GROUNDWATER SUSTAINABILITY PLAN PETALUMA VALLEY GROUNDWATER BASIN

December 2021

Prepared by Sonoma Water

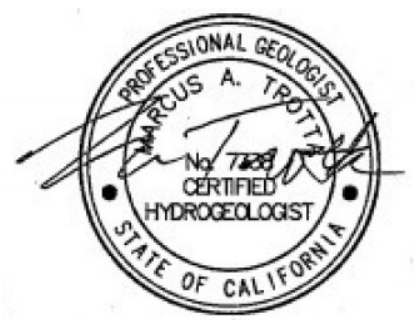
Adopted by the Petaluma Valley Groundwater Sustainability Agency on December 8, 2021

Submitted to California Department of Water Resources January 2022

PETALUMA VALLEY GROUNDWATER SUSTAINABILITY AGENCY

Signature Page

Section 3 (Basin Setting) of the Petaluma Valley Basin Groundwater Sustainability Plan was prepared under the direction of a professional geologist licensed in the state of California as required per California Code of Regulations, Title 23 Section 354.12 consistent with professional standards of practice.



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December 8, 2021

Acknowledgments

The Petaluma Valley Groundwater Sustainability Agency gratefully acknowledges funding contributed by the California Department of Water Resources (DWR) through the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1) and the California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018 (Proposition 68) and through an agreement with DWR. Additional funds and in-kind support were provided through the generous contributions of the following local agencies:

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- County of Sonoma (County)
- City of Petaluma (Petaluma)
- Sonoma Resource Conservation District (Sonoma RCD)
- North Bay Water District (NBWD)

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Rick Rogers, National Marine Fisheries Service

Melissa Rohde, The Nature Conservancy
Wendy Trowbridge, Laguna Foundation
Technical support provided by Sonoma Water staff David Cook, Patrick Lei, and David Manning

Depletion of Interconnected Surface Water

Sam Boland-Brien, Natalie Stork, Val Zimmer, State Water Resources Control Board
Maurice Hall, Environmental Defense Fund
Jessie Maxfield, California Department of Fish & Wildlife
Andrew Renshaw, California Department of Water Resources
Rick Rogers, National Marine Fisheries Service
Melissa Rohde, The Nature Conservancy

Rural Residential Growth

Pete Parkinson in consultation with Permit Sonoma, Sonoma County Transportation Authority, Association of Bay Area Governments, and the City of Sonoma

Special thank you to:

Past Board and Advisory Committee members.
All members of the public who attended Board and Advisory Committee meetings and public workshops, hearings, and events. Your contribution to this document was invaluable.

EXECUTIVE SUMMARY

California's historic Sustainable Groundwater Management Act (SGMA) became effective on January 1, 2015, at the height of the state's last drought. SGMA mandated that groundwater resources be sustainably managed to ensure that water will be available today and into the future for all beneficial users, including flora and fauna, municipal and domestic, agricultural, and business users. The Petaluma Valley Groundwater Sustainability Agency (Petaluma Valley GSA) was formed under SGMA to develop and implement this Groundwater Sustainability Plan (GSP or Plan) for the Petaluma Valley Groundwater Basin (Basin) (refer to **Figure ES-1**).

This GSP lays out a management process for ensuring a sustainable groundwater supply in the future by improving the understanding of this hidden resource, measuring progress through metrics that will be monitored, actively implementing projects, adopting policy and management actions in response to groundwater conditions if they decline unacceptably, and developing the funding needed for long-term implementation. The GSP implementation process includes active engagement of local stakeholders, including disadvantaged communities (DACs), Tribes, residential well owners, farmers, businesses, and environmental representatives.

The Basin is classified by California Department of Water Resources (DWR) as a medium-priority basin, with groundwater levels declining in some areas of the Basin. Based on the medium-priority designation, the GSA must submit the GSP to DWR by January 31, 2022. The Petaluma Valley GSA began work on the GSP in 2018, to identify and quantify existing problems and data gaps, define local goals for sustainable management of the Basin, and develop a Plan that achieves and maintains groundwater sustainability 50 years into the future.

Prior to the passage of SGMA, the U.S. Geological Survey (USGS) began work on a comprehensive study of groundwater resources in the Basin and contributing watershed. The USGS study was sponsored by the City of Petaluma and Sonoma County Water Agency (Sonoma Water) and is foundational to this GSP.

This GSP presents detailed, technical information to build upon the work done by USGS and to better understand groundwater in the Basin. The GSP uses quantifiable sustainable management criteria to define sustainability and includes projects, management actions, and an implementation plan necessary to achieve locally determined sustainability goals.

Because Petaluma Valley once again faces historic drought conditions, and with climate change projections showing that longer, more severe droughts are inevitable, the GSP lays out a path for long-term sustainability and resiliency as defined by SGMA. While the current drought highlights water resource challenges, GSPs are not intended to address immediate short-term issues, but are focused on long-term, systemic groundwater issues. For example, using a computerized model, described in **Section ES-3**, the GSP projects a 50-year climate future characterized by a few very dry years, followed by several wet or very wet years, and then a long drought. This scenario is representative of projected conditions in the North Bay, but is one of multiple options that could have been used. The climate scenario will be re-evaluated as more refined projections become available, and at a minimum of every 5 years when the

Figure ES-1 Plan Area / Petaluma Valley Groundwater Basin

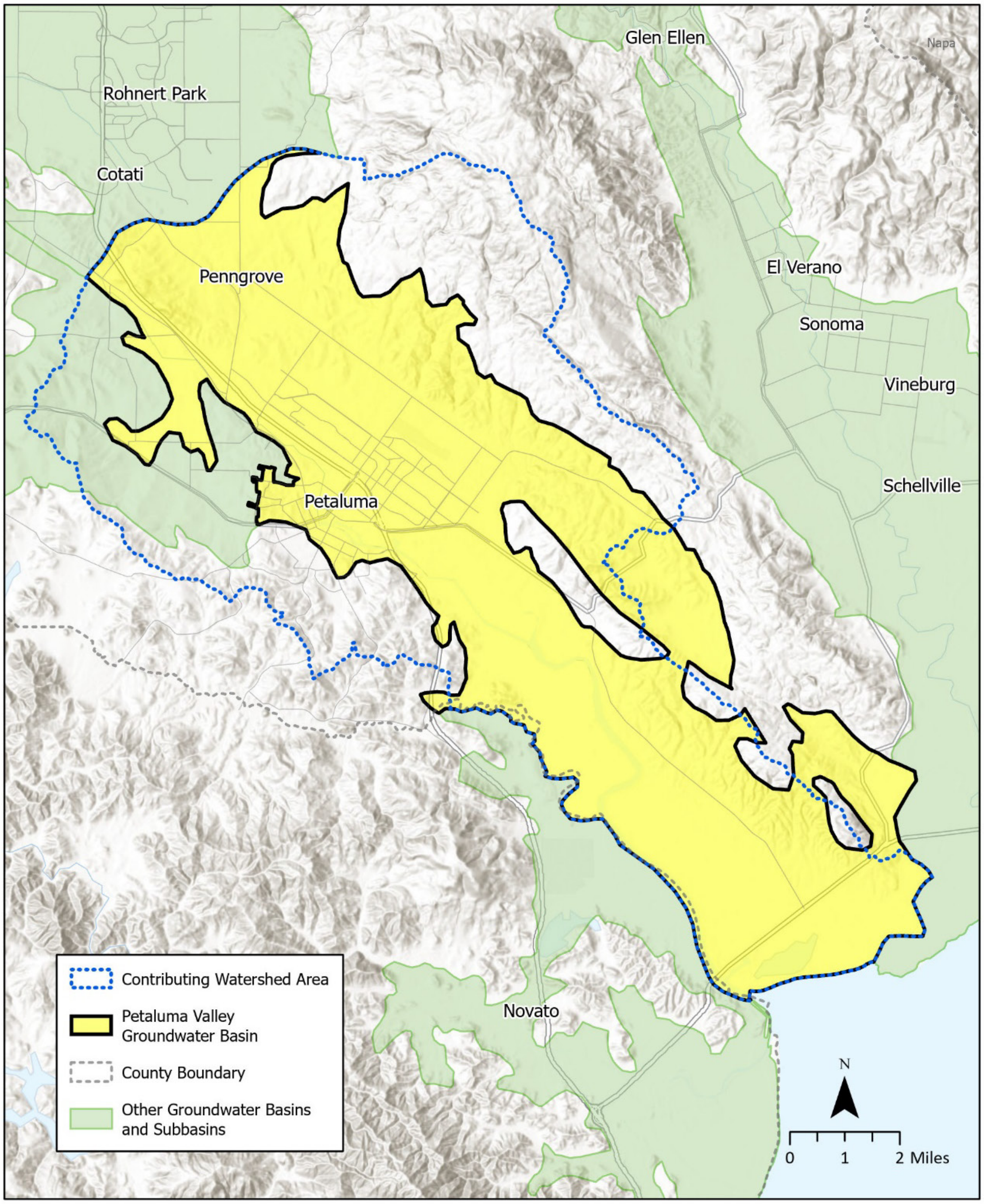

Figure ES-1. Plan Area/Petaluma Valley Groundwater Basin

GSP is required to be updated. This approach reflects a key component of this GSP, which is adaptive management. The document identifies areas of uncertainty, describes how new information will developed and incorporated into GSP implementation and how to make adjustments and correct course if necessary.

Adaptive Management
A key tenant of this GSP is adaptive management. Adaptive management is a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via monitoring and through the incorporation of new information as it becomes available.

This GSP and Executive Summary are organized following DWR's guidance documents (DWR 2016a):

- Executive Summary
- Section 1 Introduction
- Section 2 Description of the Plan Area
- Section 3 Basin Setting
- Section 4 Sustainable Management Criteria
- Section 5 Monitoring Networks
- Section 6 Projects and Management Actions to Achieve Sustainability
- Section 7 Implementation Plan
- Section 8 References and Technical Studies Used to Develop the GSP

ES.1 Introduction

In June 2017, the Petaluma Valley GSA, whose jurisdiction is the Basin, was formed as a Joint Powers Authority with five member agencies: North Bay Water District, Sonoma County (County), Sonoma Water, Sonoma Resource Conservation District, and the City of Petaluma. The Petaluma Valley GSA Board of Directors (Board) includes one representative from each member agency. The Board meets approximately six times annually in meetings that are open to the public.

In recognition of the importance of stakeholder input, the Board created a 10-member Advisory Committee to provide feedback and advice on all aspects of the GSP to the Board. The Advisory Committee meetings are open to the public, advertised through a monthly email update, and posted on the Petaluma Valley GSA website, petalumavalleygroundwater.org.

Both the Board and Advisory Committee continued to meet despite multiple wildfire emergencies affecting our community. During the public health emergency, meetings continued virtually. GSP development was a collaborative effort among the Board, Advisory Committee, and technical consultants, and was further informed by input from member agencies, resource agencies, and the community, including representatives of residential well owners, agriculture, business, and environmental interests (**Figure ES-2**). Key policy issues were vetted, discussed, and modified based on this open, public exchange.

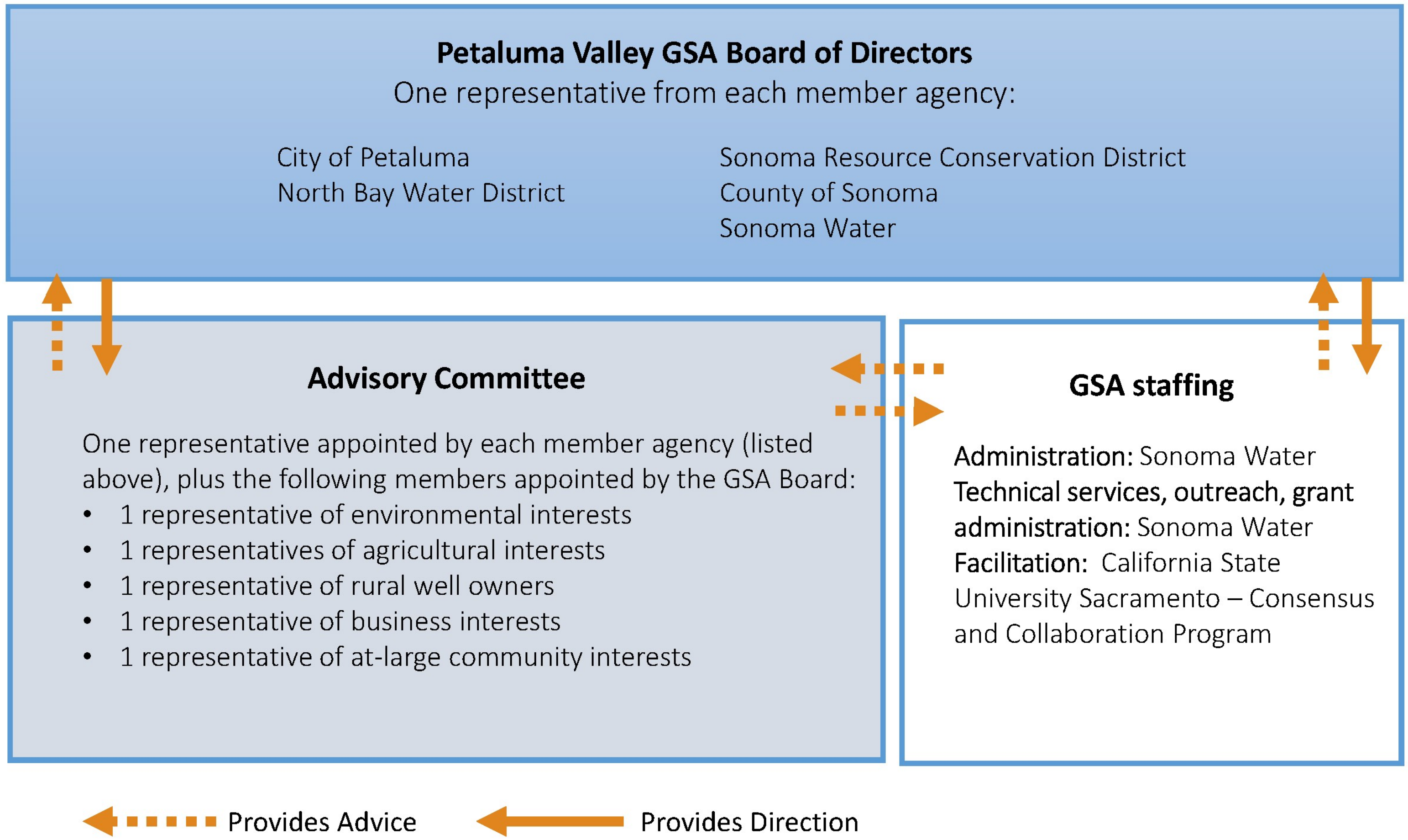

Figure ES-2. Petaluma Valley GSA Organizational Structure

ES.2 Plan Area

Section 2 of the GSP or Plan describes the Plan Area, including government jurisdictions, land use, water sources and uses, topography, surface water features, current monitoring and water management programs, and the well-permitting process.

The Plan Area is the entire Petaluma Valley Basin (**Figure ES-1**), located immediately north of San Pablo Bay, bounded on the east by Sonoma Mountains and on the west by low-lying hills. The approximately 46,000-acre Basin stretches from the Baylands northward, incorporating the City of Petaluma and the communities of Penngrove and Lakeville. The Petaluma River, which is the principal stream draining the Basin, is located within the larger Petaluma Valley watershed. In August 2019, the Basin boundaries were modified as part of DWR's reprioritization process to include additional areas of the City of Petaluma and the northwest section of Marin County.

The major urban water supplier in the Basin is the City of Petaluma, which relies primarily on imported Russian River water supplied by Sonoma Water. The City also pumps groundwater for supplemental supply, and during droughts and in emergencies. The exact number of domestic wells is unknown but is estimated to be between 400 and 600. The majority of land in the Basin is native vegetation or surface water (57 percent) followed by agriculture (23 percent) and urban, commercial, and industrial, which total about 20 percent of land use. The majority of the native vegetation is located in the lower portions of the Basin along the tidal marshlands and in the hills northeast of the City of Petaluma (**Figure ES-3a**).

Figure ES-3b shows the DACs in the Basin. These communities are located in and receive water from the City of Petaluma, which relies primarily on surface water supply.

Climate, water, and streamflow conditions in the Basin are informed by monitoring networks. Multiple studies, programs, land use plans, and regulations affect, inform, and protect current and future water resources, water use, and water quality in the Basin. The County is responsible for administering well permits in both the City of Petaluma and the unincorporated areas.

ES.3 Basin Setting

Section 3 describes the Basin setting based on existing studies related to geology, climate, and historical groundwater conditions.

ES.3.1 Hydrogeologic Conceptual Model

The Hydrogeologic Conceptual Model (HCM) characterizes the physical components of the surface water and groundwater systems, regional hydrology, geology, water quality, and principal aquifers and aquitards.

The Basin and its contributing watershed are located within a region of geologic complexity caused by long periods of active tectonic deformation, volcanic activity, and sea level changes. The northern Coast Ranges structure is dominated by the San Andreas zone of faults to the west, and the Rodgers Creek, Burdell Mountain, and Petaluma Valley fault zones. The regional tectonic faulting has helped shaped the Basin, the surrounding northwest trending valleys and ridges, and underlying geology.

Figure ES-3a Petaluma Valley Water Sector and Water Use Type

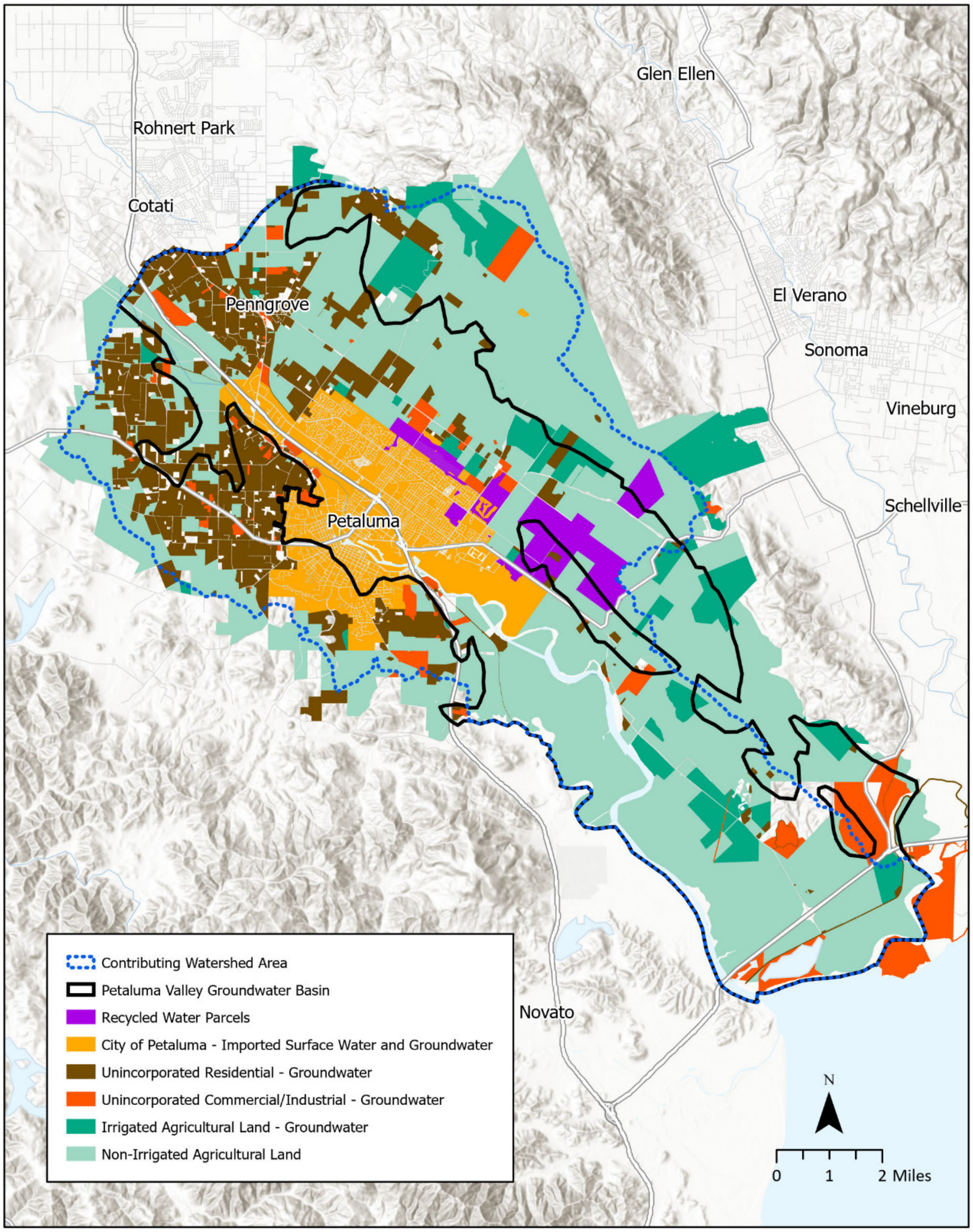

Figure ES-3a. Water Sector and Water Use

Figure ES-3b Petaluma Valley Disadvantaged Communities

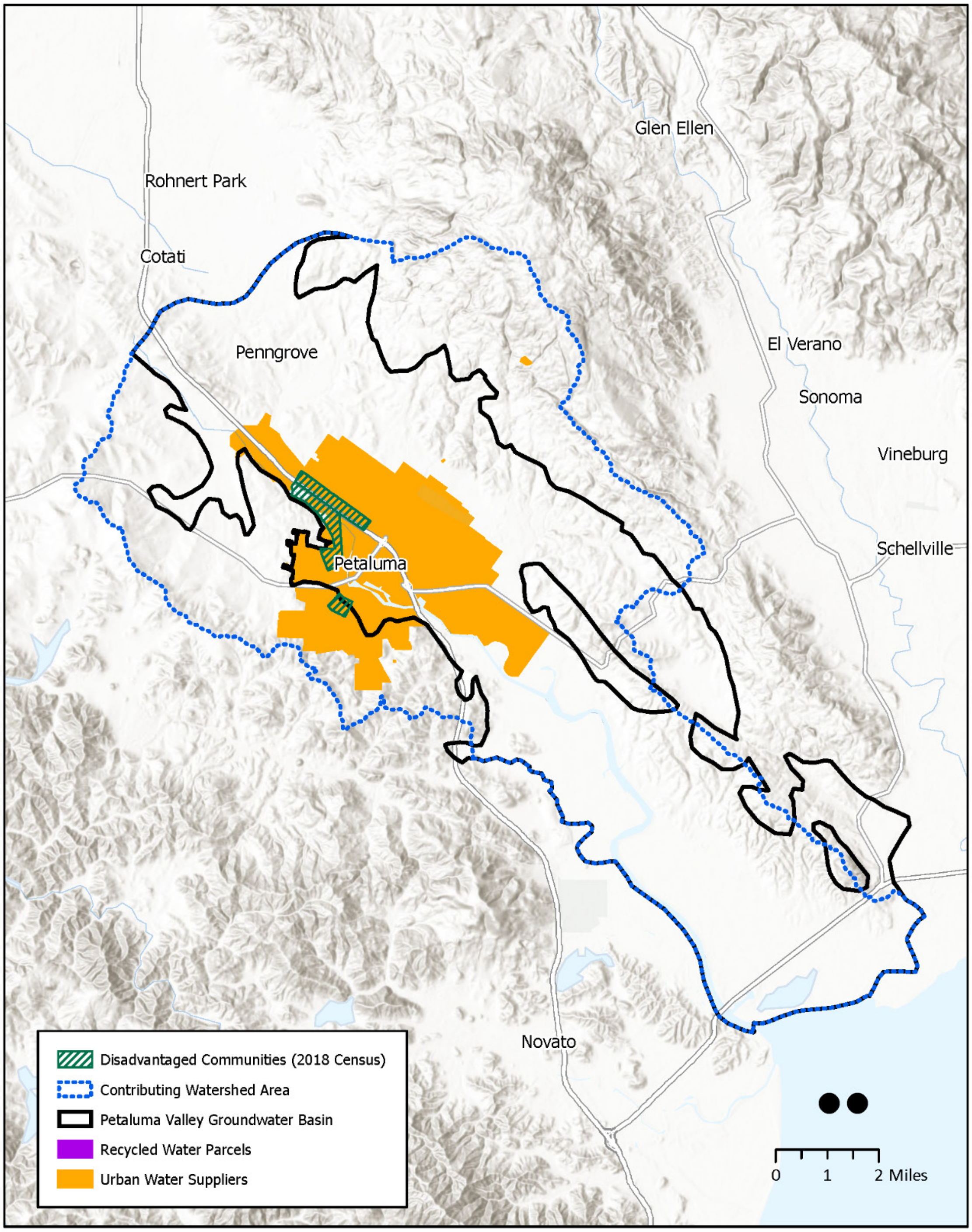

Figure ES-3b. Petaluma Valley Disadvantaged Communities

Groundwater resources are variable throughout the Basin. Wells in the Petaluma Formation aquifer unit, which covers the largest area of the Basin, generally have low yields; wells in the Wilson Grove Formation aquifer unit are generally considered to be fair to good groundwater producers; and wells in the Sonoma Volcanics have large variations in water-bearing properties (**Figure ES-4**).

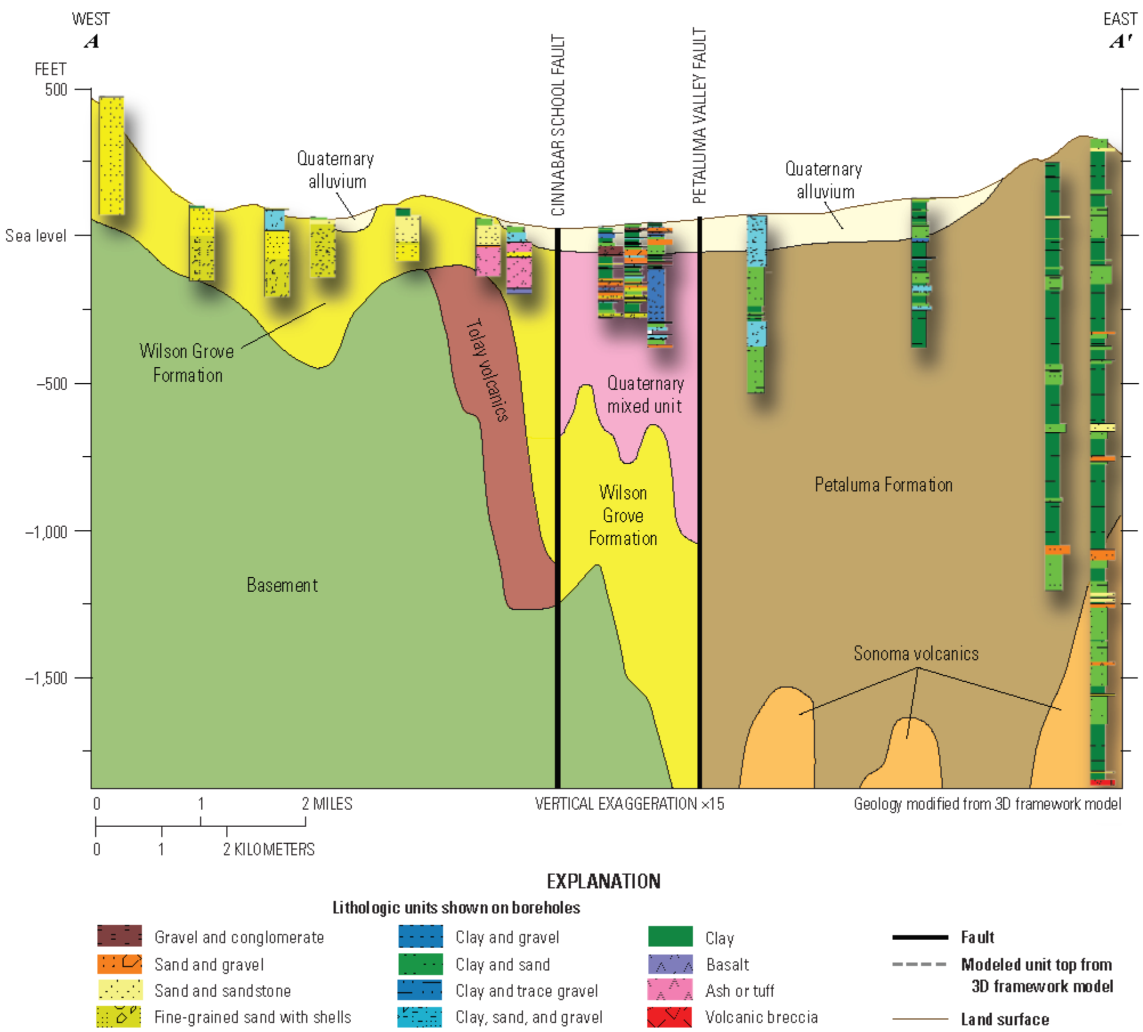

Figure ES-4. Cross-section of the Basin (U.S. Geological Survey)

The aquifer system is recharged primarily through streambed recharge along portions of Petaluma River and its tributaries, as well as through direct infiltration of precipitation and along the margins of the valley areas (mountain-front recharge). Groundwater is discharged to the Petaluma River, streams, springs, seeps, interconnected wetlands, through evapotranspiration, and by groundwater pumping.

Data gaps in the HCM include the geometry and properties of aquifer and aquitards, the origin and extent of brackish water, and how faults in the Basin affect groundwater flow. Additionally, more data are needed to better understand groundwater recharge and discharge mechanisms in the Basin, including surface water-groundwater interaction and the amount and locations of groundwater extractions.

ES.3.2 Current and Historical Groundwater Conditions

SGMA requires GSAs to evaluate groundwater conditions using six indicators of groundwater sustainability: groundwater levels, groundwater storage, groundwater quality, land subsidence, seawater intrusion, and interconnected surface water (SW) and groundwater. In **Section 3**, previous studies, monitoring well data, and data from other monitoring networks are used to describe current and historical groundwater conditions for these six sustainability indicators.

Groundwater Levels: Groundwater levels for the majority of observed wells are generally stable and predominantly above sea level (except in the southern portion of the Basin near the Baylands and the tidally influenced reach of the Petaluma River). However, some wells near the upper reaches of Lynch Creek, near the northeastern edge of the Basin, and along the northern boundary of the Basin exhibit decreasing groundwater levels.

Groundwater Storage: The groundwater budget finds that the amount of groundwater stored in the aquifers is declining on average by about 40 acre-feet per year (AFY), but is shown as zero in **Table ES-1**, due to rounding.

Table ES-1. Summary Historical (WY 1969-2018), Current (WY 2012-2018), and Projected (WY 2021-2070) Average Annual Change in Groundwater Storage (acre-feet/year) [a]

Water Budget Periods	
Average, Historical Period (1969-2018)	0
Average, Current Period (2012-2018)	-100
Average, Future (2021-2070)	100

Note:
[a] Values rounded to nearest 100.

Land Surface Subsidence: Existing data from both Interferometric Synthetic Aperture Radar (InSAR) and global positioning system (GPS) stations do not indicate that inelastic (irrecoverable) land subsidence is occurring as a result of groundwater pumping.

Groundwater Quality: Groundwater quality sampling performed throughout the Basin for numerous different studies and regulatory programs finds that groundwater quality is generally adequate to support existing beneficial uses. Groundwater quality is poor in some local areas, related to the brackish waters of San Pablo Bay and tidal marshland areas and deep connate waters related to ancient seawater. There are some limited human-caused inputs from land use activities, such as agriculture, septic systems, and urban uses.

Seawater Intrusion: The seawater/freshwater interface likely occurs beneath the tidal marshlands near the boundary with San Pablo Bay. While salinity has been found in groundwater in the Basin, the limited data make it difficult to discern whether potential groundwater quality changes are due to either the distribution of monitored wells over different timeframes and/or the presence of older connate water.

Interconnected Surface Water and Groundwater: Information on ISW is limited within the Basin and is complicated by the presence of tidal-influenced reaches of streams. The groundwater flow model developed by the USGS (described briefly in **Sections ES.3.3** and **3.3**) indicates that much of the Petaluma River, along with much of Tolay Creek and the lower reaches of Lichau, Lynch, Washington, Adobe, Ellis, and Capri creeks are likely ISWs. Groundwater dependent ecosystems (GDEs) in the Basin support steelhead, red-legged frogs, riparian woodlands, oak woodlands, and freshwater marshes. More data are needed from monitoring wells near creeks and from stream gages to determine the specific impacts of groundwater pumping on surface water and on these GDEs.

ES.3.3 Groundwater Flow Model

A computerized numerical groundwater flow model, the Petaluma Valley Integrated Groundwater Flow Model (PVIHM), developed by USGS in conjunction with Sonoma Water, and used as a groundwater management tool, calculates groundwater flows into and out of the Basin (**Figure ES-5**). The model accounts for precipitation, surface water, and groundwater entering the Basin through runoff, streams, septic systems, and other sources; and surface water and groundwater leaving the Basin through evapotranspiration, streams, pumping, diversions, and other means.

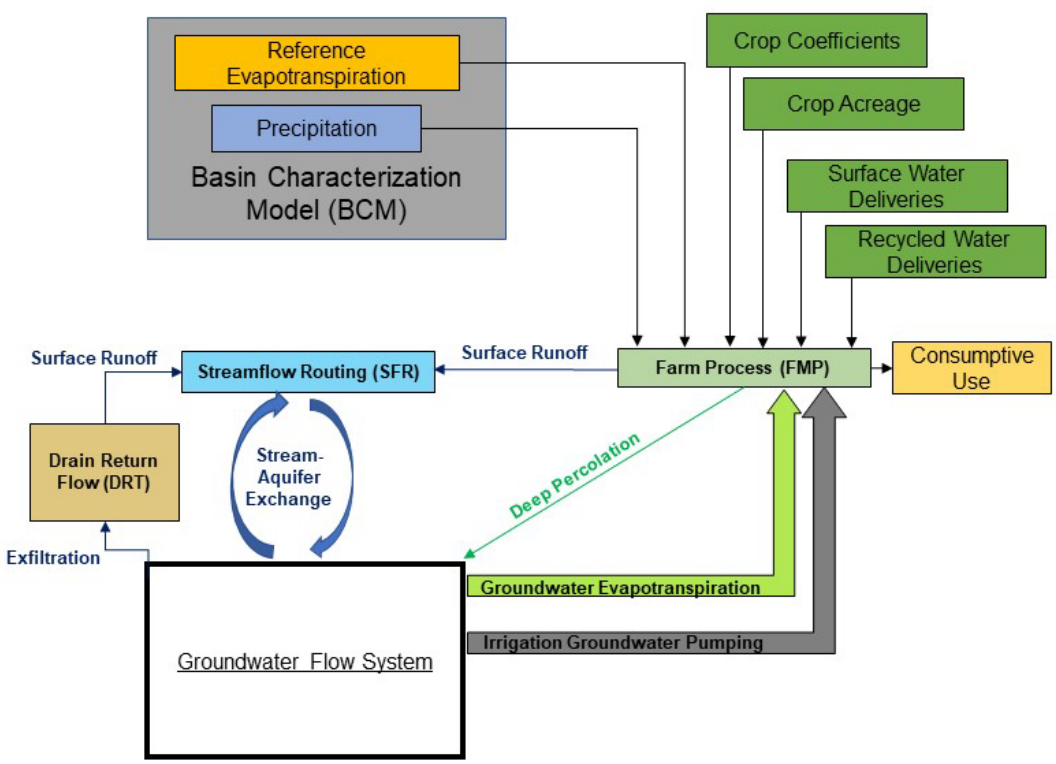

Figure ES-5. Representation of Water Budget Components in Petaluma Valley Integrated Groundwater Flow Model

ES.3.4 Projected Future Basin Conditions, Land Use, and Climate Change

Sustainability in the Basin must be achieved and maintained even as conditions—including land use and the climate—change.

Assumptions for future projected land use changes and water demands were estimated for rural-residential groundwater pumping, agricultural land use footprint, and municipal demands. Two practitioner workgroups, and surveys and input from the Advisory Committee, helped develop the data used in the projected model.

The Petaluma Valley GSA chose a climate change scenario that provides for several very dry years through 2025; normal and wetter years through 2050; and then a long-term drought after the mid-twenty-first century. This climate scenario allows for a significant stress test for groundwater resources planning during the GSP implementation horizon. The PVIHM was modified to simulate the 1-in-200 chance sea level rise trajectory, which results in a projected sea level rise of 3.5 feet at the end of the projected 50-year water budget. As part of its adaptive approach to groundwater management, the GSA anticipates revising and updating climate projections as part of the 5-year update.

ES.3.5 Water Budget

The water budget was developed using the surface water and groundwater computer model. The water budget provides an accounting and assessment of the total annual volume of surface water and groundwater entering and leaving the Basin and the change of the volume of groundwater in storage under historical, current, and projected water budget conditions.

For the current water budget (2012-2018), groundwater outflows are larger than inflows, resulting in a loss of groundwater in storage by about 100 AFY during the current period (2012-2018) (**Figure ES-6**).

During the future period (2021-2070), groundwater inflows are projected to be greater than groundwater outflows through 2045, due to a projected wetter climate. Consequently, groundwater storage is projected to increase at a rate of 500 AFY through 2040. After 2045, projected groundwater outflows exceed projected inflows, due to the projected severe longer drought, resulting in groundwater losses from storage at a rate of 100 AFY from 2041 through 2070. Overall, groundwater in storage is projected to increase by 100 AFY on average over the future period.

Table ES-1 summarizes the historical, current, and projected annual changes in groundwater storage for the Basin.

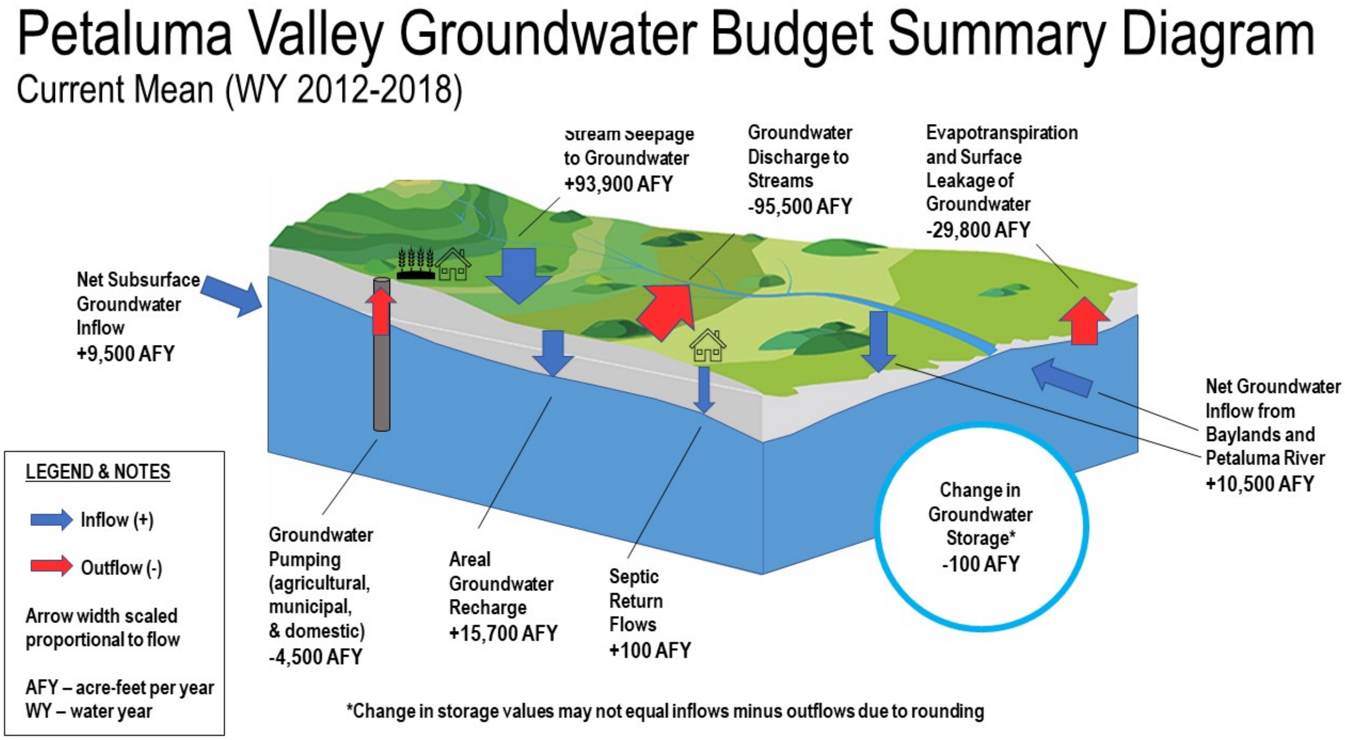

Figure ES-6. Water Budget for Current Period (2012-2018)

ES.3.6 Sustainable Yield

The sustainable yield of the Basin is an estimate of the quantity of groundwater that can be pumped on a long-term average annual basis without causing undesirable results. Basin-wide pumping within the sustainable yield estimate is neither a measure of, nor proof of, sustainability, but estimates of sustainable yield using the historical simulations may prove useful in estimating the need for projects and management actions to help achieve sustainability.

The sustainable yield of the Basin is 8,000 AFY of total groundwater pumping. Both the estimated current average groundwater pumping of 4,500 AFY and the projected future groundwater pumping of 2,300 AFY are below the sustainable yield. There is a significant amount of uncertainty in the estimate of the sustainable yield and as new information is developed, the sustainable yield will be refined and updated.

ES.4 Sustainable Management Criteria

SGMA provides specific language and criteria for establishing and maintaining sustainability, including the development of a sustainability goal, which Petaluma Valley GSA defines as follows:

The goal of this GSP is to adaptively and sustainably manage, protect, and enhance groundwater resources while allowing for reasonable and managed growth through:

- Careful monitoring of groundwater conditions
- Close coordination and collaboration with other entities and regulatory agencies that have a stake or role in groundwater management in the Basin
- A diverse portfolio of projects and management actions that ensure clean and plentiful groundwater for future uses and users in an environmentally sound and equitable manner

Central to SGMA is the development of sustainable management criteria (SMC) for six sustainability indicators depicted on **Figure ES-7.** The Petaluma Valley GSA identified undesirable results, minimum thresholds (MTs), measurable objectives (MOs), and interim milestones for the sustainability indicators as discussed in GSP **Sections 4.4** through **4.10**. The six sustainability indicators required by SGMA are listed in **Table ES-2** with a summary of what the GSA considers significant and undesirable conditions for each indicator. **Table ES-2** also provides the quantitative SMC for all sustainability indicators, which will be monitored by the GSA to ensure these significant and unreasonable conditions are avoided.

Figure ES-7. Sustainability Indicators

Components of Sustainable Management Criteria

Sustainability Goal: A succinct statement of the GSA's objectives and desired conditions and how the basin will achieve these conditions.

Significant and Unreasonable Condition: A qualitative statement regarding conditions that should be avoided. **Undesirable Results:** A quantitative description of the combination of MT exceedances that cause significant and unreasonable effects in the Basin.

Minimum Thresholds: The quantitative values that reflect what is significant and unreasonable at every measuring site. **Measurable Objectives:** Specific, quantifiable goals at each representative monitoring site to maintain or improve groundwater conditions in order to maintain or achieve the sustainability goal for the basin.

Representative Monitoring Sites: These are typical monitoring sites within the broader network of sites that reliably provide high-quality data that characterize groundwater conditions in the basin.

Table ES-2. Petaluma Valley Basin Sustainable Management Criteria

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result
Chronic lowering of groundwater levels	Chronic lowering of groundwater levels that significantly exceed historical levels or cause significant and unreasonable impacts on beneficial users.	Maintain above historical low elevations while accounting for droughts/climate variability and protect at least 95 percent of nearby water supply wells. Metric: Shallower (more protective) of historical low elevations minus 4-year drought OR above the 95th percentile of nearby water supply well depths.	Monthly or monthly-averaged groundwater levels measured at representative monitoring point wells.	**Stable Wells:** Maintain within historical observed ranges. Metric*:* Historical median spring groundwater elevation. **Wells with Declining Trends**: Recover groundwater levels to historical groundwater elevations prior to declining trend. Metric: Historical (generally pre-2010) median groundwater elevation.	25 percent of RMPs exceed MT for 3 consecutive years.
Reduction in groundwater storage	Reduction of groundwater storage that causes significant and unreasonable impacts to the long-term sustainable beneficial use of groundwater in the Basin, as caused by: • Long-term reductions in groundwater storage • Pumping exceeding the sustainable yield	Measured using groundwater elevations as a proxy. MT for groundwater storage is identical to the MT for the chronic lowering of groundwater levels.	Annual groundwater storage will be calculated and reported by comparing changes in contoured groundwater elevations. However, monitoring for the chronic lowering of groundwater levels will be used to compare with MT and MOs.	MO for groundwater storage is identical to the MO for the chronic lowering of groundwater levels.	Undesirable result for groundwater storage is identical to the undesirable result for the chronic lowering of groundwater levels.
Seawater Intrusion	Seawater intrusion inland of areas of existing brackish groundwater that may affect beneficial uses of groundwater is a significant and unreasonable condition.	The 250 mg/L chloride isocontour located in an area that is protective of beneficial users of groundwater. This MT isocontour is initially located between the currently inferred 250 mg/L isocontour (inferred interface of brackish groundwater) and beneficial users of groundwater (known water wells supplying beneficial users). This MT will need to be reassessed during early stages of GSP implementation once additional monitoring data and information are available, because the initial location is selected from very limited available data.	The chloride isocontour will be developed based on chloride concentrations measured in groundwater samples collected from an RMP network, which will be developed during the early stages of GSP implementation.	The 250 mg/L chloride isocontour at the currently approximate interface of brackish groundwater (that is, current conditions).	When two conditions are met: (1) Three consecutive years of MT exceedances and (2) The MT exceedance is caused by groundwater pumping.
Degraded water quality	Significant and unreasonable water quality conditions occur if an increase in the concentration of COCs in groundwater leads to adverse impacts on beneficial users or uses of groundwater, due to: • Direct actions by Petaluma Valley GSP projects or management activities • Undesirable results occurring for other sustainability indicators	The MT is based on two additional supply wells exceeding the applicable maximum contaminant levels for (1) arsenic, (2) nitrate, or (3) salts (measured as TDS).	The number of public water supply wells with annual average concentrations of arsenic, nitrate, or TDS that exceed maximum contaminant levels in groundwater quality data available through state data sources.	The MO is based on no additional supply wells exceeding the applicable maximum contaminant level for (1) arsenic, (2) nitrate, or (3) salts (measured as TDS).	An undesirable result occurs if, during 2 consecutive years, a single groundwater quality MT is exceeded when computing annual averages at the same well, as a direct result of projects or management actions taken as part of GSP implementation.

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result
Subsidence	Any rate of inelastic subsidence caused by groundwater pumping is a significant and unreasonable condition everywhere in the Basin and regardless of the beneficial uses and users.	0.1 feet per year of total subsidence.	DWR-provided InSAR dataset average annual subsidence for each 100-meter-by-100-meter grid cell.	The MO is identical to the MT (0.1 feet per year of subsidence).	Annual MT of 0.1 feet total subsidence is exceeded over a minimum 50-acre area or cumulative total subsidence of 0.2 foot is exceeded within a 5-year period and MT exceedance is determined to be correlated with: (1) groundwater pumping, (2) an MT exceedance of the chronic lowering of groundwater-level SMC (that is, groundwater levels have fallen below historical lows).
Depletion of Interconnected Surface Water	Significant and unreasonable depletion of surface water from interconnected streams occurs when surface water depletion, caused by groundwater pumping within the Basin, exceeds historical depletion or adversely impacts the viability of GDEs or other beneficial users of surface water.	Maintain estimated streamflow depletions below historical maximum amounts. Metric: Shallow groundwater elevations are used as a proxy for stream depletion. The MT is set at 1 foot below the 2020 dry-season average minimum groundwater levels.	Monthly-averaged groundwater levels measured in representative monitoring points (shallow monitoring wells near ISW).	The MO is to maintain groundwater levels within historical observed ranges. Metric: The halfway point between the MT value and the average observed dry-season surface water stage from November 2019 to December 2020.	Undesirable result occurs if MT is exceeded at two wells during dry years <u>or</u> at one well during normal and wet years.

Notes:

COC = constitute of concern

ISW = interconnected surface water

mg/L = milligram(s) per liter

RMP = representative monitoring point

TDS = total dissolved solids

ES.5 Monitoring Networks

SGMA requires monitoring networks to quantitatively measure Basin health and the GSA's progress in meeting or maintaining sustainability. **Section 5** describes the monitoring networks that are planned in the Basin and in the contributing watershed area. The section also discusses how the existing monitoring networks described in **Section 2** were evaluated and refined.

The purpose of the monitoring networks is to demonstrate progress toward achieving MOs, monitor impacts on groundwater users and uses, monitor changing groundwater conditions, and quantify changes in the water budget.

Consideration of Public Trust Resources

While SGMA does not require the Plan to address California's public trust doctrine, a 2018 California Court of Appeal ruling found that groundwater pumping that reduces the flow or volume of water in a navigable stream (and tributaries that supply navigable streams) may violate the public trust in certain fact specific circumstances (Environmental Law Foundation et al. v. State Water Resources Control Board [2018] 26 Cal.App.5th 844). This Plan recognizes the importance of considering and protecting public trust resources to the extent feasible, including fish and wildlife and recreation, in the Subbasin streams that are interconnected with groundwater. Working groups, which included state and federal resource agencies and environmental non-profits and non-governmental organizations, were created and helped to develop the SMC for ISW and to identify plants and animals that could be affected by surface water depletion due to groundwater pumping. The GSA developed a Plan that considers public trust resources.

RMP networks are a subset of the larger set of monitoring networks and area. The RMPs described in detail in **Section 5** and summarized in **Table ES-3** are wells where sustainability indicators are monitored. **Figure ES-8** shows the RMP network for the chronic lowering of groundwater levels.

Table ES-3. Monitoring Networks and Initial Representative Monitoring Point Networks

Sustainability Indicator	Monitoring Network	Initial Representative Monitoring Point Network
Chronic Lowering of Groundwater levels	20 wells within the contributing watershed area (including 15 wells in the Basin)	11 wells (3 dedicated monitoring wells; 5 private supply wells; 3 inactive municipal wells)
Reduction in Groundwater Storage	20 wells within the contributing watershed area (including 15 wells in the Basin)	11 wells (3 dedicated monitoring wells; 5 private supply wells; 3 inactive municipal wells)
Seawater Intrusion	Within 1 to 2 miles of Baylands: 9 public water supply wells	Within 1 to 2 miles of Baylands: 9 public water supply wells
Degraded Water Quality	Existing supply well groundwater quality monitoring programs, as follows: Arsenic: 18 wells Nitrate: 30 wells Salts: 13 wells	Existing supply well groundwater quality monitoring programs, as follows: Arsenic: 18 wells Nitrate: 30 wells Salts: 13 wells
Land Surface Subsidence	1 GPS location; InSAR satellite in most of the Basin	InSAR dataset
Interconnected Surface Water	16 stream gages; 3 shallow monitoring wells adjacent to streams	3 shallow monitoring wells adjacent to streams

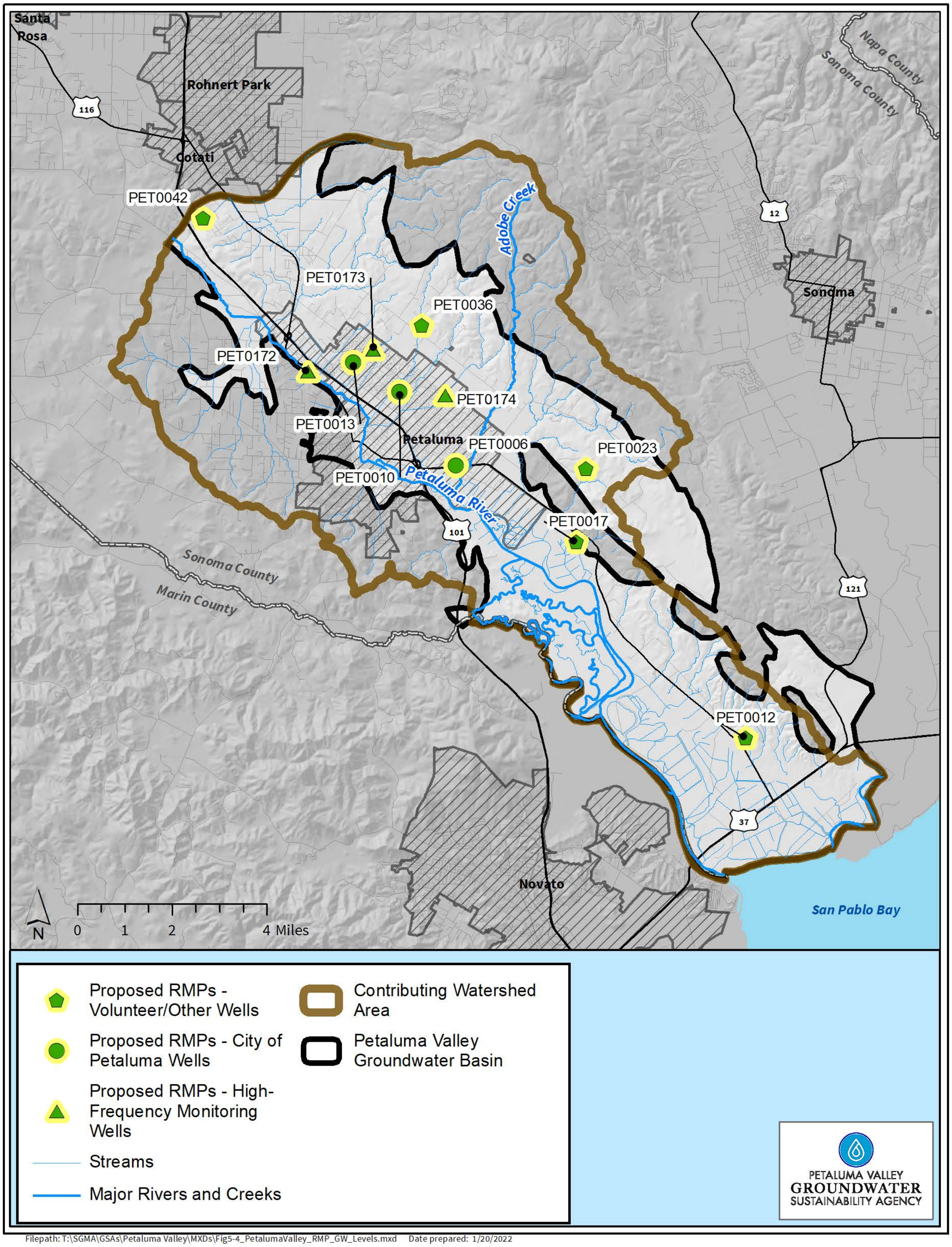

Figure ES-8. Representative Monitoring Point for Groundwater Levels

Section 5 also identifies the data gaps that exist in the monitoring networks, and describes how these gaps will be filled during GSP implementation. The early years of GSP implementation will specifically focus on filling additional data needs to better monitor ISW, seawater intrusion, and specific groundwater levels.

ES.6 Projects and Management Actions

GSPs are intended to help communities achieve groundwater sustainability as defined by the SMC and based on current and projected future groundwater conditions. **Section 6** of the GSP identifies conceptual projects and management actions to help avoid undesirable results as described in **Section 4**. As described in **Section 6**, only the voluntary water-use efficiency and alternate water source projects (Group 1 projects) are defined enough for evaluation using model scenarios and are deemed necessary in the near term. To address uncertainty and prepare for future droughts and other unknown conditions, a portfolio of other projects and management actions (consisting of expanded recycled water deliveries, aquifer storage and recovery [ASR], stormwater capture and recharge, and policy options to reduce groundwater demand) that have been discussed and considered by the Advisory Committee and GSA Board are included in the GSP. Initial implementation steps for these include performing studies or analyses to refine the concepts into actionable projects.

Projects and management actions considered are:

1. Voluntary reductions in groundwater use through water conservation tools (such as appliance rebates and replacement, smart irrigation controllers, and water-use audits), onsite rainwater capture, and greywater use.
    - The programs and education offered to domestic, commercial, and industrial groundwater users will mirror programs offered to regional municipal water users, which have led to a 37 percent reduction in per capita water use since 2010.
    - The programs and education offered to agricultural users would be focused on leveraging existing best management practices and working with farmers who have not had access to or the resources available to reduce water use.
    - For the purposes of simulating these projects using the model, it was assumed that these tools would result in a 20 percent reduction in rural domestic groundwater use and a 10 percent reduction in agricultural groundwater use.
2. Recycled water system expansion: The GSA will coordinate with the City of Petaluma to assess additional recycled water opportunities.
3. Assessment of stormwater capture and recharge and ASR: The GSA will coordinate and support studies with other entities to assess the feasibility of enhanced recharge projects including stormwater capture (such as floodplain inundation) and recharge and ASR. Stormwater capture and recharge includes multi-benefit projects that can help reduce flooding and contribute to increasing summer and fall streamflows. Conceptually, ASR

entails using dedicated groundwater wells in reverse during the rainy season to store treated Russian River water when it is plentiful. A feasibility study found that even during drought years, there are periods when river flows are high enough to store water in aquifers for use during the summer, in droughts, or during emergencies.

4. Study of and prioritization of potential policy options: This management action involves a collaboration between the GSA Board, local land use agencies, GSA member agencies, other Sonoma County GSAs, and stakeholders to assess and prioritize future policy options that may be appropriate for the GSA Board to consider adopting or recommending for adoption by other agencies. Policy options for potential inclusion in the assessment include:
   - Water conservation plan requirements for new development
   - Discretionary review of well permits for any special areas identified in GSP
   - Expand low impact development or water efficient landscape plan requirements
   - Modifications to the County well ordinance to improve monitoring of groundwater conditions
   - Well construction and permitting recommendations (for example, water quality sampling/reporting for contaminants of concern, requirement for water-level measurement access, and procedures for preventing cross-screening of multiple aquifers)
   - Well metering program for non-residential wells
   - Domestic well mitigation program
   - Study of water markets
   - Permitting and accounting of water hauling
5. Coordination of farm plans with GSP implementation: This management action involves a collaboration between the three Sonoma County GSAs and interested members of the agricultural community to evaluate the feasibility of developing a program that coordinates farm plans, developed at individual farm sites, with the implementation of the Basin-wide GSP.

Model simulations of the voluntary reductions in groundwater use result in improvements in groundwater conditions, with some increases to groundwater levels, groundwater storage, and groundwater contributions to surface water.

ES.7 Plan Implementation

Section 7 describes how the GSA will implement the projects and management actions while monitoring groundwater conditions, reporting each year to DWR, closing data gaps, engaging with stakeholders, and managing the organization. The GSA will continue to conduct business in meetings open to the public, maintain an Advisory Committee of representative basin stakeholders to provide recommendations on implementation activities and actions, and hold periodic community meetings to inform and receive input from the community. **Section 7** describes the following implementation components:

- GSA Administration
- Communication and Engagement
- Routine Monitoring, Data Evaluation and Annual Reporting
- Address Data Gaps
- Maintenance, Updates, and Improvements to Model
- Refine, Study, and Implementation of Potential Projects and Actions
- Five-Year Update to GSP

A major focus of the initial 5 years of implementation will be to gather information and data in many key areas to improve the understanding of potential impacts associated with groundwater conditions to sensitive beneficial users, primarily shallower domestic well users (including DACs) and GDEs. This information and data will inform consideration of future refinements to SMC and appropriate response actions protective of these sensitive beneficial users.

ES.7.1 Estimated Implementation Costs

Section 7 provides a high-level budget for the estimated cost over the initial 5 years of GSP implementation. Costs are based on the best estimates available and reflect Petaluma Valley GSA's understanding of the effort necessary for effective management and to comply with the SGMA requirement for monitoring and reporting. In Petaluma Valley, projects and actions are not projected to be needed in the near term to avoid undesirable results and a significant portion of the estimated costs are associated with the need to fill data gaps and improve monitoring networks.

Costs are divided into the following categories: administration and operations (including legal and grants); communication and stakeholder engagement; routine monitoring, data evaluation, and reporting; addressing data gaps; model maintenance, updates, and improvements; conceptual projects and planning design; and 5-year GSP update (**Figure ES-9**).

The mid-range budget projections for the first 5 years total about $5.6 million, averaging $1.1 million annually.

ES.7.2 Funding Sources and Mechanisms

Currently, the five GSA member agencies annually contribute funding for operations, outreach, and GSP development. The Petaluma Valley GSA has successfully applied for and received more than $2 million in funding for GSP development and to help address data gaps. Grant funding through Proposition 68 and future state bond measures will continue to be a critical source of revenue, particularly for closing data gaps and for project planning and implementation. In addition, Petaluma Valley GSA has initiated a funding study to identify local financing options moving forward, including possible groundwater user fees.

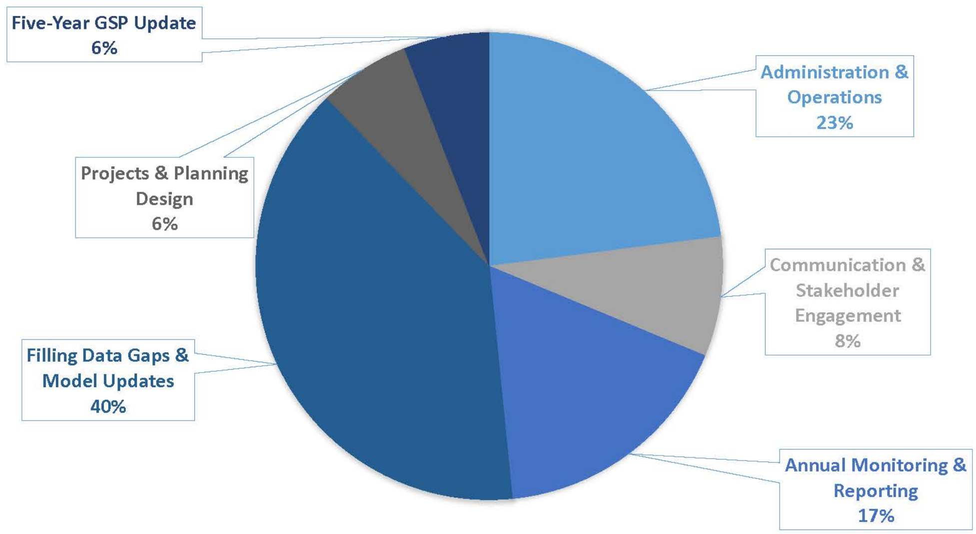

Figure ES-9. Percentage Cost Allocations for Major Spending Categories for First 5 Years of GSP Implementation

ES.7.3 Implementation Schedule

While DWR has 2 years to review the GSP before it is final, the GSA will begin implementing the Plan in 2022 (**Figure ES-10**). Administration, finance, monitoring, and reporting are ongoing tasks that begin immediately and continue throughout implementation. It is anticipated that filling data gaps and pursuing policy options will begin in 2023, and the voluntary conservation projects will be implemented by Petaluma Valley GSA and project partners by 2025.

ES.8 References and Technical Studies

The final section of the GSP includes a complete list of references and technical studies that supported the development of this GSP.

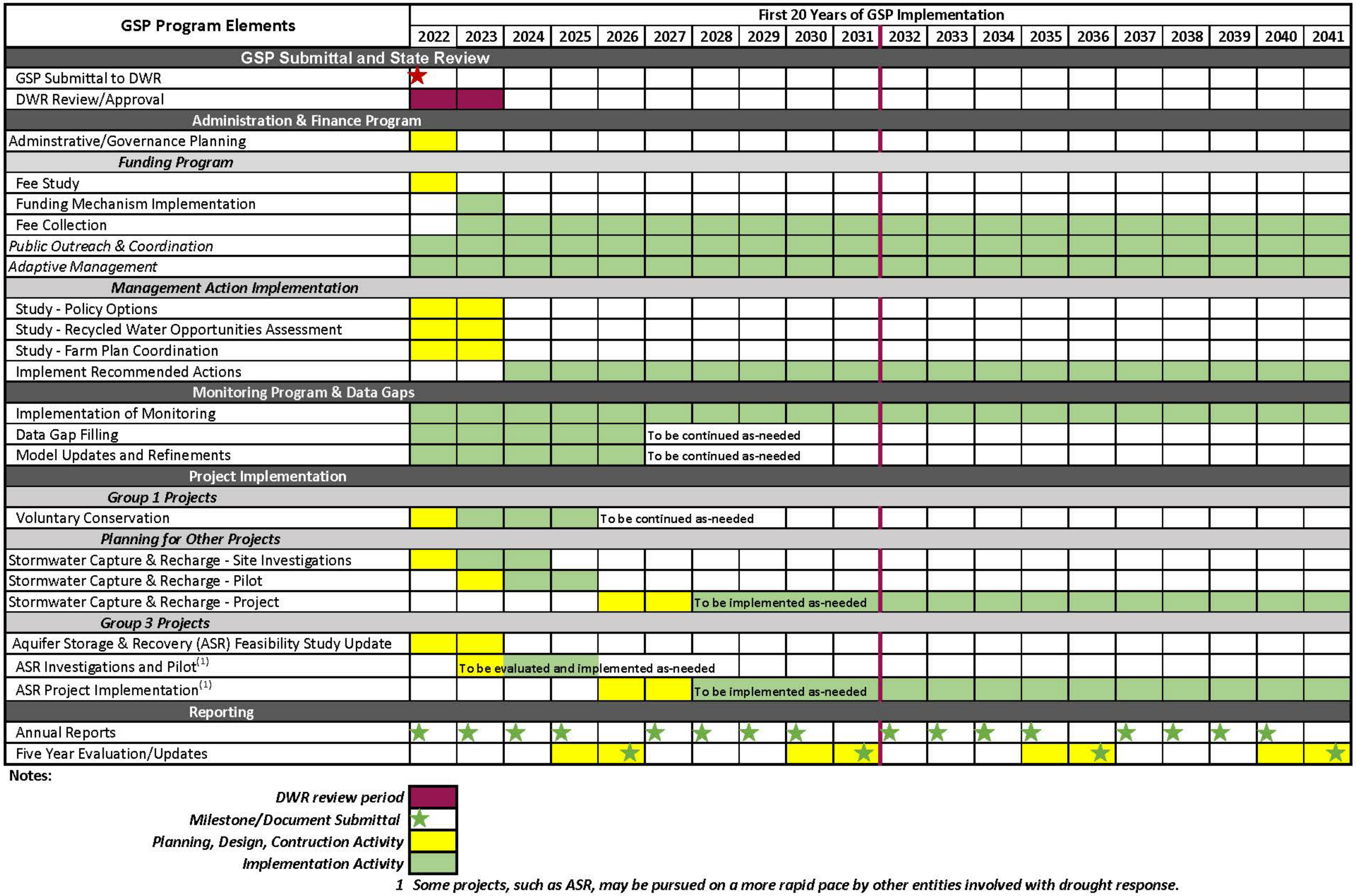

Figure ES-10. GSP Implementation Schedule

Groundwater Sustainability Plan for Petaluma Valley Groundwater Basin

Table of Contents

Appendices

GLOSSARY

* indicates definition from SGMA definitions.

Abandoned well — A well that has not been used for 1 year, unless the owner demonstrates intention to use the well again in accordance with the provisions of Section 115700 of the California Health and Safety Code.

Acre-foot (af) — Equivalent to the volume of water which will cover 1 acre of land to a depth of 1 foot; an acre-foot of water equals 43,560 cubic feet or 325,851 gallons.

Advanced wastewater treatment — Any physical, chemical or biological treatment process used to accomplish a degree of treatment greater than that achieved by secondary treatment.

Advanced water purification — Results in high-quality drinking water using advanced treatment processes available, including, but not limited to microfiltration, reverse osmosis, and high intensity ultraviolet light/advanced oxidation.

Agency* — Refers to a groundwater sustainability agency as defined in the Sustainable Groundwater Management Act.

Agricultural water management plan* — Refers to a plan adopted pursuant to the Agricultural Water Management Planning Act as described in Part 2.8 of Division 6 of the Water Code, commencing with Section 10800 et seq.

Alternative Plan* — Refers to an alternative to a Plan described in Water Code Section 10733.6.

Alluvium — A general geologic term describing stratified unconsolidated beds of sand, gravel, silt and clay deposited by flowing water.

Annual report — The report that transmits monitoring and progress towards meeting sustainable management criteria on the Plan, required on annual basis by Water Code Section 10728.

Appropriator — A party that diverts or extracts surplus water for use on nonriparian or nonoverlying land or for nonriparian or nonoverlying uses. Most public entities holding water rights are appropriators.

Aquiclude — A relatively impermeable rock formation that typically overlies or underlies an aquifer, confining its water under pressure. It usually has the capacity to absorb water, but is not sufficiently porous to conduct water quickly enough to supply a spring or a well. Generally replaced by the term aquitard.

Aquifer — A body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs.

Aquifer storage and recovery (ASR) — Injection of water into a well for storage in the aquifer and subsequent recovery from the same well.

Aquifer storage transfer and recovery (ASTR) - Injection of water into a well for storage In the aquifer and recovery from a different well, generally to provide additional water treatment.

Aquifer test — Commonly misnamed a pump test, it consists of pumping one well and recording both the drawdown in that well and may include measuring the drawdown caused by this pumping in other nearby observation wells. The data can be analyzed to show the hydraulic characteristics of the aquifer.

Aquitard — A confining bed or rock formation that retards the movement of water either to or from adjacent beds. Aquitards do not prevent the flow of water but may serve to store groundwater, although they are not effective as sources for wells or springs.

Area of origin* — In an interbasin transfer, the region exporting water.

GLOSSARY

* indicates definition from SGMA definitions.

Arid — A climate or region in which precipitation is so deficient in quantity or occurs so infrequently that intensive agricultural production is not possible without irrigation. Less than 25 cm of annual rainfall or a higher evaporation rate than precipitation rate.

Artesian — A reference to groundwater that is confined under pressure resulting in a condition in which the static water level stands above the top of the aquifer. The groundwater will rise above the overlying confining beds if provided the opportunity to escape upward via a well.

Artesian aquifer — A rock formation containing groundwater under more than hydrostatic pressure.

Artesian well — A well tapping a confined aquifer in which the static water level stands above the top of the aquifer. A flowing artesian well is one in which the tapped water flows out at the land surface. The term artesian well can be applied to a well in which pumping is required for the confined water to reach the surface.

ASR well — Dual purpose well to inject, store and recover source water in an aquifer for subsequent beneficial use.

Bank filtration — Extraction of groundwater from a well or caisson near or under a river or lake that induces infiltration from the surface water body, thereby improving and making more consistent the quality of water recovered.

Baseline* — Historic information used to project future conditions for hydrology, water demand, and availability of surface water and to evaluate potential sustainable management practices of a basin. Also baseline conditions.

Basin* — Groundwater basin or subbasin identified and defined in Bulletin 118 or as modified pursuant to Water Code 10722 et seq.

Basin setting* — The information about the physical setting, characteristics, and current conditions of the basin as described by the Agency in the hydrogeologic conceptual model, the groundwater conditions, and the water budget, pursuant to Subarticle 2 of Article 5.

Beneficial use — The use of water for some domestic, agricultural, industrial, social, recreational or instream use. The SWRCB lists 23 types of beneficial uses with water quality criteria for those uses established by the RWQCBs. Water rights holders must demonstrate that the use if both reasonable and beneficial.

Best available science* — The use of sufficient and credible information and data, specific to the decision being made and the time frame available for making that decision, that is consistent with scientific and engineering professional standards of practice.

Best management practice* — A practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science.

Board* — The State Water Resources Control Board.

Brackish water — Water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic and irrigation uses. Considerably less saline than sea water.

California Department of Fish and Game (DFG) — DFG administers and enforces the California Fish and Game Code, and the regulations promulgated by the Fish and Game Commission.

California Department of Toxic Substances Control (DTSC) — The primary regulatory authority under both state and federal law for hazardous waste disposal within California.

GLOSSARY

* indicates definition from SGMA definitions.

California Department of Water Resources (DWR) — oversees the State Water Project (SWP) and has the ability to implement, promote and encourage statewide water conservation. The DWR also has the responsibility for investigating groundwater conditions, SGMA implementation, and recommending protective actions and the safety of non-federal dams. Updates the State Water Plan every 5 years.

Capillary fringe — The zone immediately above and continuous with the water table in which all or some of the soil or rock interstices are filled with water under less than atmospheric pressure.

CASGEM* — The California Statewide Groundwater Elevation Monitoring Program developed by the Department pursuant to Water Code Section 10920 et seq., or as amended.

Chloride — A compound of chlorine and a positive radical of one or more elements. Useful in recognition of seawater in groundwater, chloride is the dominant anion of ocean water and normally occurs in only small amounts in groundwater.

Closed basin — A basin whose topography prevents surface outflow of water. It is considered to be hydrologically closed if neither surface nor underground outflow of water can occur under average hydrologic conditions.

Community water system — A public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25-year-long residents.

Cone of depression — The conical-shaped area around a well, produced in a water table or potentiometric surface by pumping.

Confined aquifer — A water-bearing subsurface stratum that is bounded above and below by formations of impermeable, or relatively impermeable, soil or rock.

Confined groundwater — Groundwater that is under pressure greater than that of the atmosphere so that, if provided an upward escape route, it will rise above the interface between the top of the aquifer and the impermeable bed which confines it.

Confining bed — A body of impermeable or distinctly less permeable material stratigraphically above one or more aquifers.

Conjunctive use — Also conjunctive operation, the operation of a groundwater basin in combination with a surface water storage and conveyance system to maximize water supply. Water is stored in the groundwater basin for later use by intentionally recharging a basin when a water supply is available.

Connate water — Water entrapped in the interstices of sedimentary rock at the time it was deposited. It may have been derived from ocean or fresh water sources and, typically, is highly mineralized.

Consumptive use — Use of water in a manner that makes it unavailable for use by others, generally because of absorption, evaporation, transpiration or incorporation in a manufactured product.

Contamination — The impairment of water quality as a result of the introduction of pathogens, chemical or industrial wastes, sewage or other pollutants in such concentrations that the water may eventually become unfit for its intended use or constitutes a public health hazard.

Contour line — An imaginary line that connects points of equal value (for example, land surface elevations) above or below a reference value or datum (for example, sea level). Contour lines may also demonstrate variations in other quantifiable properties such as sediment characteristics, porosity or the texture of deposits.

GLOSSARY

* indicates definition from SGMA definitions.

Cumulative departure plot — A graph of the departure from mean for a set of values, typically hydrologic data such as annual rainfall or annual streamflow. The difference between the annual value and the mean value for the full period of the data set is calculated for each data point, and each difference is added cumulatively from the beginning of the period to the end of the period. When portions of the graph have a positive slope, hydrologic values are greater than average (such as in a wet cycle); a negative slope occurs when hydrologic values are less than average (such as in a drought cycle).

Cycle testing — The systematic process in determining the operational recharge and backwashing routine for an ASR well.

Data gap* — A lack of information that significantly affects the understanding of the basin setting or evaluation of the efficacy of Plan implementation, and could limit the ability to assess whether a basin is being sustainably managed.

Deep percolation — Precipitation that moves downward below the root zone towards storage in subsurface strata.

De minimis well — A domestic well that extracts less than 2 acre-feet of groundwater annually. De minimis users cannot be required to report annual pumpage, but can be required to pay a fee if the GSA regulates them.

Depletion — The continued withdrawal of water from a reservoir or groundwater supply faster than its rate of replenishment.

Desalination — A process that converts sea water or brackish water to fresh water or an otherwise more usable condition through removal of dissolved solids. Also called desalting.

Destroyed well — A well that is no longer useful and that has been completely filled in accordance with the procedures described in Section ?B of the California Well Standards, DWR Bulletin 74-81 and Bulletin 74-90 (supplement to Bulletin 74-81).

Developed water — Water either imported into a groundwater basin or salvaged, reclaimed, or process for augmenting local surface water supplies that would not occur under natural conditions.

Domestic well — A water well used to supply water for the domestic needs of an individual residence or systems of four or fewer serviced connections.

Drawdown — The distance by which the potentiometric surface of a groundwater body is lowered by the withdrawal of water through pumping. Drawdown can be described as (1) the lowering of the potentiometric surface or water table as a result of groundwater withdrawal; (2) the difference between the height of a water table before pumping and the height of the water in a well during pumping; (3) diminished pressure in an aquifer as a result of groundwater withdrawal.

Drilling rig — The derrick, mast or standing equipment used to drill a well, together with the motive power, cable and tools used in drilling.

Drought — A prolonged period of dry weather characterized by an absence or a deficiency in rainfall. There is no measure for determining a drought, but qualitatively it usually causes a partial crop failure, a hydrologic imbalance or an interference with the ability to meet established water demands.

Dry well — A well that is constructed in the unsaturated zone of an aquifer and designed to optimize infiltration of water.

GLOSSARY

* indicates definition from SGMA definitions.

Effective porosity — The volume of interconnected openings available for transmission of fluids, frequently expressed as a percentage representing the ratio between volume of available openings and total volume of openings.

Electric well logging — The geophysical process of recording the formations traversed by a drill hole, based upon the measurements of two basic observable parameters: spontaneous potential and the resistivity of the formations to the flow of electric currents. Also geophysical well logging.

Emerging contaminant — A variety of synthetic chemicals, as well as some natural constituents, typically newly discovered in the environment due to improved analytical technological and heightened awareness, and not expected to be present in aquatic systems. For the most part, emerging contaminants are not new chemicals, and not new to the environment, but may suddenly become an issue due to new analytical technology and ability to quantify the constituent, change in regulatory standard, widespread or focused occurrence, heightened public awareness, new toxicological evidence, new chemical or increase in use, or a new legal issue.

Environmental water — Water serving environmental purposes, including instream fishery flow needs, wild and scenic river flows, water needs of freshwater wetlands, and Bay-Delta requirements.

Evaporation — The vaporization of a liquid from a free surface at a temperature below the boiling point; a process that occurs whenever water in a liquid state comes into contact with the unsaturated atmosphere.

Evapotranspiration — That portion of the precipitation returned to the air through direct evaporation or by transpiration of vegetation, no attempt being made to distinguish between the two, or consumptive use by vegetation.

Extraction — The process of withdrawing groundwater from storage by pumping or other controlled means.

Fault — A break or fracture zone in the Earth's crust along which movement of the rock mass adjacent to the fracture has occurred, on at least one side of the break. As a result, the strata of a previously continuous formation are separated relative to one another, with the displacement ranging from inches to thou-sands of feet or hundreds of miles. A fault frequently acts as a barrier to the movement of groundwater.

Field capacity — The amount of water held in a soil by capillary action after gravitational water has percolated downward and drained away; expressed as the ratio of the weight of water retained to the weight of dry soil.

Flowing well — A well yielding water at the land surface without pumping or the aid of any lifting device, but through artesian pressure.

Gravel pack — Artificially placed gravel filter or envelope surrounding a well screen. A gravel pack in a properly developed well serves to stabilize the aquifer, prevents sand from entering the well, permits the use of a large screen slot with a maximum open area, and provides an or annular zone of high permeability, which increases the effective radius and yield of the well.

Groundwater — Subsurface water occurring in the zone of saturation.

Groundwater basin — A groundwater reservoir, defined on the basis of geological and hydrological conditions and possibly consideration of political boundary lines. Often described as a basin or trough-shaped structure that is filled with porous or permeable material that stores and transmits water.

GLOSSARY

* indicates definition from SGMA definitions.

Groundwater budget — A numerical accounting of the recharge, discharge and changes in storage of a geographically defined groundwater system.

Groundwater capture — Increase in the productivity of an aquifer by increasing the recharge rate or by reducing the rate of unused discharge.

Groundwater dependent ecosystem* - Ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.

Groundwater flow* — The volume and direction of groundwater movement into, out of, or throughout a basin.

Groundwater management — The planned and coordinated management of a geographically defined groundwater system with the overall goal of long-term sustainability of the resource.

Groundwater management plan — A comprehensive written document developed for the purpose of groundwater management and adopted by an agency having appropriate legal or statutory authority.

Groundwater storage coefficient — The volume of water released from storage or taken into aquifer storage per unit of surface area of the aquifer per unit of change in the pressure or the head.

Groundwater table — The surface between the zone of saturation and the zone of aeration or the level at which the hydraulic pressure of a body of unconfined groundwater is equal to atmospheric pressure. No water table exists if the upper surface of the zone of saturation is in contact with an overlying confining layer.

Hardness — The content of metallic ions which react with sodium soaps to produce solid soaps or scummy residue and which react with negative ions. Hardness is normally expressed as the total concentration of Ca^{+2} and Mg^{+2} as milligrams per liter equivalent to $CaCO_3$.

Head or static head — Water-level elevation in a well or elevation to which the water of a flowing artesian well will rise in a pipe extended high enough to stop the flow.

Hydraulic conductivity (permeability coefficient) — The degree of permeability of a porous or water-bearing stratum, expressed as the rate of flow of water in gallons/day through a cross section of I square foot at a unit hydraulic gradient at either the prevailing temperature in the field or at a temperature adjusted to 60 degrees Fahrenheit or 15.6 degrees Centigrade. The conductivity can also be expressed in ft/day, cm/s or m/day.

Hydraulic gradient — The slope or gradient of the water table or piezometric or potentiometric surface in the direction of greatest change. A gradient may be expressed as a ratio (vertical to horizontal), a fraction (feet per mile, meters/kilometer), percentage (vertical distance as a percentage of horizontal distance) or as an angle (degrees).

Hydraulic head gradient — In an aquifer or surface watercourse, the change in total head per unit distance of flow in a given direction from a given point, usually in the direction of greatest rate of change.

Hydrogeology — The science that deals with subsurface waters, subsurface water quality and related geologic aspects of surface waters.

Hydrograph — A time record of groundwater level or stream discharge at a given cross section or stream surface elevation, and at a given point. Stream hydrographs generally indicate rate of flow and represent stage, flow, velocity or other characteristics, while groundwater hydrographs represent water level or head.

GLOSSARY

* indicates definition from SGMA definitions.

Hydrologic budget; balance — An accounting of the inflow, outflow, storage and evaporation of water from a hydrologic unit, such as a drainage basin, aquifer, soil zone, lake or reservoir, and expressed by the hydrologic equation as the relationship between inflow and outflow including evaporation, precipitation, runoff and water storage within a hydrologic unit over a specified period of time.

Hydrologic cycle — The process involving the continuous circulation of water from the oceans and the land surface of the Earth to the atmosphere through transpiration and evaporation, and its eventual return to the Earth's surface through various forms of precipitation.

Hydrologic equation — Inflow minus Outflow = +/- Change in Storage. Also called the Law of Mass Conservation, water budget, water balance, hydrologic equation.

Hydrologic region — A study area, consisting of one more planning subareas.

Hydrology — The study of the origin, distribution and circulation of water of the Earth including precipitation, streamflow, infiltration, groundwater storage and evaporation.

Hyporheic zone — Located in the beds and banks of a stream where water and solutes can exchange through the pores spaces and surface water and groundwater mix, linking aquatic and terrestrial systems. The hyporheic zone can be several feet to hundreds of feet deep and wide, depending upon geology and stream channel morphology.

Impermeable — A textural condition of rock, sediment or soil that makes it incapable of transmitting fluid under pressure. The cause is generally low porosity or the presence of small individual pores that lack connectivity.

Imported water — Water transported into a watershed from a different watershed. Native water is water that occurs naturally within a watershed.

Infiltration — (1) The flow of a fluid, such as water, into a solid substance through pores or small interstices, and particularly referring to the movement of water into soil or porous rock; (2) the absorption by soil of water either from precipitation or streamflow; (3) the amount of groundwater that enters pipes through breaks, joints or porous walls.

Infiltration galleries — Buried trenches (often containing slotted pipes or other structural components for water storage space) in permeable soils that allow infiltration through the unsaturated zone to an unconfined aquifer.

Infiltration rate — Rate at which a soil under specified conditions can absorb falling rain or melting snow; in recharge, the rate at which water drains into the ground when a recharge basin is flooded, expressed as quantity of water per unit time.

Injection well — A well through which water is injected to recharge an aquifer, either by pumping or by gravity flow.

In lieu recharge — Groundwater recharge by substituting surface water for groundwater, and accounting for the groundwater saved/stored for future beneficial use.

Interested parties* — Persons and entities on the list of interested persons established by the Agency pursuant to Water Code Section 10723.4.

Interim milestone* — A target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan.

Irrigation — Distribution of water to land through artificial means to enhance crop production, either where natural water sources are so deficient as to make crop production impossible or where it is advantageous to supplement the natural water supply at certain critical stages in the development of crops.

Irrigation return flow — Applied water that is not transpired, evaporated or deep percolated into a groundwater basin, but returns to a surface water.

Joint powers agreement (JPA) — An agreement entered into by two or more public agencies that allows them to jointly utilize any power common to the two contracting parties. The JPA is defined in Chapter 5, Division 7 of Title I of the California Government Code, commencing with Section 6500.

Land retirement — Taking land out of agricultural production by leaving it fallow or letting it return to a natural state.

Land subsidence — The lowering of a natural land surface in response to: Earth movements; lowering of fluid pressure (or lowering of groundwater level); removal of underlying supporting materials by mining or solution of solids, either artificially or from natural causes; compaction caused by wetting (hydrocompaction); oxidation of organic matter in soils; added load on the land surface; by tectonic activity; or by lithification.

Leaching — The flushing of salts from the soil by the downward percolation of surface water.

Leaching requirement — The theoretical amount of irrigation water that must pass (leach) through the soil beyond the root zone to keep soil salinity in the root zone within acceptable levels for sustained productive crop growth.

Level of development — In a planning study, the practice of holding constant the population, irrigated acreage, industry and wildlife so that hydrologic variability can be studied to determine adequacy of supplies.

Lithology — The description of rocks, especially in hand specimen and outcrop, on the basis of such characteristics as mineralogy, grain size and color.

Managed aquifer recharge (MAR) — Addition of surface water to a groundwater reservoir by human activity, such as putting surface water into spreading basins or injecting water through wells. Also artificial recharge (older term).

Management area — An area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors.

Maximum contaminant level (MCL) — The highest concentration of a constituent in drinking water permitted under federal and state Safe Drinking Water Act regulations.

Measurable objectives* — Specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin.

Milligrams per liter (mg/L) — The weight in milligrams of any substance dissolved in one liter of liquid; nearly the same as parts per million.

Mineralization — The process whereby concentrations of minerals, such as salts, increase in water, a natural process resulting from water dissolving minerals found in rocks and soils through which it flows.

Minimum threshold* — A numeric value for each sustainability indicator used to define undesirable results.

GLOSSARY

* indicates definition from SGMA definitions.

Mining — Withdrawal of water from a groundwater resource at a rate that exceeds the rate of replenishment so that the supply is threatened or its economic usefulness is endangered. Refer to overdraft.

MOU — Memorandum of Understanding.

NAD83* — North American Datum of 1983 computed by the National Geodetic Survey, or as modified.

NAVD88* — North American Vertical Datum of 1988 computed by the National Geodetic Survey, or as modified.

National Pollutant Discharge Elimination System (NPDES) — A provision of Section 402 of the federal Clean Water Act of 1972 that established a permitting system for discharges of waste materials to water courses. The program is administered in California by the Regional Water Quality Control Boards.

Nitrate — A salt of nitric acid, a compound containing the radical (NO_3). Dissolved nitrogen in the form of nitrate is the most common contaminant identified in groundwater. Used colloquially to denote all forms of nitrogen.

Nonpoint source — wastewater or contaminant discharge other than from point sources. Also, refer to point source. An example is the regional contamination of groundwater by the overapplication of fertilizers in an agricultural region.

Outflow — The water that is discharged from a drainage basin or from a stream, lake, reservoir or aquifer system.

Overdraft — The intentional or inadvertent withdrawal of water from an aquifer in excess of the amount of water that recharges the basin over a period of years, during which if continued over time could eventually cause the underground supply to be exhausted, cause seawater intrusion, cause subsidence, cause the water table to drop below economically feasible pumping lifts, or cause a detrimental change in water quality. Synonym: groundwater mining.

Overdraft, critical conditions of — A groundwater basin in which the continuation of present practices would probably result in significant adverse overdraft-related environmental, social or economic impacts. There are 21 SGMA priority basins that DWR has defined as critically overdrafted.

Overlying land — Property, a portion of which overlies the water-bearing portion of a groundwater basin. If a portion of the property overlies the water bearing formation, the entire parcel located within the drainage area of the basin is overlying.

Parts per million (ppm) — A measure, by weight and not by volume, of the concentration of a foreign substance in a solution.

Pathogens — Any viruses, bacteria, protozoa or fungi that cause disease.

Perched groundwater — Unconfined groundwater separated from an underlying main body of groundwater by an unsaturated zone.

Percolation — The movement of water through small openings within a porous material.

Permeability — The capability of soil or other geologic formation to transmit water.

Permeable — Porous or fissured so that water easily soaks in or passes through.

Pesticide — Any organic or inorganic substance used to kill or inhibit plant or animal life, including any insecticide, herbicide, rodenticide, algicide, miticide, nematicide or fungicide.

GLOSSARY

* indicates definition from SGMA definitions.

Phreatic zone — The zone beneath the water table in which the pore space is filled with water. Also referred to as the saturated zone.

Piezometer — The basic field device for the measurement of hydraulic head. A pipe sealed along its length, open to water flow at the bottom and open to the atmosphere at the top.

Piezometric surface (potentiometric surface) — An imaginary surface representing the level to which groundwater will rise in a well as a result of the pressure under which it is confined in an aquifer.

Plain language* — Language that the intended audience can readily understand and use because that language is concise, well-organized, uses simple vocabulary, avoids excessive acronyms and technical language, and follows other best practices of plain language writing.

Plan* — A groundwater sustainability plan (GSP) as defined in SGMA.

Plan implementation* — An Agency's exercise of the powers and authorities described in the Act, which commences after an Agency adopts and submits a Plan or Alternative to the Department and begins exercising such powers and authorities.

Plan manager* — An employee or authorized representative of an Agency, or Agencies, appointed through a coordination agreement or other agreement, who has been delegated management authority for submitting the Plan and serving as the point of contact between the Agency and the Department.

Point source — A specific site from which waste or polluted water is discharged into a water body, the source of which can be identified and measured.

Pollution — Contamination or other change in the physical, chemical or biological properties of a substance, especially water (including change in temperature, taste, color or odor) that may eventually impair its quality for use by ecosystem organisms or create a nuisance or make the substance detrimental to public health, safety or welfare. Refer to contamination.

Porosity — Voids or open spaces in alluvium and rocks that can be filled with water, frequently expressed ratio of the volume of open space to the total rock volume, expressed as a percentage.

Potentiometric surface — Refer to piezometric surface.

Precipitation — The discharge of water, in either liquid or solid form, from the atmosphere to the surface of the Earth, including rain, drizzle, sleet, snow, snow pellets, snow grains, ice crystals, ice pellets, hail, dew and frost, usually measured in inches, hundredths of inches or millimeters of equivalent depth in water.

Prescriptive rights — The rights acquired over a period of years by parties who use water adverse to the rights of the lawful owner of a property.

Principal aquifers* — Aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems.

Public water system — A system for the provision of water for human consumption though pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 6o days a year.

Public Utilities Commission (PUC) — The successor to the California Railroad Commission. The PUC regulates the affairs of private investor owned utilities. It does not possess regulatory authority over public entities.

Pumping lift — The distance water must be lifted in a well from the well pumping level to ground surface. pumping level — the position of the groundwater surface in a well during pumping.

GLOSSARY

* indicates definition from SGMA definitions.

Pump tax — Also groundwater charge, extraction fee, production assessment, replenishment assessment, replenishment fee, or basin assessment fee. Assessments levied by public agencies on the amount of groundwater pumped for use in conducting groundwater management activities such as purchasing imported water to replenish groundwater extracted in excess of the perennial yield, building recharge facilities.

Radius of influence — The distance from the center of a well to the limit of the cone of depression.

Rainwater harvesting — Roof runoff is diverted into a tank, well, sump, or caisson where it is allowed to percolate to the water table where it is collected by pumping from a well, or stored for later use.

Reasonable use — Required by the California Constitution, Article X, Section 2, but a term which is not subject to a standard definition; one of the requirements that must be satisfied by any party asserting a water right in California. Primarily thought to refer to the method, manner, or means of use.

Receiving water — Groundwater that will receive the source water recharged.

Recharge — Flow to groundwater storage from precipitation, infiltration from streams, irrigation, spreading basins, injection well and other sources of water.

Recharge area or zone — Surface area or zone in which water infiltrates into the ground, reaches the zone of saturation, recharging the underlying aquifer.

Recharge basin — A surface facility, often a large pond or other similar artificial basin used to increase the percolation of surface water into a groundwater basin thereby replenishing a groundwater supply. Also infiltration basin.

Recharge well — Well that is used to recharge water directly to an aquifer.

Recovery efficiency — Calculated as the cumulative volume of water recovered from storage in an ASR well divided by the cumulative volume previously stored during the same operating cycle, usually expressed as a percentage.

Recycled water — Previously used domestic or municipal water (wastewater) that has been treated for reuse for potable or non-potable beneficial uses, and can serve as source water for recharge. Used synonymously with reclaimed water.

Reference point* — A permanent, stationary and readily identifiable mark or point on a well, such as the top of casing, from which groundwater level measurements are taken, or other monitoring site.

Regional Water Quality Control Boards (RWQCBs) — The primary state agencies that regulate water quality and which are operated pursuant to policies adopted or approved by the State Water Resources Control Board. The RWQCBs have authority to compel cleanup and abatement of groundwater pollution under the Porter-Cologne Water Quality Control Act.

Representative monitoring* — A monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin.

Residence time — Average amount of time a fluid spends during transport through a volume of subsurface or a laboratory vessel.

Return flow — The portion of withdrawn water not consumed by evapotranspiration or system losses which returns to its source or to another body of water.

Reuse — The additional use of previously used water.

GLOSSARY

* indicates definition from SGMA definitions.

Reverse osmosis — Treatment method for removing salts from water by forcing water through a membrane.

Riparian land — Land that adjoins or abuts a natural watercourse.

Runoff — The surface flow of water from an area; the total volume of surface flow from an area during a specified time.

Safe yield — Refer to sustainable yield.

Saline — Consisting of or containing salts the most common of which are potassium, sodium or magnesium in combination with chloride, nitrate or carbonate.

Salinity — Generally, the concentration of mineral salts dissolved in water. Salinity may be measured by weight (total dissolved solids), electrical conductivity or osmotic pressure. Where sea water is known to be the major sources of salt, salinity is often used to refer to the concentration of chlorides in the water. Refer to total dissolved solids.

Salinity intrusion — The movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies. There are six types of salinity intrusion, one of which is sea water intrusion.

Saltwater barrier — A physical facility or method of operating which is designed to prevent the intrusion of salt water into a body of fresh water.

Saltwater intrusion — The phenomenon occurring when a body of salt water, because of its greater density, invades a body of fresh water. It can occur either in surface or groundwater bodies. When groundwater is pumped from aquifers that are in hydraulic connection with the sea, the gradients that are set up may induce a flow of salt water from the sea toward the well.

Saturated zone — The area below the water table in which the soil is completely saturated with groundwater. Also zone of saturation.

Seasonal high* — The highest annual static groundwater elevation that is typically measured in the Spring and associated with stable aquifer conditions following a period of lowest annual groundwater demand.

Seasonal low* — The lowest annual static groundwater elevation that is typically measured in the Summer or Fall, and associated with a period of stable aquifer conditions following a period of highest annual groundwater demand.

Seawater intrusion* — The advancement of seawater into a groundwater supply that results in degradation of water quality in the basin, and includes seawater from any source.

Sediment — Soil or mineral material transported by water and deposited in streams and channels. Sediments constitute the major aquifers in California.

Seepage — The gradual movement of a fluid into, through or from a porous medium.

Sewage — The liquid waste from domestic, commercial and industrial establishments.

Soluble minerals — Naturally occurring substances capable of being dissolved.

Source water — Referred to as the water that will be recharged in a managed aquifer recharge project.

Specific capacity — The volume of water pumped from a well in gallons per minute per foot of drawdown.

Specific retention — As applied to a rock or soil it is the ratio of : 1) the volume of water which, after being saturated, it will retain against the pull of gravity to; 2) its own volume. It is stated as a percentage.

GLOSSARY

* indicates definition from SGMA definitions.

Specific yield — The ratio of the volume of water that a given mass of saturated rock or soil will yield by gravity to the volume of that mass.

Spreading water — Discharging native or imported water to a permeable area for the purpose of allowing it to percolate to the zone of saturation.

Spring — A place where groundwater naturally flows from rock or soil onto the land surface or into a water body. The occurrence of a spring is dependent upon the location of permeable and impermeable rock layers, the level of the water table and on the local topography.

State Water Resources Control Board (SWRCB) — Administrative agency with the primary responsibility for regulating and determining rights to surface water and subterranean stream flow. In addition, the SWRCB has primary responsibility for enforcing the constitutional reasonable use requirement.

Static groundwater level — The water level in a well that is not flowing or being pumped; generally the level immediately before pumping is started after being stopped for a period of time.

Statutory deadline* — The date by which an Agency must be managing a basin pursuant to an adopted Plan, as described in Water Code Sections 10720.7 or 10722.4.

Storativity — The volume of water released from storage in an aquifer in a vertical column of 1 ft^2 when the water table of potentiometric surface declines 1 foot. In an unconfined aquifer it is approximately equal to specific yield.

Supply augmentation alternatives — Water management programs (such as conjunctive use, water banking or water project facility expansion) that increase supply.

Surface spreading — Recharging water at the surface through recharge basins, ponds, pits, trenches, constructed wetlands, or other systems.

Surface supply — Water in reservoirs, lakes or streams; expressed either in terms of rate of flow or volume.

Sustainability indicator* — Any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721(x).

Sustainable yield* — The maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.

Tertiary treatment — The treatment of wastewater beyond the secondary or biological stage. The term normally implies the removal of nutrients, such as phosphorus and nitrogen, and of a high percentage of suspended solids.

Total dissolved solids (TDS) — The quantity of minerals (salts) in solution in water, usually expressed in milligrams per liter or parts per million.

Transmissivity — The capacity of rock to transmit groundwater under pressure, expressed as a quantity of water, at the prevailing temperature, transmitted horizontally in a given period of time through a vertical strip of a given width of the fully saturated thickness of the aquifer, under a hydraulic gradient of one.

Uncertainty* — A lack of understanding of the basin setting that significantly affects an Agency's ability to develop sustainable management criteria and appropriate projects and management actions in a Plan, or to evaluate the efficacy of Plan implementation, and therefore may limit the ability to assess whether a basin is being sustainably managed.

GLOSSARY

* indicates definition from SGMA definitions.

Unconfined groundwater — Groundwater that has a free water table at atmospheric pressure. It is not confined under pressure beneath relatively impermeable rocks or soil.

Underground injection control (UIC) — the UIC Program under the Safe Drinking Water Act, found in Title 40 of the US Federal Code of Regulations, which provides minimum requirements for injection of fluids through wells into the subsurface, including ASR wells.

Unsaturated zone — A subsurface soil zone, also called the vadose zone or the zone of aeration that lies above the zone of saturation (the water table). The interstitial water tends to move under gravity despite being held by molecular capillary forces. This zone of aeration is divided into the belt of soil water, the intermediate belt and the capillary fringe which is just above the zone of saturation.

Urban water management plan* — A plan adopted pursuant to the Urban Water Management Planning Act as described in Part 2.6 of Division 6 of the Water Code, commencing with Section 10610 et seq.

Usable storage capacity — The quantity of groundwater of acceptable quality that can be economically withdrawn from storage.

U.S. Endangered Species Act (ESA) — Federal legislation which provides a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, and which provides a program for the conservation of such threatened and endangered species.

U.S. Environmental Protection Agency (EPA) — The agency was created to permit coordinated and effective governmental action on behalf of the environment. The EPA endeavors to abate and control pollution systematically, by proper integration of a variety of research, monitoring, standard setting and enforcement activities.

Vadose water — Water below the surface of the earth and above the water table, either held by the soil or percolating downward toward the water table through the vadose zone (unsaturated zone).

Waste — Loss of a resource such as water without substantial benefit or beneficial use.

Water banking — A water conservation and use optimization system whereby water is allocated for current use or stored in surface water reservoirs or in aquifers for later use. Water banking is a means of handling surplus water resources during wet years.

Water conservation — Reduction in applied water due to more efficient water use such as implementation of Urban Best Management Practices or Agricultural Efficient Water Management Practices. The extent to which these actions actually create savings in a water supply depends on how they affect total water use and depletion.

Water marketing — The selling or leasing of water rights in an open market.

Water quality — Used to describe the chemical, physical and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

Water reclamation — As used in this report. Includes water recycling, sea water desalting, groundwater reclamation and desalting agricultural brackish water.

Water recycling — The treatment of urban wastewater to a level rendering it suitable for a specific, direct, beneficial use.

Water source type* — Represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.

Water table — Refer to groundwater table.

Water transfer — Conveyance of groundwater or surface water from one area to another that involves crossing a political or hydrologic boundary. A voluntary change in a point of diversion, place of use, or purpose of use that may involve a change in water rights. A long-term transfer shall be for any period in excess of one year (California Water Code Section 1735.)

Water use sector* — Categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation.

Water year — A continuous 12-month period for which hydrologic records are compiled and summarized. In California, it begins on October 1 and ends September 30 of the following year. Water year 2003 ended Sept 30, 2003.

Water year type* — The classification assess the amount of annual precipitation in a basin.

Well, water well, "Water supply wells" or "supply wells" — Any artificial excavation constructed by any method for the purpose of extracting water from, or injecting water into, the underground. For purposes of this GSP, water supply wells includes all types of wells that provide water for beneficial uses, inclusive of private domestic wells, irrigation wells, industrial wells, commercial wells, and public supply wells. This does not include: (a) oil and gas wells, or geothermal wells constructed under the jurisdiction of the Department of Conservation, except those wells converted to use as water wells; or (b) wells used for the purpose of (1) dewatering during construction, or (2) stabilizing hillsides or earth embankments (Water Code Division 7, Chapter 10, Article 2, Section 13710).

Well casing — Serves as a lining to maintain an open hole from ground surface to the aquifer. It seals out surface water and any undesirable groundwater and also provides structural support against caving materials outside the well. Materials commonly employed for well casing are iron, steel and PVC.

Well completion report — California Water Code Section 13751 requires that anyone who constructs, alters, or destroys a water well, cathodic protection well, groundwater monitoring well, or geothermal heat exchange well must file with the Department of Water Resources a report of completion within 60 days of the completion of the work. Drillers submit their well completion reports with the Online System of Well Completion Reports (OSWCR, say ,Oscar,). OSWCR users create an account based on their C-57 license that DWR will validate. Upon approval users will be able to submit Well Completion Reports.

Well construction — The procedures necessary, using the proper materials and equipment to build a well for a specific purpose.

Well destruction — The procedures necessary using the proper materials and equipment, to ensure the boring is no longer a conduit for contamination of groundwater.

Well log — A graphic record of a well, generally a lithologic and/or stratigraphic record of the units traversed by a borehole.

Section 1: Introduction

Groundwater Sustainability Plan for Petaluma Valley Groundwater Basin

Table of Contents

Tables

Figure

Appendices

1 INTRODUCTION

In 2014, the State of California enacted the Sustainable Groundwater Management Act (SGMA), which substantially changes the way groundwater is managed in California. This law requires groundwater basins and subbasins in California designated as high- or medium-priority by the California Department of Water Resources (DWR) under SGMA to be managed sustainably.[1] To satisfy the requirements of SGMA, local agencies must do the following:

1. Form one or more Groundwater Sustainability Agencies (GSAs) to fully cover the SGMA high- or medium-priority basin/subbasin

2. Develop one or multiple Groundwater Sustainability Plans (GSPs) that fully cover the SGMA high- or medium-priority basin/subbasin

3. Implement the GSP and manage to achieve quantifiable objectives and sustainability within 20 years of GSP adoption

4. Report data and GSP progress to the DWR

The Petaluma Valley Groundwater Basin (Basin), designated as basin number 2-1 in DWR's Bulletin No. 118 (DWR 2016a), is categorized as a medium-priority basin by DWR (DWR 2020) and is, therefore, required to comply with SGMA (**Figure 1-1)**.

[1] DWR prioritizes groundwater basins as critically overdrafted, high-, medium-, low-, and very low-priority based on a variety of technical factors. Refer to https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization.

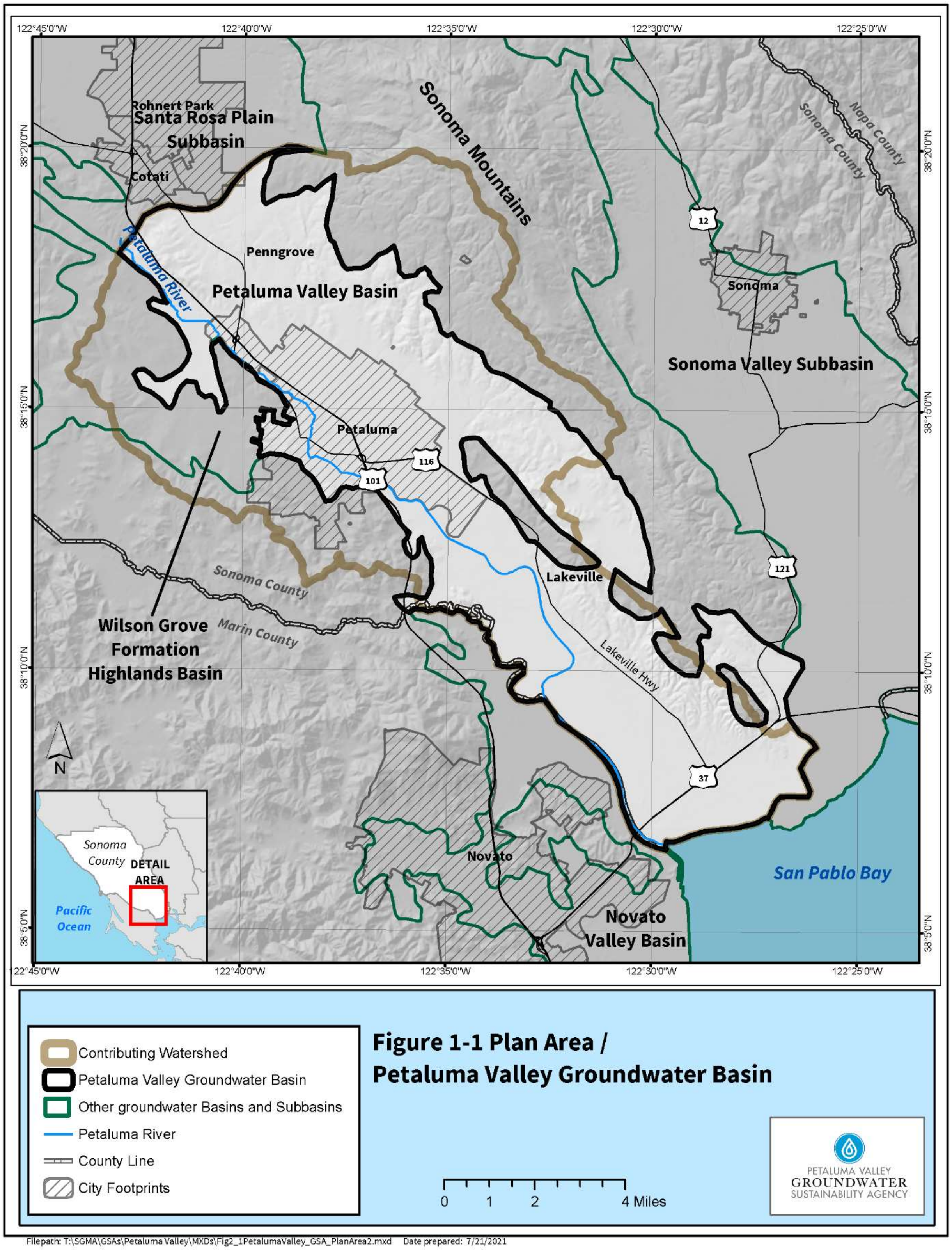

Figure 1-1. Plan Area/Petaluma Valley Groundwater Basin

1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this document is to fulfill the GSP requirement and present paths for sustaining groundwater resources in the Basin. Primary objectives addressed by this GSP are to:

- Meet the requirements of SGMA and DWR's GSP Emergency Regulations (GSP Regulations) by establishing criteria and management actions that will achieve and maintain sustainable groundwater management in the Basin within 20 years of GSP adoption.
- Incorporate the best available scientific and technical information by building on the strong technical foundation established through previous technical studies and voluntary groundwater management activities in Petaluma Valley.
- Integrate the perspectives and interests of the many diverse users and uses of groundwater resources within the Basin through a process that provides opportunity for significant public and community engagement. Dozens of comments were received and considered during multiple phases of revising the GSP (**Appendix 1-A**).
- Leverage the limited available funding and local resources through continued regional coordination and information sharing with other local entities and GSAs.

The development of this GSP benefits from collaborative groundwater and water-resource planning and studies by local stakeholders, which had focused on addressing groundwater sustainability issues in the Basin prior to the passage of SGMA.

The purpose of the GSP is not to tackle water supply risk and resilience issues or prepare emergency response plans for community drinking water systems. The America's Water Infrastructure Act (AWIA) of 2018 requires community drinking water systems to develop or update risk assessments and emergency response plans to identify vulnerabilities, including malevolent acts and natural disasters, such as floods and droughts, that may potentially threaten the ability of community water systems to deliver safe drinking water.

The Petaluma Valley GSA, in collaboration with Sonoma County Water Agency (Sonoma Water), other Sonoma County GSAs, and local water suppliers, has and will continue to provide information to the local community on the severe multiyear drought occurring during the preparation of this GSP and other droughts in the future, including, but not limited to:

- News releases on the status of historically low surface water reservoir supplies
- Messaging to encourage communities to change everyday habits and adapt to eliminate water waste, and to conserve and reduce water usage by 20 percent
- Participation in public workshops on drought conditions and what the community can do to help address this issue

The GSAs do have the authority to mandate conservation and manage extractions but ultimately cannot affect water rights under SGMA. While California's Human Right to Water (California Water Code [CWC] 106.3) does not apply to the Petaluma Valley GSA (which does not provide drinking water and is not a State agency), the GSP is developed to be protective of both groundwater levels and groundwater quality for all beneficial users, including residential well owners and disadvantaged communities (DACs). By addressing all beneficial uses and users, the GSP has addressed California's Human Right to Water.

1.2 Guide to the Groundwater Sustainability Plan

The Petaluma Valley GSP is organized sequentially, starting with a high-level overview of the Basin (**Section 2**), and drilling into more details on hydrology, geology, and the current and projected groundwater conditions (**Section 3**). A discussion of what sustainability means locally is provided in **Section 4**, and **Section 5** details how sustainability will be monitored over time. **Sections 6** (Projects and Management Actions) and **7** (Implementation Plan) describe how sustainability will be achieved. Each section builds on the prior section and contributes to the reader's understanding of the issues facing the Basin and the proposed solutions.

This document is composed of the following sections:

- **Front Matter** – This includes a table of contents that can help readers locate specific plan components, and a list of acronyms and abbreviations that can help readers navigate arcane water lingo.
- **Executive Summary** – A brief overview of the GSP, providing high-level information about the Basin, sustainability goals, and how the GSP will be implemented.
- **Section 1, Introduction** – Basic administrative information about the GSA, its composition and authorities, and how it communicates with and engages stakeholders.
- **Section 2, Plan Area** – A description of the Basin, including jurisdictions, land uses, water uses, and well permitting.
- **Section 3, Basin Setting** – A detailed overview of the Basin, including its physical setting; climate; the hydrogeologic conceptual model (which includes the factors that describe and effect its hydrology, such as geologic features, aquifer, and aquitards); current and historical groundwater conditions; the current and projected water budget; and management areas.
- **Section 4, Sustainable Management Criteria** – This section describes proposed management criteria for each of SGMA's six sustainability indicators: groundwater levels, groundwater storage, water quality, land subsidence, seawater intrusion, and surface water depletion.
- **Section 5, Proposed Monitoring Plan** – The Sustainable Management Criteria described in **Section 4** are quantifiable and are measured over time. This section describes the current

monitoring network and proposed enhancements needed to accurately monitor data into the future.

- **Section 6, Projects and Management Actions** – This section describes and ranks projects and actions that could be used to achieve or maintain sustainability by 2042.
- **Section 7, Implementation Plan** – This section describes how the GSP will be implemented over time, including a draft high-level budget and potential funding sources.
- **Section 8, References** – This section provides a list of all documents cited in this GSP.
- **Appendices** – The appendices to this report provide a wealth of additional information.

Tables 1-1 and **1-2** provide a detailed list of the DWR-required GSP components from the GSP Regulations and SGMA statutes, respectively.

Table 1-1. Cross-reference of GSP Regulations and GSP Section Numbers

Sub-article	Section	Paragraph	Requirement	GSP Section
1. Administrative Information	354.4. General Information	(a)	Executive summary	00
		(b)	List of references and links to technical studies	Appendices
	354.6. Agency Information	-	Agency information pursuant to CWC Section 10723.8 (notification of GSA formation to DWR), along with:	1.2 and Appendices
		(a)	Agency name and mailing address	1.2
		(b)	Agency organization and management structure, persons with management authority for GSP implementation	1.2
		(c)	GSP manager name and contact information	1.2
		(d)	Legal authority of agency	1.2
		(c)	Estimate of GSP implementation costs and description of how agency plans to meet costs	7
	354.8. Description of Plan Area	(a)	Maps of GSP area	Figure 2-1
		(b)	Written description of GSP area	2.1
		(c)-(d)	Identification of existing water-resource monitoring and management programs, and description of any such planned programs	2.4 and 2.5
		(c)	Description of conjunctive use programs	2.5
		(f)	Description of the land use elements or topic categories	2.6
		(g)	Description of additional GSP elements (CWC Section 10727.4)	2.7 and 2.8

Sub-article	Section	Paragraph	Requirement	GSP Section
	354.10. Notice and Communication	(a)	Description of the beneficial uses and users of groundwater in the subbasin	1.3
		(b)	List of public meetings	1.3
		(c)	Comments and responses regarding the GSP	Appendices
		(d)	Description of communication procedures	1.3
2. Basin Setting	354.12. Introduction to Basin Setting	-	Information about the basin setting (physical setting, characteristics, current conditions, data gaps, uncertainty)	3
	354.14. Hydrogeologic Conceptual Model	(a)	Description of the subbasin hydrogeologic conceptual model	3.1
		(b)	Summary of regional geologic and structural setting, subbasin boundaries, geologic features, principal aquifers, and aquitards	3.1
		(c)	Cross-sections depicting major stratigraphic and structural features	Figures 3-6
		(d)	Maps of subbasin physical characteristics	Figures 3-1 through 3-10
	354.16. Groundwater Conditions	(a)-(g)	Description of current and historical groundwater conditions, including: 1. Groundwater elevation 2. Change in storage 3. Seawater intrusion 4. Groundwater quality issues 5. Land subsidence 6. Interconnected surface water systems 7. Groundwater-dependent ecosystems	3.2
	354.17. Water Budget	(a)	Water budget providing total annual volume of groundwater and surface water entering and leaving the subbasin, including historical, current, and projected water budget conditions, and change in storage	3.3
		(b)-(f)	Development of a numerical groundwater and surface water model to quantify current, historical, and projected: 1. Total surface water entering and leaving by water source type 2. Inflow to the groundwater system by water source type 3. Outflows from the groundwater system by water use sector 4. Change in groundwater storage 5. Overdraft over base period 6. Annual supply, demand, and change in storage by water year type	3.3 and Appendix

Sub-article	Section	Paragraph	Requirement	GSP Section
			7. Estimated sustainable yield	
	354.20. Management Areas	(a)	Description of management areas	3.4
		(b)	Describe purpose, minimum thresholds, measurable objectives, monitoring, analysis	NA
		(c)	Maps and supplemental information	NA
3. Sustainable Management Criteria	354.22. Introduction to Sustainable Management Criteria	-	Criteria by which an agency defines conditions that constitute sustainable groundwater management for the subbasin	4
	354.24. Sustainability Goal	-	Description of subbasin sustainability goal, including basin setting information used to establish the goal, sustainability indicators, discussion of measures to ensure the subbasin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved and maintained	4
	354.26. Undesirable Results	(a)	Processes and criteria used to define undesirable results applicable to the subbasin	4
		(b)-(c)	Description of undesirable results, including cause of groundwater conditions and potential effects on beneficial uses and users of groundwater	4
	354.28. Minimum Thresholds	(a)	Establish minimum thresholds to quantify groundwater conditions for each applicable sustainability indicator	4
		(b)-(d)	Describe information and criteria to select, establish, justify, and quantitatively measure minimum thresholds	4
	354.30. Measurable Objectives	(a)-(g)	Establish measurable objectives, including interim milestones in increments of 5 years, to achieve and maintain the subbasin sustainability goal	4
4. Monitoring Networks	354.32. Introduction to Monitoring Networks	-	Description of monitoring network, monitoring objectives, monitoring protocols, and data reporting	5
	354.34. Monitoring Network	(a), (e)-(g)	Development of monitoring network to yield representative information about groundwater conditions	5
		(b)-(d)	Monitoring network objectives	5
		(h)	Maps and tables of monitoring sites	5
		(i)	Monitoring protocols	Appendices

Sub-article	Section	Paragraph	Requirement	GSP Section
	354.36. Representative Monitoring	(a)-(c)	Designation of representative monitoring sites	5
	354.38. Assessment and Improvement of Monitoring Network	(a)-(d)	Evaluation of monitoring network, including uncertainty, data gaps, and efforts to fill data gaps	5
		(e)	Adjustment of monitoring frequency and density to assess management action effectiveness	5
	354.40. Reporting Monitoring Data to the Department	(f)	Copy of monitoring data from data management system	Digital Submittal
5. Projects and Management Actions	354.44. Projects and Management Actions	(a)-(c)	Description of projects and management actions to achieve and maintain the subbasin sustainability goal.	6

Note:
NA = not applicable

Table 1-2. Cross-reference of SGMA Statute Related to GSP Requirements and GSP Section Numbers

Requirement	GSP Section
Chapter 5 Powers and Authorities	
10726.9 REQUIREMENT OF PLAN TO TAKE ACCOUNT OF GENERAL PLAN ASSUMPTIONS	
A groundwater sustainability plan shall take into account the most recent planning assumptions stated in local general plans of jurisdictions overlying the basin.	2.6
Chapter 6 Groundwater Sustainability Plans	
10727. REQUIREMENT TO DEVELOP GROUNDWATER SUSTAINABILITY PLAN FOR MEDIUM- AND HIGH-PRIORITY BASINS; FORM OF PLAN	
(a) A groundwater sustainability plan shall be developed and implemented for each medium- or high-priority basin by a groundwater sustainability agency to meet the sustainability goal established pursuant to this part. The groundwater sustainability plan may incorporate, extend, or be based on a plan adopted pursuant to Part 2.75 (commencing with Section 10750).	1.0
10727.2. REQUIRED PLAN ELEMENTS A groundwater sustainability plan shall include all of the following:	
(a) A description of the physical setting and characteristics of the aquifer system underlying the basin that includes the following:	3.0
(1) Historical data, to the extent available.	3.2, 3.3
(2) Groundwater levels, groundwater quality, subsidence, and groundwater-surface water interaction.	3.2
(3) A general discussion of historical and projected water demands and supplies.	3.2, 3.3
(4) A map that details the area of the basin and the boundaries of the GSAs that overlie the basin that have or are developing GSPs.	Figure 3-1

Requirement	GSP Section
(5) A map identifying existing and potential recharge areas for the basin. The map or maps shall identify the existing recharge areas that substantially contribute to the replenishment of the groundwater basin. The map or maps shall be provided to the appropriate local planning agencies after adoption of the groundwater sustainability plan.	Figures 3-8a and 3-8b
(b) (1) Measurable objectives, as well as interim milestones in increments of 5 years, to achieve the sustainability goal in the basin within 20 years of the implementation of the plan.	4.0
(2) A description of how the plan helps meet each objective and how each objective is intended to achieve the sustainability goal for the basin for long-term beneficial uses of groundwater.	4.0
(3) (A) Notwithstanding paragraph (1), at the request of the groundwater sustainability agency, the department may grant an extension of up to 5 years beyond the 20-year sustainability timeframe upon a showing of good cause. The department may grant a second extension of up to 5 years upon a showing of good cause if the groundwater sustainability agency has begun implementation of the work plan described in clause (iii) of subparagraph (B). (B) The department may grant an extension pursuant to this paragraph if the groundwater sustainability agency does all of the following: (i) Demonstrates a need for an extension. (ii) Has made progress toward meeting the sustainability goal as demonstrated by its progress at achieving the milestones identified in its groundwater sustainability plan. (iii) Adopts a feasible work plan for meeting the sustainability goal during the extension period.	NA
(4) The plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015. Notwithstanding paragraphs (1) to (3), inclusive, a groundwater sustainability agency has discretion as to whether to set measurable objectives and the timeframes for achieving any objectives for undesirable results that occurred before, and have not been corrected by, January 1, 2015.	4
(c) A planning and implementation horizon.	3.4.1.2
(d) Components relating to the following, as applicable to the basin: (1) The monitoring and management of groundwater levels within the basin.	4.0, 5.0, 6.0
(2) The monitoring and management of groundwater quality, groundwater quality degradation, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin.	4.0, 5.0, 6.0
(3) Mitigation of overdraft.	4.0, 5.0, 6.0
(4) How recharge areas identified in the plan substantially contribute to the replenishment of the basin.	3.1.7
(5) A description of surface water supply used or available for use for groundwater recharge or in-lieu use.	2.3.2
(e) A summary of the type of monitoring sites, type of measurements, and the frequency of monitoring for each location monitoring groundwater levels, groundwater quality, subsidence, streamflow, precipitation, evaporation, and tidal influence. The plan shall include a summary of monitoring information such as well depth, screened intervals, and aquifer zones monitored, and a summary of the type of well relied on for the information, including public, irrigation, domestic, industrial, and monitoring wells.	5.0

Requirement	GSP Section
(f) Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin. The monitoring protocols shall be designed to generate information that promotes efficient and effective groundwater management.	Appendix
(g) A description of the consideration given to the applicable county and city general plans and a description of the various adopted water resources-related plans and programs within the basin and an assessment of how the groundwater sustainability plan may affect those plans.	2.4, 2.5
10727.4. ADDITIONAL PLAN ELEMENTS In addition to the requirements of Section 10727.2, a groundwater sustainability plan shall include, where appropriate and in collaboration with the appropriate local agencies, all of the following:	
(a) Control of saline water intrusion.	
(b) Wellhead protection areas and recharge areas.	3.1.7
(c) Migration of contaminated groundwater.	2.1
(d) A well abandonment and well destruction program.	2.7
(e) Replenishment of groundwater extractions.	6.0
(f) Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage.	2.1
(h) Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects.	2.5, 6.0
(i) Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use.	2.5.4
(j) Efforts to develop relationships with state and federal regulatory agencies.	7
(k) Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.	7
(l) Impacts on groundwater-dependent ecosystems.	4
10727.8. PUBLIC NOTIFICATION AND PARTICIPATION; ADVISORY COMMITTEE (a) Prior to initiating the development of a groundwater sustainability plan, the groundwater sustainability agency shall make available to the public and the department a written statement describing the manner in which interested parties may participate in the development and implementation of the groundwater sustainability plan. The groundwater sustainability agency shall provide the written statement to the legislative body of any city, county, or city and county located within the geographic area to be covered by the plan. The groundwater sustainability agency may appoint and consult with an advisory committee consisting of interested parties for the purposes of developing and implementing a groundwater sustainability plan. The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin prior to and during the development and implementation of the groundwater sustainability plan.	1.2, 1.3, Appendix
(b) For purposes of this section, interested parties include entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency.	NA

Requirement	GSP Section
10728. ANNUAL REPORTING BY GROUNDWATER SUSTAINABILITY AGENCY TO DEPARTMENT On the April 1 following the adoption of a groundwater sustainability plan and annually thereafter, a groundwater sustainability agency shall submit a report to the department containing the following information about the basin managed in the groundwater sustainability plan: (a) Groundwater elevation data. (b) Annual aggregated data identifying groundwater extraction for the preceding water year. (c) Surface water supply used for or available for use for groundwater recharge or in-lieu use. (d) Total water use. (e) Change in groundwater storage.	7.0
10728.2. PERIODIC REVIEW AND ASSESSMENT A groundwater sustainability agency shall periodically evaluate its groundwater sustainability plan, assess changing conditions in the basin that may warrant modification of the plan or management objectives, and may adjust components in the plan. An evaluation of the plan shall focus on determining whether the actions under the plan are meeting the plan's management objectives and whether those objectives are meeting the sustainability goal in the basin.	7.0
10728.4. ADOPTION OR AMENDMENT OF PLAN FOLLOWING PUBLIC HEARING A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing, held at least 90 days after providing notice to a city or county within the area of the proposed plan or amendment. The groundwater sustainability agency shall review and consider comments from any city or county that receives notice pursuant to this section and shall consult with a city or county that requests consultation within 30 days of receipt of the notice. Nothing in this section is intended to preclude an agency and a city or county from otherwise consulting or commenting regarding the adoption or amendment of a plan.	1.3, 7.0
10728.6. CEQA NOT APPLICABLE TO PLAN PREPARATION AND ADOPTION Division 13 (commencing with Section 21000) of the Public Resources Code does not apply to the preparation and adoption of plans pursuant to this chapter. Nothing in this part shall be interpreted as exempting from Division 13 (commencing with Section 21000) of the Public Resources Code a project that would implement actions taken pursuant to a plan adopted pursuant to this chapter.	5

Note:

CEQA = California Environmental Quality Act

1.3 Groundwater Sustainability Agency Authorities and Administrative Information

The Petaluma Valley GSA was formed to meet SGMA requirements in June 2017 and is one of three GSAs established in Sonoma County (the other two are Sonoma Valley and Santa Rosa Plain). The jurisdictional area of the Petaluma Valley GSA is the entire Basin, and no other GSAs have jurisdiction within the Basin. The Petaluma Valley GSA was formed through a Joint Exercise of Powers Agreement (JPA) entered into by the North Bay Water District, Sonoma County, Sonoma Water, Sonoma Resource Conservation District (RCD), and the City of Petaluma, in accordance with requirements of CWC Section 10723 for establishing GSAs under SGMA. A copy of the resolution forming the JPA and a copy of the JPA are included in **Appendix 1-B**.

In August 2019, the Basin boundaries were amended to include additional areas of Petaluma. The boundary change was a result of DWR's proposed 2018 reprioritization of the neighboring

Wilson Grove Formation Highlands Basin (Wilson Grove) from very-low priority to medium-priority. Entities within Wilson Grove were concerned about their ability to comply with SGMA, and the cities of Sebastopol and Petaluma, three mutual water districts (Fircrest, Belmont Terrace, and Kelly), and the County of Marin made jurisdictional requests to DWR to change the basin boundaries. DWR authorized the boundary changes. As a result, portions of the City of Petaluma formerly within Wilson Grove are now within the Petaluma Valley Basin. Sebastopol and the water companies are now solely within the Santa Rosa Plain Basin.

Contact information for the Petaluma Valley GSA is:

Petaluma Valley Groundwater Sustainability Agency
404 Aviation Boulevard
Santa Rosa, California 95403
www.petalumavalleygroundwater.org
(707) 524-8378

GSA Administrator: Ann DuBay, Community & Government Affairs Manager, Sonoma County Water Agency

GSA Plan Manager: Jay Jasperse, Chief Engineer and Director of Groundwater Management, Sonoma County Water Agency

1.3.1 Petaluma Valley Groundwater Sustainability Agency

SGMA requires GSAs to be formed to cover high- and medium-priority basins/subbasins. Any local agency that has water supply, water management, or land use responsibility for a groundwater basin is eligible to form a GSA. The legislative intent of SGMA is to encourage GSA-eligible agencies to form one GSA that covers an entire SGMA basin/subbasin and prepare one GSP; however, SGMA offers local agencies the flexibility of forming multiple GSAs and preparing multiple GSPs in a basin/subbasin. SGMA empowers GSAs with new management tools and authorities to, among other things:

- Register groundwater wells
- Collect data/conduct studies
- Measure extractions (with the exception of de minimis wells [that pump fewer than 2 acre-feet per year])
- Require reporting
- Manage extractions
- Assess fees

1.3.2 Petaluma Valley Groundwater Sustainability Agency Board and Advisory Committee

The Petaluma Valley GSA is governed by five board members and alternates from the five member organizations, which each appoint one member and one alternate member. Petaluma Valley GSA Board (GSA Board) members are elected or appointed members of their governing bodies who serve at the pleasure of the member organization appointing them. GSA Board members annually elect the officers of the GSA Board for one-year terms, which may be extended to multiple consecutive terms. The GSA Board's role in the GSP development process is to provide guidance and direction on key components of the GSP and consider recommendations from the Petaluma Valley GSA Advisory Committee (Advisory Committee) and input from the public. The GSA Board is responsible for approving the GSP, authorizing its submission to DWR for evaluation, assessment, and approval and for implementation of the GSP through the decision-making processes outlined in the JPA.

The Petaluma Valley GSA has an agreement with Sonoma Water for technical support, public outreach and community engagement, grant writing, and GSA administrative support, and with the Sonoma RCD for monitoring services. The GSA also has service agreements with outside firms for legal, financial decision making, and facilitation services for Advisory Committee meetings.

The Petaluma Valley GSA formed an advisory committee of 10 members with 5 at-large members appointed from the five member agencies, and 5 interest-based members appointed by the Petaluma Valley GSA Board, as follows:

- Environmental representative
- Rural residential well owner
- Business community
- Agricultural interest
- At-large community representative

As described in **Section 2.1**, the DACs in the Basin are generally located in areas that receive water from municipal water suppliers, which rely primarily on surface water (not groundwater). For this reason, the Advisory Committee does not include a seat designated for a DAC representative. As described in **Section 1.4.2.1**, government-to-government outreach was conducted from the County to Tribes when the Petaluma Valley GSA was formed. Tribal participation is welcomed by the GSA; however, no Tribe expressed interest in participation on the Board or Advisory Committee. For the implementation phase of the GSP, federally and non-federally recognized Tribal governments will be contacted to reassess their interest in participating in GSA activities.

The role of the Advisory Committee in the GSP development process is to work toward consensus and incorporate community and stakeholder interests into recommendations to the GSA Board on GSP development and SGMA implementation. Advisory Committee members also report to, and seek input, from their larger constituency groups on key components and proposals related to GSP development. The Advisory Committee meets 6 to 10 times annually, and the meetings are open to the public in compliance with California's Ralph M. Brown Act (Government Code Section 54950).

The Advisory Committee makes recommendations to the GSA Board that reflect the outcome of Advisory Committee discussions. To ensure that all viewpoints are heard and considered by the GSA Board, the Advisory Committee identifies areas of agreement and disagreement among the Advisory Committee. The names of GSA Board and Advisory Committee members can be found in **Appendix 1-C**, and the Advisory Committee Charter is shown in **Appendix 1-D**.

1.3.3 Groundwater Sustainability Agency Coordination

Implementation of SGMA in the Petaluma Valley Basin is closely coordinated with neighboring GSAs in Sonoma Valley and the Santa Rosa Plain, as well as local agencies with land use responsibilities, including the City of Petaluma and the County of Sonoma. In addition to closely coordinating on managing and monitoring along shared Basin boundaries, resources are leveraged and shared by the three existing GSAs in Sonoma County to maximize efficiencies, including shared templates and methodologies for certain GSP components, outreach resources, grant opportunities, and the development of data management system tools and technologies.

The Petaluma Valley GSA has an agreement with Sonoma Water for technical support, public outreach and community engagement, grant writing, and GSA administrative support. The GSA also has service agreements with outside firms for legal counsel, financial decision making, monitoring, and facilitation services for Advisory Committee meetings and other public meetings.

1.4 Stakeholder Engagement and Communication

SGMA requires that GSAs consider the beneficial uses and users of groundwater. As a result, GSP development included robust outreach and stakeholder engagement through a variety of methods and tools, which are described in detail in **Sections 1.4.2.1** through **1.4.2.3**.

As described in **Section 1.3**, the Petaluma Valley GSA is governed by a board, which receives and considers recommendations from an advisory committee representing multiple stakeholder interests. Both the GSA Board and Advisory Committee hold regular public meetings in compliance with California's laws governing public meetings (commonly known as the Brown Act). A list of meetings, including those in which the GSP was discussed, can be found in **Appendix 1-E**.

All phases of SGMA compliance in the Basin have been, and will continue to be, characterized by an open collaborative process with strong stakeholder engagement allowing stakeholders and the public opportunities to provide input and to influence the process. Information is available on the website, www.sonomavalleygroundwater.org, where all meeting materials and notifications are posted.

1.4.1 Beneficial Uses and Users of Groundwater

SGMA requires GSAs to identify and consult with people and agencies who represent the "beneficial uses and users of groundwater in the basin, including the land uses and property interest potentially affected by the use of groundwater in the basin" (California Code of Regulations [CCR] Section 354.10). The *Community Engagement Plan for Development and Adoption of a Groundwater Sustainability Plan* (Petaluma Valley GSA 2018), provided in **Appendix 1-F**, identifies beneficial users and uses as "interested parties" that include water suppliers, agricultural users, business and commercial uses, rural residential well owners, DACs, state and local landowners, and environmental users.

As described in **Section 1.3**, many of these beneficial users and those engaged in beneficial uses are included on the GSA Board or the Advisory Committee. Specific information regarding consultation with representatives of beneficial users and uses is described in **Section 1.4.3**.

1.4.2 Sustainable Groundwater Management Act Phases of Work

Outreach for SGMA is associated with the following four work phases:

Phase 1: GSA formation and Coordination – The formation of the Petaluma Valley GSA began in 2015, with an initial stakeholder assessment conducted by the Consensus Building Institute (CBI), followed by negotiations between GSA-eligible entities in the Basin. This phase was completed in June 2017, when the GSA was created by a JPA (described in **Section 1.2**).

Phase 2: GSP Preparation and Submission – This phase of work began in 2018, and will be completed in January 2022. During this phase, outreach was largely guided by the Community Engagement Plan (**Appendix 1-F**). Pre-submission, the final draft GSP was released for public comments and review.

Phase 3: GSP Review and Evaluation – This phase began in 2019, with the majority of the review taking place in 2021. This phase will continue through 2022, when the GSP is submitted and DWR provides additional opportunity for additional public review and comments.

Phase 4: Implementation and Reporting – Following the submission of the GSP to DWR, the Petaluma Valley GSA will begin implementing projects and programs to reach sustainability in the Basin. This will be an ongoing phase, with 5-year updates that will include public input and feedback, as the GSA strives for sustainability by 2042.

1.4.2.1 Phase 1: GSA Formation and Coordination

From 2015 through 2017, local agencies worked with CBI to facilitate the formation of the Petaluma Valley GSA. CBI began by conducting a stakeholder assessment in the three Sonoma County basins and subbasins (Petaluma Valley, Santa Rosa Plain, and Sonoma Valley) that were immediately subject to SGMA. Assessment results were described in *Findings and Recommendations on Implementing the Sustainable Groundwater Management Act in Sonoma County* (**Appendix 1-G**).

The assessment included interviews with and surveys of representatives of key stakeholder groups. During the assessment phase, the County of Sonoma sent government-to-government letters to federally recognized Tribes within the three basins and subbasins. While the Federated Indians of Graton Rancheria chose to participate on the Santa Rosa Plain Advisory Committee, no Tribe expressed interest in participation on the Petaluma Valley GSA Board or Advisory Committee. For the implementation phase of the GSP, Tribal governments will be contacted again to reassess their interest in participating in GSA activities.

The stakeholder assessment resulted in recommendations for a transparent and inclusive process for local implementation of SGMA, and also recommended that separate GSAs be created for each of the three basins/subbasins in order to reflect the local basin characteristics and stakeholder concerns. Other findings include the following:

- There is an overall commitment to long-term sustainable groundwater management and awareness of the importance of groundwater-surface water interaction, conjunctive use, and integrated water resources management.
- Respondents respect local knowledge and control for water management and expressed concern about (1) needing to participate in management decisions for other basins and (2) having agencies or stakeholders from external jurisdictions making decisions about local groundwater. At the same time, some recognized a need for a regional perspective on water resources and land use; those with this perspective feel confident that regional considerations can blend with local decisions.
- Agencies expressed concerns about costs and funding SGMA implementation.
- Stakeholders demonstrated a high level of expectation for public outreach and stakeholder involvement. Respondents urged expansive outreach to rural residential well owners and those seeking guidance and input from Basin advisory panels and the public on forming the GSA.

The assessment prescribed a process for input and decision making, which involved representatives of the GSA-eligible entities in the Basin. The process was implemented, and included community forums that were held in 2016 to receive and consider input from the public on GSA formation.

Some areas of the Basin are classified as DACs by the DWR (DWR 2021a), the Sonoma County Transportation Authority (SCTA 2017), and Sonoma County Department of Health Services (2014). Representatives of DAC stakeholders were included in the assessment survey, or were separately interviewed by staff during the GSA formation process.

The beneficial users and users, as defined by SGMA (CWC Section 10723.2), in the Basin are represented in the structure of the GSA Board and the Advisory Committee. GSP beneficiaries include private domestic well owners, agriculture, businesses, municipal public water systems, DACs, and environmental users.

Stakeholders on the GSA Board and Advisory Committee include representatives from municipal water suppliers, agriculture, environmental organizations, businesses, rural well owners, and at-large community members. Refer to **Section 1.2** for additional information about GSA Board and Advisory Committee composition.

1.4.2.2 Phase 2: Preparation and Submission

The GSA Board and Advisory Committee were actively engaged in the development of the GSP, including:

- Reviewing and commenting on GSP sections as they were prepared
- Providing feedback and suggestions for Sustainable Management Criteria (SMC) (discussed in **Section 4** of this GSP)
- Actively engaging and soliciting feedback from the stakeholders they represent

All meetings were publicly advertised and conducted in accordance with California's Ralph M. Brown Act (Government Code Section 54950). Meetings held during the pandemic were advertised and conducted in accordance with Governor Newsom's Executive Order N-25-20 issued on March 3, 2020. Public comment was included on every item, and meeting minutes were taken and are available via the website (https://petalumavalleygroundwater.org/).

Broader public input was determined to be a critical component of GSP development, and was guided by the *Community Engagement Plan for Development and Adoption of a Groundwater Sustainability Plan Petaluma Valley Groundwater Sustainability Agency* (Petaluma Valley GSA 2018) (**Appendix 1-F**), which was adopted by the Board in January 2018. To encourage stakeholder engagement, key outreach tools included:

- Development of an Interested Parties List through both meeting attendance and by soliciting the public to sign up via the website (https://petalumavalleygroundwater.org/)
- Monthly informational emails to the Interested Parties list that provided information regarding SGMA, GSP planning, and groundwater management
- Development of a website (https://petalumavalleygroundwater.org/) with meeting information and GSP materials, including a location for public comments as draft GSP sections were released
- Public forums on the SGMA process, Basin conditions, SMC development, draft SMC, and the draft GSP
- Forums coordinated with the other Sonoma County GSAs on cross-cutting issues, including climate change modeling and groundwater recharge
- Presentations to and discussions with key stakeholder groups in the Basin, including the Sonoma Water Coalition (a countywide coalition of environmental groups), environmental

stakeholders, the Sonoma County Farm Bureau's water committee, cannabis growers, and the Board of Petaluma People and Family Services Center (which serves DACs in the basin)

- A survey mailed to all domestic well owners in the Basin, in both English and Spanish, assessing their priorities regarding groundwater sustainability and identifying key issues related to groundwater resources
- Focus groups, including a Basin-wide group, a DAC group that included representatives from the other Sonoma County basins, and an agricultural focus group
- A campaign to inform domestic well owners, including a website revision, social media messaging, newspaper ads, and lawn signs
- Participation in 2021 Drought Drop By, where groundwater users were provided information about the GSP along with a water-saving toolkit

1.4.2.3 Phase 3: Groundwater Sustainability Plan Review and Evaluation

Phase 3 began in 2019, with the majority of the review occurring in 2021. During this phase, sections of the draft GSP were released sequentially to the GSA Board, Advisory Committee, and public for comments. In addition, the draft GSP was posted on the website and made available at regional libraries and at Petaluma City Hall. During the 30-day review period, 15 comments were received from 9 individuals and organizations. All comments submitted through the various Advisory Committee, Board, and public reviews are available in **Appendix 1-A**. During the public comment period, a community workshop attended by approximately 30 people provided an overview of GSP content. In addition, a Board meeting held during the comment period allowed the public the opportunity to provide verbal comments and feedback.

Public comments were incorporated into the GSP as appropriate, and the final GSP will be considered by the Board in early December.

Following submittal to DWR, there will be a 75-day comment period through DWR's SGMA portal at http://sgma.water.ca.gov/portal/. Comments will be posted to the DWR website prior to the state agency's evaluation, assessment, and approval.

1.4.2.4 Phase 4: Implementation and Reporting

Phase 4 will continue through the duration of the 50-year planning window to ensure that sustainability is achieved and maintained, and that the activities, programs, and policies of the GSA are transparent and inclusive.

Both the Board and Advisory Committee will continue to meet, and the Advisory Committee's scope and purpose will be refined to focus on GSP implementation. Tribal governments will be contacted to reassess their interest in participation in the GSA and in the implementation process.

Section 2: Description of Plan Area

Groundwater Sustainability Plan for
Petaluma Valley Groundwater Basin

Table of Contents

Figures

2 DESCRIPTION OF PLAN AREA (23 CCR 354.8 B)

This section provides a description of the Plan Area, including the Basin's general physical setting and jurisdictional areas, topography and surface water features, land use characteristics, water source types and uses, existing monitoring and management programs, applicable land use plans, and the well permitting process. The numbers in parentheses in each subheading indicate the applicable SGMA regulation.

2.1 General Setting and Jurisdictional Areas (23 CCR 354.8 b)

The Plan Area for this GSP is the entire Petaluma Valley groundwater Basin, as defined by California Department of Water Resources (DWR) through its Bulletin 118 (DWR 2003), and was modified through basin reprioritization in 2018 (DWR 2020). The Basin within a northwest trending structural depression in the Coast Ranges immediately north of San Pablo Bay in the San Francisco Bay Hydrologic Region. The Basin is generally bounded on the east by the Sonoma Mountains and on the west by low-lying hills. As shown on **Figure 2-1**, the approximately 46,000-acre Basin extends from San Pablo Bay northward to a series of low hills bordering the Santa Rosa Plain Subbasin and includes the City of Petaluma and communities of Penngrove and Lakeville.

The Basin is part of the Petaluma River watershed, which is drained by the Petaluma River (**Figure 2-2**). The U.S. Geological Survey (USGS) modified the Petaluma River watershed to include parts of the Basin that extend outside the boundaries of the watershed; primarily along the southeast section of the boundary to better represent the complete area of the Basin referred to herein as the Petaluma Valley watershed (USGS 2021c).

Neighboring groundwater basins and subbasins are also shown on **Figure 2-1** and include the high-priority Sonoma Valley Subbasin (designated as basin 2-002.02 by DWR) to the east, the medium-priority Santa Rosa Plain Subbasin (designated as basin 1-55.01 by DWR) to the north, the very low-priority Wilson Grove Formation Highlands Basin (designated as basin 1-059 by DWR) to the northwest and the very low-priority Novato Valley Basin (designated as basin 2-030 by DWR) to the southwest. The Santa Rosa Plain GSA and the Sonoma Valley GSA are the only neighboring GSAs and were formed in June 2017 to implement SGMA in those two neighboring subbasins. As very low-priority groundwater basins/subbasins, the Wilson Grove Formation Highlands and Novato Valley are not required to form GSAs or develop GSPs; only high- and medium-priority basins are required to meet SGMA mandates.

Available technical information related to the hydrologic connection between the Petaluma Valley Basin and adjacent basins and subbasins is included in **Section 3** (Basin Setting) and provisions for coordinating with applicable GSAs and other local agencies within neighboring basins are described in **Section 7** (Implementation Plan).

While the Plan Area and jurisdiction of the Petaluma Valley GSA is limited to the Bulletin 118 Basin, technical studies (including monitoring data and groundwater-flow modeling) indicate that contributing watershed areas outside of the Bulletin 118 Basin are hydrologically connected and represent important sources of inflow (both in the form of surface streamflows and subsurface inflows) to the Bulletin 118 Basin. In recognition of the hydrologic connection with the contributing watershed areas, available data and information from these areas are also included in this GSP. Distinctions between metrics and features associated with the Bulletin 118 Basin and contributing watershed areas are clearly indicated or displayed in relevant sections and figures.

Figure 2-3 shows the jurisdictional boundaries of local agencies with water supply, water management, or land use responsibilities within the Basin, mutual water companies and public water systems, state and federal lands, and protected lands within the Basin. State lands include the Petaluma Marsh Wildlife Area within tidal marshlands in the southern portions of the Basin managed by the California Department of Fish and Wildlife and the Petaluma Adobe State Historic Park. Federal lands of the San Pablo Bay National Wildlife Refuge are also present within the tidal marshlands in the southern portions of the Basin and are managed by the U.S. Fish and Wildlife Service. Other protected lands located within the Basin and contributing watershed areas (**Figure 2-3**) include city parks and fields, county regional parks and preserves, special district properties and preserves, and nonprofit preserves. **Figure 2-3** also displays the DACs in the Basin. These communities are located in the City of Petaluma, which relies primarily on surface water supply, as described in **Section 2.3**.

The California Legislature assigned primary responsibility for protecting and enhancing California's surface water and groundwater quality to the State Water Resources Control Board (SWRCB), and the nine regional water quality control boards (Regional Boards). The SWRCB provides state-level coordination for the water quality control program and regulatory monitoring by establishing statewide policies and plans for implementing state and federal laws and regulations. The Regional Boards adopt and implement water quality control plans (basin plans), recognizing the unique characteristics of each region's natural surface water and groundwater quality, actual and potential beneficial uses, and surface water and groundwater-quality problems. Article 3 of Chapter 4 of the Porter-Cologne Act directs the Regional Boards to adopt, review, and revise basin plans, and provides specific guidance on factors that must be considered in the adoption of surface water and groundwater-quality objectives and implementation measures.

The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) implements water quality regulations in the watershed, including establishing Total Maximum Daily Loads for pathogens and sediment in Sonoma Creek, adopting General Waste Discharge Requirements for agricultural lands, dairies, recycled water, and for stormwater and wastewater discharges. The SFBRWQCB and the California Department of Toxic Substances Control are responsible for regulating the cleanup of contaminant sites and contaminated groundwater; the GSA has no authority to regulate groundwater contaminant site cleanups or the migration of plumes.

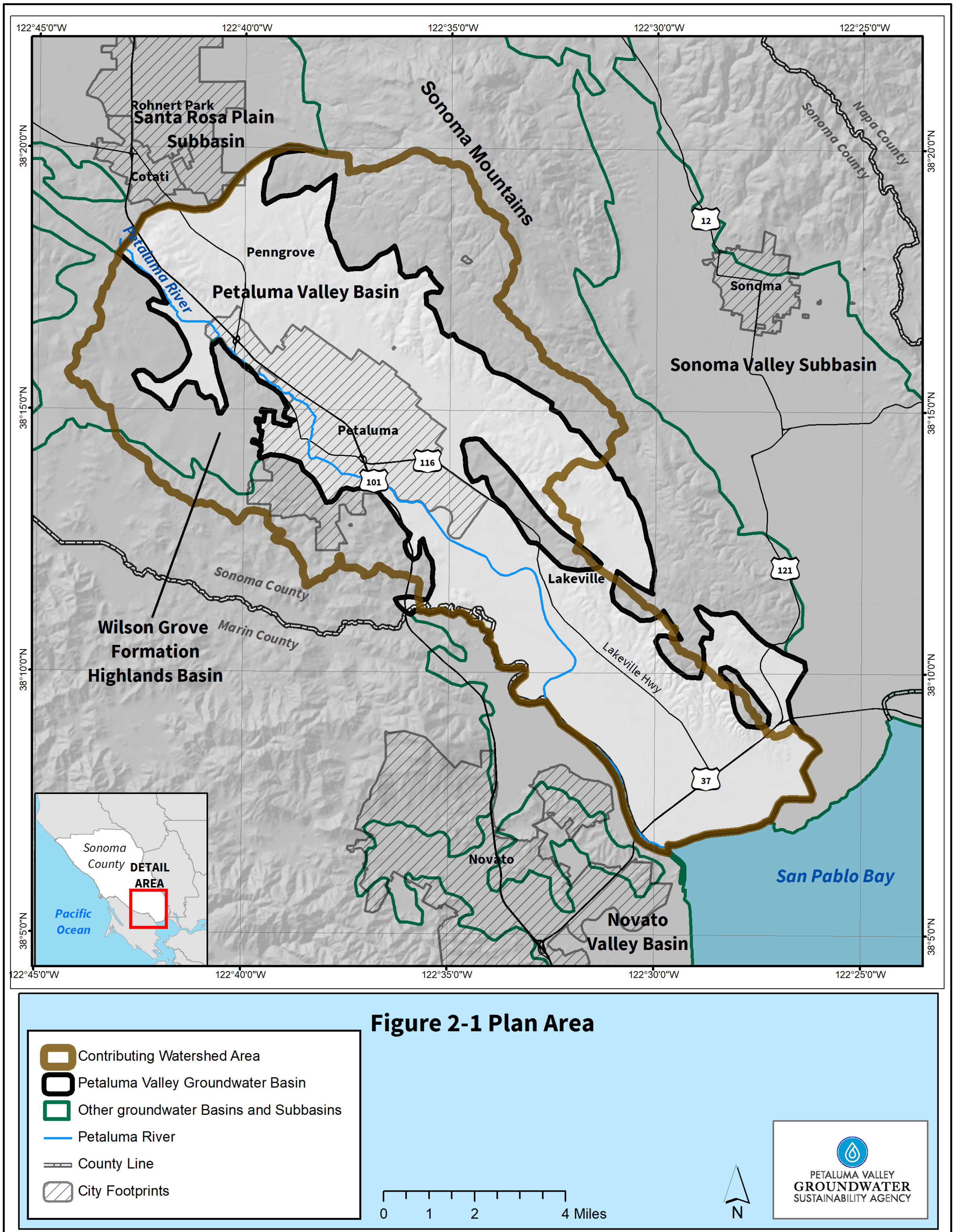

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Figure 2-1. Plan Area

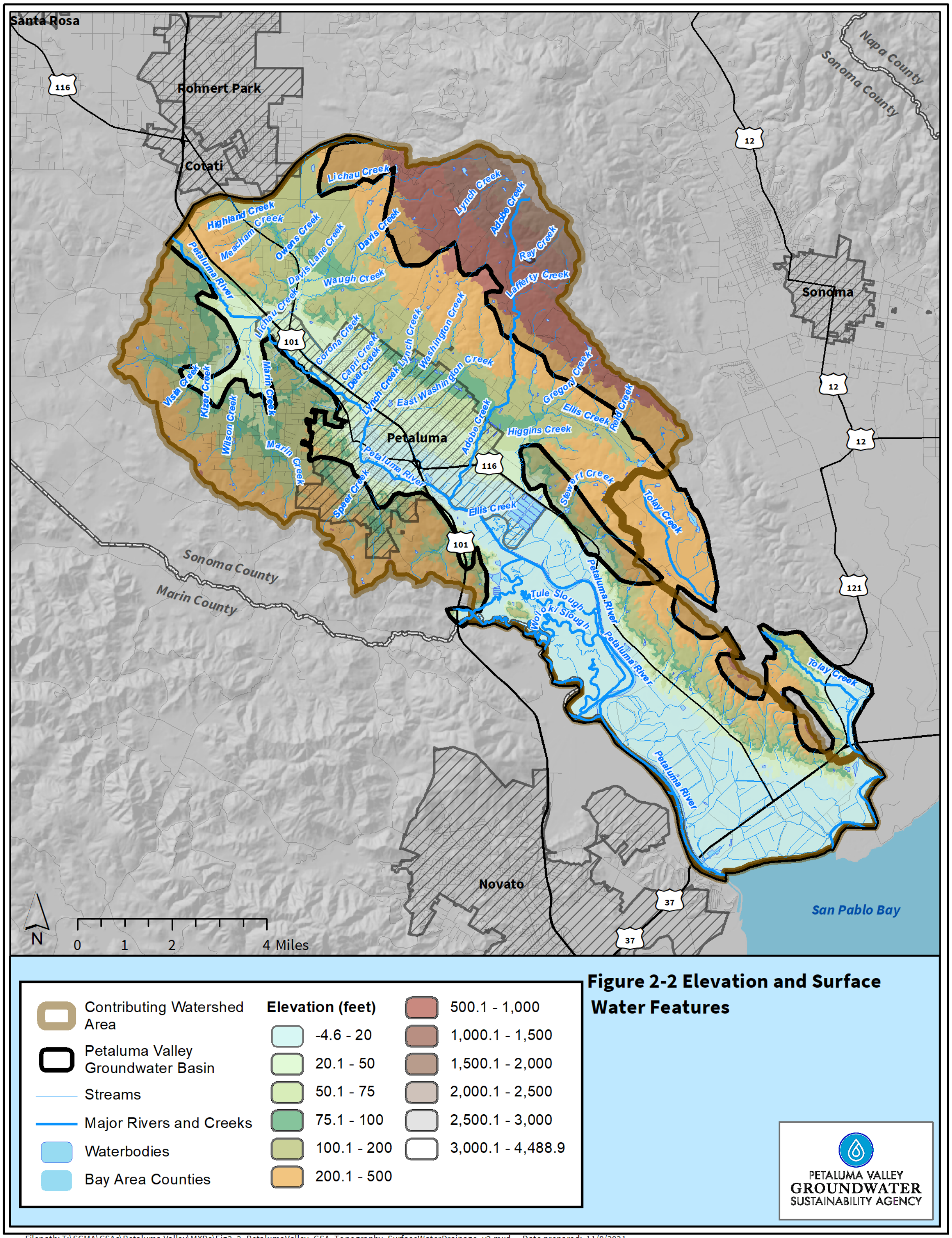

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Figure 2-2. Elevation and Surface Water Features

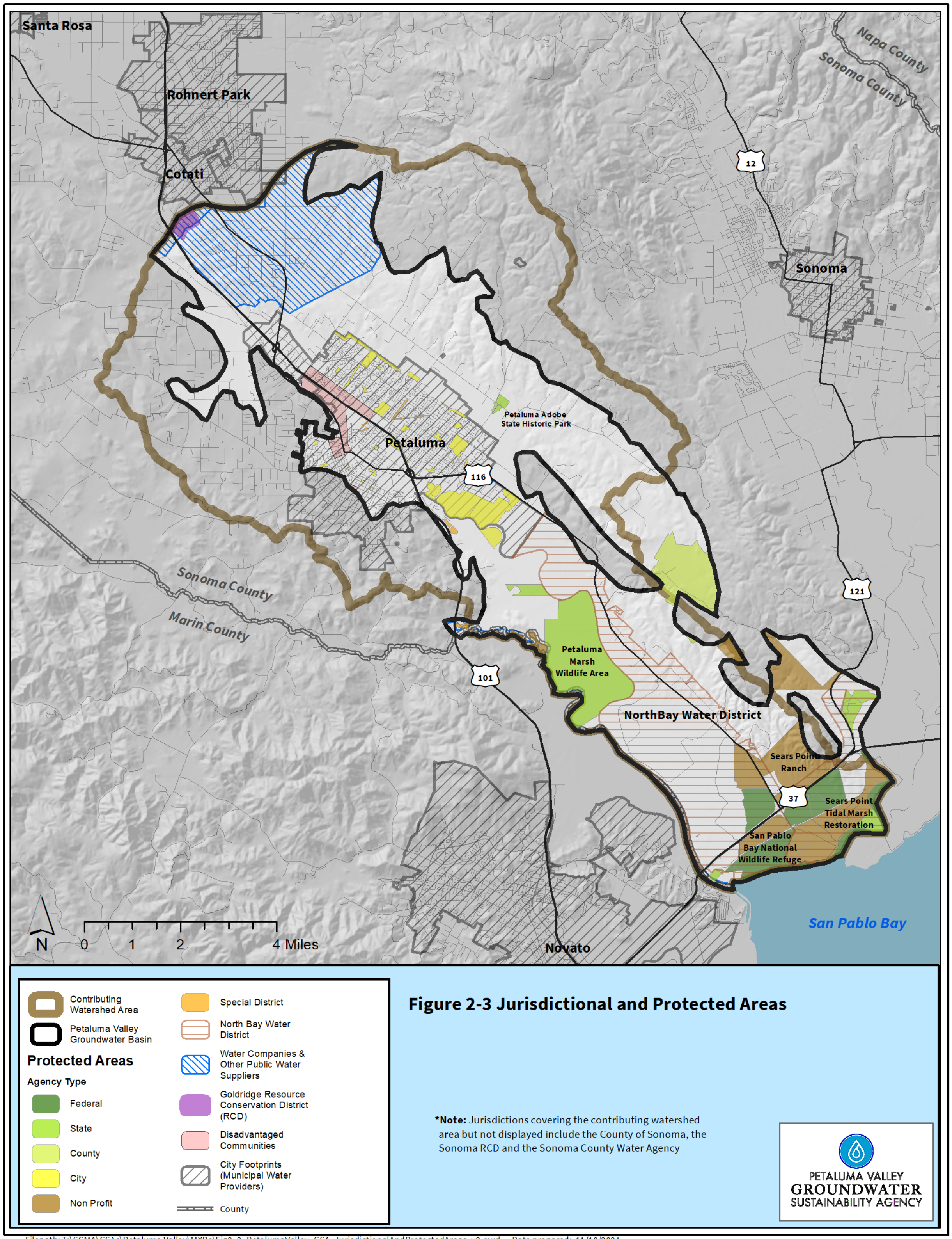

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Figure 2-3. Jurisdictional and Protected Areas

2.2 General Land Use Characteristics (23 CCR 354.8 b)

Land use maps for 1999, 2012, and 2013 are shown on **Figures 2-4a** through **2-4c**, respectively. Land use mapping over the past several decades provides a measure of growth and land use changes in the Basin, which includes increases in residential and commercial land uses and irrigated agriculture and a resulting decrease in native vegetation or water (**Figures 2-4a** and **2-4b**). **Figure 2-4c** presents more detailed classification of vegetation types within the Basin and contributing watershed areas from the Sonoma County Light Detection and Ranging and Vegetation Mapping Program.

Existing conditions correlate most closely with the Land Use Survey (DWR 2012) (**Figure 2-4b**), which indicates the majority of the land in the Basin is native vegetation or water (57 percent) followed by agriculture (23 percent) and residential, commercial, and industrial (16 percent). The majority of the native vegetation is located in the lower portions of the Basin along the tidal marshlands and in the hills northeast of the City of Petaluma. Throughout the last several decades, the primary irrigated agricultural crop has been vineyards for wine production. Pastures, grains and hay, and dairies, which are primarily not irrigated, are also important land use categories, with a total area exceeding that of irrigated agriculture. The urban and residential areas in the Basin include the City of Petaluma, unincorporated community of Penngrove, and areas of rural and semirural residential development.

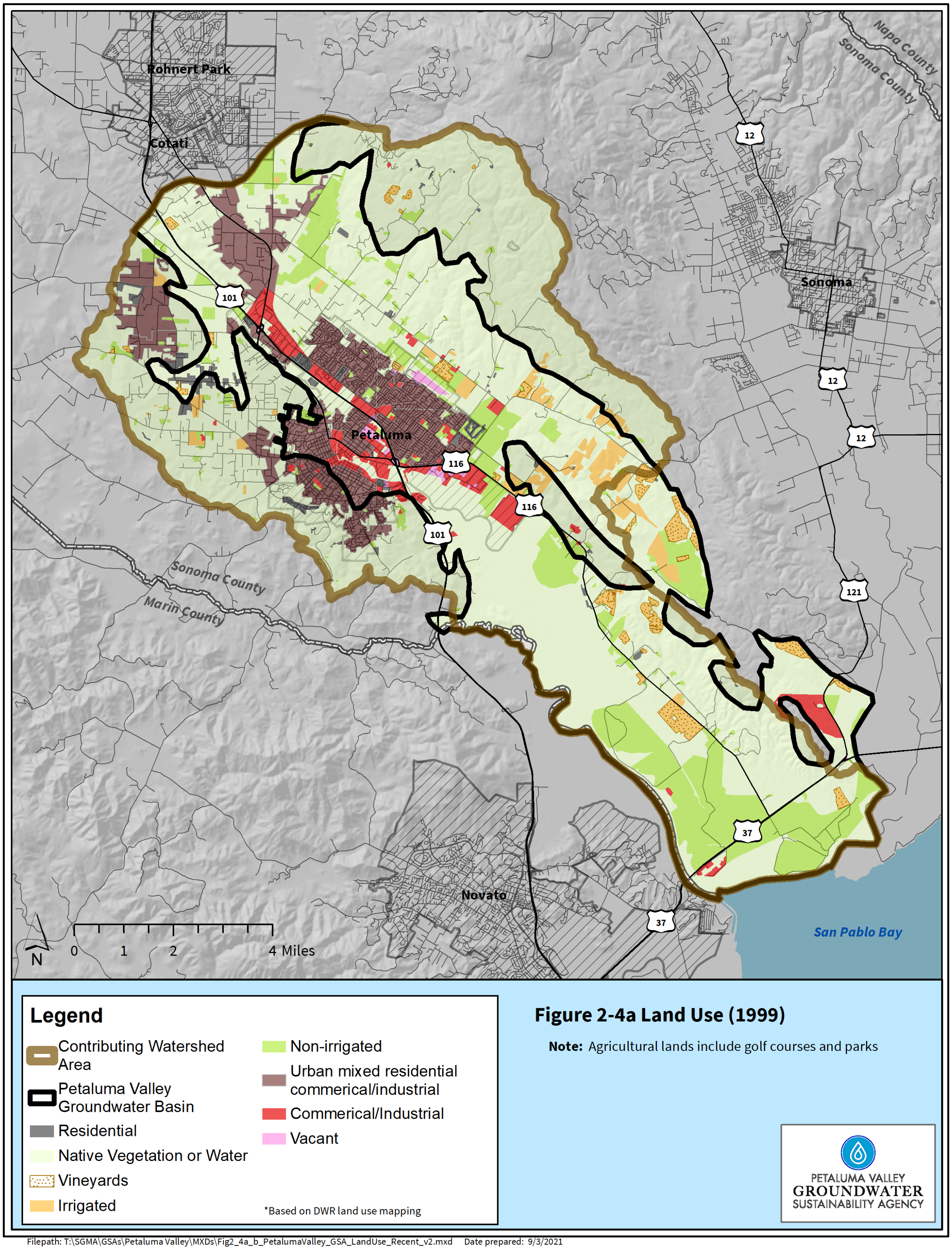

Figure 2-4a. Land Use (1999)

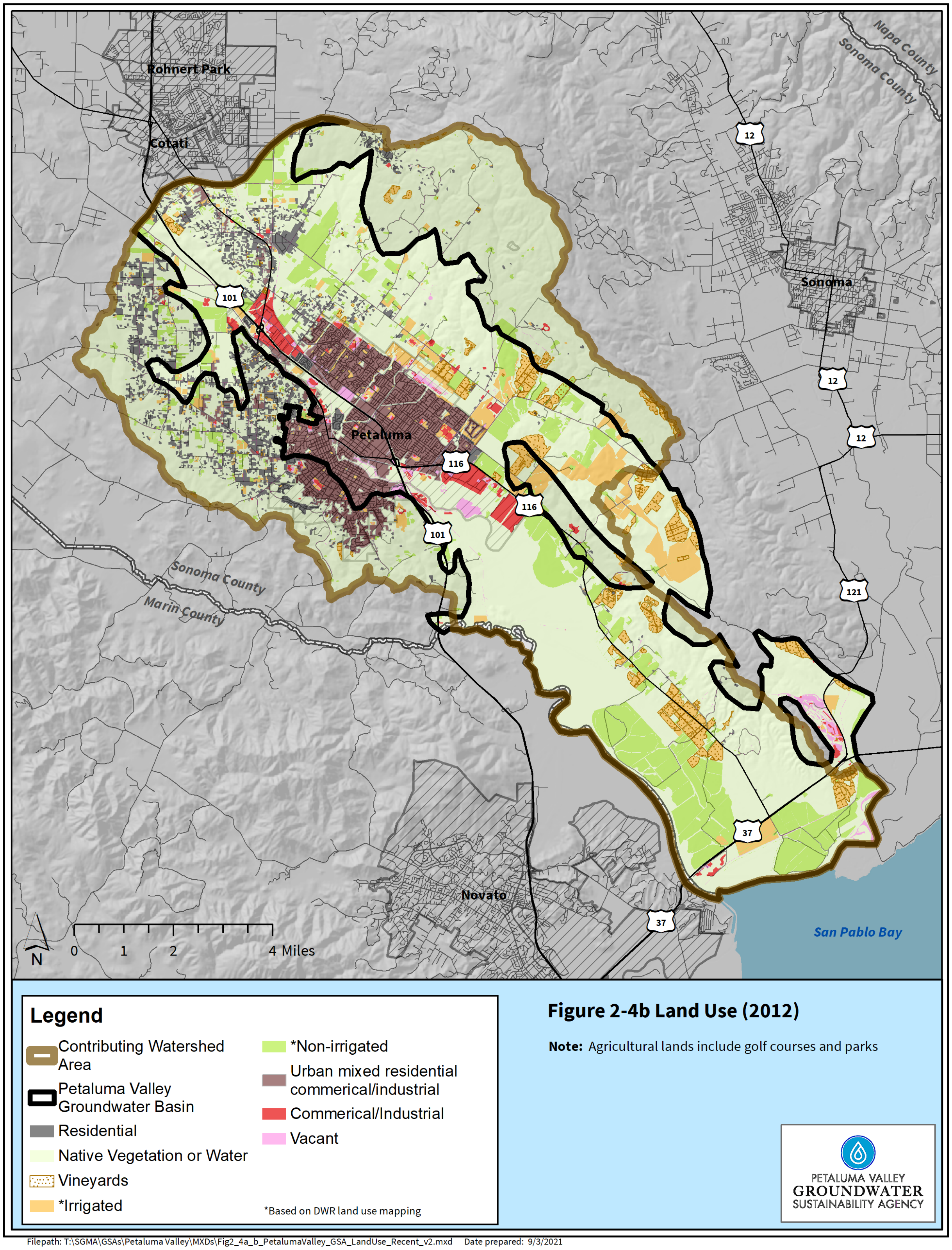

Figure 2-4b. Land Use (2012)

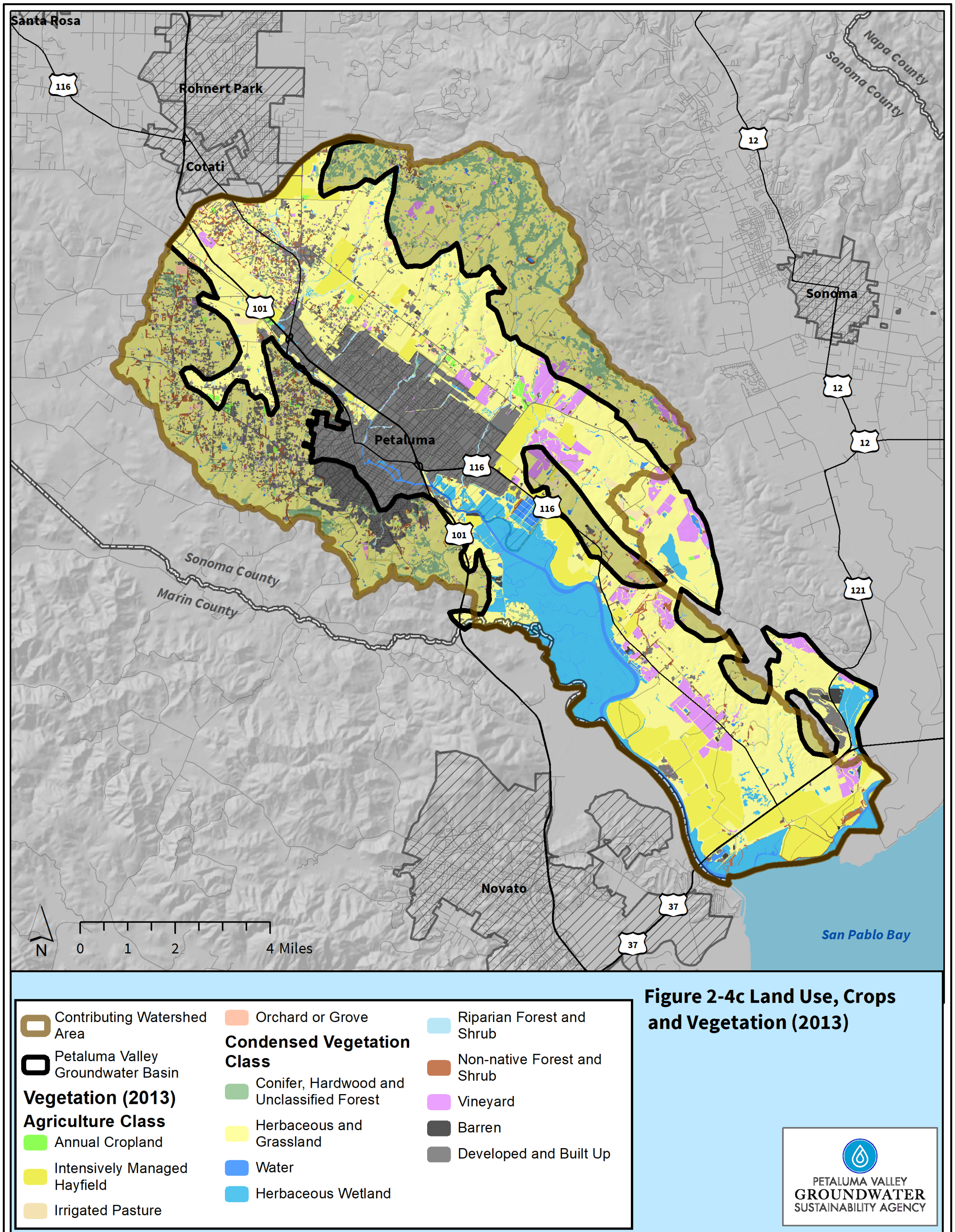

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Figure 2-4c. Land Use, Crops, and Vegetation (2013)

2.3 Water Source Types and Water Use Sectors (23 CCR 354.8 b)

The GSA recognizes that the efficient use and conjunctive management of the various available water sources is integral to achieving sustainable groundwater management in the Basin. The Basin has four primary water source types: groundwater, imported surface water, local surface water, and recycled water. An overview of the spatial distribution of the reliance on the four primary water source types by primary water use sectors in the Basin is shown on **Figure 2-5**. Additional details on water uses associated with the Basin water budget are described in **Section 3** (Basin Setting), and additional information on the availability and feasibility for future uses is included in **Section 6** (Projects and Actions).

Historically, the Petaluma Valley relied completely on its local groundwater and surface water resources until 1972 with the completion of the Petaluma Aqueduct and initiation of Russian River-imported surface water deliveries resulted in a mix of imported surface water and groundwater to meet water supply demands. Deliveries to the City of Petaluma have been between 7,000 and 11,000 acre-feet per year (AFY) over the past 25 years. Russian River-imported water supply accounts for about 60 percent of the Basin water supply today.

Unlike a good portion of the rest of Sonoma County, irrigated pastures have historically accounted for most of the agricultural demand expansion, from about 4,000 AFY in 1969 to nearly 10,000 AFY in 2013 in the Basin. Since that time, irrigated pasture demand has dropped significantly to less than 2,000 AFY. Groundwater pumping for irrigated crops in the Basin was estimated through the groundwater model, ranging from 2,000 AFY to nearly 10,000 AFY historically, and has averaged approximately 2,000 AFY within the last 5 years. Urban and private systems groundwater demands have ranged from 0 AFY to 1,400 AFY with an average of 200 AFY during the current period. Rural residential well pumping has ranged from 100 AFY to 300 AFY with an average of 300 AFY during the current period. Due to incomplete well permit information, the exact number of domestic wells is unknown but is estimated to be between 400 and 600. Today, groundwater accounts for approximately 20 percent of the overall Basin water supply.

Deliveries of recycled water commenced in 1990 and is used for agricultural, landscape and turf irrigation. An estimated 700 AFY to 1,400 AFY between 1990 and 2018 has been used for irrigation of pastures and vineyards, replacing groundwater pumping. Recycled water accounts for about 20 percent of the water supply in the Basin.

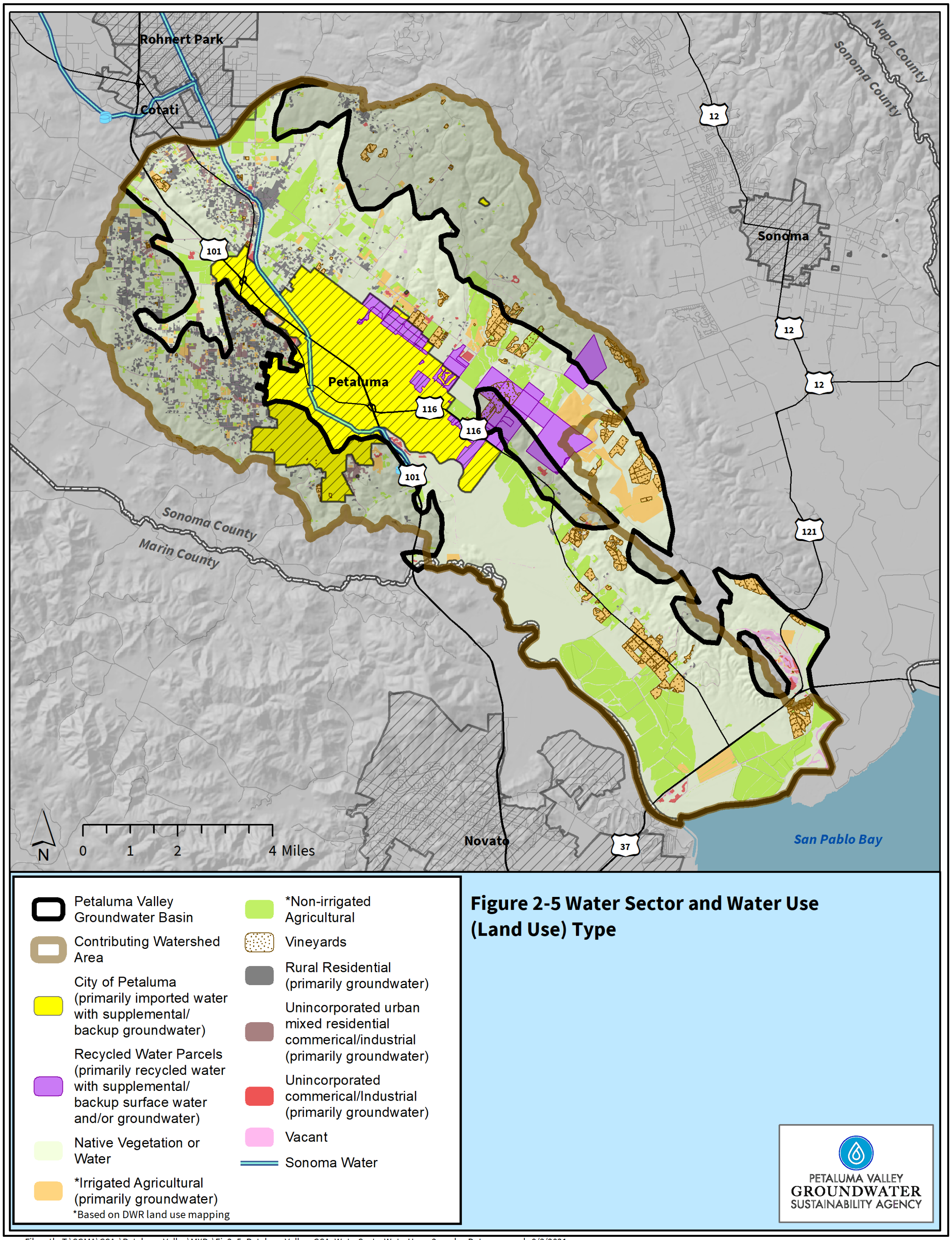

Figure 2-5. Water Sector and Water Use (Land Use) Type

2.3.1 Groundwater

Groundwater resources represent an important, and often only, source of water supply for many communities and water users in the Basin. **Figure 2-6a** presents a map showing the approximate location and density of water wells within the watershed, based on available data from DWR. **Figure 2-6b** illustrates the depth of groundwater wells. While data are not complete due to old or incomplete well logs, shallower wells (less than 200 feet deep) are generally located in the northwest area of the Basin and watershed. These groundwater resources are relied upon to varying degrees by rural and urban residents, vineyards, wineries, dairies, and commercial and industrial users, and also support streamflows and ecosystems present in the Basin. Local groundwater represents an important supplemental source of supply for the City of Petaluma, which operates a municipal wellfield within the watershed.

2.3.2 Imported Surface Water

Imported surface water consists of Russian River surface water sourced from Sonoma Water's production facilities located outside the watershed that is delivered via aqueduct to the City of Petaluma, as shown on **Figure 2-5**. Imported water represents the primary source of water for urban residents and businesses that are served by the City of Petaluma.

2.3.3 Local Surface Water

Local surface water from the Petaluma River and its tributaries represents an important source of supply for some water users. Information on the approximate amounts of surface water is available through reported surface water diversions filed with the SWRCB.

2.3.4 Recycled Water

Recycled water is treated to tertiary standards at the Ellis Creek Water Recycling Facility (ECWRF) (**Figure 2-1**) and is used for crop and landscape irrigation in lieu of using groundwater or imported water. The ECWRF opened in July 2009 and provides advanced secondary treatment, anaerobic digestion, and tertiary treatment of wastewater. The treatment facility treats domestic, commercial, and industrial wastewater generated in the City and in unincorporated Penngrove. The facility treats on average 4.6 million gallons of wastewater each day and 1,900 million gallons annually (City of Petaluma 2021).

Tertiary-treated recycled water, distributed through a system of pump stations and pipelines, provides irrigation for agriculture, golf courses, school yards, parks, and other landscaped areas. Urban use of recycled water saves potable water and supplements the City's water supply. Agricultural use of recycled water reduces the amount of groundwater pumping for local farming, including dairies and vineyards.

Recent production and deliveries of recycled water from the ECWRF are approximately 650 AFY within the City's service area and 1,115 AFY outside of the City's service area (primarily to agricultural customers).

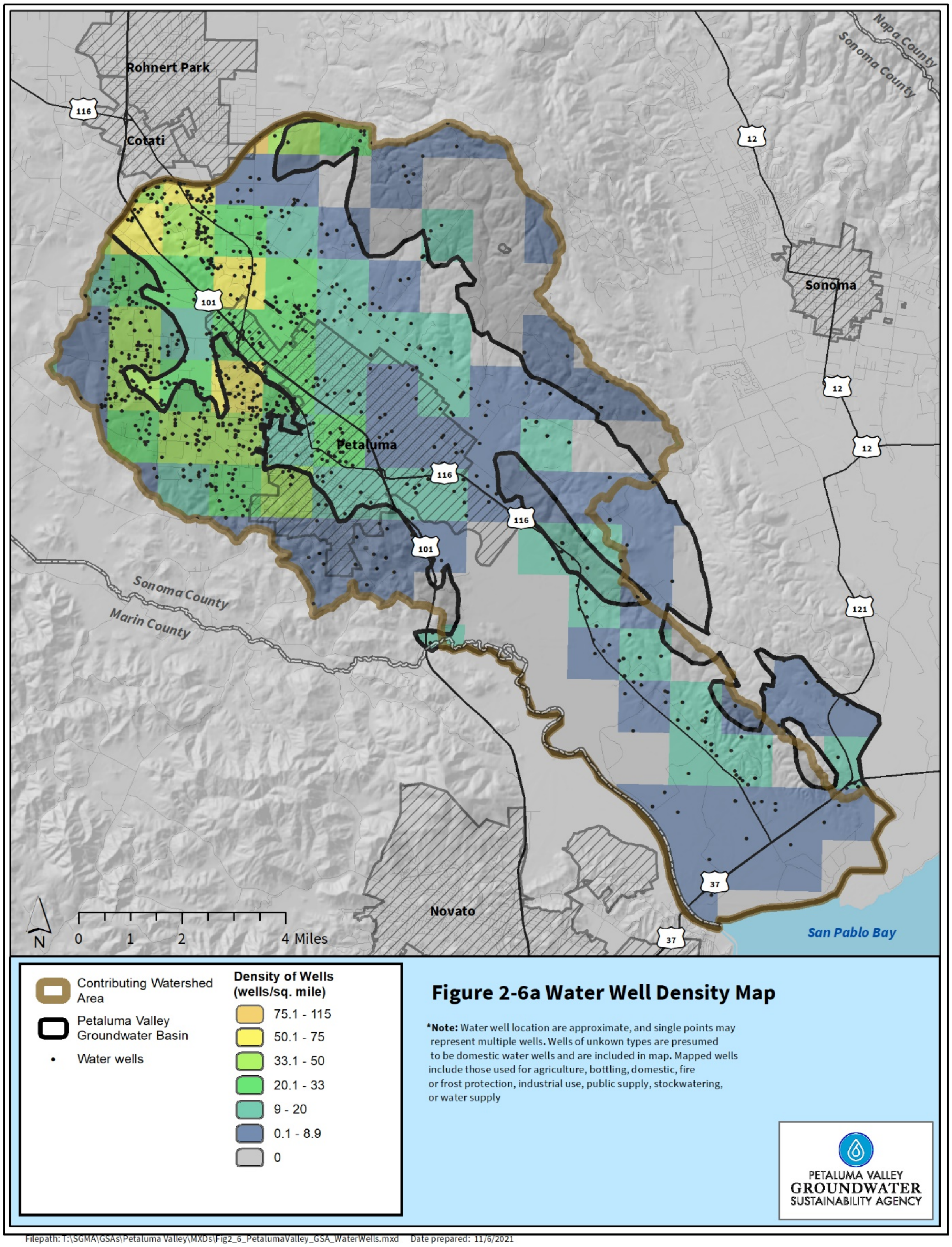

Figure 2-6a. Water Wells

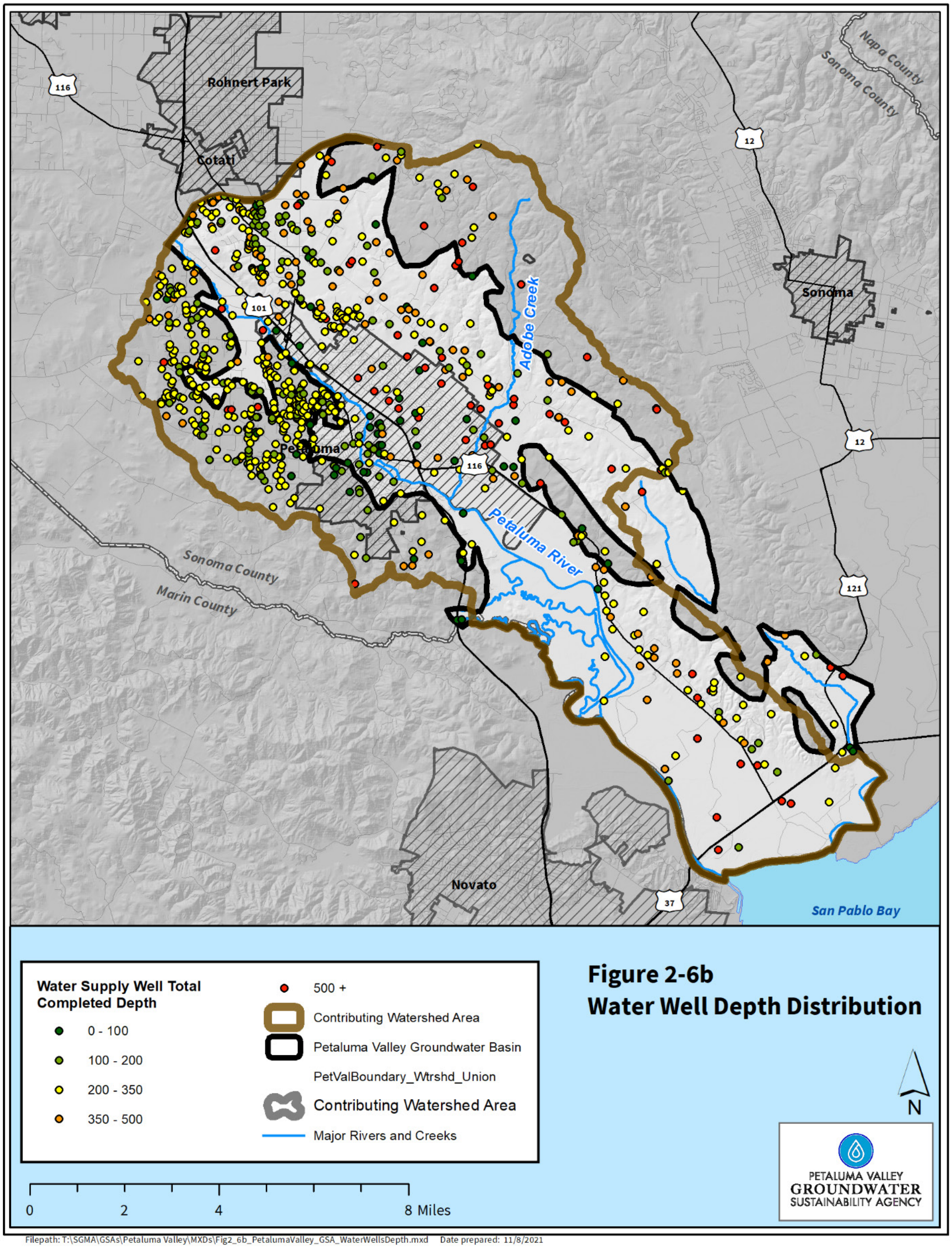

Figure 2-6b. Water Well Depth Distribution

2.4 Existing Monitoring Programs and Networks (23 CCR 354.8 c, d, e)

Existing monitoring programs and networks within the Basin have been developed and implemented by many agencies, organizations, and volunteers for a variety of purposes. This section provides a description of the existing monitoring programs and networks. An assessment of the existing monitoring networks and programs for their suitability to comply with DWR's GSP Regulations, including identification of data gaps, is described in **Section 5** of this GSP (Proposed Monitoring Program).

2.4.1 Groundwater-level Monitoring

Groundwater-level data in the watershed have been collected by the DWR since the 1950s. Historically, these have included approximately 24 wells and currently include 13 wells, which are privately owned wells monitored through voluntary agreements with DWR. Most of these wells were incorporated into DWR's monitoring network between the mid-1950s and 1981. Measurements are generally collected from these wells semiannually in the spring and fall, although a subset of wells are monitored monthly (**Figure 2-7a**).

The Groundwater-level Monitoring Network has been supplemented through the California Statewide Groundwater Elevation Monitoring (CASGEM) program since approximately 2012. Monitoring responsibilities for CASGEM are split between the City of Petaluma, which monitors city wells, and Sonoma RCD, which monitors private wells under contract with the GSA. All CASGEM data are reported by the City of Petaluma, and includes nine wells as follows:

- Five are former public-supply wells that are located within the city's boundaries. The remaining four wells in the monitoring network are privately owned.
- One is a private well in the north part of the basin between Penngrove and Cotati.
- Two private wells are in east Petaluma, one just east of the city limits on Adobe Road, and the other in the hills to the east of the wastewater treatment plant on Lakeville Highway.
- One private well is southeast of Petaluma at the Sonoma Raceway near Highway 37.

Permit Sonoma administers a Groundwater Monitoring Program, which requires the measurement and reporting of groundwater levels on a quarterly or monthly basis for all cannabis permits and commercial/industrial projects requiring a use permit and use more than 0.5 AFY of water.

Groundwater-level data from DWR, SWRCB, and the USGS are also available to the public. The SWRCB GeoTracker program provides groundwater-level monitoring data on a number of soil and groundwater cleanup sites in the Basin. The USGS operates the National Water Information System (NWIS; https://waterdata.usgs.gov/nwis), which is a database of surface water and groundwater data.

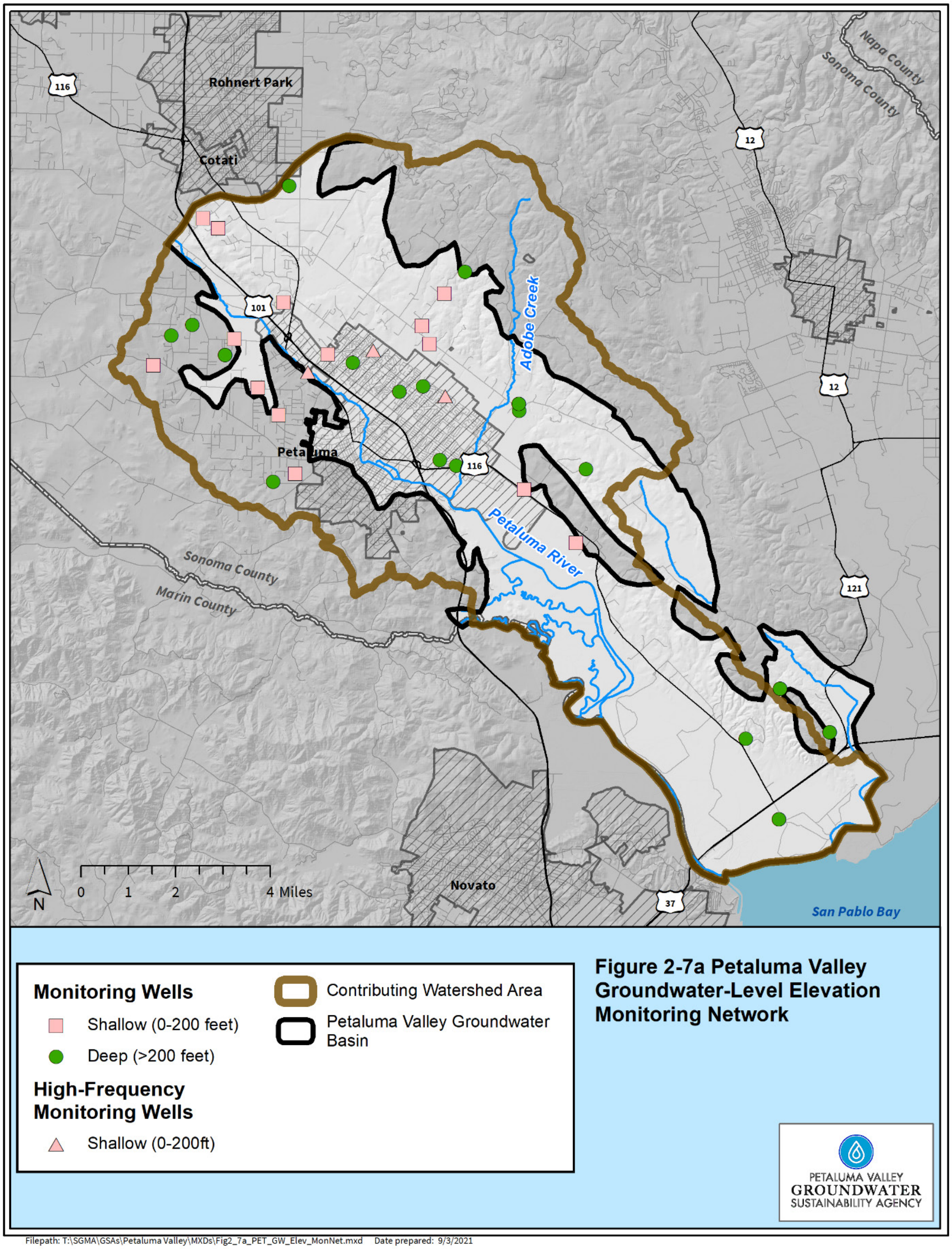

Figure 2-7a. Petaluma Valley Groundwater-Level Elevation

2.4.2 Groundwater-quality Monitoring

Groundwater-quality data have been collected through state and federal programs and initiatives described in the following subsections. The synthesis and evaluation of results from water quality monitoring programs are described in **Section 3** (Basin Setting).

2.4.2.1 Public Water Supply Well Monitoring

The SWRCB's Division of Drinking Water (DDW) monitors public-water-system wells for CCR Title 22 requirements relative to levels of organic and inorganic compounds such as metals, microbial compounds, and radiological analytes. Data are available for active and inactive drinking water sources, for water systems that serve the public, and wells defined as serving 15 or more connections, or more than 25 people per day. In the Basin, DDW wells were monitored for Title 22 requirements.

2.4.2.2 SWRCB Groundwater Ambient Monitoring and Assessment Program

Established in 2001, the Groundwater Ambient Monitoring and Assessment (GAMA) Program monitors groundwater quality throughout the State of California. GAMA is intended to create a comprehensive groundwater monitoring program and increase public access to groundwater-quality and contamination information. GAMA receives data from a variety of monitoring entities, including DWR, USGS, and the SWRCB.

2.4.2.3 Water Data Library

DWR monitors groundwater quality and reports the results through its Water Data Library. Samples are collected from a variety of well types, including irrigation, stock, domestic, and some public-supply wells. Wells are not sampled regularly, and most wells have only a few sampling measurements and large temporal gaps between the results. Constituents most frequently monitored include chloride, sodium, calcium, boron, magnesium, and sulfate. Measurements taken include conductance, pH, total alkalinity, and hardness. Additional dissolved nutrients, metals, and total dissolved solids (TDS) are also sampled but have fewer sample results available.

2.4.2.4 U.S. Geological Survey

The groundwater study conducted by the USGS within the Petaluma Valley Basin included the collection and analysis of groundwater-quality data. Water quality analyses have included major ions, trace elements, nutrients, and stable isotopes (oxygen-18 and deuterium), tritium, the radioactive isotope of carbon (carbon-14), and the stable isotope carbon-13. Data collected by the USGS through this study are available on the NWIS database (https://waterdata.usgs.gov/nwis).

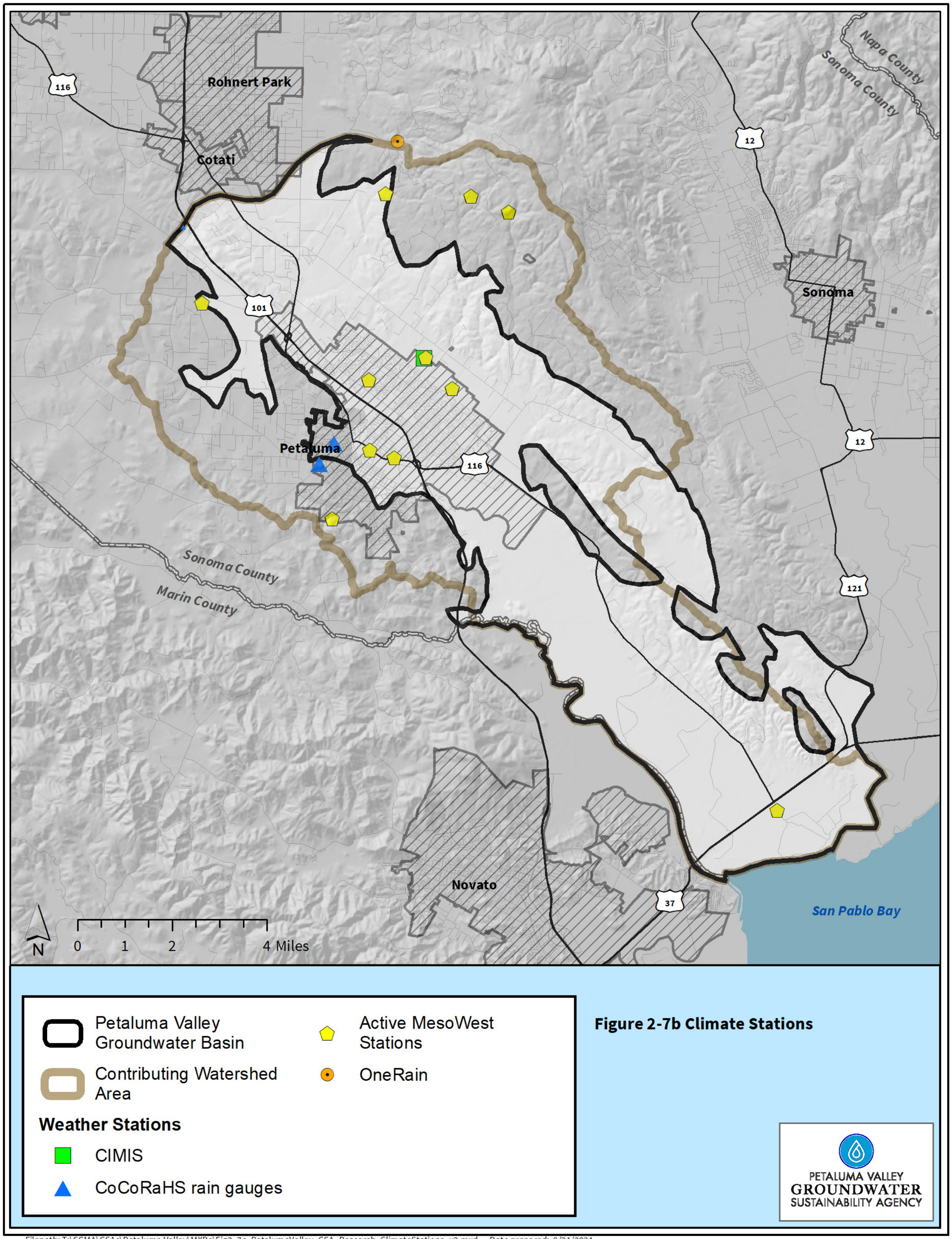

Figure 2-7b. Climate Stations

2.4.3 Climate Monitoring

Climate data (**Figure 2-7b**) in the Basin are collected by stakeholders and agencies, including:

- Western Weather Group (http://www.westernwx.com/sonoma)
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS 2021)
- Sonoma Water, OneRain program (https://sonoma.onerain.com/home.php)
- California Irrigation Management Information System, operated by DWR (https://cimis.water.ca.gov/Stations.aspx)
- National Oceanic and Atmospheric Administration (NOAA)

Climate-related monitoring stations in the watershed provide information necessary for forecasting weather conditions, flood preparedness, drought preparedness, water supply planning, and for determining the Basin water budget. Climate monitoring stations may include sensors to collect data on rainfall, air temperature, relative humidity, wind speed and direction, solar radiation, and soil temperature and moisture.

The primary weather station in the Petaluma Valley Basin that has been used to calculate mean annual rainfall is the Western Regional Climate Center climate station in the City of Petaluma (046826). Data are available from 1913 to the present at this station.

2.4.4 Surface Water Monitoring

Existing continuous surface water monitoring locations in the watershed are operated by the USGS, Sonoma Water (OneRain), and the City of Petaluma (**Figure 2-7c**). The USGS previously maintained two streamflow gages on the Petaluma River and one on San Antonio Creek (**Figure 2-7c**). Stream gage 11459150 (Petaluma River at Copland Pumping Station) is located near the City of Petaluma, along the northern end of the tidally influenced reach of the river. Data collection at this streamflow gage began in February 1999 and ended in November 2016 (USGS 2021a). Because water-surface elevation in the Petaluma River fluctuates with the tides, beginning in 2011, streamflow data for this stream gage were tidally filtered to provide a better understanding of streamflows at the stream gage.

Streamflow gage 11459000 (Petaluma River at Petaluma) was located north of the City of Petaluma, along the non-tidally influenced reach of the river. Data collection at this stream gage began in October 1948 and ended in September 1963 (USGS n.d.).

The USGS also historically operated streamflow gage 11459300 (San Antonio Creek near Petaluma) which was located on San Antonio Creek approximately 3 miles upstream of the confluence with the Petaluma River at the Petaluma Marsh. Data collection at this stream gage began in August 1975 and ended in September 1981 (USGS 2021b).

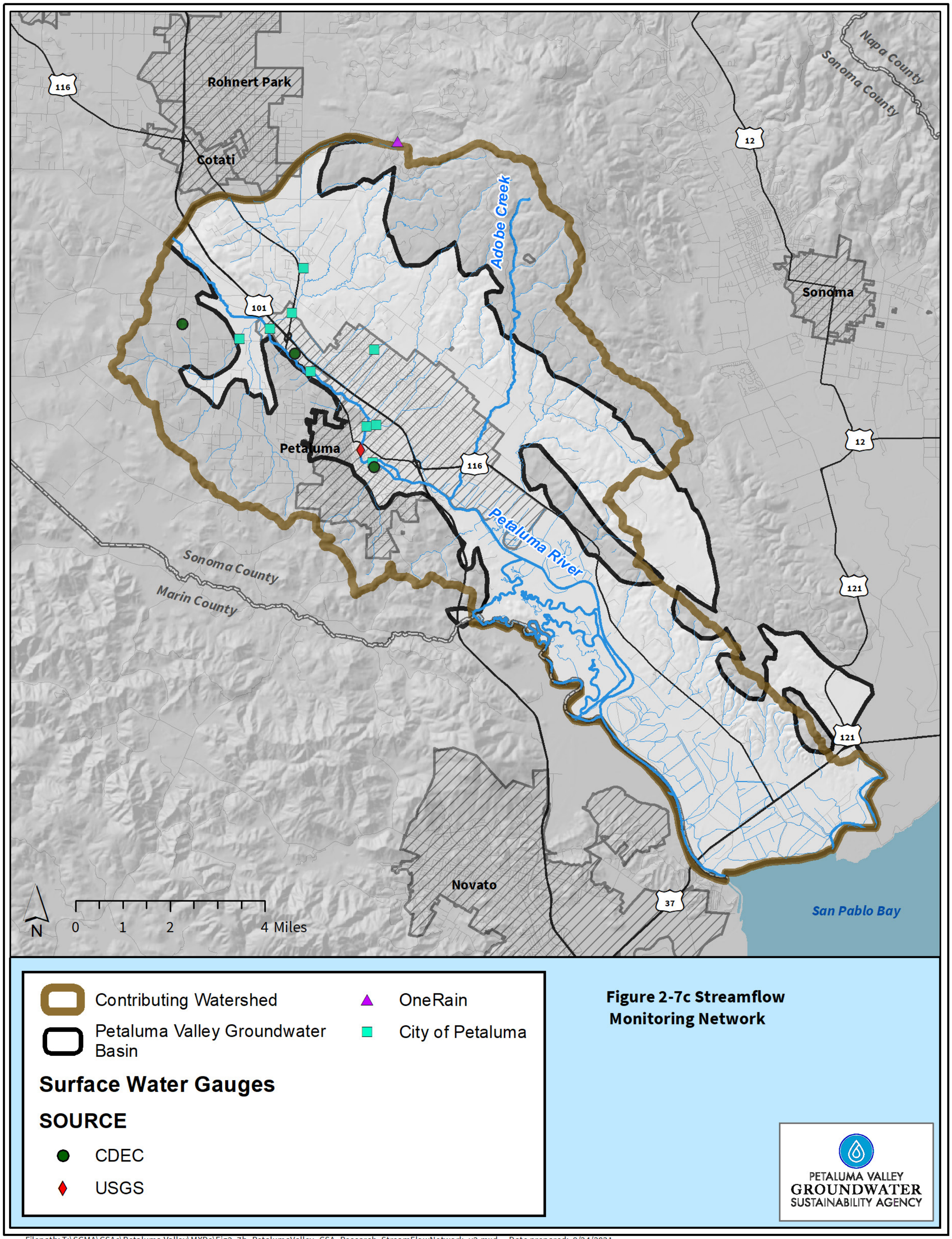

Figure 2-7c. Streamflow Monitoring Network

2.4.5 Land Surface Subsidence Monitoring

In the Petaluma Valley, a global positioning system (GPS) station monitored by the University NAVSTAR Consortium's (UNAVCO) Plate Boundary Observatory (PBO) program is available for use as an indicator for subsidence. The UNAVCO PBO network consists of a network of about 1,100 continuous GPS and meteorology stations in the western United States used to monitor multiple pieces of information, including subsidence. There is one station in the Basin located near the Petaluma Municipal Airport (Station P198). There are currently no regularly scheduled theodolite or total station surveys and no extensometers in the Petaluma Valley.

2.5 Existing Management Programs and Studies (23 CCR 354.8 c, d, e)

There are many existing and previous water management programs, studies, and initiatives covering the Petaluma Valley Basin that have been developed for a variety of purposes by multiple agencies and organizations. This section summarizes those deemed most relevant to groundwater management planning and indicates the type of information to be incorporated into subsequent sections of this GSP.

2.5.1 USGS Petaluma Valley Groundwater Study

A study conducted by the USGS and funded by the City of Petaluma, Sonoma Water, and the USGS underpins much of the development of the Basin setting of the GSP. The objective of the study is to develop an updated assessment of the hydrogeology, geochemistry, and geology of the Petaluma Valley. Tasks include development of a geographical information system database, collection and interpretation of water quality data and streamflow measurements, estimates of groundwater recharge and annual groundwater pumping, and development of a groundwater-flow model. The study was completed in 2021 with publication of a report in 2022 consisting of the following major sections:

- Hydrogeologic characterization
- Data collection and interpretation
- Numerical groundwater-flow model

The study uses information from previous studies and integrates them with a digital geologic map, borehole, and geophysical data to create a three-dimensional geologic framework model of the Basin and surrounding Petaluma Valley watershed that defines the subsurface stratigraphic and structural architecture for the study area. The integrated numerical groundwater-flow model simulates groundwater flow, surface water flow, and landscape processes in the basin for 56 years of historical hydrology from 1959 to 2015. The model incorporates the updated hydrogeologic model to represent the multi-layered aquifer system and was calibrated using groundwater-level data from groundwater monitoring wells and measured streamflow data from streamflow gages.

2.5.2 Bay Area Integrated Regional Water Management Plan

In November 2002, California voters approved Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002. The Act encourages regional cooperation in water resources planning by providing grant funding for projects identified in a regional plan, referred to as an Integrated Regional Water Management Plan (IRWMP). DWR designed the IRWM planning process to be consistent with the California Water Plan, a statewide water resources planning document that is updated periodically, and intends that IRWMPs and future updates of the California Water Plan be integrated further in the future.

The Bay Area IRWMP (San Francisco Bay Area IRWMP Coordinating Committee 2019) defines the Bay Area region according to the SFBRWQCB's (Region 2) jurisdiction, which includes the Petaluma Valley Basin. This region includes all or major portions of the nine counties that surround the San Francisco Bay. The Bay Area IRWMP is a living document and involves a diverse group of water supply, water quality, wastewater, stormwater, flood management, watershed and habitat agencies, local governments, environmental groups, business groups, and community-based organizations (San Francisco Bay Area Region Coordinating Committee 2019).

Stakeholders from the nine counties developed four Functional Areas to identify specific needs and challenges related to each specific functional area, describe water management strategies to address these needs, and develop a list of potential strategies and implementation projects that maximize benefits and enhance opportunities for regional cooperation within a given functional area. The four Functional Areas are as follows:

- Water Supply and Water Quality
- Wastewater and Recycled Water
- Flood Protection and Stormwater Management
- Watershed Management-Habitat Protection and Restoration

2.5.3 Urban Water Management Planning

Urban Water Management Plans (UWMPs) are prepared every 5 years by California's urban water suppliers to support long-term resource planning and ensure adequate water supplies are available to meet existing and future water demands. Every urban water supplier that either provides more than 3,000 AFY or serves more than 3,000 customers is required to assess the reliability of its water sources over a 20-year planning horizon considering normal, dry, and multiple dry years. The plans are submitted to DWR, which then reviews the submitted plans to ensure they have completed the requirements identified in the UWMP Act (Division 6 Part 2.6 of the Water Code Section 10610 - 10656).

Within the Basin, UWMPs are prepared by Sonoma Water (as a wholesaler; Sonoma Water 2021) and the City of Petaluma (as a water retailer; City of Petaluma 2021). The two UWMPs were adopted in 2021. The UWMPs discuss and describe the following:

- Existing water supplies and infrastructure

- Projected water demands over the next 20 years, based on population growth projections, land use designations and growth policies in city and county general plans

- Projected water supplies available over the next 20 years, the reliability of that supply, and general plans for water supply projects
- Current and planned water conservation activities, targets, and compliance
- A water shortage contingency analysis
- A comparison of water supply and water demand over the next 20 years under different hydrological assumptions (normal year, single dry year, 4 consecutive dry years)

As local groundwater makes up a portion of the urban water supply within the Basin, the UWMPs also discuss and describe groundwater production facilities, historical and projected groundwater use, and the conditions of the groundwater basin. These UWMPs serve as a routine mechanism for local urban water providers to coordinate and plan for future urban groundwater use. The most recent projections for future urban groundwater use are incorporated into the future demand projections in **Section 3** (Basin Setting). UWMPs do not consider rural residential, agriculture, and small municipal/mutual water systems.

In addition to the UWMPs required by the state, local urban water providers perform other water supply planning activities related to groundwater, including development of water-master plans, preparation of water supply assessments for larger proposed developments (more than 500 dwelling units or equivalent), updates of city and county general plans, and other activities. Information regarding some of these activities is summarized as follows:

- The City of Petaluma developed a Groundwater Feasibility Study (Petaluma 2003) to evaluate groundwater supplies as part of the city's General Plan update.
- Sonoma Water developed the 2018 Water Supply Strategies Action Plan in coordination with its water contractors to increase water supply system reliability, resiliency, and efficiency in the face of limited resources, regulatory constraints, and climate change uncertainties. The 2018 Water Supply Strategies Action Plan is an update of a 2013 plan and incorporates SGMA-related requirements and initiatives (Sonoma Water 2018).
- Beginning with the passage of Senate Bill (SB) 610 in 2002, water supply assessments must be furnished to local governments for inclusion in any environmental documentation for certain projects that are subject to the CEQA. The water supply assessments are required to determine water supply sufficiency for a 20-year projection in addition to the demand of existing and other planned future uses.

2.5.4 Water Conservation Programs

Numerous regional and local water conservation programs are operational in the Plan Area, including the Sonoma-Marin Saving Water Partnership, the LandSmart Program, and the Sustainable Winegrowing Program.

These programs are described in the following sections; however, it is anticipated that changes will likely occur as a result of sweeping legislation approved in 2018: Assembly Bill (AB) 1668 (Friedman) and SB 606 (Hertzberg), which lay out a new long-term water conservation framework for California. The framework addresses both the urban and agricultural sectors, with goals to establish long-term improvements in water conservation and drought planning that recognize the need to adapt to climate change and the resulting longer and more intense droughts in California. The development of programs and initiatives is organized around the following four primary goals:

1. Use water more wisely.
2. Eliminate water waste.
3. Strengthen local drought resilience.
4. Improve agricultural water use efficiency and drought planning.

To fully plan, develop, and implement the new framework, DWR and the SWRCB are working together in collaboration with stakeholders to develop new standards for the following:

- Indoor residential water use
- Outdoor residential water use
- Commercial, industrial, and institutional (CII) water use for landscape irrigation with dedicated meters
- Water loss

Based on these standards, urban water suppliers will be required to stay within annual water budgets for their service areas. In addition, water suppliers will need to report on implementation of new performance measures for CII water use.

The legislation also made important changes to existing urban and agricultural water management planning, and enhanced drought preparedness and water shortage contingency planning for both urban water suppliers and small water systems and rural communities. Currently, state agencies are conducting necessary studies and investigations as well as developing standards and performance measures, web-based tools and calculators, data and data platforms, and reports and recommendations for the adoption of new regulations.

2.5.4.1 Sonoma-Marin Saving Water Partnership

The Sonoma-Marin Saving Water Partnership represents 10 water utilities in Sonoma and Marin counties that are signatories to the California Water Efficiency Partnership and have joined to create a regional approach to water use efficiency. Within the Basin, these utilities include the City of Petaluma and Sonoma Water. Each of these member utilities have water conservation programs to assist their communities in reducing water use. Water conservation and water use efficiency program elements specific to the Sonoma-Marin Saving Water Partnership include the following:

- Establishing a conservation coordinator, water waste prohibition, assistance and water loss control programs (audits, leak detection, and repair).
- Metering urban water and conservation pricing (tiered structure).
- Developing and maintaining public information and school education programs on water and conservation.
- Increasing conservation through specific urban residential programs for indoor (high-efficiency toilets, fixtures, and washers) and outdoor landscaping assistance, surveys, and retrofits.
- Increasing conservation through specific industrial and large landscape assistance, surveys, and retrofits.
- Initiating rebate programs for high-efficiency appliances and fixtures.
- Training for qualified water efficient landscapers that provides education on proper plant selection for local climates, irrigation system design and maintenance, and irrigation system programming and operation.
- Offering an online water wise gardening website that offers a Mediterranean and native plant list, design and garden installation tips, and irrigation system design and maintenance information.
- Providing a green business program that provides businesses with water and energy conservation information and incentives, to reduce waste and prevent pollution.

More information pertaining to the bulleted items listed above is available at http://www.savingwaterpartnership.org.

2.5.4.2 Local Landscape Ordinances

The State Legislature adopted the Water Conservation in Landscaping Act of 2006 (AB 1881) requiring the DWR to update the State Model Water Efficient Landscape Ordinance. All local land use agencies were required to adopt the model ordinance, or develop an ordinance that is at least as effective by January 1, 2010. Sonoma County and the City of Petaluma have developed individual water efficient landscape ordinances. The new water efficient landscape ordinances require a landscape plan check for certain projects, as described in the ordinance. It includes requirements for landscape water budgets, landscape and irrigation design, and irrigation scheduling.

2.5.4.3 LandSmart Program

The Sonoma RCD, Napa RCD, and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) developed the LandSmart Program to help land managers identify and meet their natural resource management goals that support productive landscapes and thriving streams while meeting or exceeding environmental regulations. The program is applicable to a variety of agricultural lands. LandSmart Plans are developed by the agricultural producer, either independently, through workshops, or through one-on-one assistance from an RCD. Producers can also seek certification from the RCD's certification team once plans are complete. Plan templates and guidance materials are designed to assess current practices and identify recommendations for other practices that would benefit natural resources such as water quantity and quality. Practices are prioritized and tracked over time. Information on the LandSmart Program is available at: www.LandSmart.org.

2.5.4.4 Sustainable Winegrape Program

Members of Wine Institute and the California Association of Winegrape Growers introduced the Code of Sustainable Winegrowing Practices Self-Assessment Workbook in 2002 (updated in 2006, 2013, and 2020) to promote environmental stewardship and social responsibility in the California wine industry (California Sustainable Winegrowing Alliance 2020). The workbook addresses a number of criteria for measuring performance, including Vineyard Water Management and Winery Water Conservation and Quality. Additionally, the Sonoma County Winegrowers have developed a Sustainability Certification Program for vineyards, which includes water conservation assessments.

2.5.5 Climate Change Studies and Planning

Projected changes in climate include increased variability in precipitation and rises in air temperature, resulting in a shorter wet season, longer dry season, more droughts, and more extreme high flows. To face these potential changes in climate, local organizations are working with federal and state partners, including the USGS, DWR, NOAA, and the U.S. Army Corps of Engineers, to advance the science in our region in an effort to plan for and adapt to predicted changes. Local agencies have also partnered to form the Sonoma County Regional Climate Protection Authority and have developed a Regional Climate Action Plan (Sonoma County Regional Climate Protection Authority 2016). Findings and results from these efforts are described in **Section 3** (Basin Setting) and incorporated into future model projections in this GSP.

2.5.6 Groundwater Banking Feasibility Study

Because of uncertainties in the reliability of regional future water supplies (both surface water and groundwater), Sonoma Water, City of Sonoma, and other local partners, including the cities of Rohnert Park and Cotati, Valley of the Moon Water District, and the Town of Windsor conducted the Groundwater Banking Feasibility Study for a regional groundwater banking program to investigate the viability of enhancing the conjunctive management of surface water and groundwater resources (GEI et al. 2013).

Conceptually, the groundwater banking program would involve the diversion and transmission of surplus Russian River water produced at existing drinking water production facilities during wet weather conditions (that is, the winter and spring seasons) for storage in groundwater basins. The stored water would then be available for subsequent recovery and use during dry weather conditions (that is, the summer and fall seasons) or emergency situations. The Groundwater Banking Feasibility Study provided an evaluation of the regional needs and benefits, source water availability and quality, regional hydrogeologic conditions, and alternatives for groundwater banking. While groundwater resources in Petaluma Valley were not evaluated as part of the Groundwater Banking Feasibility Study, regional information from the feasibility study is applicable to potential groundwater banking alternatives in Petaluma Valley.

Based on the findings from the study, pilot studies to further assess the technical feasibility of Aquifer Storage and Recovery (ASR) as a method for groundwater banking were recommended and currently are being pursued in Sonoma Valley, where a pilot project was completed in fall of 2018 in the City of Sonoma. The pilot project resulted in the empirical verification of specific hydrogeologic and water quality factors. The next steps are a technical and economic viability assessment of ASR technology in the region. If deemed feasible, the pilot project results could be used to complete environmental documentation and design for a full scale or permanent ASR project in the region.

2.5.7 Stormwater Management Planning

Sonoma Water conducted a scoping study (Sonoma Water 2012) in the Petaluma River watershed to identify opportunities to alleviate flooding, while possibly recharging groundwater aquifers or providing other benefits. The study assessed the feasibility of projects in the Upper Petaluma River watershed. Information and results from the study have informed the development of a Storm Water Resources Plan (SWRP). SWRPs are required by SB 985 (Pavley 2014) to be eligible to seek funding from any future state bond measures for stormwater projects. A SWRP is a nonregulatory, watershed-based and stakeholder-driven plan that builds on local stormwater management objectives and identifies and prioritizes projects that capture, treat, or reuse stormwater and dry weather runoff. These projects must provide at least two benefits, which may include environmental enhancement, flood protection, groundwater recharge, water quality improvement, and/or recreational opportunities.

Sonoma Water, with support from a Technical Advisory Committee, collaboratively developed the Southern Sonoma County SWRP (Sonoma Water 2019) covering the Petaluma River and the Sonoma Creek watersheds (including the Basin). Through the planning process, more than 60 projects were identified and submitted by proponents for consideration and inclusion. The resulting plan provides a framework for submitting, quantifying, scoring, and ranking future projects in an objective and data driven format.

2.5.8 Water Quality Regulatory Programs

The California Legislature assigned primary responsibility for protecting and enhancing California's surface water and groundwater quality to the SWRCB, and the nine regional water quality control boards (Regional Water Boards or SFBRWQCB).

The SWRCB provides state-level coordination for the water quality control program by establishing statewide policies and plans for implementing state and federal laws and regulations. The Regional Water Boards adopt and implement water quality control plans (basin plans), recognizing the unique characteristics of each region's natural surface water and groundwater quality; actual and potential beneficial uses; and surface water and groundwater-quality problems. Article 3 of Chapter 4 of the Porter-Cologne Act directs regional water boards to adopt, review, and revise basin plans, and provides specific guidance on factors that must be considered in adoption of surface water and groundwater-quality objectives and implementation measures. The SFBRWQCB implements water quality regulations in the watershed, including establishing Total Maximum Daily Loads for bacteria and sediment in the Petaluma River.

2.6 General Plan and Related Land Use Planning

Existing city and county planning activities that are directly or indirectly linked with water supply and groundwater management include general plans and specific plans, in addition to the UWMPs previously described. Under SGMA, cities and counties retain their land use authorities; however, in recognizing the linkages between land use and water management, SGMA does require increased coordination between land use planners and GSAs. Cities and counties must now refer proposed general plan changes to GSAs and, similarly, GSPs must consider "the most recent planning assumptions stated in local general plans of jurisdictions overlying the basin" (CWC Section 10726.9). In addition, Government Code 65350.5 stipulates that before general plans are adopted, they must review and consider GSPs.

The City of Petaluma and Sonoma County general plans and specific plans provide growth estimates based on build out of land use designations that are used in the UWMPs and in this GSP to project future water demands, and are incorporated into the sustainable management criteria and metrics, including measurable objectives and interim milestones, the sustainability goal, proposed projects, and management actions. Projections of future groundwater availability and planned projects and actions needed for sustaining groundwater resources in the Basin will be shared with city and county planners for incorporation into their respective land use planning and decision-making.

In addition to coordinating on activities within the Basin, coordination and information sharing between the GSA and land use planning agencies will be needed for the contributing watershed areas located outside of the GSA's jurisdiction. These areas primarily fall within the purview of the county general plan.

Future land use planning and associated growth projections are incorporated into the analysis of the future water budget, over the planning and implementation horizon (**Section 3**, Basin Setting).

2.6.1 General Plans

Counties and cities are required to develop and adopt comprehensive general plans to guide future local physical development, as required in California State Government Code Title 7, Division 1, Article 5, Section 65300 et seq. Each general plan must contain a statement of policies, including maps or diagrams and text, setting forth objectives, principles, standards, and plan proposals. City general plans are focused on providing guidance on growth and development in the urban setting, while county general plans focus on the unincorporated areas of the county. Developing and updating general plans involves significant community involvement through workshops, hearings, and public review of draft plans and policies.

While there are seven mandatory elements of a general plan, the conservation element is typically where water resources are addressed, although other water-related topics may also be addressed in other elements. In particular, the conservation element of a general plan must reflect the content of the other general plan elements and must account for “rivers, creeks, streams, flood corridors, riparian habitats, and land that may accommodate floodwater for purposes of groundwater recharge and stormwater management…” as identified in the conservation element (Government Code Section 65302[d][3]). The housing elements must be updated on an eight-year cycle to correspond with state regional housing needs allocations (Government Code Section 65584[b]).

The Petaluma Valley Basin includes areas covered by the county of Sonoma’s general plan and the City of Petaluma’s general plan within the city’s jurisdictional areas.

2.6.1.1 Sonoma County General Plan 2020

The Sonoma County General Plan 2020 (Sonoma County 2008) contains the seven mandatory elements. In addition, the following four optional elements are also included: agricultural resources, air transportation, water resources, and public facilities and services. The water resources element was developed and included in the Sonoma County General Plan 2020 in recognition of the importance of water resources within unincorporated areas of the county. The main purpose of the water resources element is to ensure that Sonoma County’s water resources are sustained and protected. To achieve this main purpose, the water resources element states that water-resource management should consider the amount of quality water that can be used without exceeding the replenishment rates over time or causing long-term declines or degradation in available surface water or groundwater resources.

The water resources element includes goals, objectives, and policies for water quality; groundwater; public water systems; conservation and reuse; importing and exporting; and watershed management. These goals, objectives, and policies include supporting local groundwater studies and management programs, encouraging activities that protect natural groundwater recharge areas.

Specific water resources element goals related to groundwater include the following:

- Protect, restore, and enhance the quality of surface and groundwater resources to meet the needs of all reasonable beneficial uses.
- Manage groundwater as a valuable and limited shared resource.
- Assure that new proposals for surface and groundwater imports and exports are consistent with Sonoma County's ability to sustain an adequate supply of high-quality water for all its water uses and dependent natural resources.
- Improve understanding, valuation, and sound management of the water resources in Sonoma County's diverse watersheds.

Other water-related topics incorporated in the Sonoma County General Plan 2020 include water availability as a factor in land use map densities that is addressed in the land use element. Land use designations based on the county's General Plan 2020 are shown on **Figure 2-8**. The open space and resource conservation element addresses riparian corridors; wetlands; wildlife protection; tree protection; fishery resources and other biotic resources; water-oriented recreation; soil erosion; forestry; and mineral resources. The public facilities and services element addresses connections to public water systems. The public safety element addresses flood hazards, fire suppression, and hazardous materials. It is anticipated that the next Sonoma County General Plan update will begin in 2022 and conclude in 2028.

2.6.1.2 City of Petaluma General Plan

City general plans guide growth and development in the urban community, and typically involve an urban-growth boundary. The UWMPs and general plans are clearly linked: UWMPs calculate future water demand based on growth and development projected in the general plan.

The elements included in the City of Petaluma's 2025 General Plan (City of Petaluma 2008) include goals, policies, and implementation measures that set a course for future land use in the city. Goals summarize how development and future growth should be directed to achieve the general plan vision by identifying physical, economic and/or social ends that the community wishes to achieve.

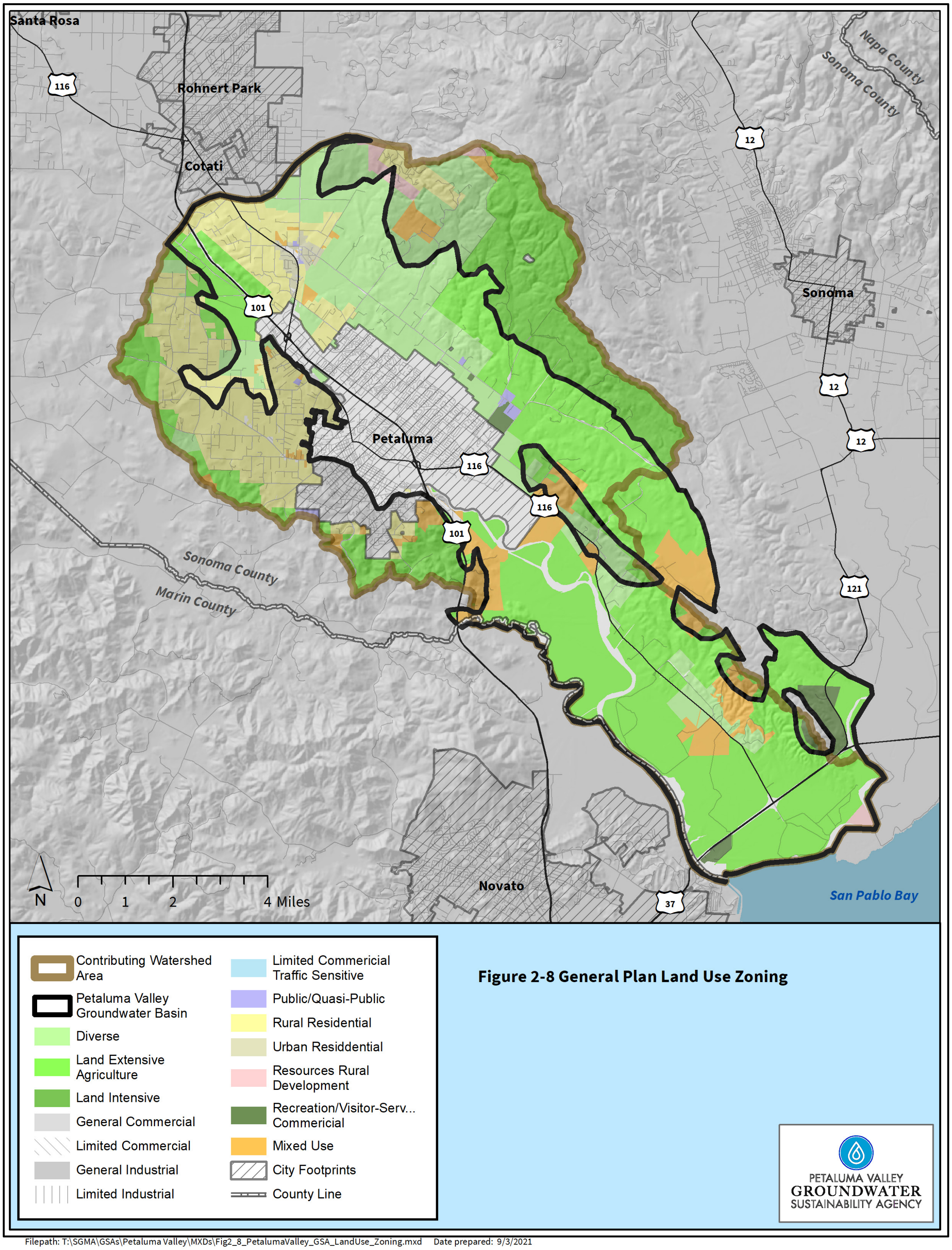

Figure 2-8. General Plan Land Use Zoning

Petaluma's 2025 General Plan water resources element includes water conservation BMPs and goals and policies for water supply and demand, wastewater, recycled water, groundwater supply, water conservation, surface water management, and water quality. The water resources element includes the following policies:

- 8-P-19 – Ensure adequate water supply during emergency situations by developing potential groundwater resources and aquifer storage capacity, combined with management of surface water, to meet overall emergency water supply objectives. The city's groundwater resources shall be preserved to meet emergency needs and to offset peak demands.
- 8-P-20 – Manage groundwater as a valuable and limited shared resource by protecting potential groundwater recharge areas and stream sides from urban encroachment within the Petaluma watershed.
- 8-P-21 – Protect groundwater quality from surface contamination by requiring 100-foot sanitary seals on all new municipal water supply wells.

2.6.2 Specific Area Plans

Specific area plans are planning documents that guide the development of a geographic area within the county. Any new developments or subdivisions within the defined area must be consistent with the general plan and specific plan. The Central Petaluma Specific Plan (City of Petaluma 2003) was prepared by the city and provides specific land use and development regulations for nearly 400 acres within the city, adjacent to downtown.

The county prepared, and in 2008 updated, three area plans specific to the Basin, as follows:

- The Penngrove Area Plan (Sonoma County 1984) provides land use and development regulations for the community of Penngrove.
- The Petaluma Dairy Belt Area Plan (Sonoma County 1985) was prepared for an area primarily located outside and to the west of the Basin.
- The West Petaluma Area Plan (Sonoma County 1981) refers to an area that straddles the Basin and covers approximately 11,000 acres west of the City of Petaluma.

2.6.3 Sonoma County Local Agency Formation Commission

The Sonoma County Local Agency Formation Commission (LAFCO) is a state-created regulatory agency that approves or disapproves proposals to expand municipal water and wastewater services outside of existing service areas. Through this power, the LAFCO is an important agency in proposals to offset groundwater use with urban water for both new and existing development in the county.

LAFCO has responsibility in four areas affecting local government in Sonoma County as follows:

1. Review and approve or disapprove proposals for changes in the boundaries and organization of the 9 cities and 54 special districts within Sonoma County including incorporations of new cities, formation of new special districts and mergers, consolidations or dissolutions of existing cities and special districts.

2. Conduct studies, including municipal service reviews, of existing local government services with the goal of improving the efficiency of providing services.

3. Establish spheres of influence, which are plans for the probable physical boundaries of each local agency, for cities and special districts within the county and to review and update those spheres of influence every 5 years.

4. Assist the public and other government agencies concerning changes in local government boundaries and organization.

2.7 Well Permitting Policies and Procedures

The GSA is not responsible for well permitting or groundwater pumping permits. Permit Sonoma is the Sonoma County agency responsible for administering permits for water supply and monitoring wells within the Basin, including within the jurisdiction of cities. The Sonoma County Department of Health Services administers permits for environmental drilling and wells, generally associated with contaminated sites. The purpose of the County's well-construction policies is to provide for the location, construction, repair, reconstruction, and destruction, and addressing abandonment of all wells to protect the groundwater resource of the county because contamination may cause serious public health, safety, or economic problems.

The Sonoma County Well Ordinance contains regulations and requirements for constructing wells to prevent groundwater contamination from the surface and between multiple water bearing zones in (Ordinance 25B).

Permit Sonoma reviews all development proposals within unincorporated areas that will rely on wells for water supply. Permit Sonoma has developed a four-tier classification system, based on geologic information and water yields, to designate general areas of groundwater availability (**Figure 2-9**). Class 1 areas are Major Groundwater Basins, Class 2 areas are Major Natural Recharge Areas, Class 3 areas are Marginal Groundwater Availability Areas, and Class 4 areas are Areas with Low or Highly Variable Water Yield (Permit Sonoma 2016).

Permit Sonoma uses this groundwater classification system in reviewing certain development and building permit applications. For example, dry season well yield tests are required in Class 4 areas prior to residential development. In addition, discretionary applications in Class 3 and 4 areas and in SGMA medium- and high-priority basins are required to include hydrogeologic reports to establish that groundwater quality and quantity are adequate and will not be adversely impacted by the cumulative developments and uses allowed in the area. The aim is to avoid causing or exacerbating an overdraft condition in a groundwater basin or subbasin.

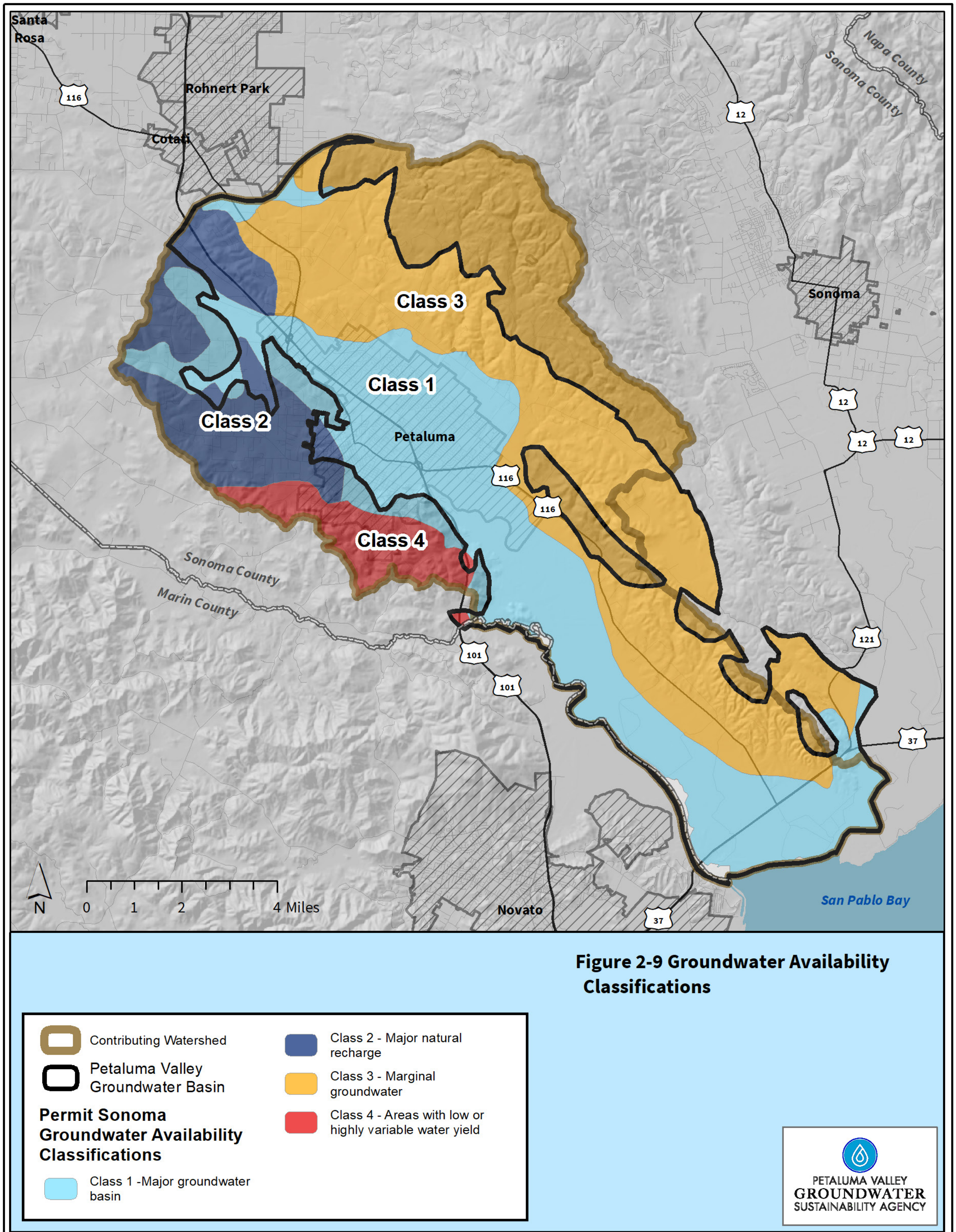

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Figure 2-9. Groundwater Availability Classifications

Section 3: Basin Setting

Groundwater Sustainability Plan
Petaluma Valley Groundwater Basin

Table of Contents

Tables

Figures

Appendices

3 BASIN SETTING

This section provides information about the physical setting, characteristics and current conditions of the Petaluma Valley Groundwater Basin, including the identification of data gaps and levels of uncertainty. The information included within this section represents current understanding of the Basin, based on available data and information, and serves as the basis for defining and assessing SMC and projects and management actions. This section contains four primary subsections:

- Hydrogeologic Conceptual Model (**Section 3.1**)
- Current and Historical Groundwater Conditions (**Section 3.2**)
- Water Budget (**Section 3.3**)
- Management Areas (**Section 3.4**)

The Basin Setting draws upon new information developed by the USGS and previously published studies and reports, including the following primary data sources that document the conditions of the Petaluma Valley Basin and contributing watershed areas:

- *Geology and ground water in the Santa Rosa and Petaluma Valley areas Sonoma County* (Cardwell 1958)
- *2015 Urban Water Management Plan* (City of Petaluma 2016)
- *Evaluation of Ground Water Resources: Sonoma County, Volume 3: Petaluma Valley* (DWR 1982)
- *Status and Understanding of Groundwater Quality in the North San Francisco Bay Groundwater Basins, 2004: California GAMA Priority Basin Project* (Kulongoski et al. 2010)
- Traum, .A., Teague, N.., Sweetkind, S., Nishikawa, T.,2022, Hydrologic and Geochemical Characterization of the Petaluma River Watershed, Sonoma County, California: U. S. Geological Survey Scientific Investigations Report (collectively referenced herein as: Traum et al. 2022)

For additional details, the reader should refer to these documents and studies.

3.1 Hydrogeologic Conceptual Model

This subsection describes the hydrogeologic conceptual model (HCM), which characterizes the physical components of the surface water and groundwater systems in the Basin. As defined in the GSP Regulations, the HCM shall provide the following:

- General physical characteristics related to regional hydrology, geology, geologic structure, water quality, principal aquifers, and principal aquitards of the Basin Setting
- Contextual information necessary to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks
- A tool for stakeholder outreach and communication

This subsection includes a description of the topography, geography, surface water features, soil characteristics, geologic setting and formations, principal aquifers and aquitards, role of faults, groundwater recharge and discharge area, and data gaps and uncertainties. This information is integrated into the water budget and numerical model described in **Section 3.3** (Water Budget) and monitoring networks described in **Section 5.0** (Monitoring Program). Additionally, figures and diagrams developed for the HCM are incorporated into community and stakeholder outreach materials.

3.1.1 Topography and Geography

The Basin is located in the North Coast Ranges geomorphic province of California, characterized by predominantly northwest trending mountains and valleys. The Basin is immediately northwest of San Pablo Bay and encompasses the majority of Petaluma Valley, bounded by the Santa Rosa Plain Basin to the north, the San Pablo Bay to the south, the Sonoma Mountains to the east, and the low lying hills of the Mendocino Range to the west, as shown on **Figure 3-1**.

Most of the upper portions of the Basin are between sea level and an elevation of 50 feet, while the lower portions primarily consist of tidal marshlands located at or slightly below sea level (Traum et al. 2022). The Sonoma Mountains separate the Basin from the Sonoma Valley to the east and vary from moderate to steep relief, sloping gently from a few hundred feet in the south to greater than 2,000 feet in the northeast areas of the contributing watershed, reaching a maximum elevation of 2,295 feet at Sonoma Mountain. The remaining uplands surrounding the Basin have modest changes in elevation and are made up of mostly low, rounded hills that generally range from 200 to 300 feet in elevation. The Basin is separated from the Santa Rosa Plain Basin to the north by a modest topographic watershed divide about 2 miles northwest of Penngrove (Traum et al. 2022).

3.1.2 Surface Water and Drainage Features

The Petaluma Valley watershed (PV or contributing watershed) is drained by the Petaluma River and its tributaries, which discharge into the tidal marshlands on the north end of San Pablo Bay (**Figure 3-1**). The Petaluma River flows at a relatively flat gradient dropping some 260 feet over just approximately 8 miles before reaching the tidal marshlands. The upper reach of the Petaluma River, north of the confluence with Lynch Creek, is ephemeral while the lower reach of the river is tidally influenced and can flood during periods of high flow (Traum et al. 2022).

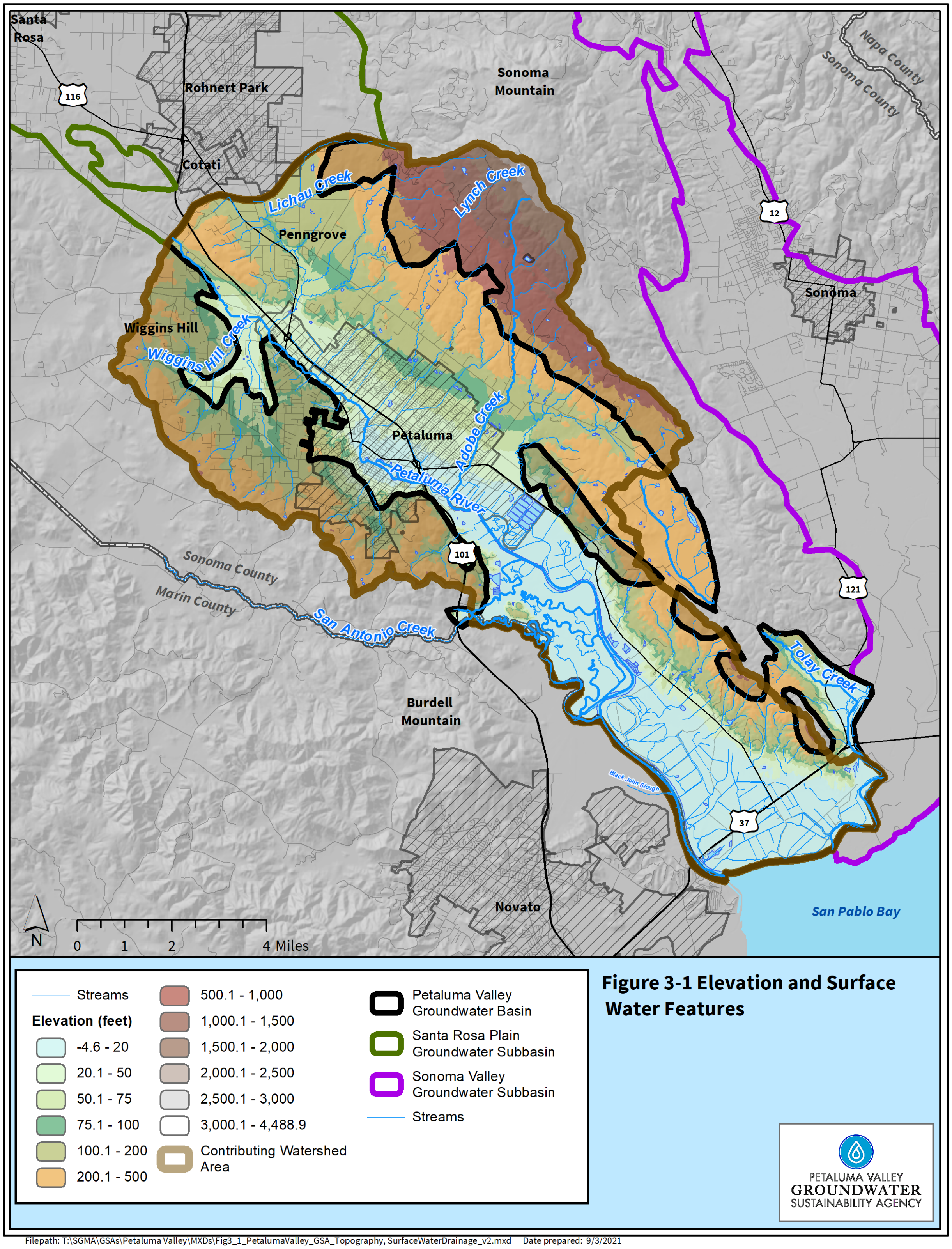

Figure 3-1. Elevation and Surface Water Features

The headwaters of the tributaries of Petaluma River are located along the southwest slopes of Sonoma Mountain (Lichau Creek, Lynch Creek, and Adobe Creek), the southern slopes of Meacham Hill (Petaluma River), and the eastern slopes of Wiggins Hill (Wiggins Hill Creek) and Burdell Mountain (San Antonio Creek and Black John Slough). Flow in the tributary channels is seasonal; when there are drier-than-normal winters, the main tributary channels will often go dry during the summer (Traum et al. 2022). The upper reach of the Petaluma River, north of the confluence with Lynch Creek, is seasonally ephemeral (often dry), while the lower reach of the river is tidally influenced and can flood during periods of high flow (Cardwell 1958). Based on the location of Adobe Creek in comparison to the upper limit of the tidally influenced reach of the Petaluma River, the lower reach of Adobe Creek may also be tidally influenced. The contributing watershed also includes Tolay Creek, which is part of the Sonoma Creek watershed, but is included in the study area because it overlies part of the Basin.

3.1.3 Soil Characteristics

Soil types and characteristics in the Basin and contributing watershed have been mapped by the USDA NRCS, which developed a spatial database of soils for the entire United States (the Soil Survey Geographic Database or SSURGO) (USDA NRCS 2007). The SSURGO database defines 17 different soil textures (excluding variable and unknown textures) present in the study area. Soil properties were analyzed based on their hydrologic soil groups to classify some of the soils into three categories of silty clay, silt, and sandy loam, resulting in a total of 14 soil textures (excluding variable and unknown textures) that are shown on **Figure 3-2a**.

The SSURGO database also assigns saturated hydraulic-conductivity values to soil groups, which are shown on **Figure 3-2b**. Saturated hydraulic conductivity is a measurement of the representative or average water transmitting properties of soils and is a good indicator of the soil's infiltration potential. As indicated on **Figures 3-2a and 3-2b**, the clay and clayey loam soils that predominate the floor of the Basin south of Willow Creek exhibit relatively low hydraulic conductivities (slow to moderate slow), on the order of 0.1 to 1 feet per day (ft/d). Coarser-grained soils which exhibit relatively higher hydraulic-conductivity values (moderate to moderate rapid) on the order of 1 to 12 ft/d are predominantly in the northwest areas of the Basin and within the contributing watershed areas outside of the Basin, including areas of the Wilson Grove Formation northwest of the Basin and the foothills of the Sonoma Mountains northeast of the Basin. At locations where subsurface storage space is available and the underlying geologic formations have sufficient permeability, these more permeable soils (moderate to moderate-rapid) could be favorable for managed aquifer recharge by surface infiltration.

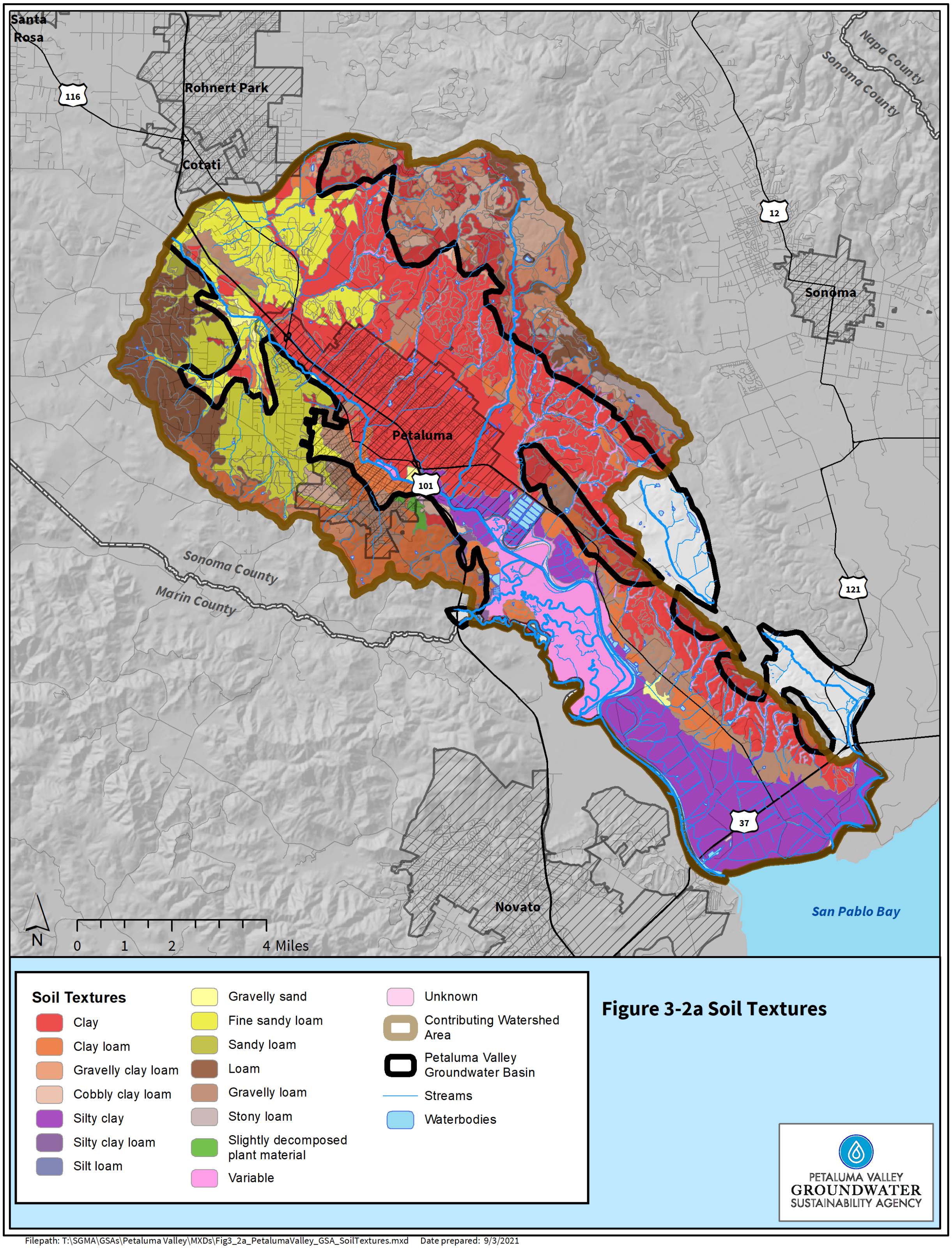

Figure 3-2a. Soil Textures

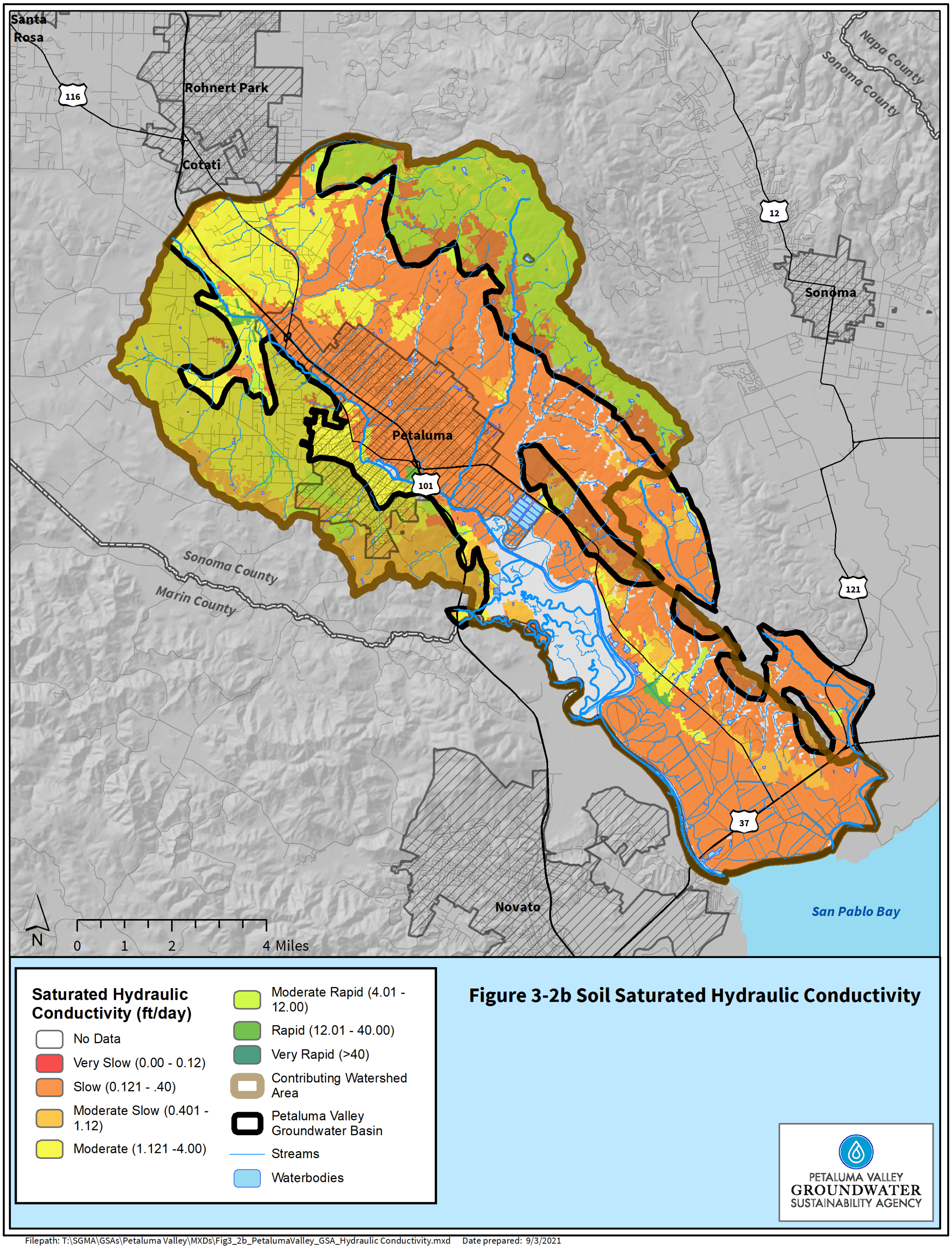

Figure 3.2b. Soil Saturated Hydraulic Conductivity

3.1.4 Regional Geologic Setting and Geologic Units

The Basin and contributing watershed are located within a region of geologic complexity caused by long periods of active tectonic deformation, volcanic activity, and sea level changes. **Figure 3-3a** displays the regional geology of the northern Coast Ranges, including generalized geologic units and primary faults that influence the geometry of the Basin and distribution adjoining groundwater basins and upland areas. **Figure 3-3b** presents a geologic map of the watershed showing the surficial distribution of geologic units within the Basin and surrounding watershed areas, with a stratigraphic column for the units shown on **Figure 3-4** (Traum et al. 2022). Geologic formations within the Basin are grouped into two broad categories based on the age, degree of consolidation, and amount of deformation, such as folding, faulting, and fracturing: (1) Mesozoic Era basement rocks (more than 66 million years old), and (2) younger Cenozoic Era volcanic and sedimentary units.

Additionally, **Figure 3-5** displays the inferred distribution of the primary geologic units within the Basin beneath the Quaternary alluvial materials. The inferred subsurface distribution of the geologic units is displayed on the hydrogeologic cross section and a three-dimensional geologic framework model developed by the USGS shown on **Figures 3-6** and **3-7**, respectively (Traum et al. 2022).

Mesozoic Era basement rocks consist of metamorphic, igneous, and metasedimentary rocks of the Jurassic/Cretaceous-aged Franciscan Complex overlain or tectonically imbricated by rocks of the Great Valley Sequence (Wagner and Gutierrez 2010; Wagner et al. 2011). A mixture of younger (Tertiary and Quaternary-aged) volcanic and sedimentary rocks and unconsolidated sediments of the Cenozoic Era overlies these basement rocks. Franciscan Complex basement rocks dominate the subsurface on the southwest side of the Basin, capped locally by Tolay Volcanics and a relatively uniform thickness of Wilson Grove Formation in the northwestern part of the PV watershed. Basin depth dramatically increases to the north and east where the Basin is filled by a thick sequence of Petaluma Formation and Sonoma Volcanics. Along the Basin axis and the trace of the Petaluma River, locally thick accumulations of the Quaternary mixed unit are present. Near San Pablo Bay at the southeast end of the study area, the Quaternary mixed unit is capped by a relatively thin veneer of bay muds (Traum et al. 2022).

3.1.4.1 Geologic Structure

The northern Coast Ranges structure is dominated by the northwest trending San Andreas right-lateral transform fault system that marks the boundary between the Pacific oceanic and North American continental tectonic plates. This includes the San Andreas zone of faults to the west, and the Rodgers Creek, Burdell Mountain, and Petaluma Valley fault zones—all generally vertical right-lateral strike slip faults that locally also demonstrate components of either shortening or extension accompanying fault dip-slip movement (Traum et al. 2022) (**Figure 3-3b**). The regional tectonic faulting has helped shaped the Basin, the surrounding northwest trending valleys and ridges, and underlying geology

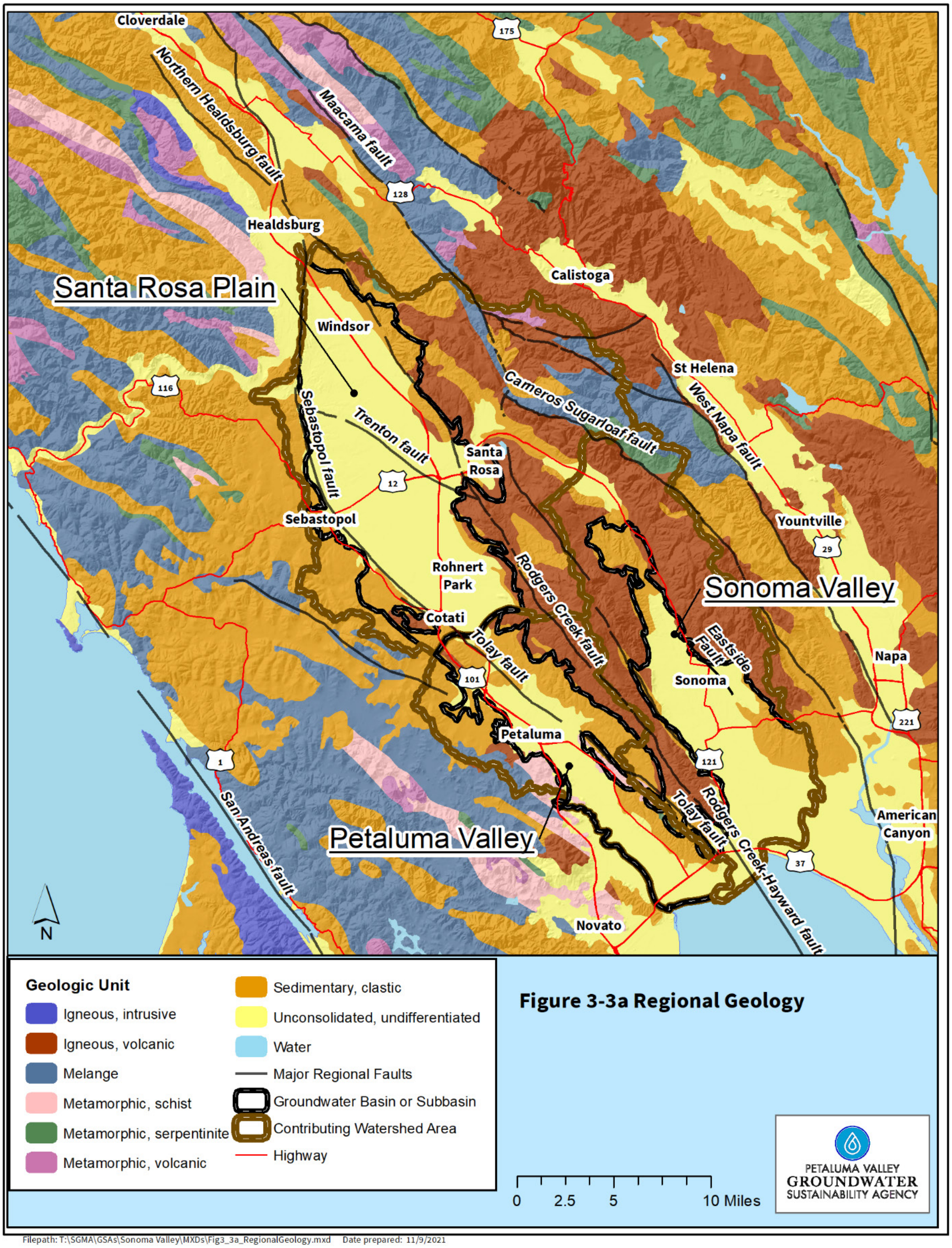

Figure 3-3a. Regional Geologic Map

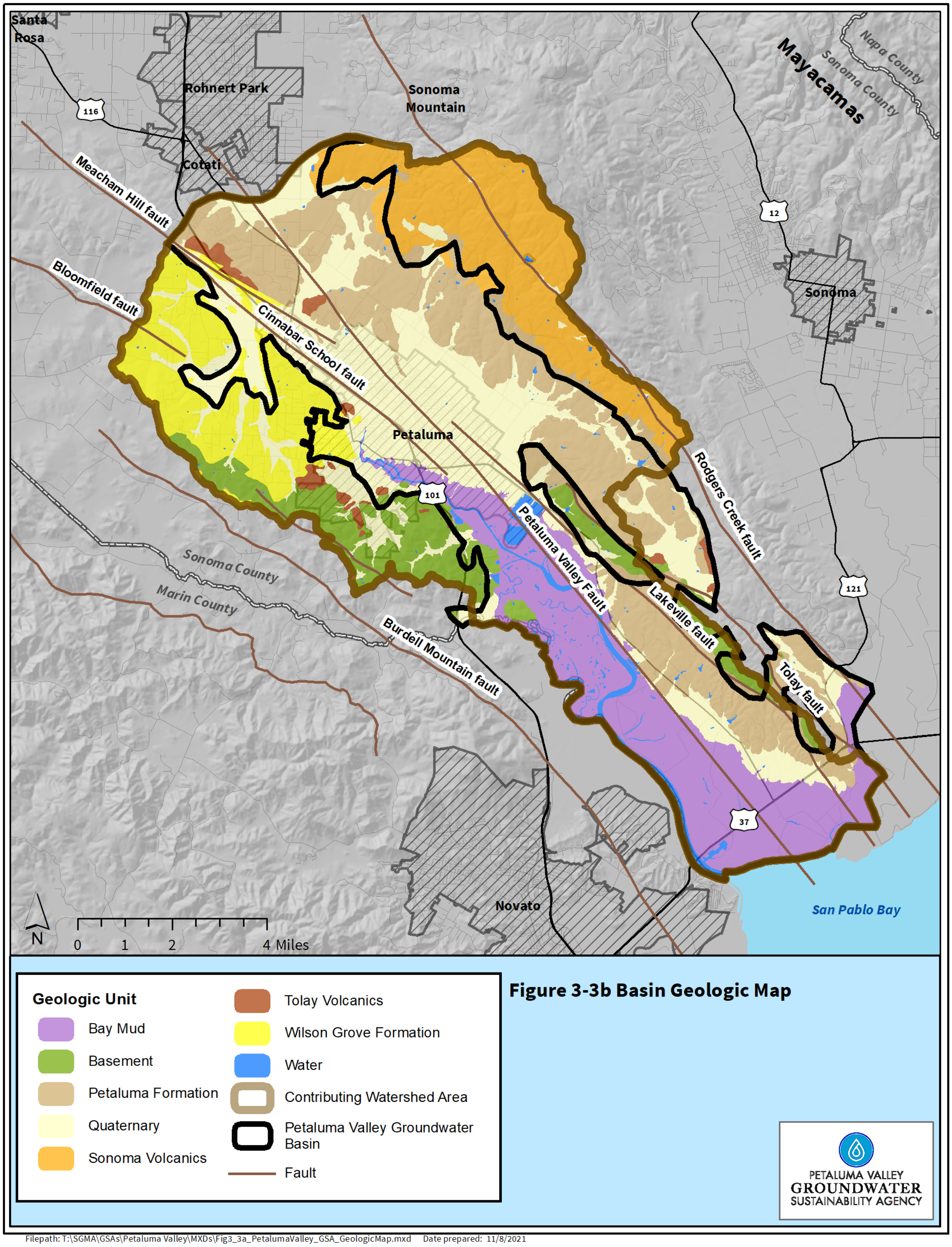

Figure 3-3b. Basin Geologic Map

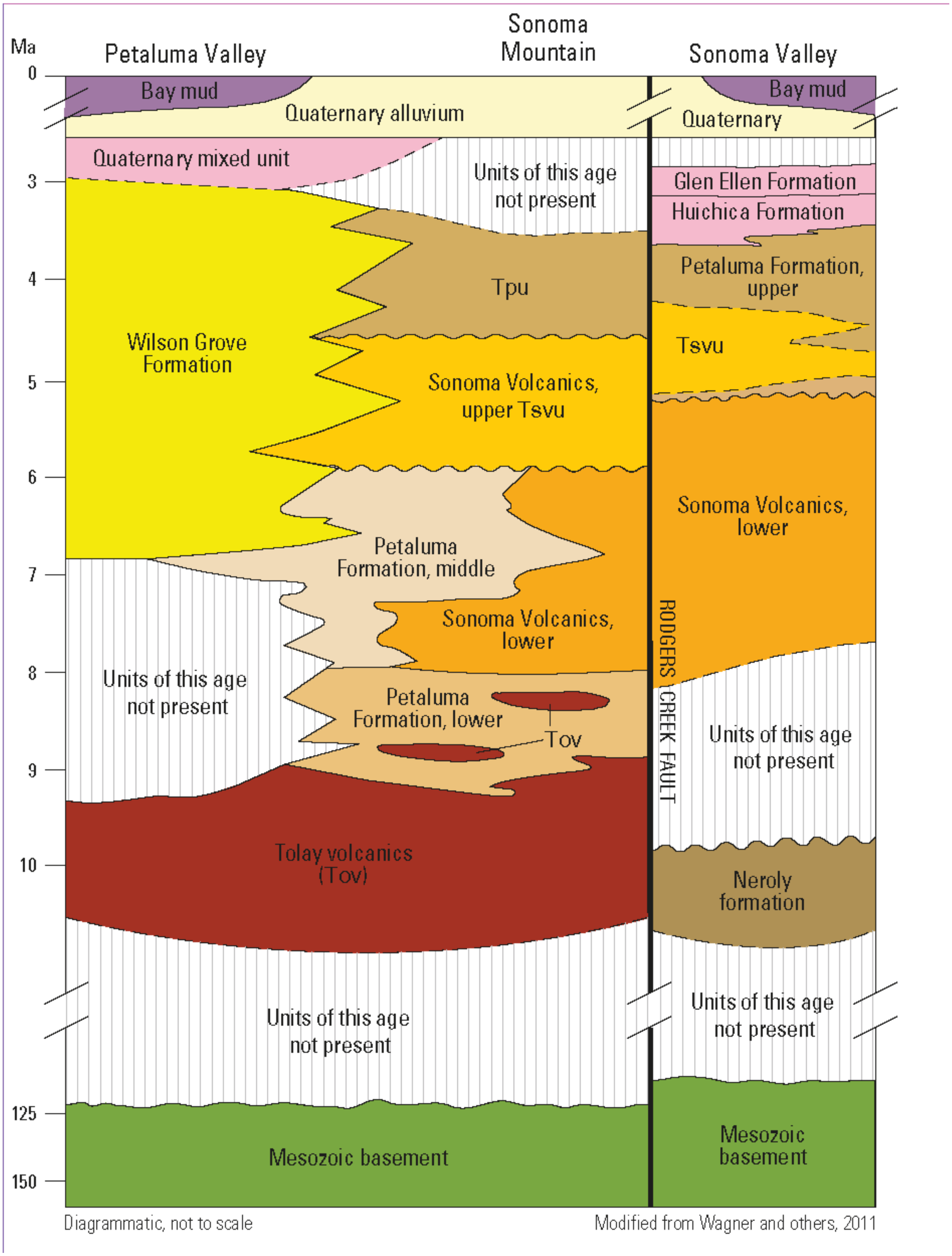

Figure 3-4. Stratigraphic Column

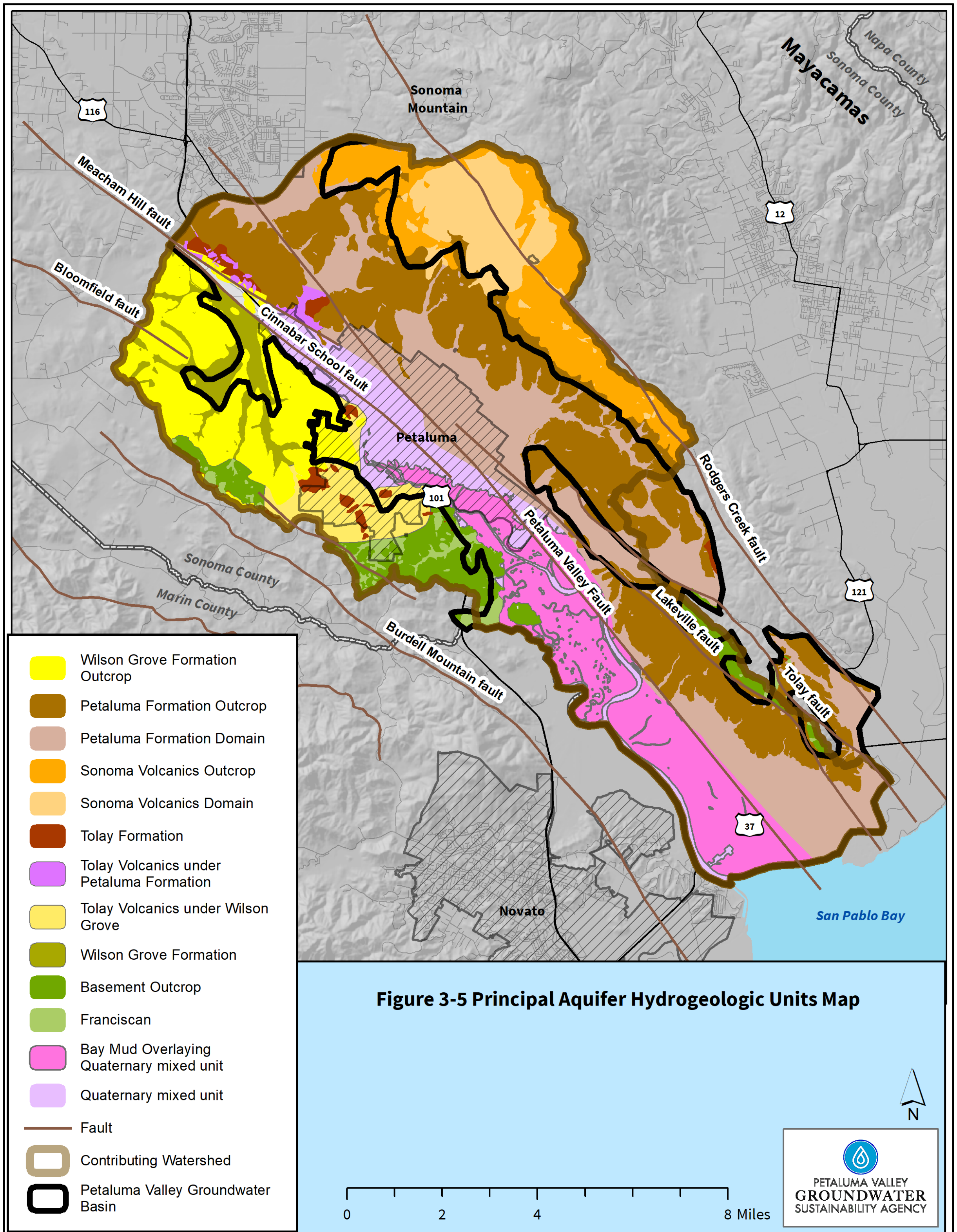

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Figure 3-5. Principal Aquifer Hydrogeologic Units Map

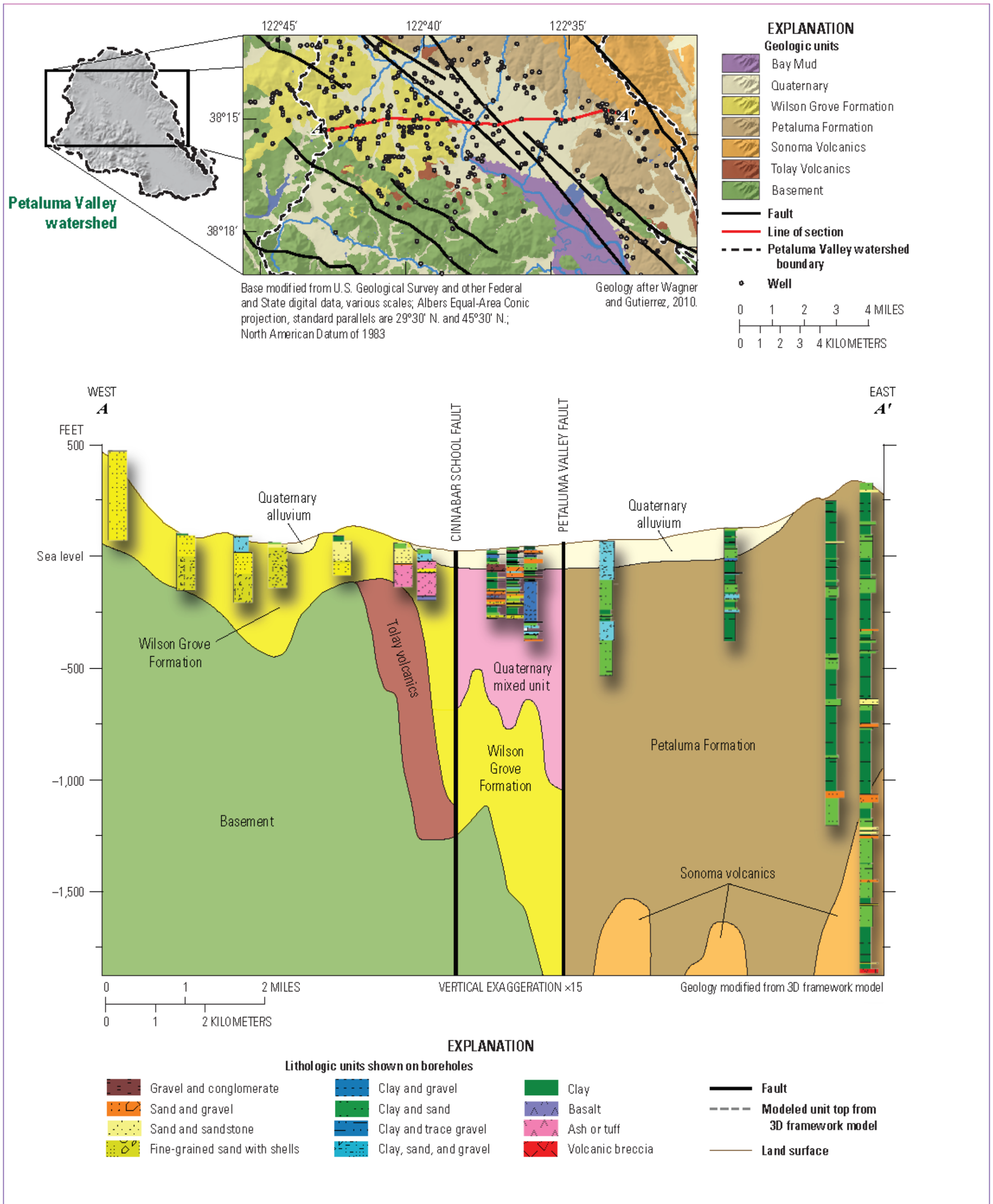

Figure 3-6 Hydrogeologic Cross Section

Figure 3-6. Hydrogeologic Cross Section

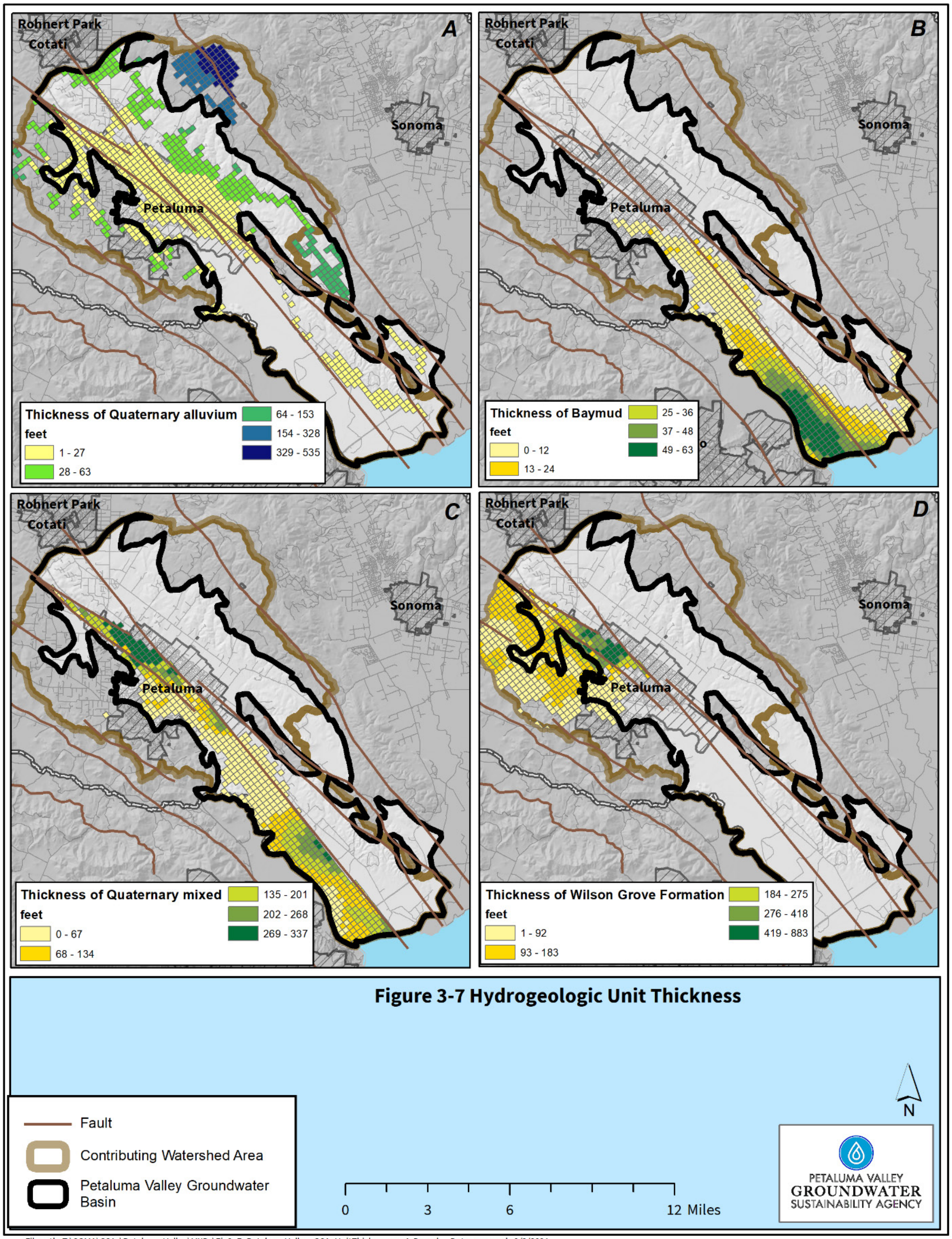

Figure 3-7. Hydrogeologic Unit Thickness

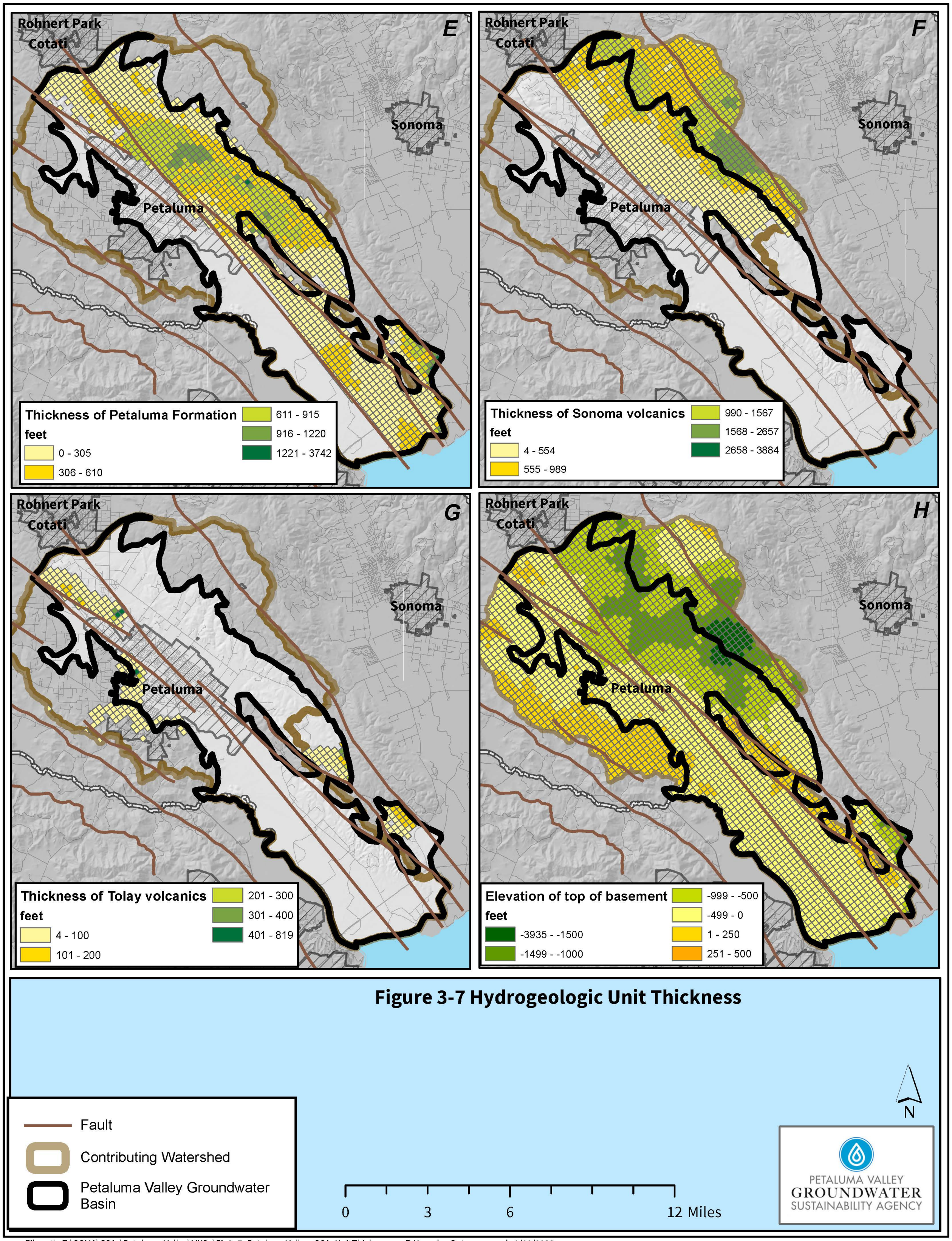

Figure 3-7 (continued). Hydrogeologic Unit Thickness

The Rodgers Creek and Burdell Mountain faults are mapped at the surface as wide, steeply dipping zones with multiple fault strands, rather than single fault planes. The Petaluma Valley fault, a northwest-trending fault running along the valley axis, is buried beneath alluvium and sharply juxtaposes rocks interpreted as Wilson Grove and Petaluma Formations against one another (Traum et al. 2022). The Meacham Hill and Tolay faults (**Figure 3-3b**) are northeast- or southwest-directed reverse thrusts that bound structural highs (areas of shallow basement rocks). In the northwest part of the Basin, several northwest-trending reverse faults of relatively small displacement occur, including the Bloomfield and the Cinnabar School faults. These are high-angle fault planes that generally dip to the east (Traum et al. 2022).

3.1.4.2 Mesozoic Era Basement Rocks

Mesozoic Era basement rocks are characterized by a variety of consolidated and deformed rock types, including shale, graywacke, mélange with blocks of chert and greenstone, and thinly interbedded shale and sandstone. Basement rocks are widely exposed in the uplands south and west of the Petaluma River and are uplifted along the Tolay fault in the southeastern part of the Basin (**Figure 3-3b**). These rocks generally yield very little water because their porosity is primarily attributed to fractures which are commonly limited in extent and water transmitting capacity. The depth to the Mesozoic basement rocks is shallowest in the west and southwest parts of the Basin and contributing watershed areas where bedrock is as shallow as 100 feet beneath surface outcrops of the Wilson Grove Formation. Basement depth increases rapidly to the east and the northeast, where basement rocks are deeper than 3,000 feet (**Figure 3-7**).

3.1.4.3 Cenozoic Era Volcanic and Sedimentary Units

Groundwater resources within the Basin are primarily located within the Cenozoic sedimentary units and, to a lesser degree, volcanic units deposited over the Mesozoic basement rocks. Geologic units that are of greatest importance for groundwater resources within Petaluma Valley are described below in general order of decreasing age (older to younger) and include both Tertiary-aged (between 66 to 2.5 million years old) and Quaternary-aged (younger than 2.5 million years old) units.

Tertiary Volcanic Units

Tolay Volcanics

Overlying the Franciscan basement rocks are local accumulations of the Miocene-aged, predominantly mafic Tolay Volcanics, consisting of lava flows, breccias, tuffs, and agglomerates with interbedded stream channel deposits, the oldest known Cenozoic deposits in the Basin (Wagner et al. 2011). Tolay Volcanics are reported to have a highly variable specific yield, and are considered to be fair to good water producers, west of the City of Petaluma (DWR 1982). The lava flows are essentially non-water bearing except where highly fractured by faulting. The Tolay Volcanics are exposed on Burdell Mountain (southwest of the City of Petaluma), on Meacham Hill (north of the City of Petaluma), and to the east of the Tolay fault (**Figure 3-3a**). Tolay Volcanics are up to 650 feet thick on Burdell Mountain; approximately 160 feet of volcanic rocks are exposed in outcrops to the west of the City of Petaluma.

Sonoma Volcanics

The Miocene to Pliocene age Sonoma Volcanics are a thick and highly variable sequence of volcanic rocks interbedded with volcaniclastic sedimentary deposits (sediments derived from volcanic rocks) deposited approximately 8 to 2.5 million years ago. The volcanic unit consists of thick deposits of lava flows with some interbedded ash flows, mud flows, tuffs, and volcaniclastic sedimentary deposits of tuffaceous sands and volcanic gravels. The Sonoma Volcanics cover an area of approximately 1,200 square miles in Sonoma and Napa Counties and have been grouped into a western, eastern, and northern groups based on their age, with the western group, which is the oldest of the three, present in Petaluma Valley (Sweetkind et al. 2011).

The Sonoma Volcanics are exposed throughout the Sonoma Mountains on both sides of the Rodgers Creek fault on the east side of the Basin and extend beneath the valley floor where they are buried beneath younger geologic units (**Figures 3-3a**, **3-5**, **3-7**). The Sonoma Volcanics are highly variable in lithology and their subsurface distribution is often difficult to discern from well drillers logs. The Sonoma Volcanics include a thick accumulation of andesitic and basaltic tuffs containing interbedded lavas and volcaniclastic rocks (Wagner et al. 2011). These volcanic rocks interfinger with the Wilson Grove and Petaluma Formations in the Basin (**Figure 3-4**). The total thickness of Sonoma Volcanics ranges up to at least a few thousand feet; however, volcanic-rock thickness is highly variable.

The Sonoma Volcanics exhibit a large variation in water-bearing properties, with a mixture of fractured lava beds, unwelded tuffs, and interbedded volcaniclastic sedimentary deposits generally providing the best aquifer materials. Lava beds have extremely low primary permeability and only fractures on the tops and bottoms of individual flows yield significant water. Unwelded tuffs can yield water similar to high porosity, high permeability alluvial sediments. Because of their heterogeneous nature, the Sonoma Volcanics have a highly variable specific yield.

Tertiary Sedimentary Units

Tertiary sedimentary units within the Basin were deposited in fault-compartmentalized basins that formed in response to the development of the San Andreas fault system. These sedimentary units are assigned to two formations: the fine-grained marine sandstone of the Wilson Grove Formation, exposed northwest of the Basin, and the fluvial, estuarine, and lacustrine Petaluma Formation, exposed on the northeast and east side of the Basin along the east flank of the Sonoma Mountains (Traum et al. 2022) (**Figure 3-3a**).

Wilson Grove Formation

The Miocene to Pliocene Wilson Grove Formation consists of fine- to medium-grained, thick-bedded to massively-bedded, moderate- to well-sorted, uncemented to weakly cemented fossiliferous marine sandstone, and its distribution is shown on **Figures 3-3a** and **3-5.** Two units have been described for the Wilson Grove Formation: (1) an upper oxidized continental unit of brown sandstone, clay, and gravel, and (2) a lower reduced, shallow marine unit of blue sandstone with shells (DWR 1982). The two units are separated by an erosional surface and sometimes by lava flows of the Sonoma Volcanics (DWR 1982). The Wilson Grove Formation is generally 650 to 950 feet thick based on outcrop exposures and drillers logs northwest of the Basin and may be as much as 3,000 feet thick in the adjacent Wilson Grove Formation Highlands Basin further to the northwest (Powell et al. 2004). The Wilson Grove Formation interfingers with the Petaluma Formation in the Basin.

Petaluma Formation

The Petaluma Formation is a Miocene- to Pliocene-aged sedimentary unit that was deposited in transitional continental and shallow marine environments, and accounts for the bulk of the Basin fill. **Figures 3-3a**, **3-5**, **and 3-7** show its distribution in the Basin. The unit is dominated by deposits of moderately to weakly consolidated, silty to clayey mudstone with local beds and lenses of poorly sorted sandstone and minor beds of nodular limestone and conglomerate. It has been subdivided into an upper, middle, and lower member (Allen 2003; Wagner et al. 2011), but is treated as a single unit for the purposes of this GSP. The formation is at least 4,200 feet thick in the Petaluma oil field, near the eastern edge of the PV Watershed (**Figure 3-3a**) (Wright 1992). The Petaluma Formation is exposed in fault-bounded blocks along a 1- to 2-mile belt in the northeastern part of the Basin, where the sand and sandstone lenses yield water to wells. Well yields vary with the thickness and extent of sands encountered in the well but are generally low.

Quaternary Sedimentary Deposits

Quaternary Mixed Unit

A lithologically heterogeneous unit of alternating thin beds of conglomerate, sand, and mudstone was identified by the USGS beneath the Quaternary alluvial deposits on the basis of well lithologic data (Traum et al. 2022) (**Figure 3-5**); this unit is not mapped at the surface and is lithologically unlike the Wilson Grove and Petaluma Formations (Traum et al. 2022). This unit may be broadly correlative with the Pliocene–Pleistocene terrestrial deposits mapped as Huichica Formation and Glen Ellen Formation that are exposed in the nearby Sonoma Valley groundwater basin. This unit is referred to as the Quaternary Mixed Unit by the USGS in this GSP, although the age of these deposits has not been determined and the deposits may be in part Pliocene in age (Traum et al. 2022).

Quaternary Alluvial Deposits

Quaternary alluvial deposits cover much of the valley floor and include Holocene (younger than 100,000 years) to modern stream channel and stream terrace deposits (loose alluvial sand, gravel, and silt) and surrounding late Pleistocene to Holocene undissected stream terrace deposits, older alluvium, and alluvial fan deposits (DWR 1982). In general, the alluvial material nearest the valley margins and directly along major stream courses contain the greatest proportions of coarse-grained sediments.

Quaternary alluvial fan deposits form a nearly continuous layer over the northeastern Petaluma Valley (**Figure 3-3a**). These deposits consist of poorly sorted coarse sand and gravel and moderately sorted fine sand, silt, and silty clay, with gravel content increases near the alluvial fan heads (Traum et al. 2022). The alluvial fan deposits contain lenses of very fine sand, which may be derived from the adjacent, older Wilson Grove Formation. The alluvial fan deposits typically have moderate to high yields, and good water quality (DWR 1982).

Quaternary Bay Muds

Quaternary bay mud deposits of Holocene age cover the southern part of the Basin along the Petaluma River (**Figure 3-3a**). These deposits are primarily composed of organic rich muds and silts with small amounts of sand. The bay muds were deposited during a higher stand of sea level and, as such, contain entrapped brackish and saline water.

The thickness of the bay muds is uncertain as very few wells exist in this unit but is estimated to range from 200 feet along the shore of San Pablo Bay to near zero at its margins. Due to the low permeability and poor water quality associated with the bay muds, they are generally not tapped for groundwater supply.

3.1.5 Principal Aquifer System

The GSP Regulations require the identification of principal aquifers and aquitards within groundwater basins. Principal aquifers, which are defined by DWR as "aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems" have unique and important requirements defined in the GSP Regulations, which require the following for each principal aquifer:

- Characterization of physical properties, structural barriers, water quality conditions, and primary uses
- Groundwater elevation contour maps
- Hydrographs
- Change in storage estimates
- Minimum thresholds and measurable objectives
- Sufficient monitoring network, including groundwater levels and water quality

Based on available data and information, a single principal-aquifer system is proposed for the Basin. The principal aquifer system consists of the following aquifer units, which have been identified within the Basin and contributing watershed areas and described by the USGS: the Petaluma and Wilson Grove Formations, Sonoma Volcanics, Quaternary mixed unit, and, to a lesser degree, the Quaternary alluvial deposits (**Figure 3-5**).

While these aquifer units exhibit distinct lithologic and aquifer properties, data limitations regarding the degree of hydraulic connection between the units both laterally and vertically do not allow for the characterization of these units as separate principal-aquifer systems. The limitations on available information and data are due in part to the high degree of heterogeneity associated with the geologic units, deformation related to folding and faulting of Tertiary-aged units (which are difficult to discern in the subsurface), similarities in texture and composition of many of the sedimentary units, and related lack of high-quality lithologic descriptions for the subsurface. The appropriateness of this single principal aquifer designation within the Basin will continue to be evaluated and considered as more data and information are developed during implementation of the GSP, including but not limited to, the lateral and vertical characteristics and hydraulic interconnection between the different aquifer units.

3.1.5.1 Principal Aquifer System Framework and Properties

The principal aquifer system consists of the following aquifer units, which occur to varying degrees within the Basin: the Petaluma and Wilson Grove Formations, Sonoma Volcanics, Quaternary mixed unit, and, to a lesser degree, the Quaternary alluvial deposits. The distribution, subsurface extent, and structural and stratigraphic boundaries between these primary aquifer units are strongly controlled by displacement along faults within the Basin, most notably the Petaluma Valley and Meacham Hill faults. As shown on **Figures 3-3a** and **3-6**, west of these two fault zones the primary aquifer units are primarily limited to the Quaternary mixed unit and Wilson Grove Formation, and east of the fault zones the Petaluma Formation and Sonoma Volcanics represent the primary aquifer units. The Quaternary alluvial deposits, which are much more limited in vertical extent, occur on both sides of these faults.

Groundwater flow between aquifers in the Basin is controlled by the areal extent of each aquifer unit, the degree of hydraulic connection to underlying or adjacent aquifers, and the permeability of fault zones that separate aquifers. The aquifer system is conceptualized as a set of distinct aquifer units, which are strongly compartmentalized into fault-bounded domains. On **Figure 3-3a**, the shallow Quaternary alluvial deposits have been removed, exposing the fragmented nature of the underlying aquifer system in the subsurface.

To provide an assessment of aquifer properties, data from 125 wells were compiled by the USGS throughout the Basin to determine the range and distribution of well productivity. Drillers' reports provided information on well tests, including discharge rate, water-level drawdown, and the length of the test. Productivity was computed as specific capacity, given in terms of gallons per minute per foot (gpm/ft) of drawdown. Coarse-grained, well-sorted sedimentary materials have high values of specific yield and specific capacity because of the large amount of connected pore volume in the material. Conversely, cemented deposits and clay-rich deposits have limited or very small pore spaces, and correspondingly lower values of specific yield and specific capacity (Traum et al. 2022).

Quaternary alluvial deposits are considered aquifer units of more limited areal extent along major streams and beneath the alluvial fans primarily on the eastern side of the Basin. Herbst (DWR 1982) suggests that these alluvial aquifers are vertically continuous and may be hydraulically connected with underlying aquifers in permeable formations, such as to the northwest of Petaluma where alluvial deposits overlie the Wilson Grove Formation. Reported specific-yield values of the Quaternary alluvial deposits ranged from 8 to 17 percent (DWR 1982); specific capacity was not computed because of uncertainty identifying wells open only to this unit. Well yields range from 50 to 150 gpm (DWR 2014).

The Quaternary mixed unit is present only along the axis of Petaluma Valley, generally beneath the course of the Petaluma River (**Figure 3-5** and **3-6**). This aquifer is likely hydraulically connected with both overlying Quaternary alluvial deposits and with the Wilson Grove Formation, which is present only in the northwest part of the Basin. Although previous studies of the Basin did not report aquifer properties for the Quaternary mixed unit, this unit is similar to the Glen Ellen Formation in the Santa Rosa Plain Subbasin; therefore, reported values of specific yield between 3 and 7 percent may be applicable (DWR 1982).

The Wilson Grove Formation forms a single, continuous aquifer unit, due to general lithologic homogeneity and the absence of faults. The sand and sandstones of the Wilson Grove Formation are generally productive aquifers, with reported specific yield of 10 to 20 percent (DWR 1982) and a range in specific capacity of 0.05 to 0.5 gpm/ft (Traum et al. 2022). The yields of wells in the Wilson Grove Formation range from 100 to 1,500 gpm (DWR 2014).

The Petaluma Formation has the greatest extent of any of the aquifer units, occupying much of the eastern part of the Basin (**Figure 3-3a**). The Petaluma Formation aquifer unit is composed of discontinuous lenses of sands and gravels surrounded by silty to clayey mudstones, and hydraulic connections with overlying and adjacent aquifers exist only where these lenses are juxtaposed and interfinger with other aquifers. Wells in the Petaluma Formation produce moderate amounts of water when they intercept the sand and gravel lenses, but well productivity can be low because of the clay-dominated lithology of the Petaluma Formation. Estimated specific yield for the Petaluma Formation from previous studies ranges from 3 to 7 percent (DWR 1982) and specific capacity ranges from 0.015 to 7.5 gpm/ft (Traum et al. 2022). The specific capacities of the Petaluma Formation are approximately equivalent to transmissivities of 4.0 to 2,005 square feet per day (ft^2/d) for confined aquifers and 3.7 to 1,504 ft^2/d for unconfined aquifers.

Sonoma Volcanics are present only at the northeast edge of the Basin, while Tolay Volcanics occur in relatively isolated regions within the Basin (**Figure 3-5**). Water production from the Sonoma Volcanics is highly variable and specific yield is estimated to range from 0 to 15 percent (DWR 1982) while specific capacity ranges from 0.03 to 0.5 gpm/ft (Traum et al. 2022). The specific capacities for the Sonoma Volcanics are approximately equivalent to transmissivities of 8.0 to 133.7 ft^2/d for confined aquifers and 6.0 to 100.2 ft^2/d for unconfined aquifers.

3.1.5.2 Principal Aquifer System Primary Uses

The principal aquifer system serves a number of different users and uses within the Basin, with groundwater extractions from a combination of domestic water supply wells on rural residential properties in the unincorporated areas of the Basin, agricultural irrigation wells used for crop irrigation, industrial uses for businesses, and public water supply wells for municipal and smaller public supply systems.

In some areas, shallow portions of the principal aquifer system also provide a significant amount of base flow to streams within the Basin, which contribute to streamflow and provide benefits to ecosystems in the Basin. Additionally, in some areas where groundwater levels are close to the ground surface such as near streams and in the tidal marshland areas, the shallow portions of the principal aquifer system provide water for natural vegetation communities, including riparian habitat, in the Basin.

3.1.5.3 Aquitards

Aquitards composed of clay deposits can locally separate the shallow and deeper portions of the principal aquifer systems and serve to locally confine deeper portions of the principal aquifer system. Regionally continuous aquitards have not been identified within the Basin. Due to the more clay-rich lithology of the Petaluma Formation and the Quaternary Mixed Unit, aquitards are more prevalent within these aquifer units and likely locally separate shallow and deeper portions of the principal aquifer system vertically. Wells spanning unconfined and confined layers, however, can provide pathways for groundwater to flow between layers vertically that could affect both the hydraulics and water quality of these areas.

3.1.6 Lateral and Vertical Extent of Basin

The structural setting and distribution of geologic units and primary aquifer units described above influence the Basin geographical extent, which are defined by DWR, as documented in Bulletin 118 (DWR 2003). In general, the lateral extent of the Basin is defined by the surficial distribution of the Quaternary sedimentary units and the Tertiary Petaluma Formation based on the 1982 Geologic Map of the Santa Rosa Quadrangle (Wagner and Bortugno 1982). Exceptions to this occur at the northern boundary, where the surface watershed divide between the Petaluma Valley Basin and Santa Rosa Plain Basin forms the boundary, and within the western portions of the City of Petaluma, where a basin boundary modification approved by DWR in 2019 extended the boundary to encompass the jurisdictional areas of the City where the Wilson Grove Formation is present at the surface.

The base of the Basin is defined by a combination of the depth to basement rocks and the approximate depth at which viable water supply aquifers are no longer present. Productive freshwater aquifers within the Basin generally occur at shallower depths with the deeper wells within the Basin extending to an average of approximately 800 feet, and no existing known water wells extending deeper than 1,300 feet. At depths exceeding approximately 1,500 feet, aquifers are likely not usable for water supply due to a combination of (1) lower well yields related to increased consolidation and cementation of aquifer materials at these depths, and (2) poor quality water related, in part, to the presence of brackish connate water. The term connate implies that the solute source is older seawater trapped in the geologic formations when they were deposited (Hem 1992). The base of the Basin is, therefore, defined to occur at 1,500 feet except where the depth to basement rocks occurs shallower than 1,500 feet, in which case the top of the basement rocks represents the base of the Basin.

3.1.7 Effects of Faults on Groundwater

Faults can affect water flow and well production because groundwater movement may be inhibited or preferentially increased across or within faults and fault zones. Faulting can break even very strong rocks, producing fracture zones that tend to increase permeability, and may provide preferential paths for groundwater flow. Conversely, some faults can form groundwater barriers, if the faulting grinds the broken rock into fine-grained fault gouge with low permeability, or where chemical weathering and cementation over time have reduced permeability. The hydraulic characteristics of materials in a fault zone, and the width of the zone, can vary considerably so that a fault may be a barrier along part of its length but elsewhere allow or even enhance groundwater flow across it. Faults also may displace rocks or sediments so that geologic units with very different hydraulic properties are moved next to each other (Traum et al. 2022).

The effect of faults on the groundwater flow is difficult to determine in the Basin for two reasons: (1) the lack of aquifer-test data near faults, and (2) northwest-trending faults in the Basin run parallel to the predominant direction of groundwater flow along the axis of the valley. Although there are insufficient data to determine the effect of these faults on groundwater levels and flows, previously published work of Cardwell (1958) and DWR (1982) do not indicate any potential effect of the Burdell Mountain and Rodgers Creek faults. Current analyses based on historical groundwater-level mapping also suggests that the Bloomfield, Cinnabar School, and Petaluma Valley faults do not influence groundwater levels in this area (Traum et al. 2022). Previous work of Herbst (DWR 1982) suggests that the fault-related juxtaposition of low-permeability rocks (basement or Tolay Volcanics) with more permeable units may influence groundwater levels in the vicinity of the Meacham Hill and Tolay faults, rather than the result of any special hydraulic properties of the fault zones themselves. Sweetkind and Teague (Traum et al. 2022) did not evaluate the potential effect of the Lakeville fault on water levels, due to the lack of water-level data on the east side of the fault.

3.1.8 Natural Groundwater Recharge and Discharge

Sources of groundwater recharge in the Basin are infiltration from precipitation, seepage from the Petaluma River and its tributaries, irrigation-return flow, and inflow from San Pablo Bay and the adjacent saltwater marshes. Leakage from water-supply infrastructure is another possible source; however, the city estimates that losses are minimal and are not considered important sources (Traum et al. 2022). Groundwater discharges as baseflow to streams, spring flow, evapotranspiration (ET), and groundwater pumpage. Basin groundwater recharge and discharge can also occur as underflows across the Basin boundary.

3.1.8.1 Groundwater Recharge

Recharge to aquifers in the Basin primarily occurs through streambed recharge along portions of Petaluma River and its tributaries, as well as through direct infiltration of precipitation and along the margins of the valley areas (mountain-front recharge) (Traum et al. 2022). West Yost (2004) concluded potential recharge occurs through infiltration along stream channels where erosion has exposed permeable beds within the Petaluma and Wilson Grove formations. Herbst (DWR 1982) estimated that approximately 20 percent of the Basin is capable of contributing to groundwater recharge using criteria based on measured infiltration rates (greater than 0.6 inch per hour) and land slopes (less than 15 percent), primarily within and northwest of the City of Petaluma and along the crest of Sonoma Mountain. Herbst (DWR 1982) estimated the average total annual natural recharge in the Petaluma Valley groundwater basin to be about 40,000 acre-feet (8 inches). Using a basin characterization model (BCM) (Flint and Flint 2007), Micheli et al. (2012) estimated an annual average of 29 inches (230,000 acre-feet) of precipitation and 25,000 acre-feet of natural recharge in the PV watershed for 1981-2010. **Figure 3-8a** shows the various simulated groundwater recharge components in the Basin. The greatest areal recharge occurs at locations that correspond to agricultural areas, whereas the areas with the greatest total recharge correspond to areas receiving stream recharge to groundwater.

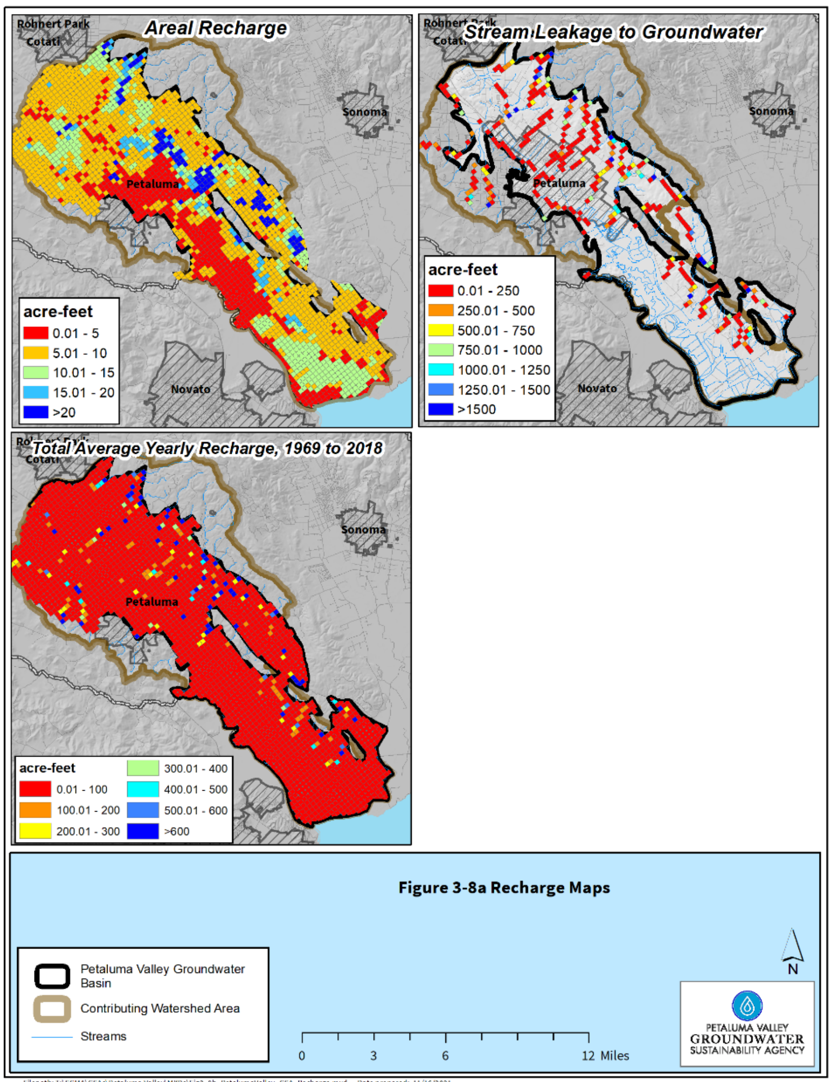

Figure 3-8a. Simulated Spatial Patterns of Mean Groundwater Recharge, from WY 1969 to WY 2018

Areal recharge (upper left), stream leakage from groundwater (upper right), and total average yearly recharge, from 1969 to 2018 (lower left)

3.1.8.2 Groundwater Discharge

Groundwater discharge occurs in the Basin as stream baseflow (gaining streams), discharge at springs, seeps, and interconnected wetlands. Groundwater also discharges through ET from phreatophytes and groundwater pumping; however, these two components of groundwater discharge are described in **Section 3.3** (Water Budget).

Natural groundwater discharge to streams, or baseflow, occurs during the wet season along the Petaluma River and its tributaries north of the tidally influenced reach. Groundwater discharges through springs in areas of the Sonoma Mountains where stratigraphic contacts between fractured volcanic rocks and the underlying Franciscan basement forces water to the land surface. Micheli et al. (2012) estimated the actual ET rate for 1981 to 2010 was about 20 inches per year. Assuming a total area for the PV watershed of about 99,060 acres, the total actual ET was 165,100 AFY. Most of the groundwater discharge through ET occurs where the depth to groundwater is shallow, such as in the tidal marshlands. **Figure 3-8b** shows the simulated groundwater discharge in the Basin. The greatest groundwater ET occurs in the marshlands near the Petaluma River, whereas the greatest total discharge occurs along various stream reaches throughout the basin. The greatest surface leakage occurs in the portions of the Basin near the outlet of the Petaluma River into San Pablo Bay.

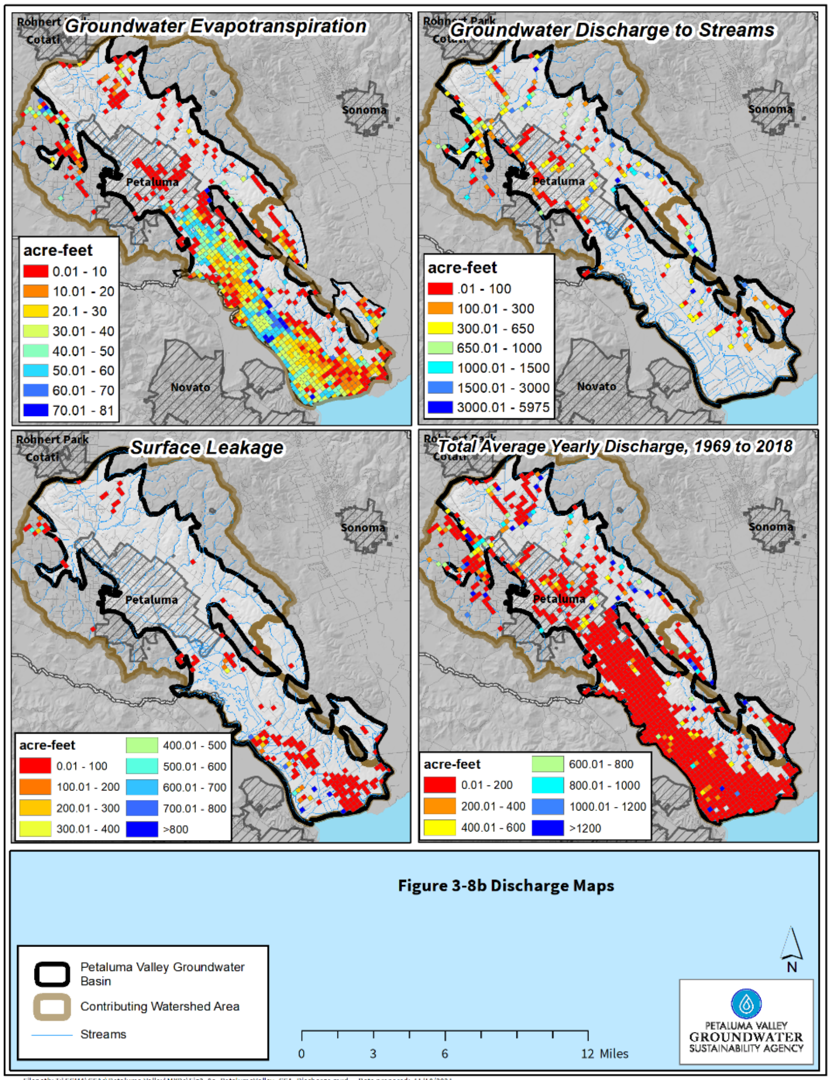

Figure 3-8b. Simulated Spatial Patterns of Mean Groundwater Discharge, from WY 1969 to WY 2018

Groundwater ET (upper left), groundwater discharge to streams (upper right), surface leakage (lower left), and total average yearly discharge, from 1969 to 2018 (lower right)

3.1.9 Addressing Data Gaps and Uncertainty

While the information and data presented in this HCM incorporate the best available information and datasets, it is recognized that all HCMs will contain varying degrees of uncertainty that can be improved through additional data collection and analysis. Addressing the following primary identified data gaps would improve and reduce uncertainty of the HCM for the Basin. The data gaps are further discussed in **Section 6** (Projects and Management Actions) and **Section 7** (Implementation Plan).

3.1.9.1 Aquifer and Aquitard Continuity and Properties and the Role of Fault Zones

As described in the preceding sections, the geologic complexities of the Basin and limited high-quality subsurface lithologic data limit the understanding of the lateral and vertical continuity and properties of aquifers and aquitards in the Basin. The following will help address these data gaps:

- Filling three-dimensional data gaps in the monitoring network for the primary aquifer system in the Basin. Depth-dependent water level and water-quality data are needed to improve the understanding of the hydrogeology and aquifer system, which could be improved through the construction of dedicated nested monitoring wells in key areas.

- Gaining a better understanding of the role of faults within and along the boundaries of the Basin, with a focus on the role of the Meacham Hill, Petaluma Valley, and Cinnabar School faults. Potential methods for addressing this data gap could include the performance of aquifer tests, geophysical surveys, and geochemical sampling and analyses in the vicinity of these faults.

- Developing better information on basin-boundary characteristics, such as the direction and magnitude of groundwater fluxes across Basin boundaries, including boundaries between the Basin and adjoining groundwater basins and boundaries between the Basin and the upper contributing watershed areas outside of the Bulletin 118 basin (DWR 2014). Potential methods for addressing this data gap could include the construction of dedicated nested monitoring wells and/or the performance of aquifer tests and geophysical surveys in the vicinity of the boundaries.

- Improving the understanding of groundwater flow paths near areas of brackish water in southern Petaluma Valley will support the appropriate refining of SMC in this area. Potential methods for addressing this data gap could include the construction of dedicated nested monitoring wells and/or and geophysical surveys in this area.

3.1.9.2 Recharge and Discharge Areas and Mechanisms and Surface Water/Groundwater Interaction

Improved understanding recharge and discharge mechanisms within the Basin would support the appropriate selection of projects and actions needed for the Basin. The following can help address these data gaps:

- Improving estimates of the annual volume of groundwater recharge and discharge, including pumping.
- Gaining an improved understanding of the interconnection of streams to the shallow portions of the aquifer system, including seasonal variability and how groundwater pumping can affect streamflow. Additional shallow monitoring wells near stream courses, stream gages, and meteorological stations can help advance this understanding.
- Geochemical or tracer studies can help better understand both recharge and discharge mechanisms to both the aquifer system, as well as surface water/groundwater interaction within the Basin.

3.2 Current and Historical Groundwater Conditions

This subsection describes the current and historical groundwater conditions within the Basin and contributing watershed areas. As described in the GSP Regulations, "Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:"

- Groundwater elevation data: Contour maps, hydrographs
- Change in storage estimates: Annual and cumulative changes, including groundwater use and water year (WY) type
- Seawater intrusion: Maps and cross sections for each principal aquifer
- Groundwater quality: Issues that may affect supply and beneficial uses, map of contaminant sites and plumes
- Land subsidence: Extent and annual rate
- Interconnected surface water: Timing of depletions, map of groundwater dependent ecosystems

To assess and evaluate the above-listed conditions for the Basin and contributing watershed areas, this subsection includes a description of the following conditions based on available information and data:

- Climate conditions and trends
- Groundwater elevation data and trends
- Estimates of storage changes
- Groundwater quality data and trends, including an assessment of seawater intrusion
- Land surface subsidence data and trends
- Surface water conditions and trends
- Assessment of interconnected surface water and groundwater dependent ecosystems

3.2.1 Climatic Conditions and Trends

Regional climate patterns in the Northern California region encompassing the basin and contributing watershed are characterized by Mediterranean conditions. Distributions of temperature and rainfall display high spatial and temporal variability due to the combination of coastal and inland weather systems. The intersection of these variable weather patterns with the rugged topography of the Coast Ranges results in a variety of microclimates.

The Mediterranean climate in the Basin and contributing watershed influences water demands by separating the year into wet and dry seasons. During the dry season, outdoor irrigation demands, particularly for agriculture, are not met by precipitation. Approximately 95 percent of the annual precipitation normally falls during the wet season (October to April), with a large percentage of the rainfall typically occurring during three or four major winter storms. The occurrence of precipitation is affected by atmospheric rivers, which concentrate rainfall and runoff along narrow bands in the atmosphere. Nearly 50 percent of precipitation in the Sonoma County area is due to atmospheric rivers (Dettinger et al. 2011). The quantity of rainfall over the contributing watershed increases with elevation, with the greatest precipitation over the highest ridges reaching nearly 50 inches per year in the Mayacamas and Sonoma Mountains (**Figure 3-9**).

Mean annual precipitation in the Basin has been assessed using both observed data from Climate Station Petaluma (USC00046826), which is located in Petaluma at an elevation of 25 feet (National Geodetic Vertical Datum of 1929 [NGVD 29]), as well as yearly averages calculated using Parameter-elevation Regressions on Independent Slopes Model (PRISM) for the Basin and contributing watershed area. The station has moved locations throughout its operations, and has been located and named PETALUMA, PETALUMA AIRPORT, PETALUMA AP, PETALUMA FIRE STA 2, PETALUMA FIRE STN 2, and PETALUMA FIRE STN 3. The Petaluma station has operated from 1893 to present, with periods of negligible data coverage until 1913, generally good coverage from 1913 to 1937 (85 percent of days with reported data), and from 1938 to present consistent coverage (97 percent of days reported). Records for this station are stored on the U.S. Historical Climatology Network until the year 2019. The yearly averaged precipitation measured from this station from 1893 through WY 2018 is 24.3 inches, compared with 24.5 inches, as calculated by the PRISM model. This calculation is based on the annual WY standard nomenclature, which begins on October 1 and ends the following calendar year on September 30.

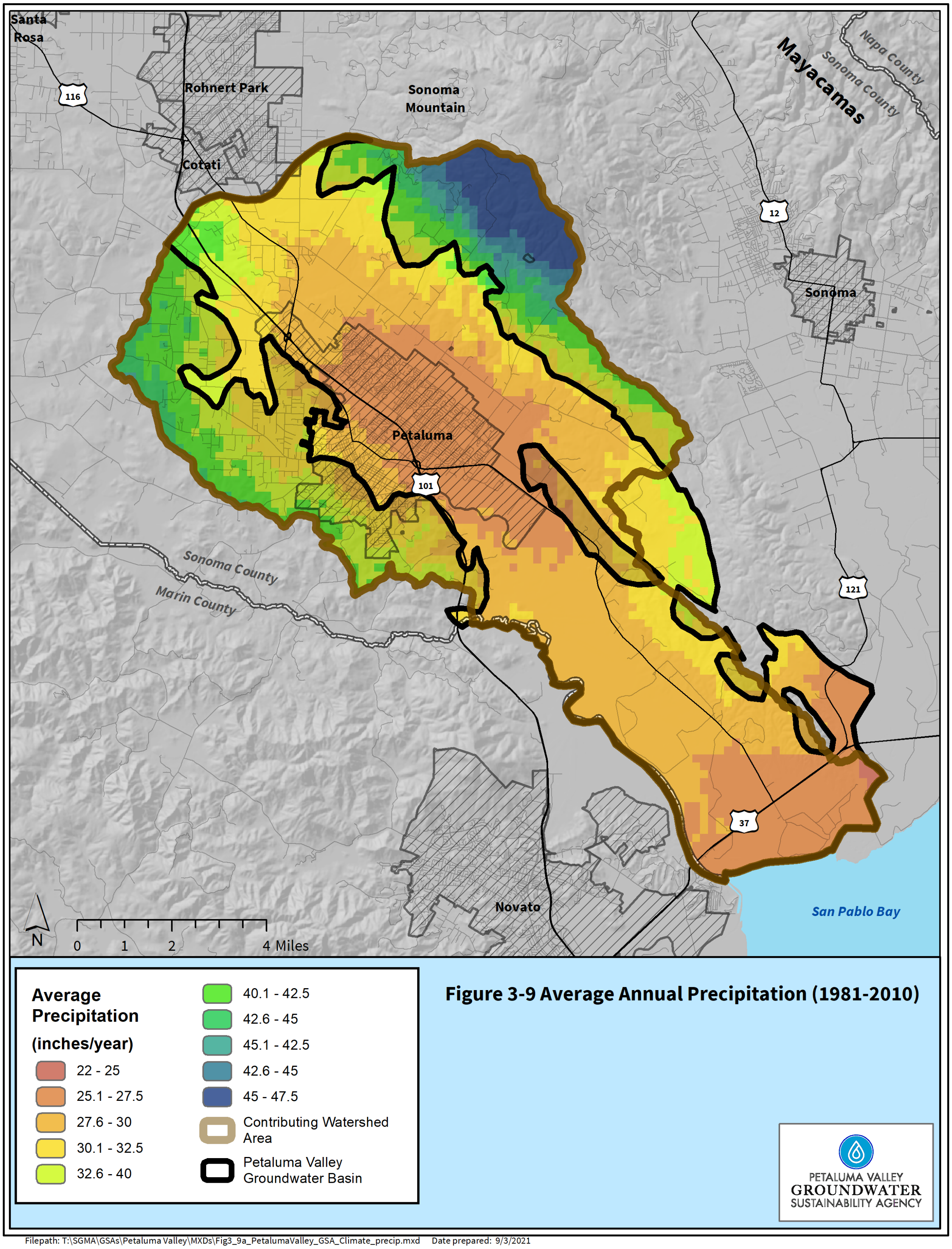

Figure 3-9. Average Annual Precipitation (1981-2010)

For the purposes of comparing and classifying WY types for the GSP, data from the PRISM model and historical data were used from Sonoma Valley, Santa Rosa Plain, and Petaluma Valley to develop an aggregated WY classification for all three basins. The methodology and results are provided in **Appendix 3-A**. Climate change projections are described in the Water Budget Section (**Section 3.3**).

3.2.2 Groundwater Elevations and Trends

This subsection describes current and historical groundwater elevation conditions and trends based on Sweetkind and Teague (Traum et al. 2022) and available data from the monitoring programs described in **Section 2.4**. Data presented and evaluated as part of this section include:

- Groundwater-level contour maps (**Figures 3-10a** through **3-10c**)
- Long-term groundwater-level hydrographs (**Figures 3-11** and **3-12a** through **3-12e**, and **Appendix 3-B**)

3.2.2.1 Groundwater-level Contour Maps

Preliminary groundwater-level elevation contour maps from Sweetkind and Teague (Traum et al. 2022) for spring 1951, fall 1980, and spring 2015 are shown on **Figures 3-10a**, **3-10b**, and **3-10c**, respectively, and indicate the following:

- Spring 2015 groundwater-level elevations ranged from approximately 465 feet mean sea level (msl) near the eastern edge of the Basin to -13 feet msl in the southern central portion of the Basin near the confluence of Adobe Creek and the Petaluma River.

- Flow patterns have remained relatively similar in the Basin since 1951, with groundwater moving from the higher elevations in the east and west of the watershed, toward the Petaluma River.

- Groundwater-level elevations are near or below sea level in the areas adjacent to the Petaluma River from the southern portion of the City of Petaluma to San Pablo Bay. In this area of low water levels, the river may be gaining or losing flow to groundwater depending on the tidal cycle and the resultant river stage height in relation to groundwater elevations, with the river generally gaining during low tides and losing during high tides (Traum et al. 2022).

It is important to note that groundwater elevations measured in nearby wells can be highly variable due to differences in well design (that is, the depth and length of well-screen intervals) and the spatial variations in aquifer materials (which can vary abruptly due to the complex geologic conditions and numerous fault zones present in Petaluma Valley). Therefore, the associated groundwater-level contour maps represent generalized groundwater-level flow patterns and should not be used to interpret more localized or site-specific conditions.

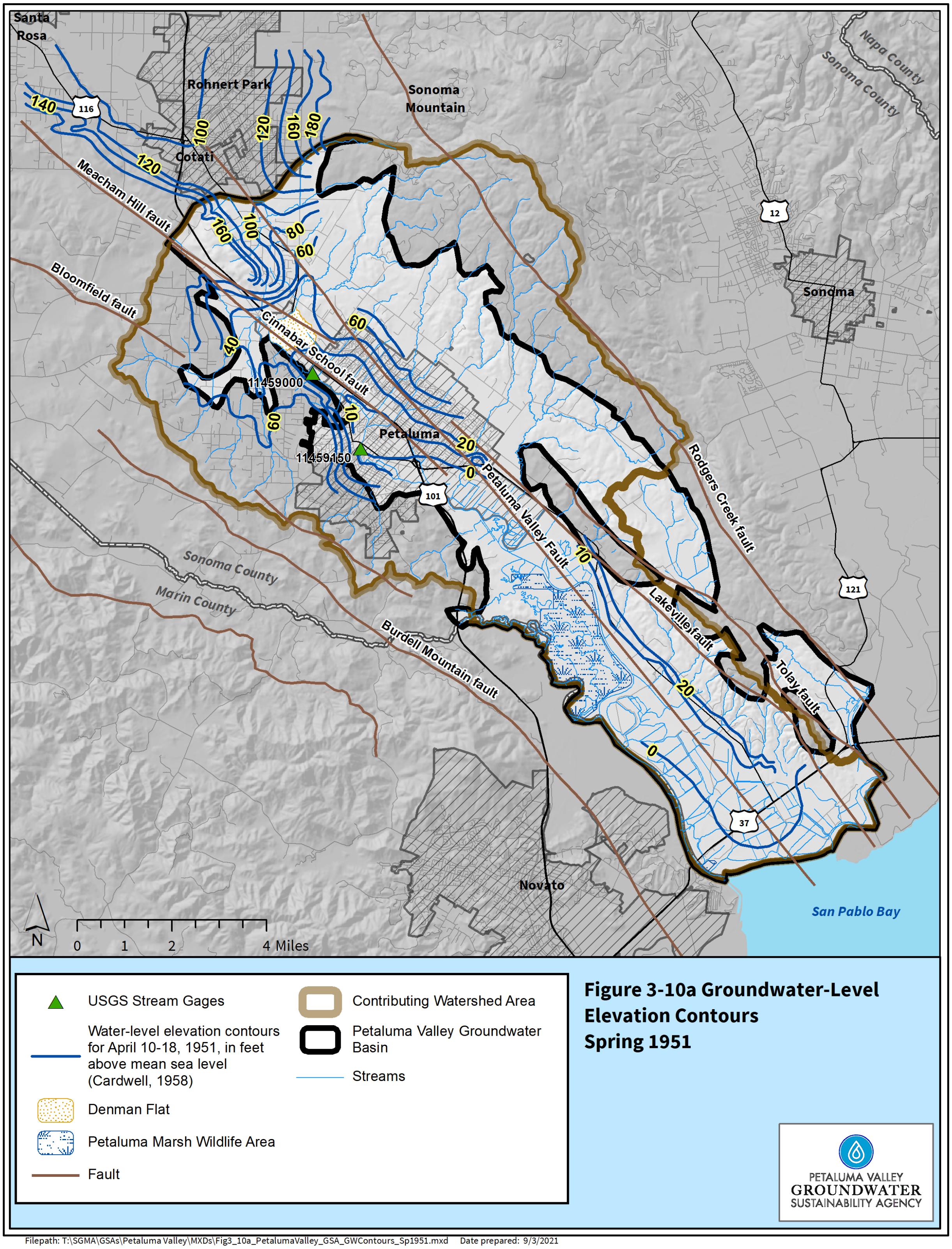

Figure 3-10a. Groundwater-level Elevation Contours Spring 1951