED SITE
- MILITARY UST SITE
- SCHOOL
- TIERED PERMIT
- UNDERGROUND INJECTION CONTROL (UIC)

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTES

FUDS: Formerly Used Defense Sites
LUST: Leaking Underground Storage Tank
RCRA: Resource Conservation and Recovery Act
UST: Underground Storage Tank

N

0 1,900 3,800 5,700
Feet

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021), GeoTracker (2022)

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section2\Figure2-33_Contaminated_Sites.mxd, abarry

3 Groundwater Pumping and Injection

3.1 Groundwater Pumping

The first wells were drilled in the Basin in about 1890 (Upson, 1951). They were shallow artesian wells, generally less than 100 feet deep. During the early history of groundwater use, there was sufficient piezometric pressure to raise water from a well as much as 30 feet above ground surface (Upson, 1951), but that diminished with time as more wells were drilled and aquifer pressures dropped. Deeper, larger-diameter wells were drilled, pumps were installed, and groundwater was used to develop fruit and nut orchards. By the late 1930s, various reports estimated groundwater use to be somewhere between 3,000 and 6,000 AFY, with Upson (1951) reporting average pumping of 4,600 AFY during the 1930s and 1940s.

As urbanization replaced agriculture, potable water suppliers used an increasing share of groundwater in the Basin. La Cumbre formed in 1925 to serve the developing Hope Ranch area. For close to 40 years, groundwater pumping was the sole source of La Cumbre's water supply. GWD was established in 1944 and began producing groundwater as a substantial source of supply in 1963, with less than 1,000 AFY produced before 1970 (GWD, 2008).

Figure 3-1 shows annual pumping volumes since 1970 for GWD, La Cumbre, and private groundwater users. (Records of pumping by private parties are available for the period from 1970 through 1991.) Total pumping in the Basin peaked in the latter half of the 1980s in the range of 6,000 to 8,500 AFY. Starting in the 1990s, basin pumping declined dramatically, largely as the result of the Wright Judgment, the SAFE Ordinance, SWP importation, and the end of the drought. Since then, GWD pumping has mainly occurred during the dry period of 2007 to 2009 and the drought that began in 2012. As can be seen in **Figure 3-1**, GWD pumping increased notably between 2012 and 2016 because of curtailments of SWP and Cachuma Project water supplies. Pumping has decreased since 2018 but still remains an important source of water. As a result of the District's reliance upon groundwater and accessing its stored groundwater supplies, groundwater levels overall in the Basin began declining in 2013. In 2015, groundwater levels fell below the 1972 level specified in the SAFE Ordinance. Following a 100 percent allocation of Cachuma water in 2018, groundwater production water was reduced to maintenance levels, allowing the basin to recharge following 6 years of substantial pumping. The groundwater basin remains a critical source of local supply for the District. La Cumbre pumping has declined somewhat over the last 10 years, during which time annual pumping has ranged between 329 and 1,204 AFY and averaged 637 AFY (**Figure 3-1**).

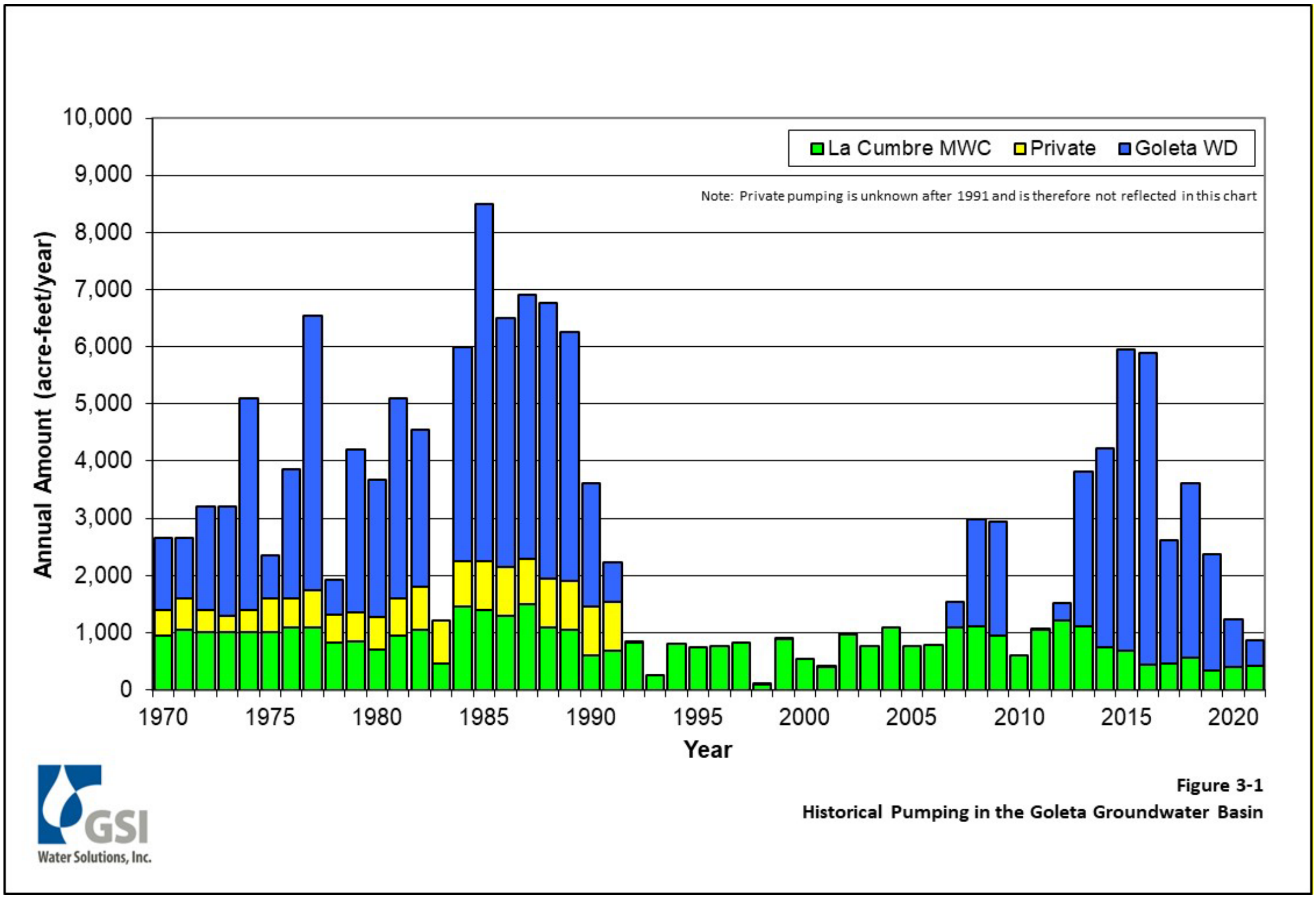


Figure 3-1. Historical Pumping in the Goleta Groundwater Basin

3.2 Operation of Aquifer Storage and Recovery Program

The Goleta Basin was one of the first basins in the state to enhance natural recharge by injecting drinking water into wells. GWD's early injection method was simple: place a fire hose in the well, connect it to a hydrant, and fill the well to near its top, allowing gravity to push the water into the aquifer through the same perforations in the well casing from which water was produced from the aquifer. Injection into the aquifer began in the late 1970s and has been conducted whenever there are excess surface supplies available in wetter years. In the past, more than 2,500 AF of water was injected into the aquifer in a single year. **Figure 3-2** shows annual volumes of pumping and injection in the Basin, and **Figure 3-3** displays cumulative injection over time.

The main source of water injected by GWD is spill water from Lake Cachuma. GWD rehabilitated its well facilities before the completion of the initial GWMP in 2010 and included a special retrofit of its wells for use as dual-purpose injection-extraction wells (commonly referred to as ASR wells) to maximize injection capacity. Water that is injected can later be used in dry years when surface water supplies are reduced. These actions enable GWD to maximize the efficiency of conjunctive use of groundwater and surface water from Cachuma Reservoir. Since the SAFE Ordinance was passed in 1991, GWD has injected 7,734 AF into the Basin. Cumulative injections for which records are available since 1978 total 13,306 AF.

In March 2019, GWD submitted a permit application to the Central Coast Regional Water Quality Control Board (CCWB) as required by a 2012 SWRCB Water Quality Order for injection of water into the Basin. In December 2020, the CCWB issued an ASR permit to GWD that includes five of the District's 14 injection-capable wells: Anita, El Camino, San Marcos, San Ricardo, and University wells. In November 2021, the CCWB updated the ASR permit to include four additional wells for injection: Berkeley, Oak Grove, SB Corp, and San Antonio wells.

While these nine wells have a theoretical combined injection capacity of approximately 2,600 AFY, permit requirements and certain operational constraints may limit injection under certain conditions. Specifically, the permit allows for injection as long as groundwater levels in three specified wells in the Goleta Valley remain below groundwater elevations set forth in the permit to avoid high groundwater levels interfering with environmental remediation projects. Injection is also allowed as long as water quality meets drinking water standards and does not cause or worsen an exceedance of the CCWB's groundwater basin Water Quality Objectives, some of which are stricter than drinking water standards. From an operational perspective, injection is constrained by groundwater wells that are operating in production mode, i.e., water cannot be injected into a well at the same time water is being pumped out of a well.

As of the adoption of this GWMP, GWD injection of treated surface water into the Goleta Basin most recently occurred in 2011, which is when Lake Cachuma last spilled. (Heavy rains in early 2023 may result in Cachuma spills, but data for 2023 is not included in this Plan and will be addressed in the next Plan.) The District is currently planning to construct an additional well with full injection capability as part of its Infrastructure Improvement Plan 2020 to 2025. It is anticipated that the new well will be permitted for injection and add to the District's current injection capacity.

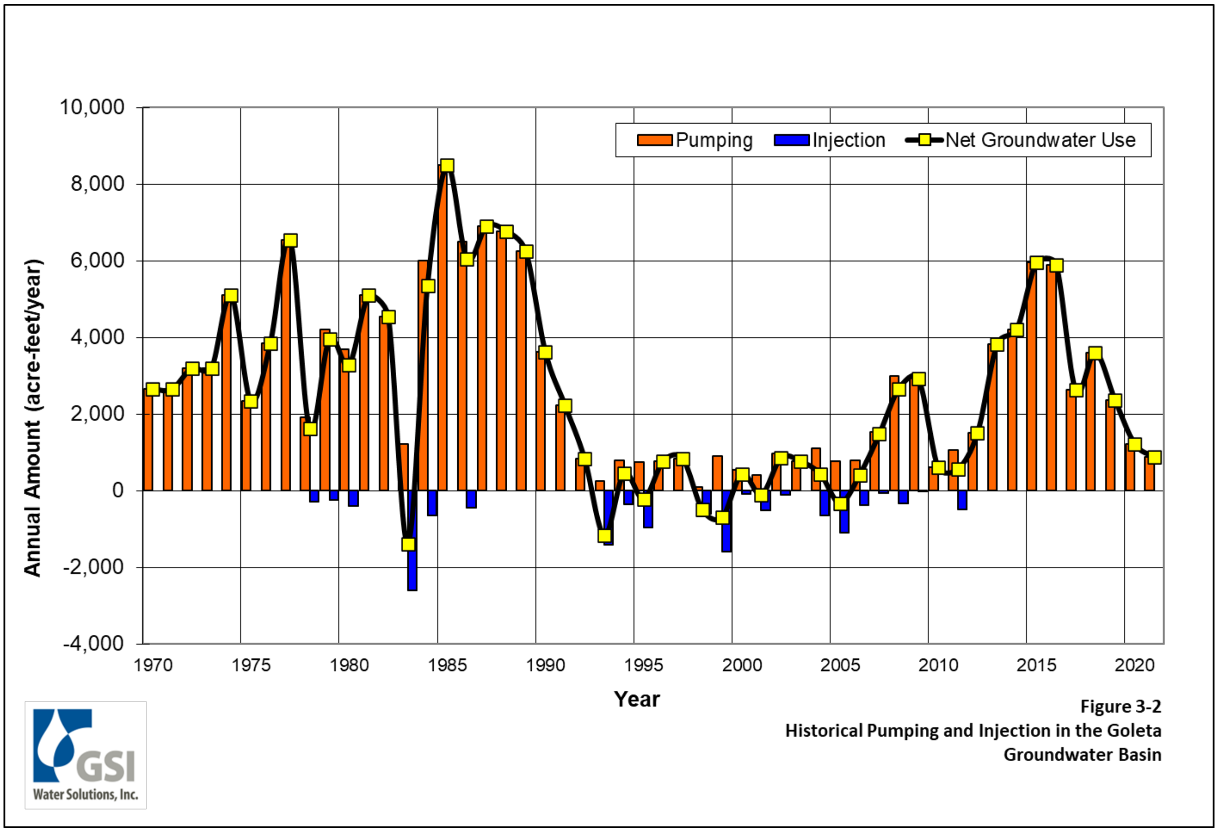


Figure 3-2. Historical Pumping and Injection in the Goleta Groundwater Basin

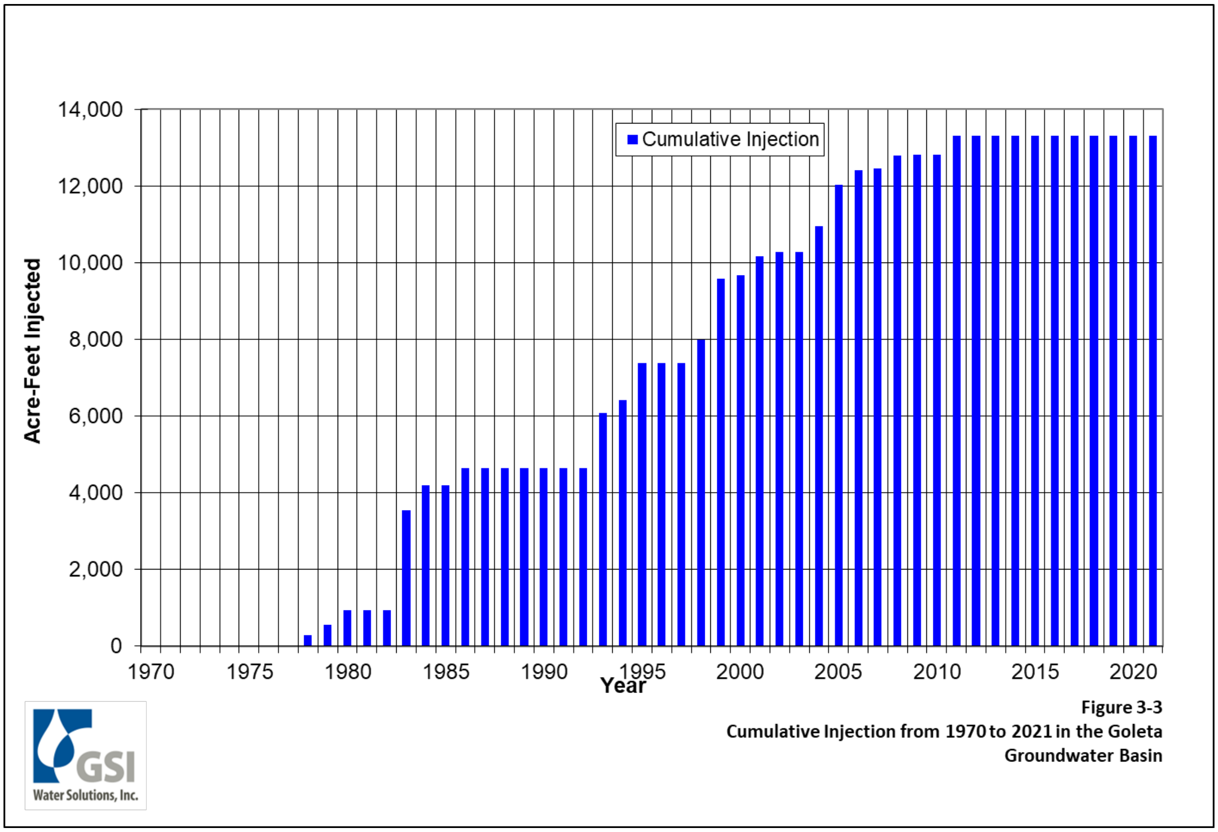


Figure 3-3. Cumulative Injection from 1970 to 2015 in the Goleta Groundwater Basin

4 Basin Yield and Storage

The basin yield is the amount of groundwater that can be pumped for a long-term period of overall average hydrology without causing undesirable results, such as chronic lowering of groundwater levels, loss of groundwater in storage, land subsidence, groundwater quality degradation, etc. In many basins, pumping occurs every year, and it is therefore critical to understand how much pumping can be sustained on average each year for the long term, regardless of whether a particular year or group of years is wet or dry. For GWD, the basin yield is not used in this way because GWD does not pump groundwater unless other supplies are restricted; instead, GWD retains its share of the basin yield in the groundwater drought buffer pursuant to the SAFE Ordinance. Thus, GWD's share of the basin yield is used to establish the drought buffer. For every acre-foot of basin yield that is not pumped by GWD, an acre-foot of groundwater is considered to have been stored in the Basin for later use by GWD. GWD has also historically augmented its groundwater in storage by injecting water into the Basin.

To better understand how the pumping yield may change under a variety of conditions, an expanded analysis was performed as a best management practice to better understand the basic dynamics of the basin. This analysis does not affect GWD's legal right under the Wright Judgment to produce up to its annual adjudicated share of the perennial yield of 2,350 AFY. The critical period for most basins is during droughts, when recharge to the basin is significantly lower because of below average precipitation and increases in groundwater pumping. During droughts, groundwater levels typically decline and can approach levels where negative effects may begin to occur. The District has avoided such extremes through its history of pumping and operation of its ASR injection program. In the Goleta Basin, the focused pumping necessary to produce water from GWD's drought buffer typically results in lower groundwater levels compared to the levels that would be expected if the same total volume of pumping were spread out over the entire storage and recovery cycle.[10]

The following sections describe estimates of basin yield and groundwater storage. Estimates have been made for a variety of purposes using different methods, data, and assumed climate conditions. As a result, a range of yield and storage values is provided and discussed. The most recent estimates were developed using the updated Model, which encapsulates the most comprehensive basin data compilation and analysis effort performed to date. The basin yield and storage estimates developed using the Model are considered the best available estimates and, therefore, are recommended for planning activities.

There is always inherent and unavoidable uncertainty with basin yield and storage estimates resulting from imperfect knowledge of subsurface conditions and varying hydrologic processes. Basin yield and storage estimates may therefore be used to guide planning activities, whereas operational decisions should be informed by groundwater level monitoring results. Maintaining a baseline groundwater monitoring program remains important, and increasing monitoring during droughts is recommended, particularly when groundwater levels approach historical low levels. Section 6 of this Plan provides specific monitoring recommendations.

4.1 Basin Yield

Calculating basin yield is a complicated process, and calculated basin yields for many groundwater basins in California are characterized by uncertainty in key variables and a lack of technical agreement among experts. Rather than a precise calculation, basin yield is commonly provided as a range. It may be expressed

[10] This occurs because groundwater pumping drawdown at individual wells and drawdown interference between wells both increase with pumping rate.

as "safe yield" (a term that can have a legal meaning), "perennial yield," "basin yield," or a like term. The term is generally defined as:

> The yield of a basin is the average quantity of water that can be extracted from an aquifer or groundwater basin over a period of time without causing undesirable results. Undesirable results include chronic lowering of groundwater levels and groundwater in storage, subsidence, degradation of water quality in the aquifer, or decreased stream flow attributable to pumping. If water management in the basin changes, the yield of the basin may change. The yield of a basin is the average amount of water that can be pumped annually over the long term without causing the aforementioned undesirable results. Pumping in individual years may vary above or below this long-term yield during drought or wet years, or as part of basin management plans. (Bachman et al., 2005)

Historically, several methods have been used to calculate the yield of the Goleta Basin. Upson (1951) used the "Hill Method" (Bachman et al., 2005) where the amount of pumping each year is plotted against the change in groundwater elevations caused by that pumping. Theoretically, in a year when there is no net change in groundwater elevation, the amount of pumping in that year is the yield of the basin. Using this method, Upson (1951) calculated a basin yield of about 2,000 AFY for the years 1936 to 1950 (the confined areas of the Central subbasin were considered). Unfortunately, this method assumes that the recharge to the basin from year to year is relatively constant, making it problematic for use in California groundwater basins, including the Goleta Basin. This period coincides with a long, dry climatic cycle when recharge was below average. Thus, Upson's number is likely an underestimation of long-term basin yield.

During the adjudication proceedings, the basin safe yield was evaluated and a value of 3,410 AFY was written into the Wright Judgment. The perennial yield was estimated as 3,700 AFY.[11]

Bachman et al. (2005) further evaluated the basin yield during development of the original GWMP. The optimum situation for estimating basin yield would be to identify a period when groundwater elevations remained unchanged during a period of average precipitation (and, thus, likely to be a period of average recharge). In such a situation, the average pumping during that period would likely provide an approximation of the yield of the Basin. To attempt to identify such a time period in the Basin, a chart was prepared to show the relationships among net pumping (defined as groundwater pumping minus injection), climatic conditions, and groundwater elevations. **Figure 4-1** displays annual net pumping, cumulative departure of rainfall from the average, and the groundwater elevation of Well 4N/28W-9G3. As shown in the figure, there is no period of average precipitation during which groundwater elevations were stable, so the above-described method for estimating the basin yield could not be rigorously applied.

[11] The Court in the Wright Judgment defined the perennial yield as including 350 AFY for the GWD well injection system and 100 AFY of return flow (applied water that percolates back to the aquifer).

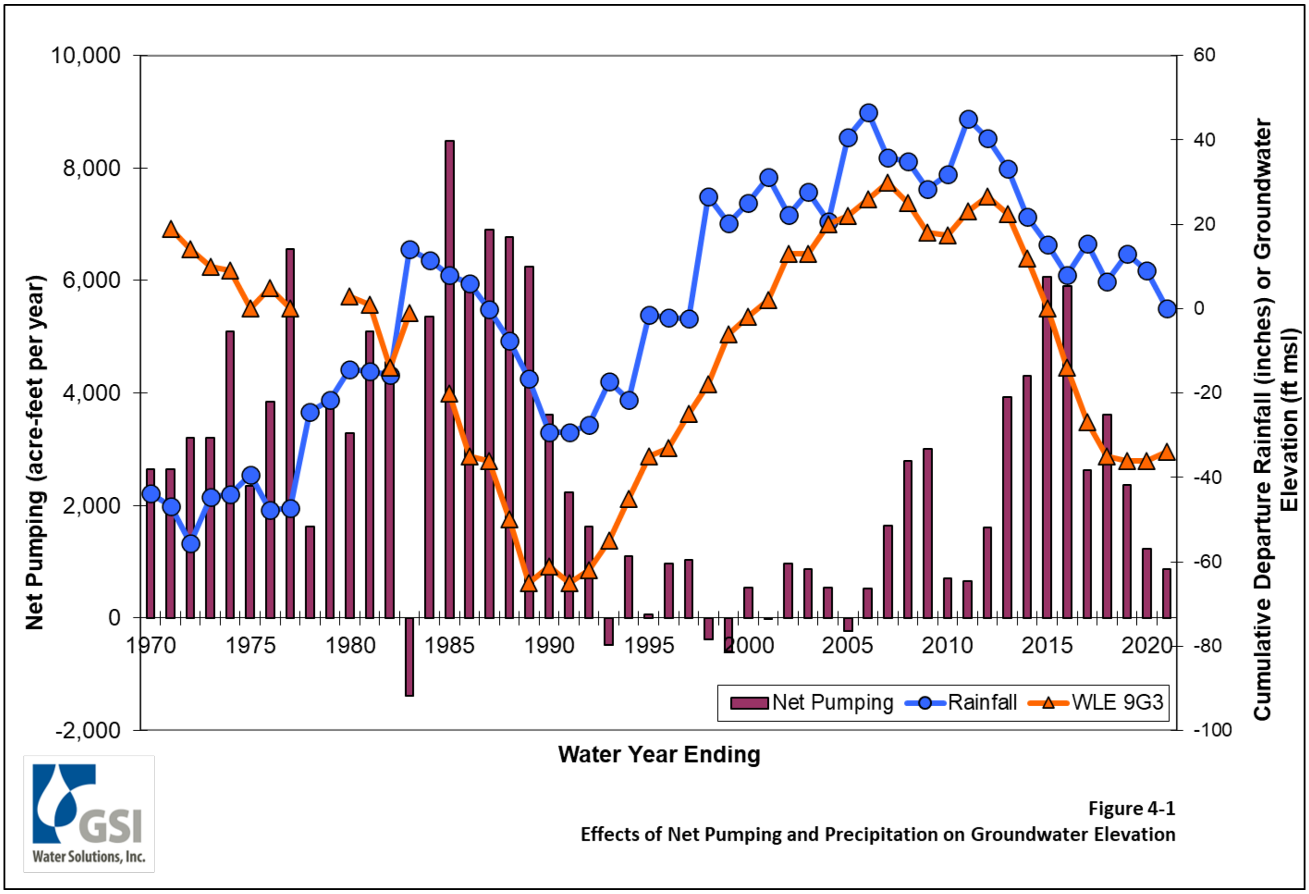


Figure 4-1. Effects of Net Pumping and Precipitation on Groundwater Elevation

In addition to examining the full period of record, Bachman et al. (2005) also subdivided the graph into periods and analyzed the trends during those periods to determine if the basin yield could be bracketed. The following are observations are based on this analysis:

- During the period from 1970 to 1982, rainfall was near average (flat cumulative departure line) or above average (rising cumulative departure curve), but groundwater elevations were dropping. This occurred when average net pumping was about 3,700 AFY. Because groundwater levels were observed to be dropping during a period of average to above average rainfall, Bachman and others concluded that the basin yield is less than 3,700 AFY.
- During the period from 1984 to 1990, rainfall was below average and groundwater elevations continued to drop. The average net pumping during this period was approximately 6,200 AFY. Because groundwater levels were observed to be dropping during a period of below average rainfall, Bachman et al. concluded that the analysis of pumping and cumulative departure of rainfall by itself cannot be used to further calculate the basin yield during 1984 to 1990.
- During the period from 1992 to 2007, precipitation and groundwater elevations both went up. Net pumping during this period was minimal. Because groundwater levels were observed to be rising during a period of above average rainfall with little pumping, Bachman et al. concluded that the analysis of pumping and cumulative departure of rainfall by itself cannot be used to further constrain the basin yield during 1992 to 2007.

Extending these observations further, there was a period of below average rainfall and declining groundwater levels from about 2012 to 2018. Average net pumping during this period was approximately 4,000 AFY. Because groundwater levels were dropping during a period of below average rainfall, the analysis of pumping and cumulative departure of rainfall by itself could not be used to further constrain the basin yield during 2012 to 2018. Since 2019, cumulative departure of rainfall from the average has decreased slightly while groundwater levels stabilized. During this time, average net pumping was about 1,500 AFY. The overall conclusion drawn from the analysis of **Figure 4-1** is that the total yield of the Basin is likely less than 3,700 AFY.

A third basin yield estimate was developed by CH2M HILL in 2010 using the GWD's groundwater Model (CH2M HILL, 2010). The perennial yield was estimated to range from 2,400 to 3,400 AFY; however, CH2M HILL did not evaluate the basin yield during a period of average hydrologic conditions, and thus this estimate is not considered representative and is not discussed further.

As part of the scope of work developing this GWMP, GSI Water Solutions, Inc. (GSI), updated the Model originally constructed in 2010 by CH2M HILL and updated in 2016 for the previous GWMP. For the current update, monthly areal recharge is derived from the USGS Basin Characterization Model, and monthly pumping data was provided by GWD. Monthly stress periods were implemented from 2002 through 2021, and the calibration of the model was reviewed to validate that it still maintains industry standards for model calibration and verification.

The new model was then utilized to perform an updated perennial yield analysis. It is important to note that methods and assumptions used in this analysis may not entirely align with methods and assumptions used in previous yield analyses, and as a result it is possible, or even likely, for the yield estimates to vary from previous estimates. Different base periods, model parameters, climate conditions, and model assumptions may lead to results that do not exactly correspond to previous analysis results. For example, the base period used in the current analysis includes the droughts of 1988 to 1992 and the recent drought (2012 to 2018); the Wright Judgment was finalized in 1989, so neither of these droughts could have been considered at that time. The yield analysis is accomplished by evaluating the modeled change in storage over the course of the selected hydrologic base period, and determining the required net extractions necessary to result in no significant change in storage over the base period.

The first task in the perennial yield analysis is selection of a hydrologic base period. A representative hydrologic base period was selected to use the model to assess perennial yield. The criteria of a representative hydrologic base period for a yield analysis are the following:

- It should be representative of long-term hydrologic conditions.
- It should include at least one (and multiple, if possible) wet, dry, and average periods of precipitation.
- It should span at least a 20- to 30-year period.
- Its start and end years should be preceded by comparable rainfall quantities.
- It is preferable that it start and end in a dry period, thus minimizing any water draining in transit through the unsaturated zone.
- It should include recent cultural conditions.

The hydrologic base period selected for calculating perennial yield is the 50-year period from 1972 to 2021. This hydrologic base period adheres to all of the selection criteria listed above, as observed in the annual precipitation and cumulative departure data displayed in **Figure 4-2**.

The updated perennial yield calculations were completed by GSI using the revised and calibrated Model that includes updated pumping data, precipitation data, and mountain front recharge data. The Model water budget of the historical calibration period representing all historical inflows and outflows was evaluated over the hydrologic Base Period of 1972 to 2021. When the Basin is in balance and has zero change in storage over an average hydrologic base period, the net extracted volumes represent the perennial yield. For the Base Period, the estimated perennial yield is approximately 2,760 AFY, which is consistent with previous estimates. The District intends to augment the basin yield through increased injection during wet periods, consistent with historical practices under the ASR program. The District has the right to continue to produce up to its annual adjudicated share of the perennial yield of 2,350 AFY under the Wright Judgment. The District will continue to monitor basin conditions and water levels and will periodically review the perennial yield estimate during future updates of this Plan and the groundwater model.

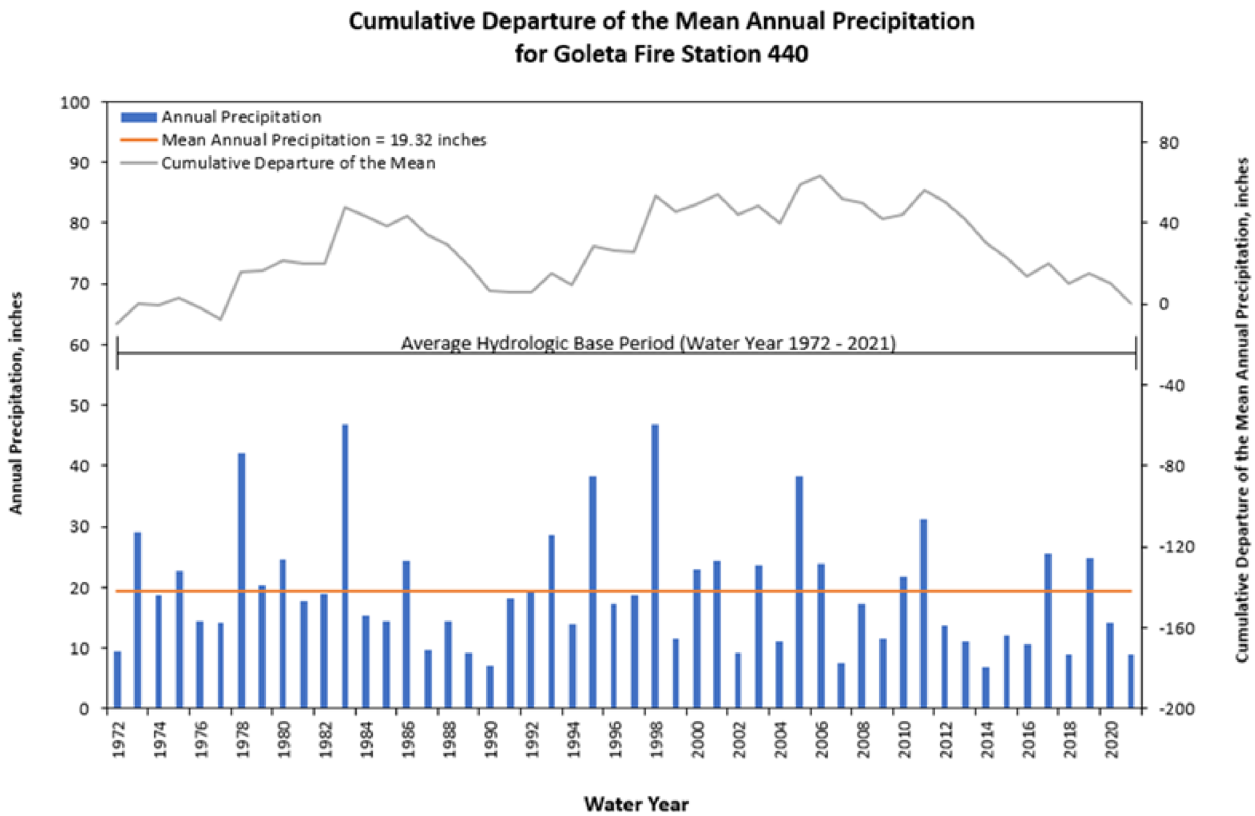


Figure 4-2. Precipitation Data Used to Select Hydrologic Base Period

In summary, historical estimates of the basin safe yield range from 2,000 to up to 3,700 AFY. The large range of safe yield estimates reflects the various estimates that have been made using different methods and data. The basin yield estimate developed using the updated Model (about 2,760 AFY) encapsulates the most comprehensive basin data compilation and analysis effort to date, and the Model reasonably replicates observed groundwater levels under various climactic conditions. There is always some level of uncertainty with basin yield estimates due to imperfect knowledge of basin boundary fluxes, subsurface conditions, and hydrologic processes.

4.2 Basin Storage

The SAFE Ordinance requires GWD to maintain groundwater levels above 1972 levels when possible to create a drought buffer consisting of groundwater storage in the Basin. This buffer can be used to provide water supply when a drought on the South Coast causes a reduction in GWD's annual deliveries from Lake

Cachuma. Following periods of increased groundwater pumping during droughts and when surface supplies are replenished, GWD may inject water to recharge the Basin and rebuild the buffer. The volume of the drought buffer depends on groundwater levels when the drought begins and the rate at which GWD, La Cumbre, and private pumpers extract groundwater during the drought. The drought buffer is determined based on groundwater levels in the Index Wells and consists of the recoverable groundwater in storage between 1972 groundwater levels and historical low levels.

To maintain the drought buffer, the SAFE Ordinance established an Annual Storage Commitment that is operative when the Index Wells average groundwater elevation is below the 1972 level. The initial Annual Storage Commitment was 2,000 AFY and has increased to 2,477 AFY as GWD made new service connections. When in effect, GWD has complied with the Annual Storage Commitment through groundwater storage using SWP water and spill water from Lake Cachuma. The SAFE Ordinance requires that the equivalent of any SWP deliveries in excess of 3,800 AFY be stored in the Central subbasin when the Annual Storage Commitment is operative. Physically, this is accomplished by using the SWP water in lieu of pumping GWD's annual groundwater right.

Through 2012, a total of 50,394 AF of water was credited to GWD's basin storage through in lieu use of SWP water and direct injection. No additional storage via injection has occurred since 2012. The bulk of the water stored to date has been achieved via in lieu use of SWP water (42,556 AF). Injection has contributed 7,838 AF of water. The current storage balance (as of December 31, 2021) is 46,014 AF. The current balance is less than the 2012 storage total because of pumping during drought in 2007 to 2009 and again in 2012 to 2017.

GWD relies on groundwater stored in the drought buffer for water supply during droughts, so it is important to understand how much groundwater can actually be recovered from storage. The recoverable volume of groundwater is generally expected to be less than the total volume stored in accordance with the Wright Judgment and SAFE Ordinance for two reasons. First, there may be natural losses of water from the Basin. Second, focused pumping to produce water from the drought buffer is generally concentrated into a relatively short period of time during droughts when other supply sources are unavailable or unreliable. This causes groundwater levels to decline more quickly than if the same total volume of pumping were spread out over the entire storage and recovery cycle.

The physical amount of water in storage depends on the actual recharge to the Basin (natural and managed) that occurred during the storage period as well as any recharge that occurs during the period of recovery (pumping) of groundwater, which would be expected to take place during droughts. If the natural recharge to the Basin during the storage and recovery cycle is different than the amount assumed in the storage accounting methodology (i.e., Wright Judgment), then the actual amount of water stored in the Basin would differ from the storage volume on paper. The yield estimates described in the preceding section suggest that the physical storage in the drought buffer is likely to be less than the storage volume on paper. This is an important consideration for water supply planning, particularly for relying on this storage during droughts.

A typical method of calculating total physical storage in the Basin is to choose a depth to which groundwater can be drained without undesirable effects and multiplying the aquifer volume to that depth by the percentage of drainable pore space in the aquifer (specific yield). Specific yield varies by aquifer and area, but it is commonly in the range of 10 to 20 percent. Historical calculations of total physical storage in the Basin have used somewhat different assumptions in the calculation. Toups (1974) estimated the total storage at 200,000 AF for the upper 400 feet of saturated sediments, with usable storage between measured high and low water levels as between 40,000 and 60,000 AF. Those storage numbers are consistent with the DWR Bulletin 118 Basin Report for Goleta Basin (DWR, 2004).

In work done by CH2M HILL and used by GWD, usable physical storage down to historical low water levels was calculated at 30,000 to 60,000 AF (CH2M HILL, 2006; GWD, 2008). In addition, there may be another 10,000 to 20,000 AF of currently dewatered aquifer that could be filled (CH2M HILL, 2006; GWD, 2008). Based on the conservative assumption that groundwater elevations should not be allowed to decline below historical lows (having observed that no undesirable effects occurred at this level), then the useable storage estimate for the Basin is between 40,000 and 80,000 AF. Most of this storage is in the Central and North subbasins.

The current amount of water stored in the Basin at the end of 2021 according to GWD's annual report to the Court pursuant to the Wright Judgment was 46,014 AF. Although this volume "on paper" falls within the estimated range of usable storage, the calculation approach described above is challenging to implement in basins such as the Goleta Basin where large portions of the basin consist of confined aquifers that may never drain or may not drain until water levels reach low levels. Furthermore, the useable storage may not all be recoverable for several reasons, including the number and location of wells, uneven distribution of pumping, pumping interference between wells, rate of natural discharge from the Basin, and rate that groundwater is pumped. For these reasons, it is important to estimate how much of the useable storage may actually be recoverable. Groundwater models typically provide better estimates of recoverable storage because they account for confining conditions, the actual distribution of pumping in the Basin, and pumping interference effects, which all affect the amount of groundwater that can be recovered.[12] For these reasons, the updated Model was used to estimate the amount of recoverable groundwater storage available for GWD pumping during droughts.

The updated Model results suggest that the total potentially recoverable groundwater storage in the Basin (defined as groundwater in storage between historical high and low groundwater levels) is approximately 33,500 AF; this is based on the model reported change of groundwater in storage between the periods of highest and lowest water levels. Assuming a linear relation between the average index well water levels and groundwater in storage, an estimated 10,000 AF of the total resides above the drought buffer (defined as groundwater in storage between the historical high groundwater and 1972 levels) and approximately 23,500 AF reside in the drought buffer (defined as groundwater in storage between 1972 and historical low levels). Total pumping in the Basin during the most recent period in which water levels fell from historical highs to 1972 levels (i.e., 2012 to 2014) was approximately 10,000 AF. This suggests that the Model estimates of groundwater storage are reasonable for the groundwater between historical high and 1972 levels. The estimates of recoverable groundwater storage below 1972 levels (the drought buffer) are less certain because they rely on historical pumping and water level records, which may be less accurate than more recent records. This estimate should be periodically checked using water levels measured in index wells on an ongoing basis.

An important consideration is that GWD cannot always expect to pump all of the potentially recoverable storage. The volume of recoverable groundwater for GWD varies with pumping rate, because GWD's pumping competes with other pumpers and natural discharge processes for the available groundwater storage. As a result, the volume of recoverable groundwater in storage for GWD is less if it pumps at a lower rate, whereas GWD could recover more groundwater if it pumps at a higher rate. For example:

- At a GWD drought pumping rate of 2,350 AFY, GWD might expect to recover:
  - 23,200 AF over a period of 10 years if the drought begins with groundwater levels at historical highs
  - 16,900 AF over a period of 7 years if the drought begins with groundwater levels at 1972 levels

[12] For example, if all of the wells in a basin were located in one area, the recoverable volume of groundwater would be significantly less than if the wells were spread out across the basin.

- At a theoretical GWD drought pumping rate of 8,000 AFY, which has never been produced historically, GWD might expect to recover:
  - 29,700 AF over a period of 3.7 years if the drought begins with groundwater levels at historical highs
  - 21,600 AF over a period of 2.7 years if the drought begins with groundwater levels at 1972 levels

The recoverable storage values presented above assume that pumping would stop when historical low groundwater levels are reached. The GWD pumping volume during the most recent period in which water levels fell from historical highs to 1972 levels (i.e., 2012 to 2014) is approximately in line with the estimates provide herein.[13] The estimates of recoverable groundwater storage below 1972 levels (the drought buffer) are less certain for the reasons described above.

Figure 4-3 depicts the relationship between GWD's drought pumping rate and recoverable groundwater storage in a set of storage curves that were developed using the updated Model. The storage curves show the estimated amount of recoverable groundwater storage available to GWD for a given Index Well Average Groundwater Elevation and GWD drought pumping rate. The two curves bracket a range of GWD drought pumping rates (2,350 to 8,000 AFY).

It is recommended that GWD use these curves to help guide drought water supply/management planning. Because of the uncertainty in the actual volumes of recoverable groundwater from the drought buffer, operational decisions during droughts should be informed by groundwater monitoring results. Thus, it is important to maintain a baseline groundwater monitoring program and then increase monitoring during droughts, particularly when groundwater levels approach historical low levels.

[13] GWD pumped approximately 6,500 AF while groundwater levels fell from historical highs to 1972 levels or, approximately 2,200 AFY. This compares with a Model-estimated groundwater recovery for GWD wells of approximately 6,300 AF.

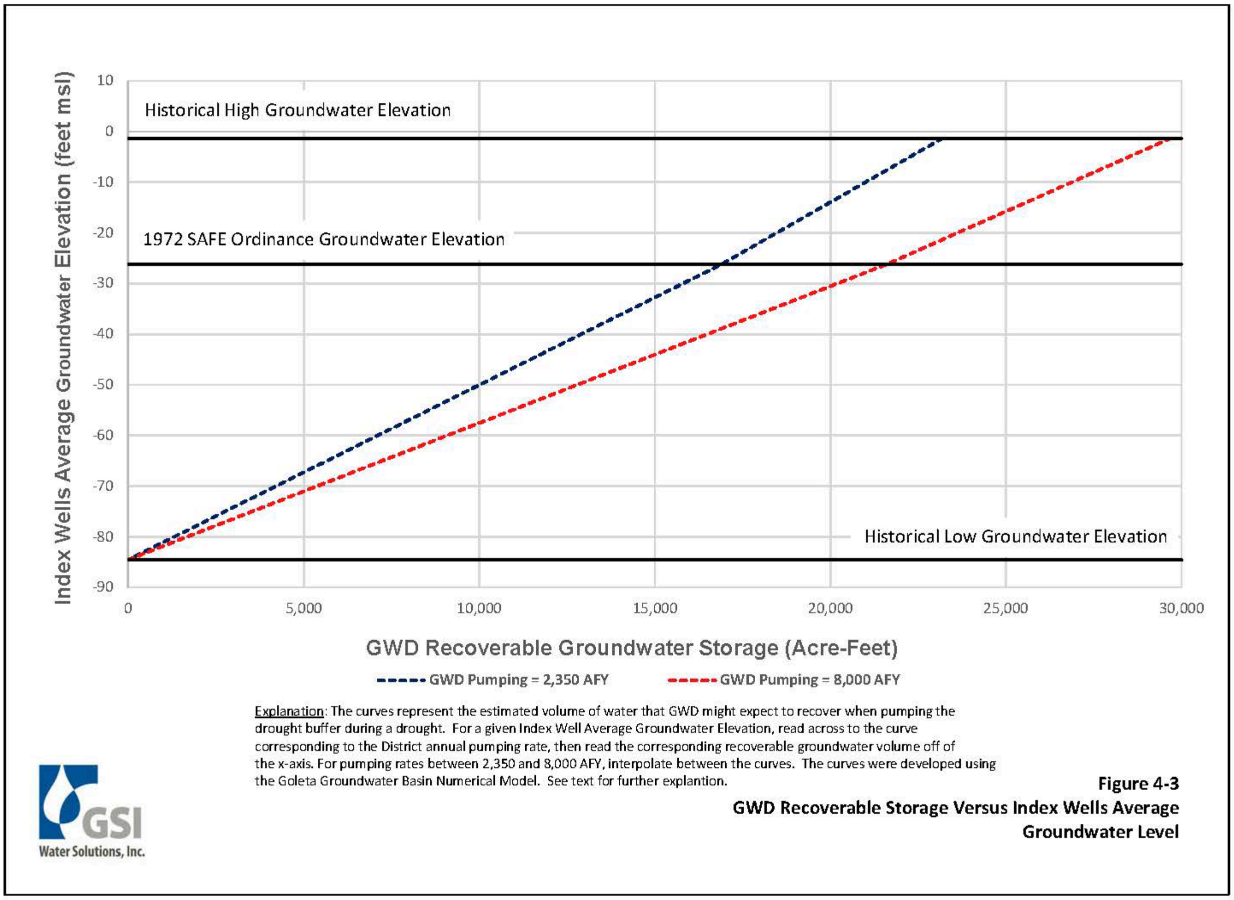


Figure 4-3. GWD Recoverable Storage Versus Index Wells Average Groundwater Level

5 Basin Management

5.1 Basin Management Objectives

Basin Management Objectives (BMOs) are quantitative targets established in a groundwater basin to measure and evaluate the health of the basin. BMOs are typically groundwater elevations and/or chemical concentrations in wells monitored for water quality. For the Goleta Basin, the water level BMOs are set at the lowest measured historical static (non-pumping) groundwater elevation in each BMO well. The historical low level is chosen because negative impacts were generally not observed at or above these levels historically. If groundwater elevations in a BMO well fall below this elevation, the Basin may be at increased risk for undesirable effects such as land subsidence or intrusion of poor-quality water. In addition to potential negative effects at these low groundwater elevations, impacts could occur at groundwater elevations somewhat higher than historical lows if those levels are sustained longer than they have been historically. This underscores the need for increased monitoring of groundwater quality as groundwater levels fall during drought conditions, as discussed later in the Plan.

BMOs for groundwater quality are generally developed for problem constituents that are either introduced at the surface (e.g., nitrate) or that migrate into the aquifer from other geologic units (e.g., salts, for which chloride is a key indicator). The BMOs in the Basin are set to maintain concentrations of nitrate and chloride at or below levels that are harmful to human health or cause damage or loss of production to irrigated crops. Although iron and manganese historically have been a problem for potable wells in the Basin, BMOs were not developed for these constituents because they are naturally occurring within the aquifer and cannot be effectively addressed through basin management measures.[14]

BMOs have been set for groundwater quality by the RWQCB and are adopted as BMOs for this Plan. The BMO for nitrate is set at one-half of the drinking water primary standard of 10 mg/L nitrate as N (one-half the standard is the level at which increased monitoring and testing is required by the RWQCB, and 5 mg/L nitrate as N is the RWQCB objective for protecting beneficial uses). A chloride concentration of 150 mg/L was selected as the BMO because it is the RWQCB objective (RWQCB, 2019) and because it is generally protective of irrigated crops, although salt-sensitive crops, such as avocado and strawberries, may show reductions in yield at concentrations slightly lower than that.

BMO monitoring wells were reviewed during this GWMP update to evaluate their utility in measuring and evaluating the health of the Basin. As noted in the previous GWMP, the Index Wells are now used as the BMO wells for groundwater levels in the Central subbasin. The BMO wells for water quality are the GWD and La Cumbre pumping wells, which are sampled regularly. No wells are being actively monitored for water quality in the North or West subbasins. **Figure 5-1** presents the locations of the Water Level BMO Wells and the Water Quality BMO Wells. The Water Level BMO Wells are monitored for water levels twice a year as part of the USGS monitoring program effort. The Water Quality BMO Wells are sampled regularly by GWD and La Cumbre, pursuant to Title 22 requirements.

Table 5-1 shows April 2021 groundwater levels compared with BMOs at each well location. The April 2021 groundwater levels at each location and the Index Well average values are above their respective BMO levels, indicating that there is currently limited risk for land subsidence or migration of poor quality (saline) water into the basin production zone. Nonetheless, groundwater levels could fall to BMO levels if drought conditions return and pumping increases. Potential impacts include groundwater quality degradation,

[14] Iron and manganese are naturally occurring metals found in the basin sediments that dissolve when in contact with groundwater having a low oxidation-reduction potential. Basin management measures are not typically effective at minimizing iron and manganese concentrations to levels that render treatment unnecessary.

subsidence, groundwater storage depletion, and decreased pumping capacity of GWD and non-GWD wells. GWD developed an updated Drought Preparedness and Water Shortage Contingency Plan in 2021 that describes various measures to lessen impacts caused by extended drought and provide for reliable groundwater supply.

Table 5-2 compares the most recent available water quality results with the established nitrate and chloride BMO values. Most results are from samples taken during 2021, with some results from 2020. Nitrate values are reported as nitrate as N rather than nitrate as NO_3, consistent with the updated drinking water standards and RWQCB objectives. While GWD meets all drinking water primary standards, the nitrate BMO was exceeded at one location (La Cumbre #17). Nitrate concentrations began to exceed the BMO at La Cumbre #17 in 2016 and have remained above the BMO (but below the drinking water primary standard) since then. In addition, the previous GWMP reported nitrate detection in only one other well, Anita #2, located west of La Cumbre #17. Since 2016, nitrate levels in Anita #2 have fluctuated, and the most recent sample taken in April 2021 showed slightly higher nitrate levels compared to the previously reported data, although it remains below the BMO. Nitrate was also detected in another well west of Anita #2, San Ricardo, for the first time in 2021. Further investigation of nitrate in the southern portion of the Central subbasin may be warranted as a best management practice since the concentrations and number of detections have increased. The chloride BMO was exceeded at one location (Shirrell well). Shirrell is a shallow well, and the elevated chloride may reflect the reduced amount of recharge during the drought in the vicinity of the well. Chloride concentrations in the remaining BMO wells are below the BMO level.

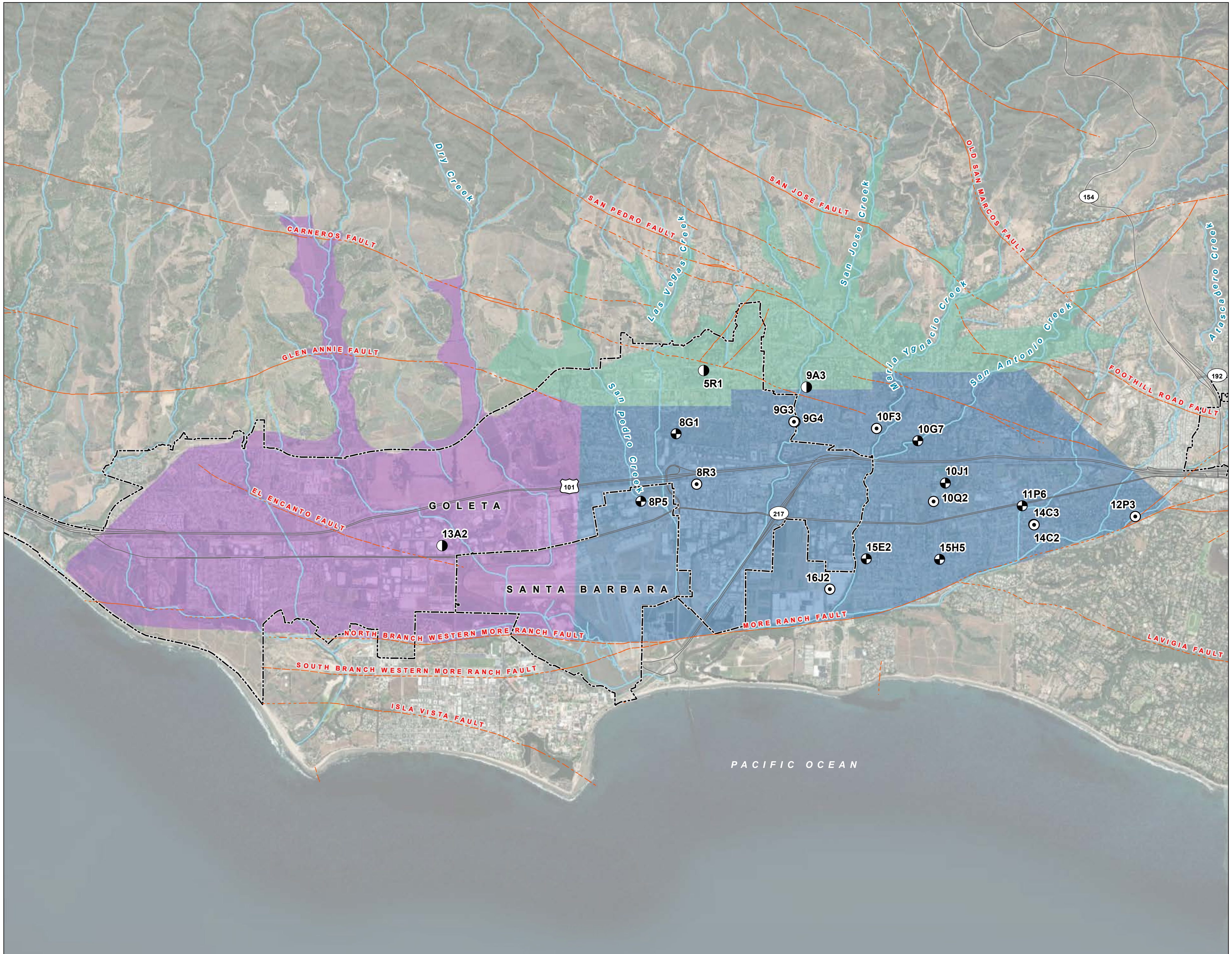


FIGURE 5-1

Location of BMO Wells

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

- Water Level BMO Well (Index Well)
- Water Quality BMO Well
- Water Level BMO Well
- Fault
- Fault (Inferred)
- Fault (Approximate)

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

All Other Features

- City Boundary
- Major Road
- Watercourse

NOTE

BMO: Basin Management Objective

N

0 1,900 3,800 5,700
Feet

GSI Water Solutions, Inc.

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

Table 5-1. Water Level Basin Management Objectives for the Goleta Groundwater Basin

Well Number	Name	Subbasin	WLE BMO	2021 WLE
04N28W08R03	Magnolia (Index Well)	Central	-84	-39
04N28W09G03	Berkeley #1 (Index Well)	Central	-65	-34
04N28W10F03	Barquero (Index Well)	Central	-80	-50
04N28W10Q02	Emmons (Index Well)	Central	-89	-50
04N28W12P03	LCMWC #7 (Index Well)	Central	-153	-111
04N28W14C02	LCMWC #2A (Index Well)	Central	-69	-1
04N28W16J02	Ciampi #1 (Index Well)	Central	-69	-55
———*Index Well Average*———		Central	-85	-49
04N28W05R01	Martini	North	15	32
04N28W09A03	Mulligan	North	15	30
04N29W13A02	Moseley	West	-5	6

Notes

WLE = Water Level Elevation BMO = basin management objective

Table 5-2. Water Quality Basin Management Objectives for the Goleta Groundwater Basin

Well Number	Name	Subbasin	Nitrate BMO (mg/L)	Current Nitrate as N (mg/L)	Chloride BMO (mg/L)	Current Chloride (mg/L)
04N28W08P05	Airport	Central	5	ND	150	51
04N28W09G04	Berkeley #2	Central	5	ND	150	110
04N28W15H05	Anita #2	Central	5	2.3	150	83
04N28W08G01	Shirrell	Central	5	ND	150	**160**
04N28W11P06	San Marcos	Central	5	ND	150	42
04N28W15E02	San Ricardo	Central	5	1.4	150	43
04N28W10G07	University	Central	5	ND	150	84
04N28W14C03	La Cumbre MWC #17	Central	5	**7.3**	150	130
04N28W10J01	El Camino	Central	5	ND	150	34

Notes

Bold values exceed the BMO.

Chemical concentrations are the most recent results within the last 2 years.

BMO = basin management objective mg/L = milligrams per liter ND = not detected

5.2 Current Management Strategies

Management strategies are the methods used to implement the GWMP. The discussion of these strategies is presented in two parts: current strategies (this section) and recommended future strategies (Section 6).

5.2.1 Groundwater Storage Programs

The current strategy for groundwater storage in the Basin follows both the Wright Judgment (for GWD and La Cumbre) and the SAFE Ordinance (for GWD). For both water suppliers, the storage strategy has used both in lieu recharge (using another water source to reduce pumping and letting the Basin refill) and direct well injection. Between the early 1990s and 2012, GWD pumped less than its water right and injected water when feasible, allowing the Basin to refill. Similarly, La Cumbre has pumped below its water right during most years since the late 1990s and has injected water at times, also helping the Basin to refill (**Table 5-3**). The basin groundwater levels reached historical high levels in the spring of 2012. It took approximately 12 years for the Basin to refill above 1972 levels with little GWD pumping.

Table 5-3. Goleta Water District Groundwater Storage in the Central Subbasin (in acre-feet) under the Wright Judgment

Year	Water Right (AFY)[1]	Pumping (AF)	Injection (AF)[2]	Annual Storage (AFY)	Cumulative Storage (AF)[3]
1992	2,023	13	0	2,010	2,010
1993	2,037	0	1,422	3,459	5,470
1994	2,051	0	346	2,397	7,867
1995	2,051	0	964	3,015	10,882
1996	2,175	0	0	2,175	13,054[3]
1997	2,224	0	0	2,224	15,272
1998	2,226	8	600	2,818	18.084
1999	2,226	8	1,595	3,807	21,891
2000	2,226	0	70	2,290	24,182
2001	2,226	8	405	2,623	26,805
2002	2,226	3	113	2,336	29,141
2003	2,350	0	0	2,350	31,492
2004	2,350	0	658	3,008	34,500
2005	2,350	0	668	3,018	37,518
2006	2,350	0	288	2,638	40,156
2007	2,350	438	0	1,912	42,068
2008	2,350	1,888	334	796	42,864
2009	2,357	1,987	26	396	43,260
2010	2,357	0	0	2,357	45,610
2011	2,357	4	349	2,702	48,305
2012	2,357	306	0	2,051	50,349
2013	2,357	2,714	0	-357	49,985
2014	2,357	3,463	0	-1,106	48,872
2015	2,357	5,263	0	-2,906	45,959
2016	2,357	5,473	0	-3,116	42,836
2017	2,357	2,188	0	169	42,998
2018	2,357	3,057	0	-700	42,291
2019	2,357	2,038	0	319	42,603
2020	2,357	822	0	1,535	44,131
2021	2,357	456	0	1,901	46,025

Notes

[1] Includes increased groundwater rights from both exchanges and augmented service (**Table 1-1**).

[2] From GWD annual reports to the Superior Court of California, Santa Barbara County and other Parties to the Wright Judgment.

[3] Several years have slight deduction for delivery to non-parties.

AFY = acre-feet per year AF = acre-feet

Historically, GWD has delivered a portion of its Lake Cachuma spill water (water that would otherwise have been lost to spill at the dam during a wet period when Cachuma was full) to La Cumbre and for recharge to the Basin. This spill water has been used by La Cumbre to offset its own pumping and for direct injection in La Cumbre's wells. However, since La Cumbre currently lacks a permit for injection, it is unable to inject any spill water. Since the beginning of 1999, GWD was required by the Wright Judgment to offer to deliver 20 percent of GWD's treated spill water to La Cumbre at GWD's actual cost. If the offer is not accepted, GWD could have used La Cumbre's wells for injection of water into the Basin. Under its new injection permit, GWD is currently prohibited from utilizing La Cumbre wells for injection. La Cumbre previously used its share of this spill water to offset pumping and for direct injection (**Table 5-4**). Total water in storage for GWD and La Cumbre peaked in 2012, when credited storage between the two water suppliers totaled 51,271 AF.

Table 5-4. La Cumbre Water Rights and Groundwater Storage in the Central Subbasin

Calendar Year	Water Right (AF)	Pumping (AF)	Unused Water Right (AF)	10-Yr Accumulated Unused Water[1,2] (AF)	Injection Storage[3] (AF)	Cumulative Injection Storage (AF)
1999	1,000	893	107	107	0	0
2000	1,000	533	467	574	27	27
2001	1,000	394	606	1,180	98	125
2002	1,000	969	31	1,211	0	125
2003	1,000	765	235	1,446	0	125
2004	1,000	1,095	-95	1,351	0	125
2005	1,000	766	234	1,586	424	549
2006	1,000	786	214	1,800	81	631
2007	1,000	1,096	-96	1,704	0	631
2008	1,000	1,105	-105	1,598	150	781
2009	1,000	953	47	1,538	0	781
2010	1,000	603	397	1,468	0	781
2011	1,000	1,045	-45	817	141	922
2012	1,000	1,204	-204	582	0	922
2013	1,000	1,112	-112	235	0	922
2014	1,000	750	250	580	0	922
2015	1,000	694	306	652	0	922
2016	1,000	448	552	990	0	922
2017	1,000	466	534	1,620	0	922
2018	1,000	561	439	2,164	0	922
2019	1,000	329	671	2,788	0	922
2020	1,000	390	610	3,001	0	922
2021	1,000	417	583	3,629	0	922

Notes

[1] Beginning in 2008, value is running 10-year total of unused water right.

[2] Pumping can vary annually as long as the average of the most recent 10 years does not exceed 1,000 acre-feet per year. 2009 was the first year where the moving average dropped a year, 1999, as the 10-year average was calculated using years 2000–2009.

[3] La Cumbre was first allowed by the Wright Judgment to store water in 1999.

AF = acre-feet

Calculation of storage under the Wright Judgment uses a different method of calculation for La Cumbre than for GWD. For La Cumbre, a 10-year moving average of pumping is used to allow annual pumping to vary above and below the water right of 1,000 AFY to accommodate wet and dry periods. In **Table 5-4**, the water available to pump above the water right is tracked in the column titled 10-Yr Accumulated Unused Water. In 2009, the 1999 data dropped off the calculation so that only the most recent 10 years were used in the calculation. The exception to this is the water La Cumbre stored by injection into the aquifer—this storage accumulated until it was pumped back out.

The SAFE Ordinance, which only applies to GWD, provides for the creation of a drought buffer of water stored in the Basin to protect against future drought emergencies. When groundwater elevations are below 1972 levels (interpreted in this Plan as the average of the Index Wells in any year being below the average in 1972), the SAFE Ordinance specifies that a certain amount of water must be committed to be recharged to the Basin during each year (Section 1.2.3). The amount of water required to be stored annually under these conditions is GWD's basic water right (2,000 AFY) plus ⅔ of the amount of any new service connection provided by the District (**Table 5-5**).

Table 5-5. Goleta Water District Required Annual Commitment to Storage under the SAFE Ordinance

Year	Base Annual Storage Commitment (AFY)	New Service (AF)	New Service Storage Commitment (AFY)[1]	Annual Storage Commitment (AFY)[2]
1997	2,000	165	110	2,110
1998	2,000	96	64	2,174
1999	2,000	13	9	2,183
2000	2,000	21	14	2,197
2001	2,000	33	22	2,219
2002	2,000	31	21	2,240
2003	2,000	11	8	2,248
2004	2,000	24	16	2,263
2005	2,000	45	30	2,294
2006	2,000	26	17	2,311
2007	2,000	77	51	2,362
2008	2,000	9	6	2,368
2009	2,000	7	5	2,373
2010	2,000	8	5	2,378
2011	2,000	64	43	2,421
2012	2,000	7	5	2,426
2013	2,000	18	12	2,438
2014	2,000	58	39	2,477
2015	2,000	0	0	2,477
2016	2,000	0	0	2,477
2017	2,000	0	0	2,477
2018	2,000	0	0	2,477
2019	2,000	0	0	2,477
2020	2,000	0	0	2,477
2021	2,000	0	0	2,477

Notes

1 Two-thirds of the new service demand is added to the Base Commitment.

2 The Annual Storage Commitment is calculated each year. It is only required to be contributed when groundwater elevations are below 1972 levels. Note that calculations have been rounded so additions of columns may appear to be erroneous (but they are not). The storage requirement for new service is additive of previous storage requirements because the new demand is present in subsequent years and must be protected using the drought buffer.

AFY = acre-feet per year AF = acre-feet SAFE Ordinance = Safe Water Supplies Ordinance

The SAFE Ordinance specifies that after providing service to existing customers, GWD is required to commit at least 2,000 AFY of its water supply to the Basin either by direct injection or reduction in pumping. To the extent there are "excess" SWP deliveries beyond 3,800 AFY not needed to serve existing customers, GWD is required to store water in the Basin until the Basin is replenished to 1972 levels. The annual storage commitment and SWP delivery to recharge are not required to be made in any year when groundwater elevations are above 1972 levels (**Table 5-6**). Since 2015, the average water level in the Index Wells has been below 1972 levels and so there is an outstanding annual storage commitment that must be satisfied by either direct injection of excess SWP water (when it becomes available) or curtailment of pumping, after demand by existing GWD customers is met. Because there is not an excess of SWP water and there is no excess water after existing GWD customer demands are met within GWD's water rights, GWD has no obligation to increase storage in the aquifer during this extended drought period.

Table 5-6. Goleta Water District Required Annual Storage Commitment under the SAFE Ordinance, Indicating Actual Recharge and Any Outstanding Commitment That Has Not Yet Been Recharged

Year	Annual Storage Commitment Calculation (AFY)	Required Annual Storage Commitment (AFY)[1]	Water Stored Under Commitment (AFY)	Annual Commitment Outstanding (AF)
1997	2,110	2,110	2,110	0
1998	2,174	2,174	2,174	0
1999	2,183	2,183	2,183	0
2000	2,197	2,197	2,197	0
2001	2,219	2,219	2,219	0
2002	2,240	2,240	2,240	0
2003	2,248	2,248	2,248	0
2004	2,263	2,263	2,263	0
2005	2,294	0	0	0
2006	2,311	0	0	0
2007	2,362	0	0	0
2008	2,368	0	0	0
2009	2,373	0	0	0
2010	2,378	0	0	0
2011	2,421	0	0	0
2012	2,426	0	0	0
2013	2,438	0	0	0
2014	2,477	0	0	0
2015[2]	2,477	2,477	0	2,477
2016	2,477	2,477	0	2,477
2017	2,477	2,477	0	2,477
2018	2,477	2,477	0	2,477
2019	2,477	2,477	0	2,477
2020	2,477	2,477	0	2,477
2021	2,477	2,477	0	2,477

Notes

[1] After 2004, GWD Board determined that groundwater elevations were above 1972 levels, so no Annual Commitment was required.

[2] Groundwater levels fell below 1972 levels in early 2015 triggering the annual storage commitment requirement.

AFY = acre-feet per year AF = acre-feet SAFE Ordinance = Safe Water Supplies Ordinance

5.2.2 Groundwater Pumping

GWD's current strategy for pumping in the Basin is to stay within water rights determined by the Wright Judgment, allow the Basin to recover by reducing pumping when possible, and store unpumped groundwater for a drought or some other water contingency.

La Cumbre has pumped groundwater somewhat below its water right during the last decade (**Table 5-4**), whereas GWD's pumping was reduced to a minimum from the early 1990s to about 2006 to allow the Basin to refill (**Table 5-3**). As a result of the reduced pumping, groundwater elevations in much of the Central subbasin rose for many years. GWD pumped significant volumes of groundwater in 2008 to 2009 because of dry conditions and began pumping larger volumes of groundwater again starting in 2013 because of drought conditions that limited SWP and Cachuma water deliveries. Following a 100 percent allocation of Cachuma water in 2018, groundwater production water was reduced to maintenance levels, allowing the Basin to recharge following 6 years of substantial pumping. With an anticipated 100 percent allocation in 2023, GWD groundwater production will again be reduced to maintenance levels to allow for further basin recovery and injection.

In the eastern portion of the Central subbasin, where groundwater elevations are lower than elsewhere in the subbasin, La Cumbre pumping balances water quality concerns against costs—groundwater is less expensive than SWP water, but the surface water (SWP water flows through Cachuma reservoir during delivery) is usually better quality.

5.2.3 Groundwater Monitoring

The existing regional groundwater level monitoring program, conducted by USGS and contracted by GWD, consists of collecting manual measurements of water levels in 42 basin wells twice a year: 34 wells in the Central subbasin, 6 wells in the North subbasin, and 2 wells in the West subbasin. A few of these wells are close to purveyors' wells, limiting their usefulness when the supply wells are being pumped. The monitoring is currently conducted in April and December of each year to capture the annual high and low groundwater levels, as recommended in the original GWMP. The location and elevation of the wells were surveyed in 2008. These wells, along with their construction details, have been entered into a geographic information system (GIS) database as part of preparing this Plan. Groundwater elevation records, including historical records as far back as the 1920s, are in digital form.

Before the GWMP, the spring measurements were made in June; now they are made in April. The schedule change was made pursuant to a recommendation in the GWMP to switch the June measurement to April, to better capture the annual high groundwater levels. This recommendation was based on an analysis of historical groundwater level data to determine the optimum monitoring months to detect annual high and low groundwater levels. A summary of the analysis can be found in Section 5.1 of the original GWMP (GSI, 2016).

The 2015 GWMP recommended evaluating supervisory control and data acquisition (SCADA) records from GWD production wells to further assess the optimum monitoring months. Operations logs (SCADA records) were provided by GWD for the period of 2007 to 2016 and were evaluated pursuant to this recommendation. Each operations log provides static water levels when the well is not pumping. The frequency of the static water level measurements is typically four or five measurements per week when a well is not pumping, which should be sufficient for evaluating the optimum monitoring months. However, because there was considerable pumping during the evaluation period, it was not possible to re-evaluate the optimum monitoring months. For this reason, it is recommended that the semiannual monitoring program continue on its April and December schedule. As discussed in Section 6.6.2, it is recommended that transducers be installed in a subset of monitoring wells to better evaluate the optimum monitoring months, among other reasons.

When the April and December water levels are measured, it is important to ensure that the measured well (if it is a pumping well) and nearby wells have not been pumped during the previous 12 hours or so. The SCADA data from GWD producing wells indicate that it takes about 10 hours in these wells for groundwater levels to recover (equilibrate to a constant level) after a pumping cycle is completed. In addition to the semiannual groundwater-level monitoring program, monitored wells may be equipped with pressure transducers as part of their automated SCADA system; water levels measured by the transducers are preserved digitally.

Currently, regional groundwater quality is monitored regularly under the required drinking water standards. For the purposes of BMO monitoring, historical water quality data provide a complementary component to the required monitoring. Historical water quality data are more complete and extensive because many more wells were sampled by a number of agencies over time were included on the maps (e.g., compare **Figures 3-1** through **3-6** to **Figures 3-7** through **3-12**). Both historical and current water quality data have been entered into a digital database as part of preparing this Plan.

A key vulnerability of relying on production wells for water quality monitoring is that this approach does not provide an early warning of intrusion of seawater (even though the Goleta Basin is at minimal risk of such intrusion), intrusion of other poor quality water sources, or movement of contaminant plumes. Additionally, more frequent monitoring than is required for DDW compliance is also warranted during drought pumping because this is when water quality changes are most likely given depressed groundwater levels. The Waste Discharge permit authorizing GWD to conduct ASR operations has expanded monitoring requirements when injection and recovery is conducted, which will improve overall monitoring in the Basin. Recommendations for addressing vulnerabilities in the current groundwater quality monitoring are provided in Section 6.6.4.

5.2.4 1972 Conditions for the SAFE Ordinance

A groundwater management consideration for GWD is ongoing compliance with GWD's SAFE Ordinance that sets 1972 groundwater levels in the Central subbasin as the baseline for determining a drought buffer. The 1972 groundwater level conditions for implementing the SAFE Ordinance and method for comparing with current/future groundwater levels were evaluated in detail during development of the original GWMP (GWD and LCMWC, 2010). Three methods were evaluated: (1) compare current/future groundwater levels against groundwater levels in all wells that were measured in 1972 (i.e., if the groundwater level at any 1972 measurement location is not met, GWD pumping would be considered to be from the drought buffer); (2) compare current groundwater storage[15] against 1972 groundwater storage; and (3) compare current average groundwater levels against 1972 average groundwater levels in a representative set of monitoring wells (GWD and LCMWC, 2010). The third method was selected because it is used successfully in several other adjudicated basins and because it provides the most management flexibility (compared to the first method) and avoids calculation errors (compared to the second method) (GWD and LCMWC, 2010). Seven wells were recommended for use in implementing the SAFE Ordinance (GWD and LCMWC, 2010). These seven wells are referred to as the Index Wells and were selected to provide a roughly even geographic distribution across the adjudicated area.

Details of the Index Wells are in **Table 5-7** and the wells are shown in **Figure 2-4**.

[15] Groundwater storage would be calculated using groundwater levels and estimated basin aquifer storage properties and geometry.

Table 5-7. Index Wells for Determination of the SAFE Ordinance 1972 Groundwater Elevations

Well Number	Name	Depth (feet)	Perforations (feet)	Years of Record
04N28W08R03	Magnolia	106	NA	1941 to current
04N28W09G03	GWD Berkeley #1	288	168–288	1964 to current
04N28W10F03	GWD Barquero	300	150–300	1970 to current
04N28W10Q02	Emmons	278	62–278	1922 to current
04N28W12P03	La Cumbre MWC #7	626	115–626	1947 to current
04N28W14C02	La Cumbre MWC #2A	Not Available at Time of Print		1938 to current
04N28W16J02	Ciampi #1	458	160–390	1954 to current

Notes

NA = not applicable

SAFE Ordinance = Safe Water Supplies Ordinance

Information concerning the selection of the Index Wells is in Section 5.2.4 and Appendix A of the original GWMP (GWD and LCMWC, 2010). Groundwater level data from 2016 through 2021 at the Index Wells were reviewed during development of this GWMP update. The Index Wells continue to be monitored semiannually and also appear to continue to provide a reasonable representation of groundwater conditions in the Central subbasin. No changes to the Index Wells are recommended at this time.

5.2.5 Groundwater Modeling

GWD's Model was originally completed in 2010 using MODFLOW-2000 and the pre- and post-processing software package Groundwater Vistas (CH2M HILL, 2010). The Model covers the Basin, with divisions representing the North, Central, and West subbasins (**Figure 1-1**). The Model grid consists of 77 rows, 120 columns, and 6 layers, resulting in 55,440 cells (12,780 cells are active). The Model provides a comprehensive accounting of all groundwater budget components, including pumping, evapotranspiration, groundwater discharge to streams, inflow from alluvial canyons, bedrock, faults, areal and stream recharge, and injection, The 2010 Model report also documents a series of Model simulations completed to estimate the perennial yield of the Basin and evaluate four alternative pumping and injection scenarios.

In 2014, GSI extended the Model from 2007 to 2013 (GSI, 2014). The Model was used to estimate the perennial and safe yield of the Basin (Section 4.1), evaluate recoverable groundwater storage (Section 4.2), develop recoverable groundwater storage curves (Section 4.2), evaluate options to optimize injection of Cachuma spills, and evaluate potential locations for new GWD production wells.

In 2022, GSI again updated the model in conjunction with and in support of the update of this GWMP. The Model update components include updating the model simulation period through 2021, incorporating monthly stress periods (e.g., monthly pumping volumes) from 2002 through 2021 (previously, annual stress periods were used), using data derived from the USGS Basin Characterization Model to estimate areal monthly recharge, and incorporating monthly pumping data developed by the GWD. The Model underwent transient calibration for the historical period 1970 through 2021, during which the aquifer properties (hydraulic conductivity/transmissivity and storage coefficient) and water budget components were adjusted to achieve a match between Model-calculated and measured groundwater elevations.

5.2.5.1 Predictive Groundwater Management Modeling Scenarios

In consultation with GWD, GSI developed predictive management scenarios with variable quantities of both groundwater pumping and injection through the District's ASR program. **Table 5-8** presents the variable quantities of pumping and injection simulated in the predictive scenarios. The hydrologic period selected to represent climatic conditions of recharge and streamflow for the predictive simulations is 2013 through 2021; this period was largely characterized by drought conditions, so in this sense the predictive simulation period may be characterized as providing conservative results. Projected basin pumping is simulated at quantities of 1,500 AFY (seasonal pumping only), 2,350 AFY (current adjudicated allotment), 5,341 AFY (maximum pumping based on historical data), and 7,185 AFY (a projected possible future maximum pumping amount). For each assignment of basin pumping, three levels of ASR injection are simulated; 0 AFY, 2,665 AFY (the currently maximum permitted amount within existing capacity), and 3,125 AFY (assuming a 25 percent expansion of the current permit amount), resulting in a total of twelve predictive management scenarios.

Table 5-8. Groundwater Management Predictive Scenario Assumptions and Inputs

Predictive Scenarios from 2022 through 2030[1]			
Scenario Number	**Scenario Description**	**Projected Pumping (AFY)**	**Projected ASR Injection (AFY)**
1a	Seasonal	1,500	0
1b			2,665[2]
1c			3,125
2a	Allocation	2,350	0
2b			2,665
2c			3,125
3a	Current Maximum	5,341	0
3b			2,665
3c			3,125
4a	Future Potential Maximum	7,185	0
4b			2,665
4c			3,125

Notes

[1] A 9-year predictive hydrologic period for pumping/injection scenarios through 2030, is based on the historical period 2013–2021.

[2] Based on daily injection permit of 7.3 acre-ft/day or 2,665 AFY.

AFY = acre-feet per year ASR = aquifer storage and recovery

Predictive model simulations were run using the inputs described in **Table 5-8** for a 9-year predictive simulation period. Model results were evaluated in terms of average annual change in storage, cumulative change in storage over the 9-year predictive period, and change in the average groundwater elevation of the seven GWD index wells. Results are presented in **Table 5-9**.

For each pumping scenario number (1 through 4), the successive injection scenarios a through c represent increasing quantities of ASR injection. The quantitative results of these assumptions are apparent upon inspection of the resulting storage values. For example, under pumping scenario 1, injection scenarios a, b, and c result in cumulative change in storage over the simulation period of -4,308 AFY, 8,853 AFY, and 9,892 AFY. The benefits of increased ASR injection when surplus water is available are apparent in the resulting basin storage. Likewise, the average index well groundwater elevation change for the same scenarios are -12 feet, 27 feet, and 30 feet. Since basin storage and the index well water levels are highly correlated, this is not surprising, but the model results provide a quantitative estimate of the effect of increased ASR injection on the index well groundwater elevations used to assess groundwater conditions in the Basin. Pumping Scenarios 2, 3, and 4 display similar trends in the model results as different ASR injection scenarios are applied. Again, these scenarios represent dry hydrologic periods. Average or wet conditions would be expected to show less reduction in storage and water levels.

As shown in **Table 5-9** and illustrated in **Figure 4-3**, Projected basin pumping at approximately 1,500 AFY causes a reduction in storage during the assumed dry period as expected, but this reduction in storage is not expected during normal or wet conditions. Higher rates of pumping do result in higher reductions of groundwater in storage unless moderate injection is implemented. For example, if basin pumping is increased to approximately 2,350 AF (allocation scenario), these results indicate that it would be necessary to inject on the order of 1,500 to 2,000 AF to avoid a significant reduction of groundwater in storage.

Another factor to consider is the duration and frequency of dry conditions. Given the observed climate variability, we cannot predict whether dry conditions will return once there has been a wet winter. This is why it is prudent to plan for injecting as much as feasible even during normal or wet climate conditions.

Table 5-9. Predictive Modeling Scenario Results

Predictive Scenarios Groundwater Storage and Groundwater Elevation Model Results[1]						
Pumping Scenario	Injection Scenario	Projected Basin Pumping (AFY)	Projected ASR Injection (AFY)	Average Annual Change in Storage (AF)	Total Cumulative Change in Storage (AF)	Change in Index Well Average GW Elevation (feet)
1	a	1,500	0	-479	-4,308	-12
1	b		2,665[2]	984	8,853	27
1	c		3,125	1,099	9,892	30
2	a	2,350	0	-946	-10,569	-31
2	b		2,665	596	5,362	15
2	c		3,125	813	7,314	21
3	a	5,341	0	-3,697	-33,277	-100
3	b		2,665	-1,474	-13,267	-43
3	c		3,125	-1,090	-9,813	-33
4	a	7,185	0	-5,128	-46,150	-176
4	b		2,665	-3,021	-27,189	-75
4	c		3,125	-2,627	-23,642	-43

Notes

[1] A 9-year predictive hydrologic period (2022–2030) for pumping/injection scenarios based on the historical period 2013–2021.

[2] Based daily injection permit of 7.3 acre-ft/day or 2665 AFY.

AFY = acre-feet per year ASR = aquifer storage and recovery GW = groundwater

5.2.6 Wellhead Protection

A Drinking Water Source Assessment is required by DDW for each purveyors' public water supply wells. Purveyors were given the option of conducting the assessment themselves or having DDW conduct the assessment. In the Goleta Basin, DDW conducted the assessments for the purveyors; the assessments are on file with DDW and the purveyors. The assessment evaluates the contamination potential for the aquifers from overlying uses ranging from leaking gasoline tanks to concentrated farm animals. Most of the purveyors' wells are relatively well protected because water is produced from confined aquifers, where low-transmissive beds, such as clays, separate surface contamination sources from the deeper aquifers. As shown on **Figure 2-33** there are numerous documented and potential contaminant sites in the vicinity of GWD production wells and also in the recharge area that is hydraulically connected to the GWD production zones. It is recommended that this contaminant inventory be periodically updated and sites that have documented groundwater contamination that could potentially impact production wells be prioritized and assessed on a regular basis. High risk sites should be discussed with the RWQCB in order to make sure GWD interests and assets are protected.

5.2.7 Cooperation with Other Agencies

GWD and La Cumbre cooperated to develop the original GWMP and continue to meet as the Basin Operating Group, as needed, to coordinate on basin management issues. GWD has a decades-long partnership with the Goleta Sanitary District for the treatment and distribution of recycled water within the Basin. GWD consults with various agencies concerning regulatory programs and issues relevant to groundwater management, including:

1. RWQCB concerning issues related to basin water quality, such as recycled water reuse and Salt and Nutrient Management Planning.
2. SWRCB's DDW and the Central Coast Regional Water Quality Control Board concerning groundwater quality issues affecting the quality of potable supplies.
3. County Environmental Health concerning well permits issued for new wells in the Basin.

GWD also participates in the County Integrated Regional Water Management Planning group to help address regional water management issues and secure state grant funding for the Santa Barbara County region.

6 Recommended Future Strategies

This section includes recommended strategies that are intended to improve groundwater production capacity, avoid limitations that could be imposed by the SAFE Ordinance, and improve the District's ability to monitor the aquifer. The strategies are discussed in order of priority.

6.1 Add New Production Wells

Because of the ongoing uncertainty regarding climate and reductions in production capacity that have resulted from contamination (e.g., the Airport Well), it is advisable to move forward with siting and drilling at least one new production well. The District is currently planning for the construction of one new production and injection well in its Infrastructure Improvement Plan 2020–2025 (GWD, 2022). Consideration is being given to site additional future wells in the southeastern portion of the Central subbasin (this may be practical only for GWD) if suitable locations can be found at a distance from potential water quality threats. Such a shift would move pumping from an area of the Basin where there are lowered groundwater elevations (**Figure 2-3**) to areas with higher groundwater elevations, allowing groundwater elevations to recover in the lowered areas. This would mitigate potential problems such as future water quality degradation or land subsidence in the areas of lowered groundwater elevations. It is recommended that the Model be used to evaluate the effect of adding new production to different portions of the Basin.

6.2 Rehabilitate or Replace Low Yielding Wells

The District owns a number of wells and well sites that are past their design life and have reduced capacity. Given that the District already owns these well sites and has considerable capital investment in the sites for piping and treatment, it would be advantageous to determine whether the capacity of the wells can be improved through redevelopment or if a new well should be drilled on the site. A cost-benefit analysis is recommended.

6.3 Optimize Aquifer Recharge

The Central subbasin takes a long time to recover to the SAFE Ordinance Elevation following drought pumping. For example, following the last major drought in the late 1980s/early 1990s, groundwater level recovery to the SAFE Ordinance Elevation took more than 12 years. As discussed in Section 3.2, GWD has injected Cachuma spill water when available to help increase basin groundwater levels and the rate of groundwater level recovery. In 2016, GSI reviewed available data relevant to GWD groundwater injection operations and performed groundwater modeling to estimate the number of facilities needed to optimize injection of Cachuma spill water when it is available (GSI, 2016b). Key conclusions from the evaluation are:

1. Maintaining and using the existing GWD injection capacity in a deliberate manner would reduce the time required to recover to the SAFE Ordinance Elevation from historical low elevations by approximately 4 years under conditions similar to those experienced following the drought of the late 1980s compared to no injection.
2. When relying solely on Cachuma spills for source water, injection volumes are controlled primarily by the frequency and duration of spill events, Corona del Mar Water Treatment Plant capacity, and potable water demands during the spill events. Thus, injection only during spill events by adding additional injection wells may not result in a substantial decrease in basin recovery time frames. Doubling the current injection capacity would reduce the time required to achieve the SAFE Ordinance Elevation by approximately an additional 2.3 years (a 21 percent reduction).

Based on the evaluation findings, GSI recommended the following:

1. Review limitations on treatment and conveyance capacity that would limit the amount of treated water available for recharge.
2. Perform injection tests to confirm current injection well capacities, particularly any wells that were not used during the 2011 injection event. Develop plans for aggressively increasing injection capacity at existing wells using annual recharge methods, injection down pump columns, well rehabilitation and redevelopment, and/or use of larger diameter injection tubes.
3. Complete a cost-benefit analysis that compares construction of additional injection wells to maximize the use of Cachuma spill supplies with injection of alternative water sources.
4. Meet with the RWQCB to explore modifying the District's ASR permit to expand injection capacity.
5. Investigate alternative water sources for injection, such as SWP water transfers, Lake Cachuma purchases, purchases of water stored by private water banks and SWP right holders, or use of recycled water to increase the amount of water that can be injected without having to rely only on Cachuma spill events (indirect potable reuse has been determined to be cost prohibitive). Estimate the cost of the additional injection supply water to determine if cost effective.
6. Design any new and replacement groundwater production wells such that they are injection-capable. Additional injection capacity will maximize injection during early to mid-spring spills and will help ensure that a minimum of 9 AF per day injection capacity is available to fully use during mid- to late-spring spills.
7. Work with private well owners in the Basin to determine if there is an opportunity to use their wells for injection during spill events.
8. Work with agricultural landowners in the North subbasin (where the aquifers are unconfined) to determine if any agricultural land is available for recharge via flooding during spill events (including water that is not treated).
9. Perform groundwater modeling to assess the benefits of injecting alternative injection water sources in conjunction with Cachuma spill water.
10. Periodically test injection wells to track individual well and system-wide injection capacity (criteria can be developed to help decide when tests should be performed).
11. Assess injection clogging potential and develop an injection well maintenance program if one does not already exist.
12. Prepare an operations plan that optimizes injection for a number of possible scenarios of injection water availability.

6.4 Consider Expanding and Optimizing Use of Recycled Water

This strategy has been studied in the District's *Potable Reuse Facilities Plan* (GWD, 2017), and ruled out at present due to costs exceeding $100 million and in favor of more cost-effective approaches. If the economics of treatment improve significantly with technology advances, this may be considered in the future.

6.5 Evaluate Temporary Surplus Strategies

The term "Temporary Surplus" is used in the Wright Judgment and is defined as the amount of water that can be extracted each year from the Basin above the safe yield. There was no further discussion in the Wright Judgment as to how to determine Temporary Surplus. The total amount of water that can be extracted safely from the Basin consists of the safe yield, water stored by GWD and La Cumbre, and any water that otherwise would be lost from the Basin when groundwater elevations are too high. The safe yield and the amount of water in storage are discussed and calculated elsewhere in this Plan. The conditions under which a Temporary Surplus condition would exist are infrequent.

Temporary Surplus conditions may have existed when groundwater elevations reached historical highs in 2012 and near historical highs in 2007 and 2011, although there was insufficient monitoring to make a definitive determination. It is recommended that the recommendations in Section 6.6.2 (install transducers in water level BMO wells) and Section 6.6.3 (among other locations, install a nested monitoring well near the North/Central subbasin boundary) be implemented to help assess whether a Temporary Surplus condition occurs when groundwater levels are at or near historical high levels. If Temporary Surplus conditions are confirmed, it is recommended that GWD evaluate whether it should pump the extra available water. If GWD were to pump the surplus water in lieu of using available SWP Table A water, the unused SWP water could be stored in San Luis Reservoir for later use. Likewise, unused Cachuma allocation could be stored in Lake Cachuma as carryover. This could increase the overall water supplies available to GWD during subsequent, potentially dry years. The SAFE Ordinance may potentially restrict this strategy. It is beyond the scope of this GWMP update to evaluate these concepts further; therefore, it is recommended that this concept be evaluated during the GWD *Water Supply Management Plan, 2017 Update* (Bachman and BGC, 2017).

6.6 Improved Monitoring

6.6.1 Identify Additional Monitoring Wells and Well Sites

Two areas of the Basin historically have lacked water level data and it is recommended that GWD evaluate available wells in each area for addition to the semiannual groundwater-level monitoring program. The areas are:

- **The Southeastern Portion of the Central Subbasin.** This is where groundwater levels are the lowest and, as a result, there could be potential for intrusion of poor quality and land subsidence. It is recommended that GWD work with La Cumbre to identify potential additional monitoring wells in this area to add to the semiannual monitoring program.
- **The Western Half of the West Subbasin Where There Are No Monitoring Locations.** Although there is little to no pumping in this area, it is a potential resource for GWD and baseline monitoring would be useful if GWD pursues wells in this part of the Basin. It is recommended that GWD review available records to determine if there are potential wells available for monitoring in this area. If no wells are identified, GWD should consider drilling monitoring wells to provide data in this area.

6.6.2 Increase Frequency of Water Level Monitoring in Basin Management Objective Wells

It is recommended that a subset of monitoring wells be instrumented with pressure transducers to provide more frequent monitoring across the Basin in wells not directly impacted by pumping. The recommended monitoring wells for installation are the 10 groundwater level BMO locations listed in **Table 5-1** and shown in **Figure 5-1**. Installing pressure transducers will provide continuous monitoring capability, which will help GWD to:

1. Better evaluate the optimum semiannual monitoring months for measuring the annual high and low groundwater levels.
2. Determine if Temporary Surplus conditions exist in years when the Basin is full or nearly full heading into the wet season.

3. Assess the relative importance of different recharge mechanisms.[16]
4. Improve the understanding of the basin hydrogeology.[17]
5. Optimize pumping and injection programs.
6. Improve calibration of the Model.
7. Detect changes in water quality (if the transducer is equipped with an optional electrical conductivity probe).
8. Provide real-time data for water management decisions during critical periods (e.g., droughts).

The transducers include on-device memory for storing the groundwater level readings (and electrical conductivity and temperature readings, if so equipped). The data should be downloaded periodically for evaluation and to ensure data are properly backed up. The download frequency should be no more than quarterly to minimize data loss in the event of equipment malfunction or tampering. A potential option for application of advanced technology for groundwater management would be to equip the transducers with remote telemetry (i.e., cellular or 900 megahertz band transmitters) that automatically uploads the data to a database server. The data could be evaluated manually, or scripts could be written to automate data visualization.

Semiannual monitoring should continue at wells outfitted with pressure transducers and the manual measurements should be compared with transducer records to verify proper operation and calibration and to provide a backup to the transducer records in the event of equipment malfunction.

6.6.3 Consider Installing Nested Monitoring Wells

Nested wells consist of multiple piezometers installed in a single borehole with each completed (perforated) at different depths in the aquifer (a typical nested monitoring site). Such a nested monitoring site provides discrete information at different vertical intervals within a basin. Other monitoring wells in a basin are former production wells, which typically are completed (open to the aquifer) over a large depth interval. Monitoring data from former production wells provide information concerning “average” water levels and quality over the open interval. A multiple completion monitoring well gives specific information at different depths, which helps define the complexity of the aquifers, vertical groundwater gradients, and water quality at different depths. In many California basins, multiple completion wells have provided information that has changed basin management strategies. A typical nested well installation also should include dedicated pressure transducers equipped with electrical conductivity sensors for each piezometer.

An alternative to nested wells is a monitoring well cluster installation where the piezometers are installed separately in a series of closely spaced boreholes. Monitoring well clusters are typically more expensive, but offer certain advantages, which can be discussed with GWD if and when it moves forward with the recommendation to install nested or cluster monitoring wells.

Six nested monitoring well locations are recommended (**Figure 6-1**):

1. Near the West/Central subbasin boundary to evaluate the vertical distribution and movement of poor quality water from the West subbasin into the Central subbasin

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[16] Transducers, particularly at monitoring locations in the North subbasin, will capture transient water level responses that will help hydrogeologists evaluate the magnitude of recharge from different recharge mechanisms.
[17] Transducers will capture transient water level responses to pumping and injection that can be used by hydrogeologists to better estimate the aquifer properties (hydraulic conductivity and storage coefficient).

2. Near the North/Central subbasin boundary to improve the understanding of movement of recharge in the North subbasin into the main pumping zones of the Central subbasin
3. Along the southern basin boundary near the Goleta Slough; serves as a sentinel for detecting seawater intrusion that could occur via leakage across the More Ranch Fault or downward migration from surface waters
4. In the southeast portion of the Central subbasin to provide depth-specific groundwater levels and early detection of intrusion of poor quality water (because of pervasive low groundwater levels)
5. Near the eastern basin boundary to improve the understanding of the rates of movement and quality of water entering from the Foothill Basin to the east
6. A central location within the Central subbasin to provide depth-specific data in the main part of the Basin

Currently, the state has grant funding opportunities that potentially could provide partial funding for one or more nested monitoring wells. It is recommended that GWD review the state's grant programs for potential funding opportunities.

6.6.4 Improve Groundwater Quality Monitoring Program

Water quality degradation is particularly problematic because it is difficult to reverse and could increase the treatment requirements of pumped groundwater. Water quality monitoring currently is limited to sampling by GWD and La Cumbre at their respective potable supply wells pursuant to DDW requirements. Sampling pursuant to DDW requirements is typically annual and is limited to production well locations. A key weakness of relying on production wells for water quality monitoring is that this approach does not provide an early warning of intrusion of seawater, intrusion of other poor quality water sources, or movement of contaminant plumes. Additionally, more frequent monitoring than is required for DDW compliance is also warranted during drought pumping; this is when water quality changes are most likely because of depressed groundwater levels.

It is recommended that a subset of the water level monitoring wells (in addition to District wells) be sampled for water quality. The subset of wells should be selected on the basis of access for well purging activities and to create a geographic distribution of monitoring sites. It is recommended that baseline water quality sampling be conducted as soon as possible given the potential for groundwater levels to remain depressed for an extended period of time or even fall below historical low elevations. Sampling should be performed semiannually thereafter until water levels begin rising again. During non-drought periods, annual sampling is recommended. All groundwater samples should be analyzed for the general minerals. Monitoring locations in areas with potential contamination also should be sampled for volatile organic compounds, metals, and other identified contaminants of concern based on review of environmental site database records for sites within 2,000 feet. The recommended nested monitoring wells should be included in the sampling program if/when they are installed. When water quality results are received, they should be entered in the database and analyzed for changes. If there is significant deterioration in water quality in any of the wells being monitored, the well should be resampled and the sampling frequency for that well should be increased if the change is confirmed.

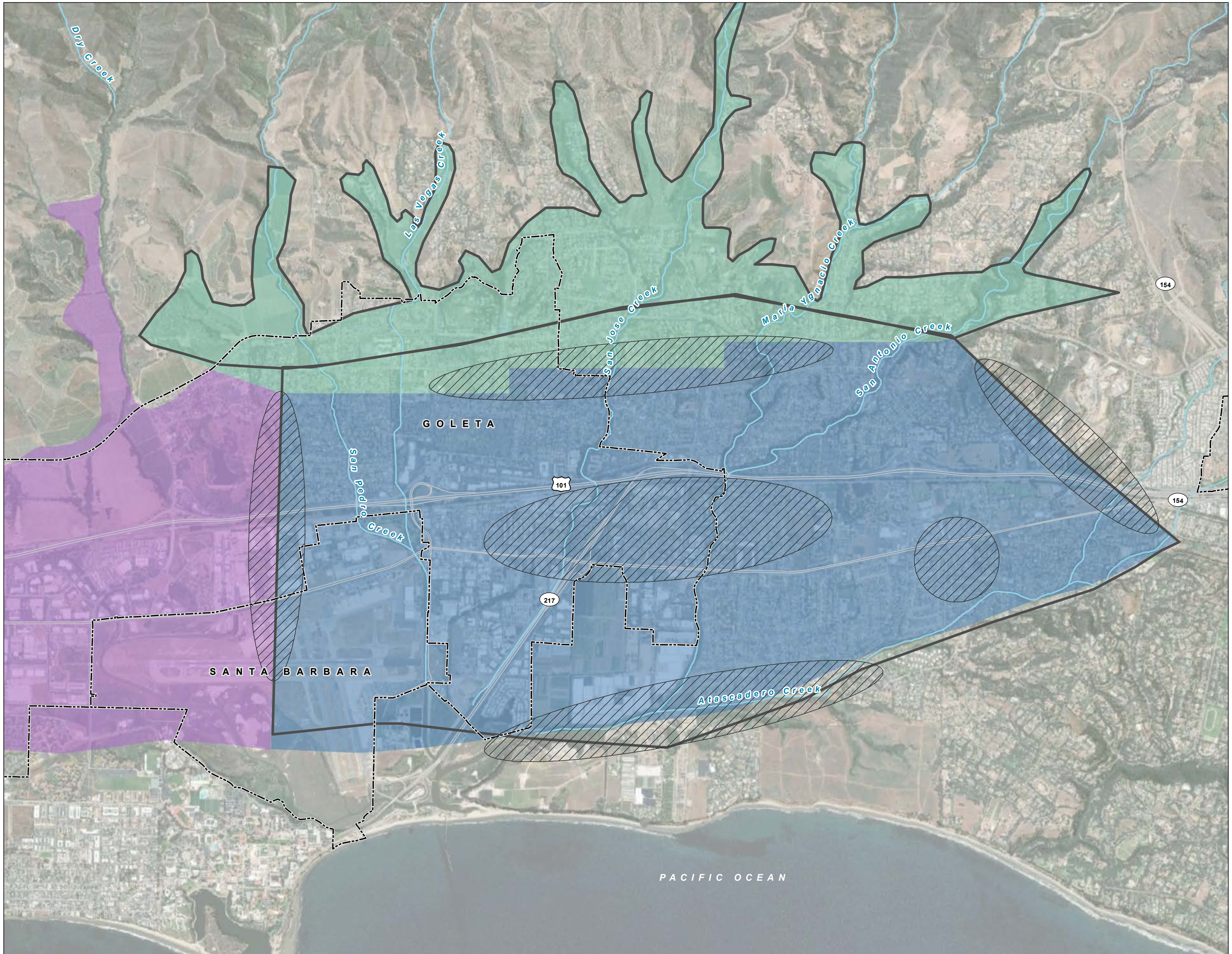

FIGURE 6-1

Proposed Areas for Nested Monitoring Well Completions

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Proposed Area for Nested Monitoring Well Completions

Wright Adjudication Judgement

Goleta Groundwater Subbasins

Central Subbasin

North Subbasin

West Subbasin

All Other Features

City Boundary

Major Road

Watercourse

N

0 1,250 2,500 3,750
Feet

Date: January 13, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021)

GSI Water Solutions, Inc.

Document Path: Y:\0528_Goleta_WD\Source_Figures\009_GWMP_Update\Section6\Figure6-1_NestedMWs.mxd, abarry

6.6.5 Monitor Land Subsidence Monitoring Data

As part of the statewide SGMA program, DWR has implemented a program to monitor changes in land surface elevation in California via satellite based remote sensing technology. This data is referred to as Interferometric Synthetic Aperture Radar (InSAR) data and is publicly available on DWR's SGMA Data Portal. Updated InSAR data has been provided by DWR for the period June 2015 through October 2022, allowing for analysis of observed land subsidence for this 7-year period. This method has a potential error of 0.1 feet (or 1.2 inches); therefore, land surface elevation changes that are in this range are not considered reliable. A land surface change of less than 0.1 feet is therefore within the noise of the data and is equivalent to no evidence of subsidence. Considering this range of potential error, examination of the June 2015 through October 2022 InSAR data indicate that the total combined change in land surface elevation for this period is between -0.1 and 0.1 feet (the actual data values ranged from -0.072 feet to 0.042 feet). Therefore, no measurable land subsidence has occurred since June 2015 (**Figure 6-2**). DWR updates the InSAR data annually as part of the statewide SGMA program. The District should continue to monitor and report annual subsidence as more data become available.

Land-based surveys or subsidence monitoring is not recommended at this time to determine if land subsidence is occurring during periods of low groundwater levels. The simplest approach to monitoring for land subsidence is to continue to collect updated InSAR data and to monitor water levels in the Basin. If water levels in the Basin approach or exceed historical low water levels, the District may consider performing land elevation surveys across the Basin according to survey transect plans that were previously established.

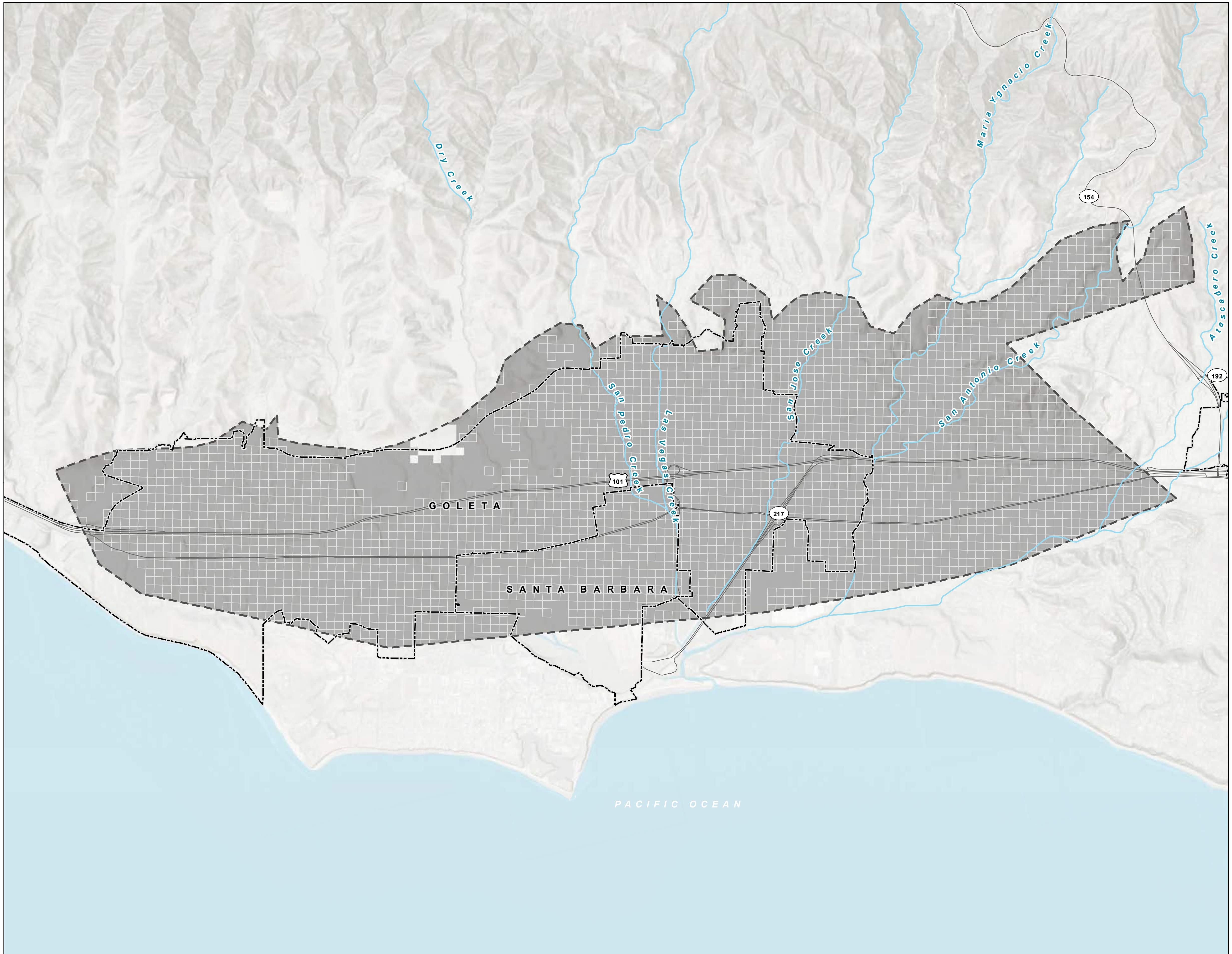

FIGURE 6-2

Land Subsidence Measured by InSAR (June 2015 - October 2022)

Groundwater Management Plan
Goleta Groundwater Basin
2022 Update

LEGEND

Vertical Displacement Point Data Location

DWR Bulletin 118 Groundwater Basin Boundary

Estimated Subsidence (decimal feet) June 2015 - October 2022

-0.1 - 0.1

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

NOTES

DWR: California Department of Water Resources
InSAR: Interferometric Synthetic Aperture Radar

N

0 1,900 3,800 5,700
Feet

GSI Water Solutions, Inc.

Date: February 22, 2023
Data Sources: USGS, ESRI, Maxar Imagery (2021), TRE Altamira InSAR dataset

6.6.6 Develop Groundwater Level Management Criteria

Reduced pumping in the Basin between the early 1990s and late 2000s, particularly by GWD, allowed groundwater elevations in the Basin to rise to historical high levels. The 2012 groundwater elevations were at the highest levels recorded in the Basin in both the Index Wells and in other wells in all three subbasins. In fact, some wells are approaching flowing artesian conditions. Allowing groundwater elevations to rise farther could cause unintended negative consequences, including leakage of groundwater to the surface in both existing and destroyed or abandoned wells. Artesian conditions in a wide area of the Oxnard Plain in Ventura County in 1998 caused wells to flow and abandoned wells to leak beneath roads and parking lots; one abandoned well flowed hundreds of gallons per minute from beneath the front yard of an urban house, creating neighborhood flooding for weeks until a drilling company could stop the flow. There were no reports of these issues in 2012 when Goleta Basin groundwater levels reached historical highs.

Low groundwater elevations in the Index Wells occurred in 1989. If groundwater were pumped in the future such that groundwater elevations fall below 1989 levels (into uncharted territory), there are potential risks associated with that action. Risks include:

- Dewatering of fine sediments (such as clays) that serve as aquitards or are interbedded in the aquifer. This dewatering causes subsidence at the land surface, which can result in structural damage and even reversal of drainage directions. Subsidence is generally irreversible. Subsidence is common in overdrafted basins in California.
- Pulling in poor-quality water from surrounding sediments, bedrock, or along faults. Significantly lowered groundwater elevations in the coastal plain of Ventura County have induced the flow of deep oil-field brines into overlying aquifers. Similar risks may exist in the Goleta Basin.
- Although it appears that a bedrock high beneath the Goleta Slough protects the Basin from intrusion of seawater, the lowering of groundwater elevations at the coast could allow seawater to intrude through yet-unknown paths. If seawater were introduced into the aquifers, management of the Basin would have to change significantly to ensure that no further landward movement of the salts occurred. Such management likely would include further limitations on future pumping, expensive capital projects to create hydraulic barriers, and/or treatment to remove salts.

Given the potential difficulties when groundwater elevations are allowed to rise too high or fall too low, there appears to be a range of groundwater elevations over which the Basin should be managed (**Figure 6-3**):

- Groundwater elevations between the low elevations in the Index Wells in 1989 and the 1972 elevations are within the Modified Operations range and should be reserved for water shortage conditions. This range coincides with average groundwater elevations of -85 feet to -26 feet for the Index Wells.
- Groundwater elevations between the 1972 and 2012 elevations for the Index Wells should continue to be considered within the Normal Operations range for the Basin. This range coincides with average groundwater elevations of -26 feet to -1 foot for the Index Wells.

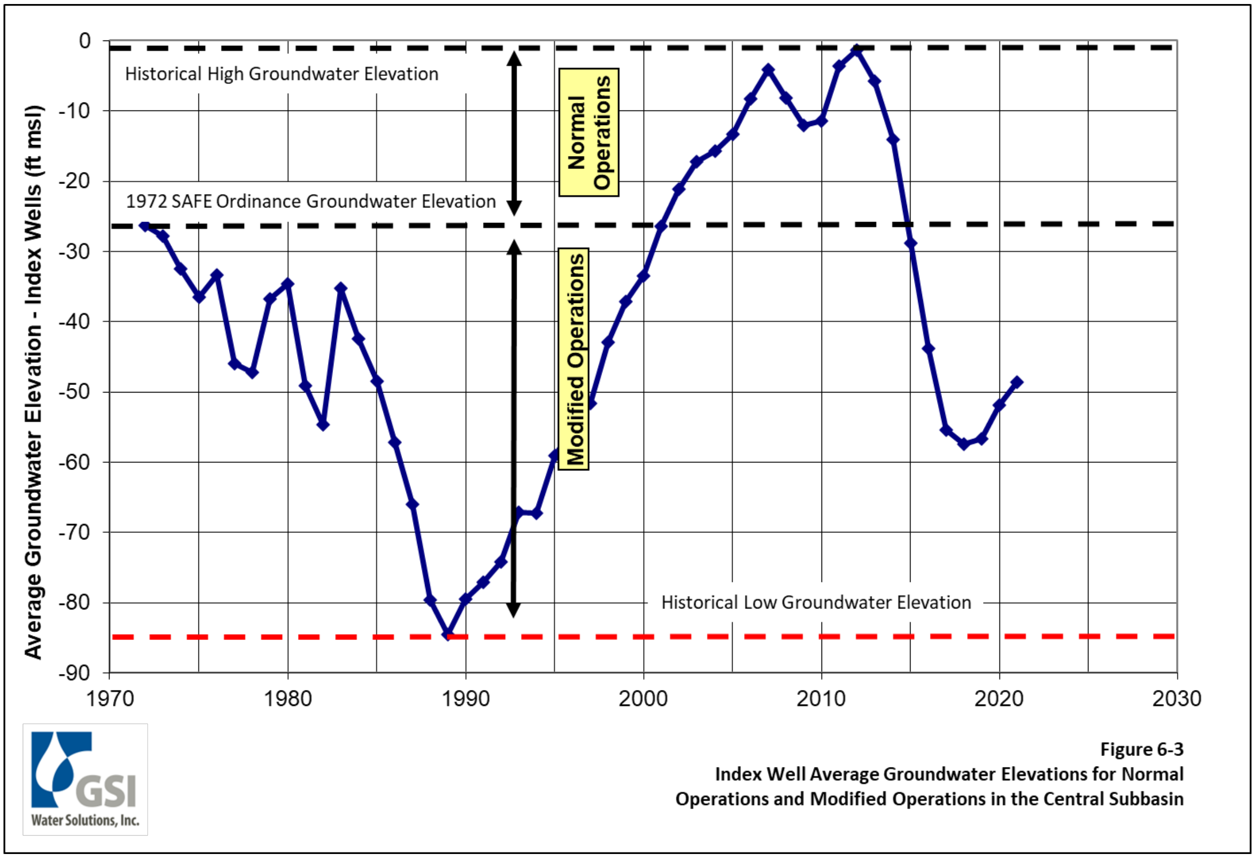

Figure 6-3. Index Well Average Groundwater Elevations for Normal Operations and Modified Operations in the Central Subbasin

La Cumbre is not as constrained in its operations as GWD is with the SAFE Ordinance, but the principles discussed here also broadly apply. If the Basin is full, La Cumbre also will have no storage space for its share of Cachuma spill water. How the purveyors can work together on operating plans is discussed in Section 5.2.7.

Within the Normal Operations range, the primary objectives should be retaining storage space for Cachuma spill water and reducing customers' costs. If groundwater elevations remain near the top of the Normal Operations range, there is less storage space for Cachuma spills, which otherwise would flow to the ocean. Thus, storage space should be maintained by pumping groundwater in volumes close to the annual water right for the purveyors (approximately 2,000 AFY for GWD and 1,000 AFY for La Cumbre), as long as groundwater elevations remain within the Normal Operations range (this assumes that appropriate water quality can be delivered to customers). Any available SWP Table A water that is not used could potentially be stored in San Luis Reservoir for later use. Likewise, unused Cachuma allocation could be stored in Lake Cachuma as carryover. This could increase the overall water supplies available to GWD during subsequent, potentially dry years. It is beyond the scope of this GWMP update to evaluate these concepts further; therefore, it is recommended that these concepts be evaluated during a future GWD *Water Supply Management Plan, 2017 Update* (Bachman and BGC, 2017).

There may be times when pumping significant groundwater does not make sense (e.g., a wet year when there is an abundance of cheaper Cachuma spill water). If groundwater elevations were maintained near the bottom of the Normal Operations range before the spill year(s), then the rise in groundwater elevations caused by reduced pumping and storage of spill water is less likely to overfill the Basin. Following the spill year(s), groundwater elevations can be lowered by resuming groundwater pumping.

It is recommended that a pumping plan be developed to help guide decisions about pumping in both the Normal Operations range and Modified Operations range and to address the above-described considerations.

6.6.7 Track Contamination Threats

As discussed in Section 2.5, there are several sites with soil and shallow groundwater contamination in the Basin. Although most of the sites overlie areas of the aquifers under confining conditions and the contamination is unlikely to leak into the underlying aquifers, it is recommended to continue the District's ongoing review of the GeoTracker database for new sites and changes in status of sites in proximity to GWD wells annually. This can be done easily on SWRCB's GeoTracker website. Of particular interest would be sites near drinking-water wells. It is recommended that GWD further investigate the status of any new contamination sites identified near GWD wells and/or in the unconfined portion of the Basin.

6.7 Periodic Groundwater Model Updates

It is recommended that information on pumping in the Basin by private well owners be added as it becomes available, and that the Model be updated and recalibrated, if necessary. The estimates of perennial yield, groundwater storage, and recoverable storage described in Sections 4.1 and 4.2 should be updated if GWD becomes aware of material changes in the volume or locations of private pumping relative to that which is assumed in the Model.

It is recommended that procedures be put in place for periodically maintaining and updating the Model as new information is obtained. The procedures should include who would be responsible for maintaining and operating the Model (in-house or a consultant), whether other organizations could use the Model, and how it would be modified in the future when additional information is known about the Basin. It is recommended that the Model be updated every few years and recalibrated when new monitoring data become available in data gap areas or when new information about the basin hydrogeology, recharge mechanisms, or aquifer properties becomes available. At a minimum, the Model should be updated and calibration reviewed (and updated, as needed) immediately before each 5-year GWMP update.

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APPENDIX A

Salt and Nutrient Management Plan
Goleta Groundwater Basin
2016 Update

Salt and Nutrient Management Plan

Goleta Groundwater Basin 2016 Update

Prepared for

Goleta Water District and

GOLETA WATER DISTRICT

November 8, 2016

Prepared by

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1 Introduction

In 2015, the Goleta Water District's (GWD) staff reviewed the Recycled Water Policy (RWP) and the GWD's Goleta Groundwater Basin (Basin or Goleta Basin) Groundwater Management Plan (GMP), and discussed salt and nutrient planning requirements (Salt and Nutrient Management Plan [SNMP]) with the Central Coast Regional Water Quality Control Board (CCRWQCB). The staff determined that the region is largely in compliance with the intent of the policy through the GMP and other foundational water resource planning documents. The 2016 GMP update provides an opportunity to integrate the remaining SNMP requirements into the GMP to avoid redundancy in planning documents. Furthermore, the 2016 GMP update involves coordination among groundwater basin stakeholders, such as La Cumbre Mutual Water Company and other groundwater users, as well as the GWD, preventing duplicative efforts and costs associated with groundwater management planning for all stakeholders involved. The RWP (State Water Resources Control Board [SWRCB] Resolution No. 2009-0011) makes it clear that a GMP is an acceptable vehicle in which to document salt and nutrient planning. Thus, this document (Appendix A to the *Groundwater Management Plan, Goleta Groundwater Basin 2016 Update*) has been prepared to supplement the GMP with the elements necessary to render the GMP "functionally equivalent" to a SNMP.

The RWP requires basin stakeholders to assess the impact of recycled water (RW) use, particularly for groundwater recharge, on groundwater basins. The intent of the SNMP is to support the use of RW by evaluating all sources of salts and nutrients to a groundwater basin and assessing where contributions from RW would have a significant impact to groundwater basins.

The RWP recognizes that the degree of specificity of the plans will be "dependent on a variety of site-specific factors, including but not limited to size and complexity of a basin, source water quality, storm water recharge, hydrogeology, and aquifer water quality." The SNMP for the Goleta Basin has been developed at the level of specificity necessary to effectively consider the potential impacts of existing and planned RW use and support effective management of salts and nutrients in the Basin to support the existing uses. Groundwater quality, including salt and nutrient loading, historically has not been a problem for the existing uses in the Basin. While GWD does distribute approximately 1,100 acre-feet per year (AFY) of RW, primarily for golf course and landscape irrigation uses, RW is not used for groundwater recharge and much of the existing RW deliveries are not made to areas that contribute significant percolation to aquifers that are used for water supply. Furthermore, GWD currently does not have plans to expand the existing RW system. Therefore, the level of detail presented for this SNMP reflects these existing and planned conditions, and provides a simplified analysis of salt and nutrient assimilative capacity, loading, fate and transport, and antidegradation. Additionally, this SNMP lays out a process for evaluating potential future RW projects.

1.1 Regulatory Framework

In February 2009, the SWRCB adopted Resolution No. 2009-0011 establishing a statewide RWP. The policy encourages increased use of RW and local stormwater capture and reuse. It also requires local water and wastewater entities, together with local salt- and nutrient-contributing stakeholders, to develop an SNMP for each groundwater basin or subbasin in

California. This SNMP was developed in coordination with the 2016 GMP update initiated in late 2015.

As outlined in the RWP, the required elements of an SNMP are:

- A basin/subbasin-wide monitoring plan that includes an appropriate network of monitoring locations.
- A provision for annual monitoring of constituents of emerging concern (CECs) consistent with recommendations by California Department of Public Health (now the Division of Drinking Water DDW, under the SWRCB) and SWRCB.
- Water recycling and stormwater recharge/use goals and objectives.
- Salt and nutrient source identification, basin/subbasin assimilative capacity and loading estimates, together with fate and transport of salts and nutrients.
- Implementation measures to manage salt and nutrient loading in the basin on a sustainable basis.
- An antidegradation analysis demonstrating that the projects included within the plan will collectively satisfy the requirements of the SWRCB's *Statement of Policy with Respect to Maintaining High Quality of Waters in California* (also referred to as Resolution No. 68-16).

As noted above, the degree of specificity of the SNMP is dependent on the complexity of the groundwater basin, source water quality, stormwater recharge, and other factors. Each SNMP is tailored toward local water conditions and may address other constituents beyond salts and nutrients that adversely affect groundwater quality.

2 SNMP Approach

Excessive concentrations of salts and nutrients in groundwater can limit the beneficial use of groundwater resources in the Basin. It is the intent of the RWP that the SNMP address sources of salts and nutrients to protect the beneficial uses of groundwater. In the Basin, the potential impacts of RW are limited and the approach to the SNMP is to provide an analysis of the existing conditions and a structure for evaluating potential future projects in the context of the uses and geology of the Basin to successfully protect the Basin's groundwater resources.

This SNMP includes required background information and an assessment of the Goleta Groundwater Basin and subbasins, along with an analysis of land use, water quality, selection of salt and nutrient indicator constituents, identification of loading estimates, source analysis, and determination of available assimilative capacity. This SNMP provides implementation measures for potential RW projects, and identifies management measures where appropriate. To meet RWP requirements and protect beneficial use throughout the Basin, this SNMP has been developed as a flexible planning document that can guide the management and regulation of discharges of salts and nutrients as projects are implemented in the future. This SNMP is organized as follows:

Section 1: Introduction

Section 2: SNMP Approach

Section 3: Basin Conceptual Model

Section 4: Loading Analysis

Section 5: Assimilative Capacity

Section 6: SNMP Goals and Objectives

Section 7: Implementation Measures to Manage Salts and Nutrients on a Sustainable Basis

Section 8: Antidegradation Analysis

Section 9: Groundwater Quality Monitoring

Section 10: References

2.1 Outreach and the SNMP Process

GWD staff engaged stakeholders and provided updates on the development of the GMP and SNMP to its Water Management and Long Range Planning (WMLRP) Committee, a subcommittee of the GWD Board of Directors, throughout the development process. Stakeholder involvement included meetings with the La Cumbre Mutual Water Company (La Cumbre), which has an appropriative right to extract water from the Basin under the Wright

Judgment, and outreach to the Goleta Sanitary District, with whom the GWD works closely to treat and distribute RW to the Goleta Valley. An update on the GMP development, including the SNMP, was provided to the WMLRP Committee in a public meeting and a draft of the GMP and SNMP provided to stakeholders for review and input. The SNMP was also reviewed by the GWD Board of Directors.

3 Basin Conceptual Model

This section presents the conceptual understanding of the Basin used to develop this SNMP. The major objectives of this task are the following:

1. Characterize and describe the setting, land use, climate, hydrology, geology, and hydrogeology of the Basin.

2. Establish the baseline conditions (i.e., current spatial distributions) for water quality constituents chosen to be addressed in this SNMP.

The features of the Basin that have been characterized are consistent with the list of groundwater basin characteristics suggested by the California Regional Water Quality Control Board (RWQCB) for inclusion in an SNMP. The Basin has been studied extensively during the last 7 decades by numerous investigators and is described in the GMP.

3.1 Setting

The Basin is formally recognized by the California Department of Water Resources (DWR) as Groundwater Basin No. 3-16 in DWR Bulletin 118 (DWR, 2003) and includes three subbasins not recognized by DWR (Central, West, and North). Due to adjudication of the North and Central subbasins, and differences between local investigators' and DWR's mapping of faults and alluvium contacts, there are notable differences between the DWR basin boundary and that used by GWD. These differences are described in detail in Section 2.1.1 of the GMP. As with the GMP, GWD's version of the Basin boundary is used for this SNMP. Since the North and Central subbasins historically have been managed together and because recharge in the North subbasin flows into the Central subbasin, the subbasins are considered together in this SNMP. The West subbasin historically has not been managed with the Central subbasin and there is a lesser degree of hydraulic connectivity with the Central subbasin (as compared to the North subbasin). Thus, the West subbasin is treated separately in this SNMP.

The Basin underlies the Goleta Coastal Plain of Santa Barbara County. The Basin is approximately 8 miles long in an east-west direction and up to 3 miles wide in a north-south direction and has an area of approximately 9,650 acres (15 square miles) (GMP Figure 1-1). The Basin is bounded on the north by bedrock of the Santa Ynez Mountains and to the south by uplifted bedrock along the More Ranch Fault. The eastern boundary consists of bedrock uplifted in a zone of deformation associated with the Modoc Fault. Bedrock near the Tecolote and Winchester canyons forms the western boundary. GMP Figure 2-1 shows Basin boundaries and faulting.

3.2 Land Use

Recent land use information was taken from GWD's geographic information system (GIS) parcel database. The database layer stores information about the land use of each parcel in GWD's service area taken from the Santa Barbara County Assessor.

Current land use in the Basin is summarized by group in **Table A-1**. The top three land use categories (Urban Residential, Urban Landscape, and Orchard) account for more than 90 percent of Basin area.

Table A-1. Goleta Groundwater Basin Land Use.

Land Use Group	Irrigated (I)/Non-Irrigated (N)	North and Central Subbasins Combined Acreage	West Subbasin Acreage	Total Area (acres)	Percent Total Area (acres)
Field Crops	I	20	---	20	0.5%
Flowers	I	---	5.2	5.2	0.1%
Golf Course	I	---	51	51	1%
Orchard	I	520.1	636	1,156.4	28.3%
Pasture	I/N	9.2	---	9.2	0.2%
Paved Areas	N	2	1	3	0.1%
Rancho Estates	I	100	23	123	3.0%
Urban Commercial / Industrial	I/N	184	20.1	204.0	5.0%
Urban Landscape	I	426	233	659	16%
Urban Residential	I/N	1,427	445	1,872	46%
Total		2,688	1,414	4,102	100%

3.3 Climate and Hydrology

The climate in GWD's service area is generally characterized as Mediterranean coastal: summers are mild and dry, and winters are cool (**Table A-2**). The average temperature is 59 degrees Fahrenheit. Average rainfall is about 16 inches per year. The average evapotranspiration (ETo) in the region is 43.7 inches per year. The area is subject to wide variations in annual precipitation. For example, the area received only 5.6 inches of rain in 1990, but received more than 45 inches of rain in 1998.

Table A-2. Climate Data for Goleta Water District.

Month	Standard Monthly Average ETo (inches)[1]	Average Rainfall (inches)[2]	Average Temperature (Fahrenheit)[2]
January	1.79	3.46	52
February	2.32	3.33	54
March	3.57	2.96	55
April	4.63	1.17	57
May	5.10	0.29	60
June	4.83	0.07	62
July	5.38	0.03	65
August	5.21	0.05	66
September	4.03	0.23	65
October	3.16	0.55	62
November	2.04	1.67	57
December	1.65	2.52	53
Annual	43.71	16.34	59

Notes:
[1]ETo (evapotranspiration) data provided Santa Barbara region, CIMIS Station #107 for years 1993 to 2015 (DWR 2015).
[2]Average for Santa Barbara Airport weather station 047905 for years 1941 to 2012 (WRCC 2015).

Droughts are a regular feature of California's climate. During the period of recorded hydrology, the most significant statewide droughts occurred during 1928-34, 1976-77, 1987-92, and 2007-09 while the last significant regional drought occurred in parts of southern California (including Goleta) in 1999-2002. In addition, 7 of the 9 years since 2007 have been dry and the 3-year period between the fall of 2011 and the fall of 2014 was the driest since recordkeeping began in 1895 (PPIC, 2015). As this document is being prepared, unprecedented drought conditions continue.

The Basin is drained by Cieneguitas, Atascadero, San Antonio, Maria Ygnacio, San Jose, Las Vegas, San Pedro, and Carneros Creeks, whose headwaters are located in the Santa Ynez Mountains north of the Basin (GMP Figure 2-1). The creeks recharge the Basin where they flow across permeable sediments located along the northern margin of the Basin. Surface water that does not percolate flows into the Pacific Ocean.

Surface water flows are gauged by the U.S. Geological Survey (USGS) at three locations in the Basin: Atascadero Creek (USGS Site No. 11120000), Maria Ygnacio Creek (USGS Site No. 11119940), and San Jose Creek (USGS Site No. 11120500) (GMP Figure 2-1). Inactive gauges with historical flow data also were operated on Atascadero Creek (USGS Site No. 11119900), San Jose Creek (USGS Site No. 11120510), San Pedro Creek (USGS Site No. 11120520), and Tecolotito Creek (USGS Site No. 11120530) (GMP Figure 2-1).

3.4 Geology and Hydrogeology

The geology and hydrogeology of the Basin are presented in Sections 2.2-2.4 of the GMP. The most important aspect of Basin hydrogeology in terms of relevance to this SNMP is the fact that only a relatively small portion of the Basin consists of unconfined areas where water applied at the land surface may percolate to the primary aquifers in the Basin. These recharge areas are located along the northern margin of the Basin, as shown in GMP Figure 2-1. The remainder of the Basin is underlain by a clay layer, or other less-transmissive layers, above the Basin aquifers (i.e., confining layer) that limits downward percolation of water from the surface. Current RW deliveries are to areas located outside of the Basin recharge zones, meaning that current RW usage is unlikely to impact groundwater quality (**Figure A-1**).

The groundwater flow regimes of the three subbasins are quite different. There is insufficient data in the West subbasin to characterize the groundwater flow regime. However, groundwater modeling results from the Goleta Groundwater Basin Numerical Model suggest that groundwater flows from the recharge area in the northwest to the southeast across the West subbasin toward Goleta Slough (GSI, 2015). Groundwater levels are measured in more than 40 wells in the North-Central subbasins and, therefore, the groundwater flow regime is fairly well characterized (see GMP Figure 2-2). Groundwater flows from the North subbasin to the south into the Central subbasin, where it then flows toward pumping wells.

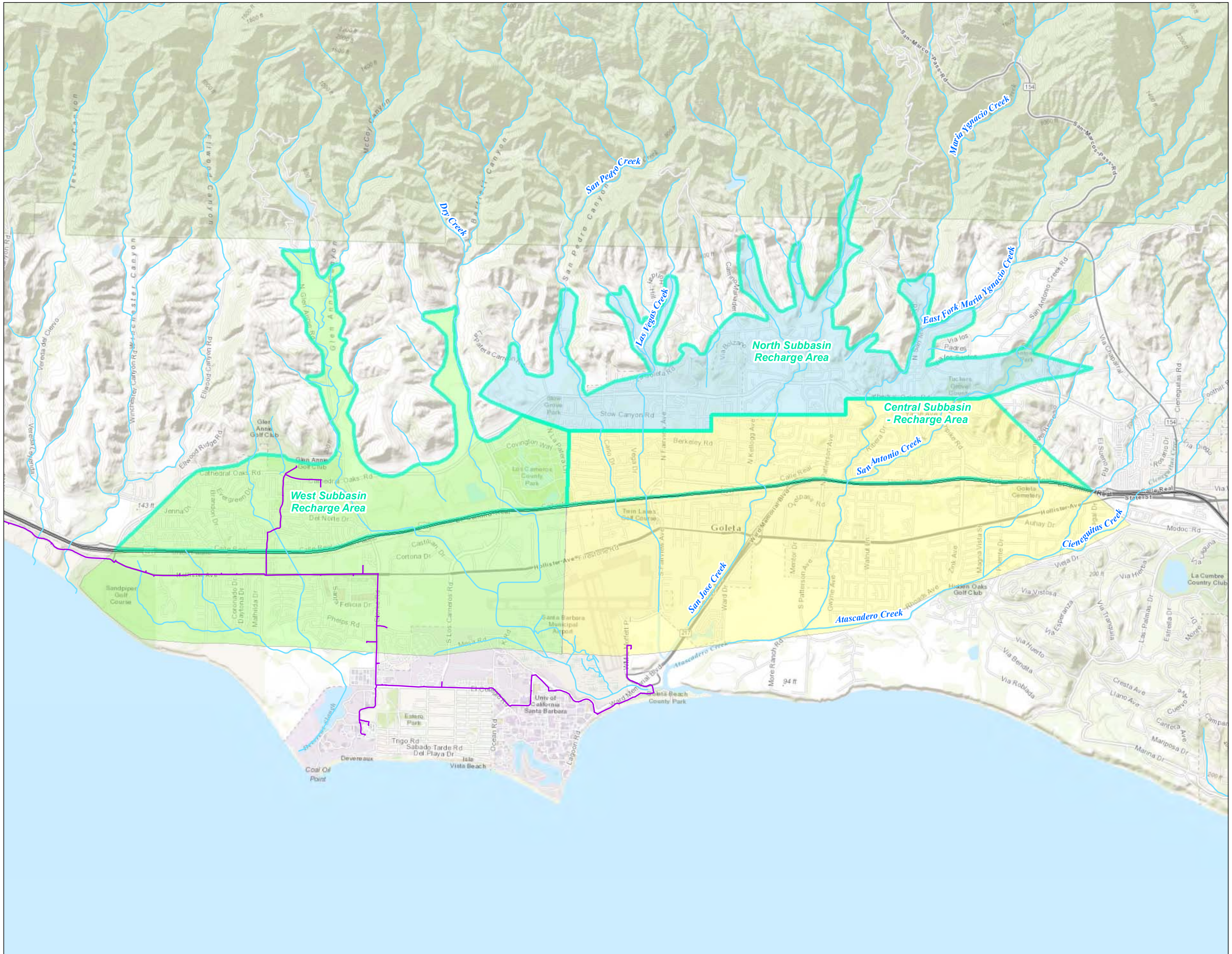

FIGURE A-1

Recharge Areas, Streams, and Recycled Water Pipelines

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update

LEGEND

- Recharge Areas
- Recycled Water Pipelines
- Streams and Creeks

Goleta Groundwater Subbasins

- Central Subbasin
- North Subbasin
- West Subbasin

US HWY 101

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, GWD
Date: 8/23/2016

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3.5 Water Quality

The four chemical constituents to be addressed in this SNMP as indicators of salt and nutrient loadings to the Basin are total dissolved solids (TDS), nitrate (as nitrogen [N]), sulfate, and chloride. Recent and historical measured concentrations of these chemical constituents at different locations in the Basin were compiled and used to establish the baseline conditions (i.e., estimated spatial distribution of constituent concentration representative of current conditions). The nitrate (as NO_3) data were converted to nitrate (as N) for the purposes of this SNMP using a conversion factor of 0.23.

The major objectives of the water quality analysis described in this section include:

1. Description of the water quality databases used in the analysis.

2. Discussion of historical trends for the four indicator constituents and estimation of the baseline conditions for each constituent. The baseline conditions for the four constituents were derived using water quality data from two different sources:

   - **North-Central Subbasins**. Data were obtained from the SWRCB DDW database for the 5-year period 2011-2015. Groundwater quality data from SWRCB Geotracker GAMA database was not used in the analysis because the monitoring wells associated with these data typically are not screened in the main producing zones of the Basin (e.g., monitoring wells typically are screened in perched zones above the main producing zones in the Basin). There are no other known sources of recent groundwater quality data available for the North-Central subbasins; monitoring wells monitored by GWD/USGS in the Basin are not sampled for water quality.

   - **West Subbasin.** No recent data are available because there is little to no pumping and wells monitored by GWD/USGS are not sampled for water quality. The most recent 5-year period with groundwater quality for the West subbasin is 1985-1989. The data are from GWD records.

Historical groundwater quality data for the constituents are plotted on maps in the GMP (see GMP Figures 3-1 through 3-4). Recent groundwater quality data for the North-Central subbasins are plotted on maps in the GMP (see GMP Figures 3-7 through 3-10). Groundwater quality trends for the constituents are shown on time-series charts in the GMP (see GMP Figures 3-14 through 3-17).

Based on review of the above-referenced maps and time-series charts, the following observations relevant to this SNMP have been made:

1. **North-Central Subbasins Area.** In general, concentrations of chloride, sulfate, and TDS are higher in the recharge areas in the northern part of the North-Central subbasins and lower in the southern confined portion of the subbasins. Nitrate concentrations are low across all three subbasins, with a few outliers. Constituent concentrations generally have been stable over time, with some wells showing increasing concentrations of chloride,

sulfate, and TDS during the drought of the late 1980s/early1990s and decreasing concentrations following the drought. Similar increases in concentrations are noted in recent years because of drought conditions. Increases in concentration during drought periods is not attributed to salt loading at land surface. Rather it is believed to be related to the release of high salinity water from marine clays interbedded within the Basin aquifers, or other subsurface sources, during periods of depressed groundwater levels.

2. **West Subbasin Area.** In general, concentrations of chloride and sulfate increase from north to south. Nitrate concentrations are low across the entire subbasin. TDS generally is elevated across much of the subbasin. It is noted that there are few data in the recharge area of the subbasin (portion of the Basin located north of Highway 101).

The historical data suggest salt and nutrient loading that occurs in portions of the recharge areas mixes with other sources of higher quality waters recharge (e.g., creeks, precipitation, etc.) along groundwater flow paths, resulting in lower overall concentrations in the confined portions of the Basin.

The water quality data were used to determine baseline conditions by calculating the average constituent concentrations in each area during the 5-year baseline period. The baseline conditions for TDS, nitrate (as N), sulfate, and chloride are required for performing assimilative capacity and antidegradation analyses for future RW projects. The baseline average concentrations are summarized in **Table A-9**.

3.6 Water Balance Estimation

Major sources of recharge, other than artificial recharge by GWD, include infiltration from rainfall, percolation from streambeds, deep percolation of irrigation waters, and underflow from the adjacent Foothill Groundwater Basin and bedrock areas north of the Basin. As discussed in Section 4.2.1 of the GMP, historical estimates of the Basin safe yield range from 2,000 to something less than 3,700 AFY. The large range of safe yield estimates reflects the fact that the various estimates have been made using different methods and data. The basin yield estimate developed using the Model (2,500 to 2,900 AFY) is considered the best available estimate because the Model encapsulates the most comprehensive Basin data compilation and analysis effort to date and the model reasonably replicates observed groundwater levels under various climactic conditions. As is the case in all groundwater basins, there is inherent uncertainty with basin yield estimates that results from imperfect knowledge of subsurface conditions and hydrologic processes. This SNMP does not include a comprehensive analysis of salt and nutrient assimilative capacity; therefore, a detailed presentation of the water balance is not included herein.

4 Loading Analysis

The current loading of salts and nutrients to the Basin was evaluated to inform future analysis of assimilative capacity, and, if needed, evaluate future proposed RW projects in the Basin.

The loading analysis involves categorizing land use types overlying the Basin, and the activities that occur on that land—such as irrigation, soil amendment application, agricultural practices—that have the potential to allow for salts and/or nutrients to migrate down to the groundwater table.

Salt and nutrient loading from surface activities to the Basin currently is attributed to numerous sources. The primary sources include:

- Irrigation water (e.g., primarily potable water and groundwater)
- Agricultural inputs (e.g., fertilizer and amendments)
- Rainfall infiltration and stream percolation

Other potential sources not considered in this SNMP include:

- Septic system recharge (few, if any areas in the Basin are on septic systems)
- Infrastructure (e.g., percolation from leaking pipes)

The purpose of this section is to document these sources of salts and nutrients.

4.1 Selection of Baseline

In accordance with Section 9.c.(1) of the SWRCB RWP, the water quality averaging period to establish the baseline (present) groundwater quality or representative current concentrations of salts and nutrients in groundwater is the most recent 5-year period for which data are available.

4.2 Identification of Salt and Nutrient Indicator Constituents

The major dissolved ions in RW that reflect its salinity and nutrient content are many and varied. Simulation of each constituent is beyond the scope of this study; therefore, indicators of salt and nutrient loading to the Basin were selected for further study.

4.2.1 Selection of Indicator Parameters of Salts and Nutrients

In choosing which constituents to consider in this SNMP, the following criteria/questions were used to identify a select number of constituents for further consideration (CCRWQCB, 2014):

1. Is the constituent regularly monitored and detected in source waters?
2. Is the constituent representative of other salts and nutrients?
3. Is the constituent conservative and mobile in the environment?
4. Is the constituent found in source waters at concentrations above those found in ambient groundwater?

5. Does the constituent have high toxicity for human health or will otherwise affect beneficial use?
6. Is the constituent a known contaminant in groundwater in the Basin?
7. Have the concentrations of the constituents been shown to be increasing in the study area?
8. Is the constituent subject to a water quality objective (WQO) within the RWQCB Basin Plan?

Each selected indicator constituent of salts and nutrients is not required to meet all the criteria, but as a group at least one should meet each criterion. **Table A-3** summarizes the results of the assessment conducted for the anions and cations that compose general groundwater quality.

Based on the analysis presented in **Table A-3**, chloride, sulfate, nitrate, and TDS were selected for further consideration.

4.3 Loading Analysis Tools

To support this SNMP and to better understand the significance of various loading factors, a GIS-based loading model was developed to simulate salt and nutrient loadings from surface activities to Basin. The loading model is a simple, spatially based mass balance tool that represents loading on an annual-average basis. It is not a calibrated model, as insufficient data are available to support such an effort; therefore, model results are more uncertain than results from a fully calibrated model. Despite the uncalibrated nature of the model, results are considered suitable for this analysis of basin conditions, with the recognition that a more rigorous model, potentially based on the ongoing groundwater numerical modeling efforts, may be developed in a future update to the SNMP, if needed to evaluate future RW projects.

Primary inputs to the model are land use, irrigation water source, and surface geology characteristics. These datasets are described in the following sections. The general process used to arrive at the salt and nutrient loads is as follows:

1. Identify the analysis unit to be used in the model. Parcels from GWD's GIS parcel database are used as the analysis unit. The database layer stores information about the land use of each parcel in GWD's service area.

2. Categorize land use categories into discrete groups. These land use groups represent land uses that have similar water demand as well as salt and nutrient loading and uptake characteristics.

3. Apply the land use group characteristics to the analysis units.

4. Apply the irrigation water source to the analysis units. Each water source is assigned concentrations of TDS, chloride, sulfate, and nitrogen.

Table A-3. Evaluation of Potential Indicator Constituents.

Constituent	Iron	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Chloride	Sulfate	Nitrate	Manganese	Boron	Total Dissolved Solids
1. Is the constituent regularly monitored and detected in source waters?	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
2. Is the constituent representative of other salts and nutrients?		☑		☑	☑		☑		☑			☑
3. Is the constituent conservative and mobile in the environment?	☑	☑	☑	☑	☑		☑	☑		☑	☑	☑
4. Is the constituent found in source waters at concentrations above those found in ambient groundwater?							☑	☑			☑	☑
5. Does the constituent have high toxicity for human health or will otherwise affect beneficial use?	☑						☑	☑	☑	☑	☑	☑
6. Is the constituent a known contaminant in groundwater in the Study Area?	☑						☑	☑	☑	☑		☑
7. Have the concentrations of the constituents been shown to be increasing in the Study Area?												
8. Is the constituent subject to a water quality objective (WQO) within the Basin Plan?				☑			☑	☑	☑		☑	☑

5. Estimate the water demand for the parcel based on the irrigated area of the parcel and the land use group. Water use estimates for the Goleta area are taken from the DWR Agricultural Land and Water Use Estimates website (DWR, 2010).

6. Estimate the TDS load applied to each parcel based on the land use practices, irrigation water source, and quantity. The loading model assumes that no salt is removed from the system once it enters the system. Other transport mechanisms, such as groundwater extraction or introduction/use of Lake Cachuma water, could reduce the total quantity of salt in the Basin.

7. Similar to TDS, estimate the chloride and sulfate loads applied to each parcel based on the land use practices and irrigation water source and quantity.

8. Estimate the nitrogen load applied to each parcel based on the land use practices and irrigation water source and quantity. The loading model assumes that a portion of the applied nitrogen is used by plants and removed from the system. Additional nitrogen is converted to other species and is lost from the system as well. Hydraulic conductivity, based on surface soil texture characteristics (NRCS SSURGO), is used to reflect the vertical mobility of the nitrogen into the aquifer before being converted or used.

4.4 Identification and Quantification of Salt and Nutrient Sources

Salt and nutrient loads result predominantly from urban, irrigation water, and agricultural inputs associated with land use. Data synthesized to provide the necessary numerical loading factors are discussed below.

4.4.1 Land Use

Land use data form the basis for estimating many of the salt and nutrient sources, including irrigation water application and agricultural inputs (e.g. fertilizer and soil amendments). Recent land use information for the Basin was taken from GWD's GIS parcel database. The database layer stores information about the land use of each parcel in GWD's service area taken from the County of Santa Barbara Assessor's office.

A land use analysis was completed for each of three recharge areas located in the Basin: (1) the entire North subbasin, and portions of (2) Central subbasin and (3) West subbasin north of Highway 101. Land use area categories provided in the GWD parcel database were compiled into the following major land use groups based on similar potential loading characteristics:

- Field Crops
- Flowers (West subbasin only)
- Orchard
- Pasture
- Paved Areas
- Rancho Estates
- Urban Commercial
- Urban Industrial (West subbasin only)

- Urban Landscape
- Urban Residential

The major land use groups of each recharge area in the Basin are shown in **Figure A-2** and the breakdown of land use groups is shown in **Table A-1**.

Constituent loading from fertilizer application and irrigation water application rates associated with each land use group are summarized **Table A-4** for the North subbasin recharge area, **Table A-5** for the Central subbasin recharge area, and **Table A-6** for the West subbasin recharge area.

4.5 Water Sources

4.5.1 Potable and Irrigation Water Source

It was assumed that the primary water source used for irrigation purposes is potable water delivered by GWD. An average of the surface water and groundwater quality results for nitrate, chloride, sulfate, and TDS provided in the 2015 Annual Consumer Confidence Report (CCR) (GWD, 2016) were used as input in the loading analysis **Table A-7.**

4.5.2 Recycled Water

The Glen Annie Golf Club, located in the West subbasin recharge area (**Figure A-2**), uses RW for irrigation purposes. It was assumed that 100 percent RW is used on the Glen Annie Golf Club property for the loading analysis. Recycled water quality data were provided by GWD for the constituents chloride and TDS. The annual average concentrations of chloride and TDS were calculated for 2015 and used as input in the loading analysis for the Glen Annie Golf Club property (**Table A-8**). Nitrate and sulfate concentrations in the RW were assumed to be the same as potable water.

4.6 Soil Textures

Soil texture significantly affects the quantity of nitrogen that infiltrates to the aquifer. Soil textures (NRCS SSURGO) were obtained from the County of Santa Barbara and assigned a hydraulic conductivity (NRCS, 1993). Hydraulic conductivity was used to develop an adjustment factor through linearly scaling the estimated conductivities from 0.1 (lowest) to 1.00 (highest). The adjustment factor is used to represent the proportion of nitrate that will migrate to the aquifer, relative to the other textural classes. Where conductivity is slower, it is reasoned (and observed) that nitrogen resides longer in the soil, increasing the proportion that is either taken up by the crop or lost through conversion to gaseous species.

Similar logic is not applied to TDS, chloride, or sulfate as salts are mostly not subject to conversion to gaseous forms, and they rapidly saturate soil capacity to absorb and retain them. **Table A-9** summarizes soil textures within the basin boundaries and how those textures are represented in the loading model.

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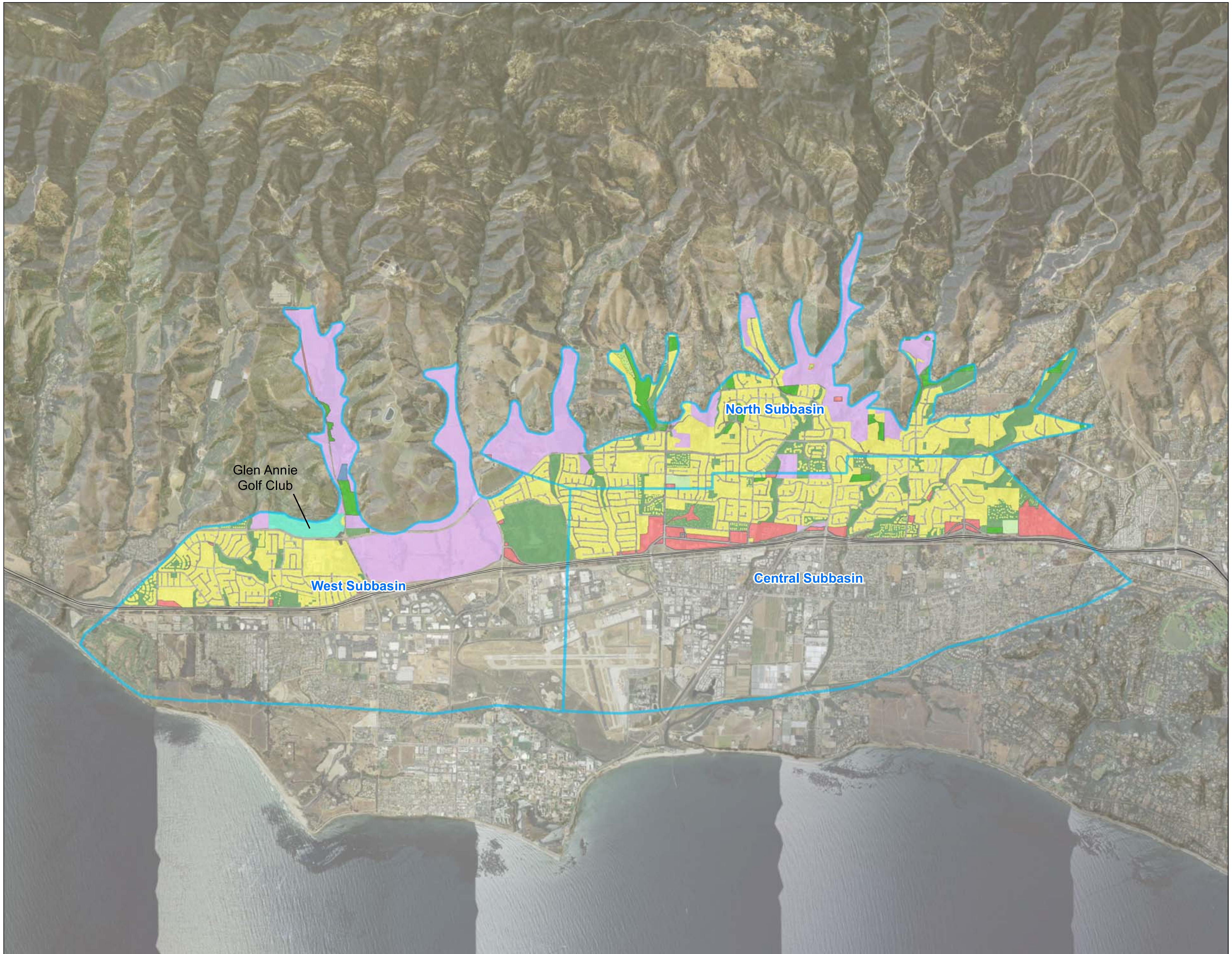
FIGURE A-2

Major Land Use Groups in Recharge Areas of the Goleta Groundwater Basin

Groundwater Management Plan
Goleta Groundwater Basin
2016 Update



LEGEND

Major Land Use Groups

- Field Crops
- Flowers
- Golf Course
- Orchard
- Pasture
- Paved Areas
- Rancho Estates
- Urban Commercial / Industrial
- Urban Landscape
- Urban Residential
- Goleta Groundwater Subbasins

US HWY 101

N

0 2,000 4,000 6,000
Feet

MAP NOTES:
Data Sources: ESRI, GWD, County of Santa Barbara
Aerial Photo Date: 6/1/2014
Date: 10/14/2016

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Table A-4. Land Use Related Loading Factors Table – North Subbasin.

Land Use Group	Total Area (Acres)	Percent Cultivated [1]	Cultivated Acres	Annual Applied Water (AF/Acre) [2]	Annual Applied N (lbs/Acre) [3]	Annual Leachable N (lbs/Acre) [4]	Annual Applied Chloride (lbs/Acre) [5]	Annual Applied Sulfate (lbs/Acre) [5]	Annual Applied TDS (lbs/Acre) [5]
Field Crops	10.5	75%	7.9	0.7	218	61	107	569	1,392
Orchard	507.4	75%	380.5	2.39	116	22	364	2,223	5,244
Pasture	9.2	30%	2.7	3.05	120	9	464	2,480	6,057
Paved Areas	0.2	0%	0.0	0	0	0	0	0	0
Rancho Estates	88.5	40%	35.4	2.39	116	22	364	2,223	5,244
Urban Commercial	4.6	5%	0.2	2.47	174	55	376	2,008	5,148
Urban Landscape	221.9	50%	111.0	2.47	174	55	376	2,008	5,148
Urban Residential	751.6	30%	225.5	2.47	174	55	376	2,008	5,148

Notes:

[1]Percent of land area assumed to be cultivated within each land use group is estimated based on review of aerial photography and professional judgement. In limited cases, it was found that land use classifications in the GWD parcel database did not line up with aerial photography inspection. The Percent Cultivated column was used as an 'adjustment knob' for incorrectly mapped parcels, based on professional judgment.

[2]Applied water values were taken from Department of Water Resources (DWR) land and water use data (http://www.water.ca.gov/landwateruse/anlwuest.cfm). The 'Detailed Analysis Unit' (DAU) for 2010 dataset was downloaded and used for the loading analysis (2010 was the most recent dataset available). It was assumed that cultivated land on Rancho Estates and Orchards was primarily avocado and lemons ('Subtrop' designation). 'Field crops' were assumed to actually be 'Oth Trk' designation ('field crops', as defined by the California Dept. of Food and Agriculture, are actually not grown in the Goleta Groundwater Basin). The applied water values for urban lands (commercial/industrial, landscape, golf course, and residential) were taken from the Paso Robles SNMP (RMC, 2015).

[3]Applied nitrogen values for 'Field Crops', 'Orchard', and 'Rancho Estates' land use groups are derived from Rosenstock (2013) Table 1 (2005 values). Values for 'Field Crops' are an average of values based on broccoli, cauliflower, celery, lettuce, bell peppers, and strawberries. Values for 'Orchard' and 'Rancho Estates' are based on an area weighted average of values for avocado and lemons (weighting is based on the percent area cultivated as avocado vs lemon in 'Orchard' and 'Rancho' land use groups. The California Augmented Multisource Landcover dataset (2010), (CAML) was used to determine avocado vs lemon acreages in the 'Orchard' and 'Rancho' land use groups. The CAML dataset does not contain data for type of 'Field Crop'). Applied nitrogen values for 'Flowers', 'Pasture', and all 'Urban' land use groups are taken from Maryland Nutrient Mgmt Manual, 2009, UC Davis, 2012 and Henry et al, 2002, respectively.

[4]Annual leachable nitrogen values for 'Pasture', and all 'Urban' land use groups (commercial/industrial, landscape, golf course, and residential) are taken from the Paso Robles SNMP (RMC, 2015). Annual leachable nitrogen values for 'Flowers', 'Field Crops', 'Orchard', and 'Rancho Estates' are calculated based on factors of atmospheric deposition, gaseous loss (volatilization and denitrification), fertilization, crop harvest loss, and runoff for each land use group. This leachable amount was then reduced to estimate nitrate loading based on soil conditions mapped for the land use group area (NRCS SSURGO).

[5]Derivation of applied sulfate and TDS values include application of solids in the form of gypsum soil amendment at 500 lbs/acre to 'Orchard' and 'Rancho Estates' land use groups based on personal communication with Goleta representative for AgRx, Danny Caveletto. Chloride is not applied within the basin in the form of fertilizer/soil amendment (per. comm., Danny Caveletto). Applied sulfate, chloride, and TDS values include dissolved input from irrigation water. With the exception of the Glen Annie Golf Club property, the average of surface water and groundwater concentrations of each constituent as reported in GWD 2016

Consumer Confidence Report (CCR) (2015 data) are used in the calculations (Table). It is assumed that the Glen Annie Golf Club property receives 100 percent recycled water, therefore the recycled water constituent concentrations are used for this property (Table).

AF = acre-feet
lbs = pounds

Table A-5. Land Use Related Loading Factors Table - Central Subbasin (portion to north of Hwy 101).

Land Use Group	Total Area (Acres)	Percent Cultivated [1]	Cultivated Acres	Annual Applied Water (AF/Acre) [2]	Annual Applied N (lbs/Acre) [3]	Annual Leachable N (lbs/Acre) [4]	Annual Applied Chloride (lbs/Acre) [5]	Annual Applied Sulfate (lbs/Acre) [5]	Annual Applied TDS (lbs/Acre) [5]
Field Crops	9.4	20%	1.9	0.7	218	61	107	569	1,392
Orchard	12.7	10%	1.3	2.39	118	24	364	2,223	5,244
Paved Areas	2.0	0%	0.0	0	0	0	0	0	0
Rancho Estates	11.7	40%	4.7	2.39	118	24	364	2,223	5,244
Urban Commercial	179.3	10%	17.9	2.47	174	55	376	2,008	5,148
Urban Landscape	204.0	50%	102.0	2.47	174	55	376	2,008	5,148
Urban Residential	675.1	35%	236.3	2.47	174	55	376	2,008	5,148

Notes:

[1]Percent of land area assumed to be cultivated within each land use group is estimated based on review of aerial photography and professional judgement. In limited cases, it was found that land use classifications in the GWD parcel database did not line up with aerial photography inspection. The Percent Cultivated column was used as an 'adjustment knob' for incorrectly mapped parcels, based on professional judgment.

[2]Applied water values were taken from Department of Water Resources (DWR) land and water use data (http://www.water.ca.gov/landwateruse/anlwuest.cfm). The 'Detailed Analysis Unit' (DAU) for 2010 dataset was downloaded and used for the loading analysis (2010 was the most recent dataset available). It was assumed that cultivated land on Rancho Estates and Orchards was primarily avocado and lemons ('Subtrop' designation). 'Field crops' were assumed to actually be 'Oth Trk' designation ('field crops', as defined by the California Dept. of Food and Agriculture, are actually not grown in the Goleta Groundwater Basin). The applied water values for urban lands (commercial/industrial, landscape, golf course, and residential) were taken from the Paso Robles SNMP (RMC, 2015).

[3]Applied nitrogen values for 'Field Crops', 'Orchard', and 'Rancho Estates' land use groups are derived from Rosenstock (2013) Table 1 (2005 values). Values for 'Field Crops' are an average of values based on broccoli, cauliflower, celery, lettuce, bell peppers, and strawberries. Values for 'Orchard' and 'Rancho Estates' are based on an area weighted average of values for avocado and lemons (weighting is based on the percent area cultivated as avocado vs lemon in 'Orchard' and 'Rancho' land use groups. The California Augmented Multisource Landcover dataset (2010), (CAML) was used to determine avocado vs lemon acreages in the 'Orchard' and 'Rancho' land use groups. The CAML dataset does not contain data for type of 'Field Crop'). Applied nitrogen values for 'Flowers', 'Pasture', and all 'Urban' land use groups are taken from Maryland Nutrient Mgmt Manual, 2009, UC Davis, 2012 and Henry et al., 2002, respectively.

[4]Annual leachable nitrogen values for 'Pasture', and all 'Urban' land use groups (commercial/industrial, landscape, golf course, and residential) are taken from the Paso Robles SNMP (RMC, 2015). Annual leachable nitrogen values for 'Flowers', 'Field Crops', 'Orchard', and 'Rancho Estates' are calculated based on factors of atmospheric deposition, gaseous loss (volatilization and denitrification), fertilization, crop harvest loss, and runoff for each land use group. This leachable amount was then reduced to estimate nitrate loading based on soil conditions mapped for the land use group area (NRCS SSURGO).

[5]Derivation of applied sulfate and TDS values include application of solids in the form of gypsum soil amendment at 500 lbs/acre to 'Orchard' and 'Rancho Estates' land use groups based on personal communication with Goleta representative for AgRx, Danny Caveletto. Chloride is not applied within the basin in the form of fertilizer/soil amendment (per. comm., Danny Caveletto). Applied sulfate, chloride, and TDS values include dissolved input from irrigation water. With the exception of the Glen Annie Golf Club property, the average of surface water and groundwater concentrations of each constituent as reported in GWD 2016

Consumer Confidence Report (CCR) (2015 data) are used in the calculations (Table). It is assumed that the Glen Annie Golf Club property receives 100 percent recycled water, therefore the recycled water constituent concentrations are used for this property (Table).

AF = acre-feet
lbs = pounds

Table A-6. Land Use Related Loading Factors Table - West Subbasin (portion to north of Hwy 101).

Land Use Group	Total Area (Acres)	Percent Cultivated [1]	Cultivated Acres	Annual Applied Water (AF/Acre) [2]	Annual Applied N (lbs/Acre) [3]	Annual Leachable N (lbs/Acre) [4]	Annual Applied Chloride (lbs/Acre) [5]	Annual Applied Sulfate (lbs/Acre) [5]	Annual Applied TDS (lbs/Acre) [5]
Flowers	5.2	5%	0.3	0.7	87	2	107	569	1,392
Golf Course	50.7	95%	48.2	2.47	174	55	1,713	2,008	8,930
Orchard	636.3	55%	350.0	2.39	120	11	364	2,223	5,244
Paved Areas	1.0	0%	0.0	0	0	0	0	0	0
Rancho Estates	22.5	70%	15.8	2.39	120	11	364	2,223	5,244
Urban Commercial / Industrial	20.1	5%	1.0	2.47	174	55	376	2,008	5,148
Urban Landscape	233.0	40%	93.2	2.47	174	55	376	2,008	5,148
Urban Residential	445.2	35%	155.8	2.47	174	55	376	2,008	5,148

[1]Percent of land area assumed to be cultivated within each land use group is estimated based on review of aerial photography and professional judgement. In limited cases, it was found that land use classifications in the GWD parcel database did not line up with aerial photography inspection. The Percent Cultivated column was used as an 'adjustment knob' for incorrectly mapped parcels, based on professional judgment.

[2]Applied water values were taken from Department of Water Resources (DWR) land and water use data (http://www.water.ca.gov/landwateruse/anlwuest.cfm). The 'Detailed Analysis Unit' (DAU) for 2010 dataset was downloaded and used for the loading analysis (2010 was the most recent dataset available). It was assumed that cultivated land on Rancho Estates and Orchards was primarily avocado and lemons ('Subtrop' designation). 'Field crops' were assumed to actually be 'Oth Trk' designation ('field crops', as defined by the California Dept. of Food and Agriculture, are actually not grown in the Goleta Groundwater Basin). The applied water values for urban lands (commercial/industrial, landscape, golf course, and residential) were taken from the Paso Robles SNMP (RMC, 2015).

[3]Applied nitrogen values for 'Field Crops', 'Orchard', and 'Rancho Estates' land use groups are derived from Rosenstock (2013) Table 1 (2005 values). Values for 'Field Crops' are an average of values based on broccoli, cauliflower, celery, lettuce, bell peppers, and strawberries. Values for 'Orchard' and 'Rancho Estates' are based on an area weighted average of values for avocado and lemons (weighting is based on the percent area cultivated as avocado vs lemon in 'Orchard' and 'Rancho' land use groups. The California Augmented Multisource Landcover dataset (2010), (CAML) was used to determine avocado vs lemon acreages in the 'Orchard' and 'Rancho' land use groups. The CAML dataset does not contain data for type of 'Field Crop'). Applied nitrogen values for 'Flowers', 'Pasture', and all 'Urban' land use groups are taken from Maryland Nutrient Mgmt Manual, 2009, UC Davis, 2012 and Henry et al., 2002, respectively.

[4]Annual leachable nitrogen values for 'Pasture', and all 'Urban' land use groups (commercial/industrial, landscape, golf course, and residential) are taken from the Paso Robles SNMP (RMC, 2015). Annual leachable nitrogen values for 'Flowers', 'Field Crops', 'Orchard', and 'Rancho Estates' are calculated based on factors of atmospheric deposition, gaseous loss (volatilization and denitrification), fertilization, crop harvest loss, and runoff for each land use group. This leachable amount was then reduced to estimate nitrate loading based on soil conditions mapped for the land use group area (NRCS SSURGO).

[5]Derivation of applied sulfate and TDS values include application of solids in the form of gypsum soil amendment at 500 lbs/acre to 'Orchard' and 'Rancho Estates' land use groups based on personal communication with Goleta representative for AgRx, Danny Caveletto. Chloride is not applied within the basin in the form

of fertilizer/soil amendment (per. comm., Danny Caveletto). Applied sulfate, chloride, and TDS values include dissolved input from irrigation water. With the exception of the Glen Annie Golf Club property, the average of surface water and groundwater concentrations of each constituent as reported in GWD 2016 Consumer Confidence Report (CCR) (2015 data) are used in the calculations (Table). It is assumed that the Glen Annie Golf Club property receives 100 percent recycled water, therefore the recycled water constituent concentrations are used for this property (Table).

AF = acre-feet
lbs = pounds

Table A-7. Water Quality Parameters for Potable Water from the GWD 2015 Annual CCR.

Source	Nitrate as N (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
Surface Water	ND	52	310	645
Ground-water	ND	60	288	814
Average	**ND**	**56**	**299**	**730**

Notes:
CCR = consumer confidence report
GWD = Goleta Water District
mg/L = milligrams per liter
ND = not detected
TDS = total dissolved solids

Table A-8. Water Quality Parameters for Recycled Water.

Nitrate as N (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
ND[1]	255	299[1]	1,293

Notes:
[1]Assumed to be the same as potable water (Table).
mg/L = milligrams per liter
ND = not detected
TDS = total dissolved solids

Table A-9. Soil Texture Loading Factors for Leachable Nitrogen.

Surface Soil Texture	Textural Class of Soil Matrix	Saturated Hydraulic Conductivity (in/hr)	Adjustment Factor
Rock Outcrop	-	0	0
Clay	Clay	0.03	0.1
Clay loam	Clay loam	0.18	0.13
Silty clay loam	Silty clay loam	0.23	0.14
Loam	Loam	0.73	0.24
Fine sandy loam	Sandy loam	1.98	0.49
Sandy loam	Sandy loam	1.98	0.49
Gravelly sand	Sand	4.49	1

Notes:
Modified from the Salt/Nutrient Management Plan for the Paso Robles Groundwater Basin (RMC, 2015). The adjustment factor linearly scales estimated hydraulic conductivities from 0.1 (lowest permeability) to 100 (highest permeability). The adjustment factor is used to represent how likely the nitrogen is to migrate to the aquifer, relative to the other textural classes.

4.7 Summary

Urban land uses (commercial/industrial, golf course, landscape, and residential) account for approximately two-thirds of the surface area of the Basin recharge area, while orchard and rancho estates make up the other third (**Figure A-3**). Similarly, percent salt and nutrient loading to the Basin recharge area (approximated by TDS) is approximately two-thirds from urban land uses and one-third from orchard and rancho estates (**Figure A-4**). Percent leachable nitrogen contribution to the Basin recharge area is approximately 88 percent from urban land uses and 12 percent from orchard and rancho estates (**Figure A-5).** The primary sources of chloride, sulfate, and TDS within the Basin are from potable water used for irrigation, whereas the primary source of nitrogen is associated with application of fertilizer. It is assumed that because the majority of the recharge areas within the Basin are serviced by sanitary sewers, there is negligible nitrogen input from septic systems.

Recycled water is used for irrigation purposes on one property located in the West subbasin recharge area (Glen Annie Golf Club). Within this property, chloride and TDS are applied at a significantly higher rate than other areas, which are irrigated with potable water. However, the Glen Annie Golf Club property accounts for only 1 percent of the total recharge (**Figure A-3**), only 2 percent of the overall TDS loading (**Figure A-4**), and only 1 percent of the leachable nitrogen contribution (**Figure A-5)** in the Basin.

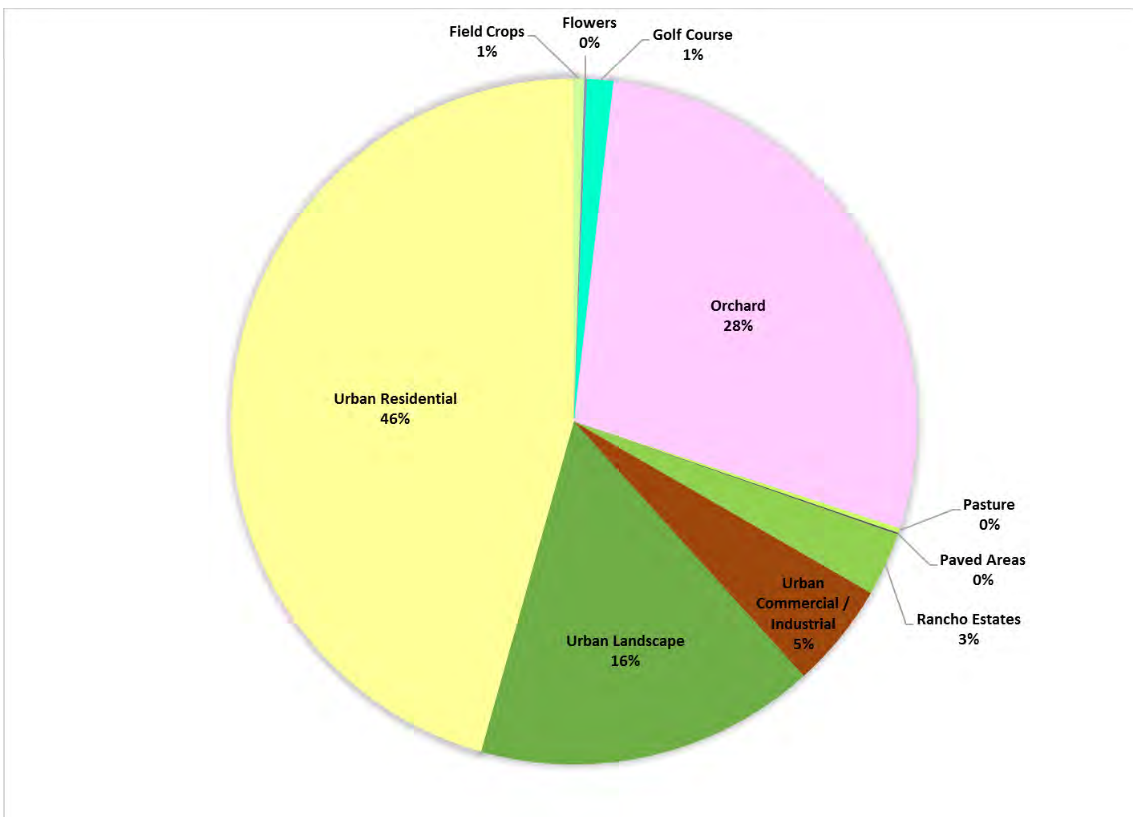

Figure A-3. Major Land Use Groups within Goleta Groundwater Basin Recharge Areas – by Percent Area

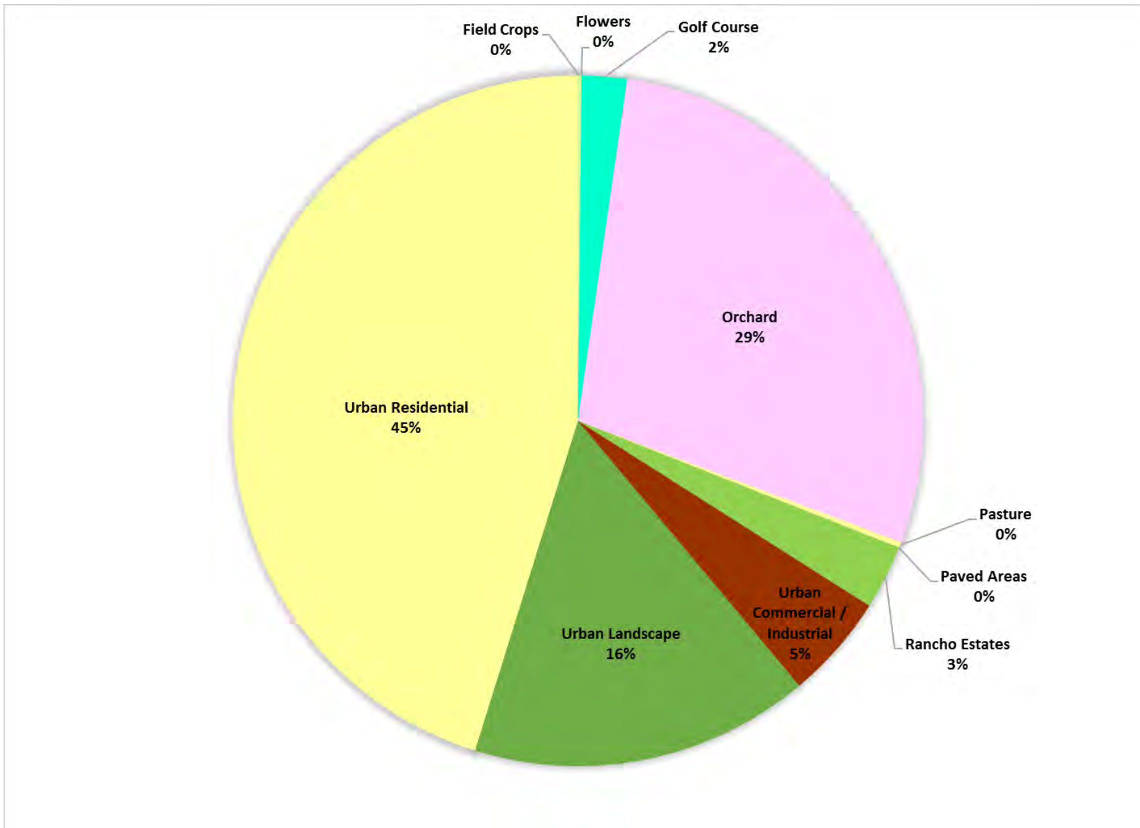

Figure A-4. Percent TDS Loading to Goleta Groundwater Basin Recharge Areas by Land Use Group

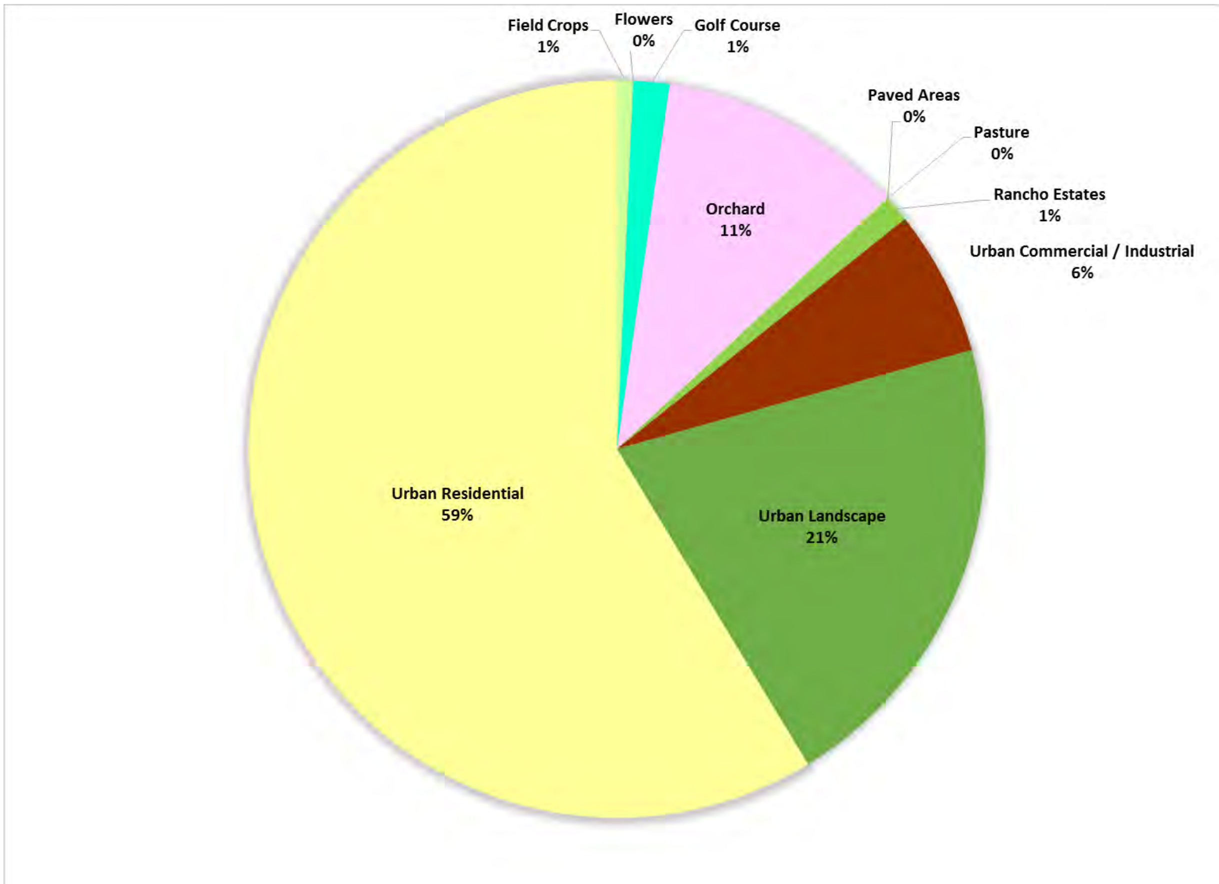

Figure A-5. Percent Leachable Nitrogen in the Goleta Groundwater Basin Recharge Areas by Land Use Group

5 Assimilative Capacity

A primary element of the SNMP is the assimilative capacity analysis of the groundwater basin. In this analysis, the average ambient groundwater quality in the management area is compared with the Basin Plan WQOs. The difference between these two values (assuming that the WQO concentration is greater than the ambient groundwater quality) represents the assimilative capacity of the groundwater basin, or the additional 'load' that the groundwater basin can accept without exceeding the WQOs. Normally, this analysis then is repeated using projected future conditions (land use, water usage and type, etc.) to determine if, under projected future conditions, the groundwater quality will remain below the WQOs. This SNMP does not complete such an evaluation of future projections because no new RW projects are currently planned. Moreover, groundwater quality data for the Basin suggest that the indicator constituents have not increased during the last 5 decades. Future changes in land use are expected to be relatively minor compared to the changes observed during the historical period and would tend to reduce loading (e.g., conversion of agricultural land to residential).

5.1 Baseline Groundwater Quality and Assimilative Capacity

This section presents baseline groundwater quality and assimilative capacity for constituents with WQOs.

5.1.1 Baseline Groundwater Quality

Historical and recent groundwater quality data are summarized in Section 3. As part of this analysis, the water quality data were used to determine baseline conditions by calculating the average constituent concentrations in each study area during the 5-year baseline period. The baseline conditions for TDS, nitrate (as N), sulfate, and chloride are required for performing assimilative capacity and antidegradation analyses for future RW projects. The baseline groundwater quality results are presented in **Table A-10**.

Table A-10. Baseline Groundwater Quality, Water Quality Objectives, and Assimilative Capacity.

Constituent	Median Groundwater Objective[1]	West Subbasin[2]			North-Central Subbasins[3]		
		Range	Average	Assimilative Capacity	Range	Average	Assimilative Capacity
TDS	1,000	710 - 2,681	1,314	0	530 - 1,500	867	133
Chloride	150	66 - 930	304	0	16 - 450	73	77
Sulfate	250	102 - 547	241	9	110 - 500	271	0
Nitrogen-N[4]	5	ND - 2.0	1.2	3.8	ND - 4	1	4

Notes:
All values are milligrams per liter (mg/L)
[1]Table 3-8 in *Water Quality Control Plan for Central Coast Basin*, June 2011.
[2]Most recent 5 years of data is 1985-1989. Data from GWD records.
[3]Most recent 5 years of data is 2011-2015. Data from SWRCB DDW records.
[4]Average calculated using ½ of detection limit for non-detect results.
ND = not detected
TDS = total dissolved solids

The baseline water quality assumes mixing in the entire groundwater storage volume. However, salt and nutrient loading occur at the land surface in the unconfined portion of the subbasins and typical production wells are on the order of 300 to 1,200 feet deep and many draw from confined portions of the Basin. Accordingly, the active loading and mixing occur in the northern and upper portions of subbasins. It should be recognized that shallow wells in the northern parts of the Basin are more vulnerable to surface loading; thus, the use of the entire Basin depth can mask a shallow problem. However, given the lack of vertically discrete groundwater quality data for the Basin as a whole and the intent of the statewide RWP that salts and nutrients from all sources be managed on a basin-wide basis, the scope of this analysis is limited to the larger, basin-wide picture.

5.1.2 Assimilative Capacity

The assimilative capacity of a groundwater basin is generally defined as the difference between the Basin Plan's WQO and the current baseline water quality in the basin. It typically represents the ability of a groundwater basin to accept additional salinity or nutrient loads without causing exceedance of the WQOs. Therefore, to determine if assimilative capacity exists, baseline groundwater quality concentrations must be compared to the WQOs.

The baseline constituent concentrations were compared to Basin WQOs to evaluate assimilative capacity for each constituent (**Table A-10**). This comparison shows that there is limited assimilative capacity in the West subbasin, as the only constituent with considerable assimilative capacity is nitrate. In the North-Central subbasins, TDS, chloride, and nitrate have considerable assimilative capacity, while sulfate concentrations slightly exceed the WQO. It is noted that the assimilative capacities suggested in **Table A-10** are based on simple averages of available groundwater quality data. A more sophisticated evaluation that considers the spatial and temporal data distributions may yield different results.

5.2 Fate and Transport in Groundwater Basin

Salt and nutrient fate and transport describes the way salts and nutrients move through an environment or media. In groundwater, it is determined primarily by the direction and rate of groundwater flow, the characteristics of individual salts and nutrients, and the characteristics of the aquifers. In certain cases, chemical reactions that occur along the flow path also can be important.

The groundwater level data and historical groundwater quality data for the Basin suggest that salt and nutrient loading occurring in portions of the recharge areas mixes with higher quality recharge waters along groundwater flow paths toward areas of groundwater discharge (principally pumping wells), resulting in lower overall concentrations in the confined portions of the Basin.

6 SNMP Goals and Objectives

This section documents the identified groundwater basin management goals and objectives that aid in managing salt and nutrient loading to groundwater.

6.1 Basin Management Goals and Objectives

General groundwater management goals focus on maintaining groundwater levels pursuant to the Wright Judgment[1], maintaining a groundwater storage "drought buffer" in accordance with GWD's SAFE Ordinance[2], and maintaining and improving groundwater quality. The GMP establishes Basin Management Objectives (BMOs) to measure and evaluate the health of the basin relative to these goals (see Section 4.1 of the GMP for further details). BMOs are typically groundwater elevations and/or chemical concentrations in wells.

For the Basin, the water level BMOs are set at the lowest measured historical static (non-pumping) groundwater elevation in each BMO well (see GMP Table 4-1). If groundwater elevations in a BMO well fall below this elevation, the BMO will be considered to have not been met and the Basin will be considered to be at risk for impacts such as land subsidence or, of greater significance to this SNMP, intrusion of poor quality water. This criterion for the water level BMO is based on the observation that a groundwater elevation that low in the well in the past did not harm the Basin, but a groundwater elevation below the BMO may create potential undesirable effects. Although not described as a BMO in the GMP, GWD's SAFE Ordinance also sets a numerical groundwater elevation target based on 1972 groundwater levels, which establishes the drought buffer.

The GMP also establishes BMOs that address water quality (see GMP Table 4-1). Nitrate and chloride were chosen as representative constituents. The BMO for nitrate is set at one-half of the drinking water primary standard of 45milligrams per liter [mg/L] nitrate as NO_3, which is also the RWQCB WQO (RWQCB, 2011). A chloride concentration of 150 mg/L was selected because it is the RWQCB WQO (RWQCB, 2011) and because it is generally protective of irrigated crops, although salt-sensitive crops, such as avocado and strawberries, may have reductions in yield at concentrations slightly lower than that.

6.2 Recycled Water and Stormwater Goals

Consistent with the State Recycled Water Policy, GWD's RW goal for this SNMP includes optimizing the use of recycled water in the Goleta Valley while still protecting groundwater quality and preserving beneficial uses. This will be accomplished through the continued addition of small recycled water projects to the existing system, while examining ways to maximize the use of RW, such as treating it to advanced standards and utilizing it as a potable water supplement. Doing so will increase local water supply reliability while reducing dependency on expensive, energy–intensive, and increasingly uncertain imported water supplies.

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[1] Martha H. Wright et al. v. Goleta Water District et al., 1989, Amended Judgment, Superior Court of Santa Barbara County Case No. SM57969.
[2] GWD Ordinances No. 91-01 and 94-03.

GWD is currently developing a Stormwater Resource Management Plan (SRMP) to quantify maximum stormwater capture potential to increase the beneficial use of stormwater as a supplemental water supply. The study will focus on development of feasible centralized stormwater capture site(s), including spreading grounds and recharge basins. It is anticipated that the SRMP will include goals for stormwater recharge.

7 Implementation Measures to Manage Salts and Nutrients on a Sustainable Basis

7.1 Approach for Evaluating Projects and Identifying Need for Potential Future Management Strategies

There are no proposed RW projects planned for the Basin at this time. If a RW project (or projects) is proposed in the Basin, it is required that the project be evaluated to determine if it will reduce assimilative capacity of the Basin if implemented. This includes determining if the proposed project will be located in an area where the application of RW at the land surface could potentially impact groundwater. If water applied at the land surface has the potential to reach groundwater, the concentration of the water produced by the project needs to be compared to the allowable RW project concentration to ensure that only the allowable portion of assimilative capacity in the groundwater basin is used. If the proposed project will produce RW with higher concentration than allowed, management measures defined in this section may be implemented to offset additional loading. Alternatively, a full antidegradation analysis could be conducted for the project to determine if the degradation is offset by important social and economic benefits to the people of the state.[3] This section outlines the process for evaluating proposed RW projects, and determining if additional management measures or a full antidegradation analysis are needed.

The procedure for evaluating projects is shown in **Figure A-6** and described in detail in this section.

7.1.1 Calculate Concentration from the Proposed Recycled Water Project

The first step in the evaluation process is to calculate the concentration of water produced by the proposed project.

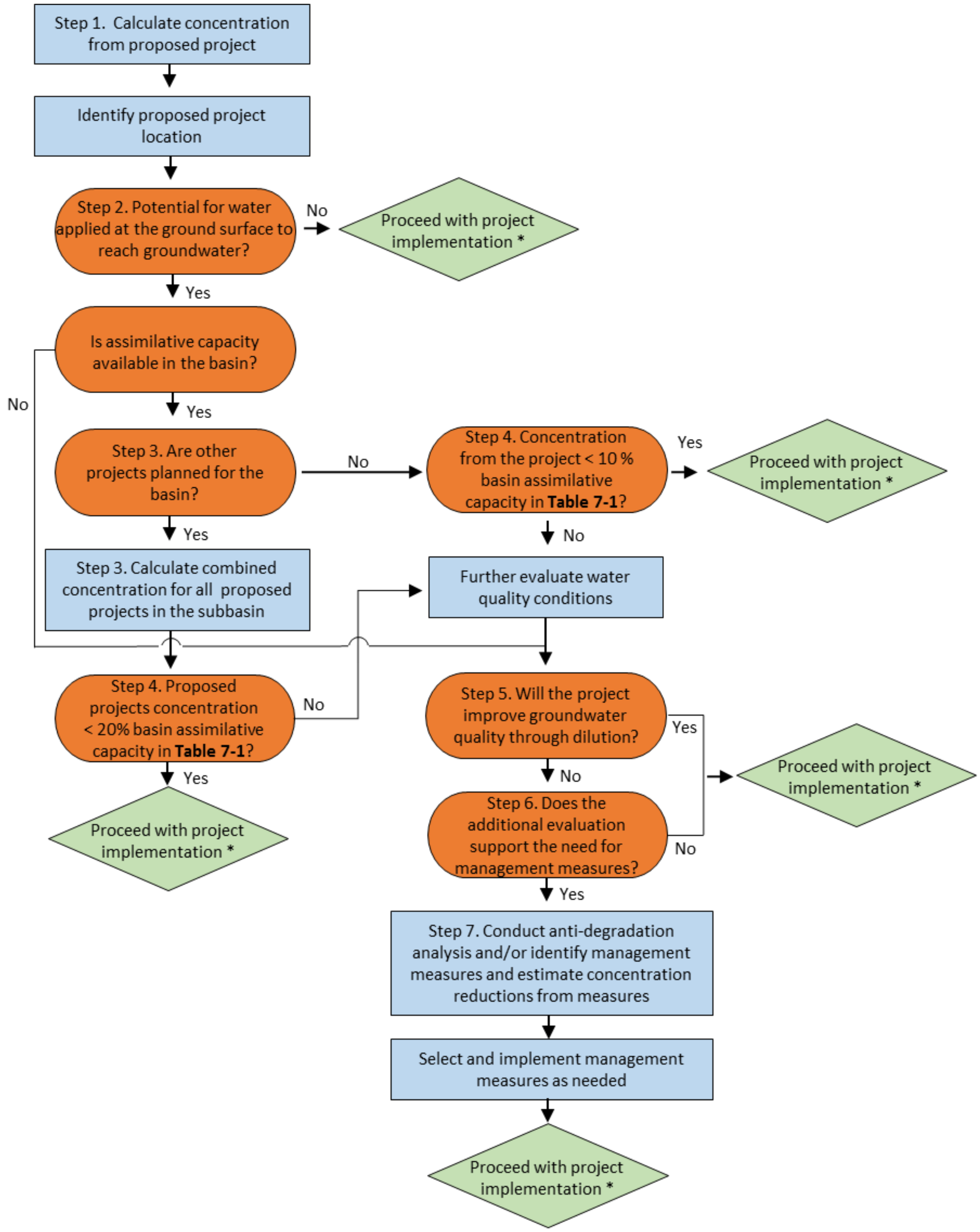
Step 1. Calculate the concentration of water produced by the proposed RW project. This should be carried out for each of the four indicator constituents defined in **Section 4.2** (TDS, chloride, sulfate, and nitrate as N).

Step 2. Determine whether there is potential for water applied at the ground surface to reach groundwater by determining whether the project is in one of the recharge areas shown in **Figure A-1**.

a. If there is no potential for water applied at the ground surface to reach groundwater, the project is not adding any additional load to the groundwater basin and no further evaluation or management measures are needed.

b. If there is potential for water applied at the ground surface to reach groundwater, proceed to the next step.

[3] Water Code Section 13000; California Antidegradation Policy Resolution 68-16.



*Contingent upon compliance with other regulatory requirements

Figure A-6. SNMP Project Evaluation Process

Step 3. Determine if any other RW projects are proposed for the Basin.

a. If other projects are proposed, the concentration from all planned projects in the subbasin must be considered together in the evaluation. Calculate the combined concentration from all the projects.

7.1.2 Compare Loading to Available Assimilative Capacity

After the concentration from the project(s) has been determined, a comparison of the project concentration to the allowable concentration for each of the four indicator constituents needs to be conducted.

Step 4. Compare the proposed RW project concentration to the allowable project concentration in **Table A-11**. As stated in the RWP, single projects may use less than 10 percent of available assimilative capacity, while multiple projects may use less than 20 percent of the available assimilative capacity.

a. If the project concentration is **less than** the 10 percent assimilative capacity threshold, no degradation is expected from the project. Management measures are not necessary and the project may proceed as planned, contingent upon compliance with other regulatory requirements.

b. If the combined project concentration for multiple projects is **less than** the 20 percent assimilative capacity threshold, no degradation is expected from the project. Management measures are not necessary and the project may proceed as planned, contingent upon compliance with other regulatory requirements.

c. If the allowable project concentration is **exceeded**, or there is no available assimilative capacity, further evaluation or implementation of management measures is needed. Proceed to the analysis outlined in **Subsection 7.1.3**.

Table A-11. Allowable RW Project Concentration*.

Constituent	10% Assimilative Capacity (1 project)		20% Assimilative Capacity (multiple projects)	
	West Subbasin[1]	North-Central Subbasins[2]	West Subbasin[1]	North-Central Subbasins[2]
TDS	< 1,314	880	< 1,314	893
Chloride	< 304	80	< 304	88
Sulfate	242	< 271	243	< 271
Boron [3]	No data	< 0.2	No data	< 0.2
Sodium	< 268	95	< 268	101
Nitrogen-N [3]	1.58	1.96	1.4	1.8

Notes:
* All values are in milligrams per liter (mg/L).
[1]Based on most recent five years of data are 1985-1989. Data from District records.
[2]Most recent five years of data are 2011-2015. Data from SWRCB DDW records.
[3]Average calculated using ½ of detection limit for non-detect results.

7.1.3 Further Evaluation

If the project will exceed the thresholds, further evaluation may be warranted before the implementation of management measures.

Step 5. If there is no assimilative capacity in the Basin, determine if the proposed project will create assimilative capacity in the Basin through dilution. This ideally will be done using a model, but also could be done by comparing the concentrations in the RW to the concentrations in the Basin.

a. If the project will create assimilative capacity, proceed with the project, contingent upon compliance with other regulatory requirements.

b. If the project will not create assimilative capacity, either conduct further analysis as outlined in Step 6 or select management measures to offset the load.

Step 6. If the project will not create dilution, additional analysis could be conducted as follows, or management measures could be selected in accordance with the next step.

a. Use more recent data collected through the SNMP monitoring plan or other available data to recalculate the assimilative capacity.

b. Evaluate model results to determine if modifications are appropriate. Conservative assumptions used to model the available assimilative capacity possibly can be modified with additional information.

7.1.4 Selection of Management Measures

Step 7. If the need for management measures is identified after completing the analysis in Steps 1 through 6, the project proponent will need to do one of the following:

1. Conduct a full antidegradation analysis to demonstrate that the additional concentration from the project, or the project with identified management measures to offset part of the additional loading, would be allowed under the antidegradation policy.
2. Select from the list, **Table A-12,** of potential future management measures to reduce the loading from the project below the thresholds.
3. Work with other sources of salts and nutrients in the Basin to reduce their concentration to offset the loading above the thresholds through implementation of potential future management measures.
   a. If this method is selected, the project proponent will need to identify potential management measures that can be implemented to offset the concentration.
   b. During the permit process, the project proponent must provide a calculation of the estimated concentration reduction to be provided by the proposed management measures.

All management actions taken at the treatment plant to reduce salt or nutrient concentration are a direct concentration reduction for the proposed RW project. Estimates of the amount of concentration reduced from the management measure should be subtracted from the estimated project concentration to evaluate if the assimilative capacity thresholds will now be met.

If management measures being implemented by another entity are to be used to offset the excess concentration from a project, the following steps must be taken to provide reasonable assurance that the management measures will be implemented:

1. Calculate the estimated concentration reduction from the proposed management measure. Effectiveness for treatment management measures will use design parameters or peer reviewed effectiveness information when available.
2. Develop a map that shows the location of the management measure implementation as compared to the RW project implementation to demonstrate the management measures will occur within the same basin.
3. Develop a comparison of the implementation period for the management measure and the proposed RW project. Demonstrate that the management measure will be in place for the same period of time as the RW project.

7.2 Potential Future Management Measures

The potential future management measures include those that were identified as potential measures in planning studies, as well as other measures tailored to the site-specific conditions in the Goleta GMP (Table A-12). The potential future management measures represent a menu of potential management measures that could be implemented if needed to manage salts and nutrients on a sustainable basis. The list is intended to represent a wide-range of potential options that could be considered on the basis of the project-specific evaluation listed above and do not represent management measures that definitely will be implemented.

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Table A-12. Other Potential Future Management Measures.

Category	Specific Measure	Description	Effect
Wastewater and reclaimed water quality	Source control – salts	Implementation of outreach, removal and incentive program aimed at reducing the number of self-regenerating water softeners in unincorporated areas of Goleta within the Goleta Basin SNMP project area.	Fewer self-regenerating water softeners will reduce the salt load in residential wastewater.
Wastewater and reclaimed water quality	Source control – salts	Implementation of a water softener ban in the Goleta Groundwater Basin, and the unincorporated areas of the Basin that are within the SNMP project area.	Fewer self-regenerating water softeners will reduce the salt load in residential wastewater.
Wastewater and reclaimed water quality	Source control – industrial control, pretreatment program	Consideration of modified local limits to improve influent wastewater quality.	Limits the pollutant concentrations in influent wastewater.
Septic system leachate	Provide connections to sewer systems	Consideration of a septic system conversion program to reduce the number of septic systems in the basins	Reduces the volume of septic system leachate that percolates into shallow groundwater. Tie-in to a treatment plant ultimately leads to a treated waste stream with a lower nutrient load.
Non-stormwater discharge control and quality	Source control of non-stormwater discharges	Ordinance banning installation and discharges of debrominated/dechlorinated swimming pool water.	Reduce primary source of salts in non-stormwater discharges.
Municipal Water Quality	Softening of groundwater supplies	Consideration of water softening to reduce hardness.	Reduces need for the self-regenerating residential water softeners. Fewer self-regenerating water softeners will reduce the salt load in residential wastewater.

Category	Specific Measure	Description	Effect
Municipal Water Quality	Advanced treatment of compromised groundwater supplies	Consideration of RO treatment to remove salts from groundwater supplies.	Through treatment, reduces salt load in potable water that is pass through to wastewater. Reduces need for residential water softeners.
Stormwater Recharge	Additional groundwater recharge with stormwater	Consideration of capture and recharge of stormwater, including opportunities identified in TMDL implementation plans and other stormwater resource plans developed for the planning area.	Provides dilution of groundwater through recharge of water with potentially low salt and low nutrient concentrations.
Municipal Water Quality	Improves municipal water quality	If other alternatives including groundwater recharge or direct potable reuse are not implemented, then additional treatment, RO, will be provided water extracted from the Mound basin.	Improves potable water quality through treatment. Reduces salt load in potable water that is pass through to wastewater. Reduces need for residential water softeners.

8 Antidegradation Analysis

8.1 Regulatory Background

The RWP requires RW projects included within SNMPs to satisfy the requirements of State Water Board Resolution No. 68-16, the state antidegradation policy adopted in 1968 to protect and maintain existing water quality in California. Resolution No. 68-16 is interpreted to incorporate the federal antidegradation policy and satisfies the federal regulation requiring states to adopt their own antidegradation policies. Resolution No. 68-16 states in part:

1. Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of such water and will not result in water quality less than that prescribed in the policies.
2. Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality water will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.

Entities that carry out actions that involve the disposal of wastes that could impact high quality waters are subject to the state's antidegradation policy and are required to implement best practicable treatment or control (BPTC) of the discharge to avoid producing a pollution or nuisance and maintain the highest water quality consistent with maximum benefit to the people of the state. The RWP finds that use of RW in accordance with the Policy is presumed to have a beneficial impact.

8.2 Approach

Existing groundwater quality and available assimilative capacity for TDS, chloride, sulfate, and nitrate-N for the Goleta groundwater subbasins were estimated so that the impact of future projects on subbasin groundwater quality can be evaluated (see **Sections 3 and 4**). Analysis of future RW projects will evaluate if the estimated degradation to groundwater quality, vis-à-vis the use of available assimilative capacity in a basin/subbasin, is consistent with provisions of the RWP and state and federal antidegradation policies. Consistent with these policies, the future use of assimilative capacity will be in compliance with the antidegradation policy by evaluating if the projects are:

(1) Subject only to verification of its use of available assimilative capacity as it individually, or in combination with other projects in the same basin/subarea, is

> estimated to use less than 10 percent (single project) or less than 20 percent (multiple projects) of available assimilative capacity; or
>
> (2) Subject to a 'complete'[4] antidegradation analysis due to its estimated use of available assimilative capacity in excess of either the 10 percent (single project) or 20 percent (multiple projects) thresholds specified in the RWP.

As discussed in **Section 5**, there are no new or proposed projects at this time to evaluate. As a result, the procedures provided in **Section 7** have been developed to ensure degradation of the groundwater subbasins does not occur at levels above those allowed under the RWP. The procedures require that any projects with loadings of salts and nutrients above the assimilative capacity thresholds implement management measures to offset the loading above the threshold. The thresholds were set consistent with the antidegradation policy.

Based on implementation measures provided in **Section 7**, the approach for evaluating compliance with the antidegradation policy for future RW projects in the Basin is presented in the following section.

8.2.1 Goleta Basin Analysis

Analysis of existing Basin-wide groundwater quality conditions indicates that there is little to no assimilative capacity available in the West subbasin and considerable assimilative capacity available in the North-Central subbasins. If RW projects are proposed in a subbasin with assimilative capacity, there is low risk that the project or projects will use enough of the subbasin's assimilative capacity to warrant a full antidegradation analysis. As mentioned above, the RWP allows RW projects to use 10 percent of a subbasin's available assimilative capacity (or 20 percent for multiple projects). To be considered in compliance with the antidegradation policy without further analysis, future RW projects in the Basin must be at or below the concentrations presented in **Table A-11**, which are based on the assimilative capacity analysis of the subbasin in its entirety. If the project meets the concentration requirements, the proposed RW project's increased salt and nutrient load will not use the entire subbasin's available assimilative capacity.

Groundwater quality analysis of the Basin suggests that concentrations of indicator constituents have not increased in the groundwater basin during the last 5 decades. Potential future changes in land use are relatively minor compared to the changes observed during the historical period, and would tend to reduce salt and nutrient loading (conversion of agricultural land to residential). Furthermore, GWD has no near-term plans to significantly expand the existing RW system; therefore, there is not expected to be a net increase in salt and nutrient concentration to the subbasin above the assimilative capacity thresholds, and the requirements of the antidegradation policy are satisfied.

[4] A complete antidegradation analysis must include a socioeconomic analysis to establish the balance between the proposed action and the public interest.

9 Groundwater Quality Monitoring

9.1 Background

The RWP (approved 2009, amended 2013) states that SNMPs should include a monitoring program (SNMP Groundwater Quality Monitoring Program) that consists of a network of groundwater monitoring locations to determine whether groundwater quality, including the concentrations of salts, nutrients, and other constituents of concern, meets the applicable water quality objectives. The SNMP Groundwater Quality Monitoring Program must focus on basin water quality near supply wells and large water recycling projects, particularly groundwater recharge projects. Furthermore, where conditions are appropriate, monitoring locations shall target groundwater and surface waters where groundwater has connectivity with adjacent surface waters (RWP, 2009). The RWP preferred approach to monitoring plan development is to utilize existing wells for sample collection, as long as the existing wells are adequately located to determine water quality throughout the most critical areas of the basin (RWP, 2009).

The SNMP Groundwater Quality Monitoring Plan should identify those stakeholders responsible for conducting, sampling and reporting the monitoring data. The data will be reported to the RWQCB at least every 3 years. With regard to CECs for basins with RW recharge projects, the RWP requires that the SNMP include a provision for annual CEC monitoring (e.g., endocrine disrupters, personal care products or pharmaceuticals) consistent with recommendations by the DDW and consistent with any actions by the State Water Board (RWP, 2009). However, Attachment A of the RWP clarifies that due to the low risk for ingestion, monitoring of CECs is not required for recycled water used for landscape irrigation (RWP, 2009). The RWP does not discuss CEC monitoring for agricultural irrigation application uses.

9.2 Summary of SNMP Groundwater Quality Monitoring Program

The GMP includes a proposed network of monitoring wells as part of a Groundwater Quality Monitoring Program pursuant to required drinking water monitoring (Section 4.4.3). Consistent with the preferred approach included in the Recycled Water Policy, water quality monitoring relies on sampling by GWD and La Cumbre at their respective potable supply wells. The GWD's existing monitoring network satisfies the SNMP requirements for monitoring. Furthermore, as there is no production and use of RW for groundwater recharge reuse in the Basin, monitoring of CECs is not required by the RWP.

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