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Groundwater Sustainability Update 2022 (GSU22) Monitoring Plan

GSP Alternative 5-Year Update

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Contents

1 INTRODUCTION 1
1.1 DWR Recommended Action 1
1.2 Proposed GSU22 Committee Statement 2
2 MONITORING OBJECTIVES 3
3 DESCRIPTION OF MONITORING NETWORK 5
3.1 Groundwater Level Monitoring Network 8
3.2 Groundwater Quality Monitoring Network 12
3.2.1 Basin-Wide Groundwater Quality Monitoring Network 12
3.2.2 Seawater Intrusion Monitoring Network 16
3.3 Groundwater Extraction Monitoring Network 16
3.4 Land Subsidence Monitoring Network 20
3.5 Surface Water Monitoring Network 22
4 MONITORING PROTOCOLS FOR DATA COLLECTION 24
4.1 Groundwater Level Monitoring Protocols 24
4.1.1 Manual Groundwater Level Measurement 25
4.1.2 Groundwater Level Measurement with Continuous Recording Devices 26
4.2 Groundwater Quality Monitoring Protocols 27
4.3 Groundwater Extraction Metering Protocols 28
4.4 Land Subsidence Monitoring Protocols 28
4.5 Surface Water Monitoring Protocols 29
5 ASSESSMENT AND IMPROVEMENT OF MONITORING NETWORK 30
5.1 Evaluation by Aquifer Unit 30
5.2 Adequacy of Network to Comply with SGMA 31
5.3 Monitoring Data Gaps 31
5.3.1 Groundwater Level Monitoring Data Gaps 32
5.3.2 Groundwater Quality Monitoring Data Gaps 39
5.3.3 Subsidence Monitoring Data Gaps 40
5.3.4 Surface Water Monitoring Data Gaps 41
5.4 Recommendations for Groundwater Monitoring Improvements 41
5.5 Recommendations for Interconnected Surface Water and Groundwater Dependent Ecosystem Monitoring Improvements 43
6 DATA MANAGEMENT SYSTEM AND DATA REPORTING 45
7 REFERENCES 46

DRAFT

Figures

Figure 1. Distribution of Groundwater Level Monitoring Wells in the Groundwater Level Monitoring Network (Public Wells are Labeled) 11
Figure 2. Distribution of Groundwater Quality Monitoring Wells in the PV Water Monitoring Network (Public Wells are Labeled) 15
Figure 3. Metered and Unmetered Extraction Wells in the Pajaro Valley Subbasin 18
Figure 4. Metered and Unmetered Extraction Wells with Groundwater Level Monitoring (Public Wells are Labeled) 19
Figure 5. Continuous Global Positioning System Stations in the Pajaro Valley Subasin 21
Figure 6. Surface Water Monitoring Gages in the Pajaro Valley Subbasin 23
Figure 7. Groundwater Level Monitoring Networks and Identified Data Gaps 34
Figure 8. RMP PV4MD and Moss Landing Area Well Hydrographs 36
Figure 9. RMP Well 2 and East of Kelly Lake Area Well Hydrographs 37
Figure 10. RMP Selection, Well 9 and North of Ellicott Slough Well Hydrographs 38

Tables

Table 1. Applicable Sustainability Indicators in the Pajaro Valley Subbasin 3
Table 2. Summary of Agencies Contributing to the PV Water Groundwater Monitoring Network 6
Table 3. Summary Wells in the GSP Alternative Public Groundwater Level Monitoring Network 9
Table 4. Summary Wells in the GSP Alternative Public Groundwater Quality Monitoring Network 13
Table 5. Summary of Existing and Recommended Monitoring for Groundwater Dependent Ecosystem and Interconnected Surface Water 44

Appendices

Appendix A. Quality Assurance Project Plan for Pajaro Valley Water Management Agency Groundwater Monitoring Program (not included in draft)
Appendix B. Information to Support Developing GWL SMC for Areas of Recommended RMPs (not included in draft)

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ACRONYMS & ABBREVIATIONS

Aromas.....Aromas Red Sands
AWD.....Aromas Water District
Basin .....Pajaro Valley Subbasin
CASGEM.....California Statewide Groundwater Elevation Monitoring
CDS.....Coastal Distribution System
CGPS.....Continuous Global Positioning System
CWD .....Central Water District
DMS.....Data Management System
DTW .....depth to water
DWR .....California Department of Water Resources
GAMA .....Groundwater Ambient Monitoring and Assessment Program
GDE .....groundwater dependent ecosystem
GSP .....Groundwater Sustainability Plan
GSU22.....Groundwater Sustainability Update 2022
GWE .....groundwater elevation
HSF .....Harkins Slough Managed Aquifer Recharge and Recovery Facility
InSAR .....Interferometric Synthetic Aperture Radar
ISW .....interconnected surface water
MCWRA.....Monterey County Water Resources Agency
NAVD88.....North American Vertical Datum of 1988
Purisima .....Purisima Formation
PV Water.....Pajaro Valley Water Management Agency
PVHM.....Pajaro Valley Hydrologic Model
QAPP .....Quality Assurance Project Plan
RMP .....representative monitoring point
RP.....reference point
RPE .....reference point elevation
SGMA.....Sustainable Groundwater Management Act
SMC .....Sustainable Management Criteria
SNMP.....Salt and Nutrient Management Plan
SqCWD.....Soquel Creek Water District
State Water Board.....State Water Resources Control Board
SWI .....seawater intrusion
UNAVCO .....University NAVSTAR Consortium
USGS .....United States Geological Survey

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1 INTRODUCTION

As part of Pajaro Valley Water Management Agency's (PV Water) Basin Management Plan: Groundwater Sustainability Update 2022 (GSU22), this monitoring plan includes an update to the monitoring networks used to evaluate Pajaro Valley Subbasin (Basin) groundwater conditions to meet requirements for the Sustainable Groundwater Management Act (SGMA). Sustainable management criteria (SMC) metrics depend on data collected by the monitoring networks to determine if undesirable results are occurring and to track progress towards groundwater sustainability.

1.1 DWR RECOMMENDED ACTION

In approving PV Water's Groundwater Sustainability Plan (GSP) Alternative, the California Department of Water Resources (DWR, 2019) found that it did not explicitly describe the monitoring network, but that PV Water monitors and has compiled extensive monitoring data that are the basis of the GSP Alternative. DWR also reviewed PV Water's Draft Monitoring Network Review Memorandum (Feeney et al., 2016), that evaluated PV Water's monitoring network compared to SGMA requirements, and recommended PV Water develop a monitoring plan based on the review. DWR recommended that PV Water more explicitly describe the monitoring network and monitoring plan for inclusion in its first 5-year update to the GSP Alternative as follows:

> Recommended Action 8: Staff recommend that the Agency finalize information contained in the Draft Monitoring Network Review Memo, which is an assessment of the monitoring network in the Subbasin; and incorporate those findings into a monitoring plan for the Pajaro Valley Subbasin that identified the timing and frequency of data collection. The monitoring plan should describe steps that will be taken to fill data gaps identified in the Monitoring Network Review Memo. As new information is acquired, the plan should be updated with the improved understanding, e.g., to provide seawater intrusion conditions for the Basin

This monitoring plan addresses the recommended action and will be included in the GSU22 the 5-year update to PV Water's GSP Alternative. The monitoring network description has been prepared in accordance with SGMA regulations §354.34 (establish monitoring network criteria) to include monitoring objectives, monitoring protocols, and data reporting requirements. Assessment and recommendations to improve the existing monitoring network have been prepared in accordance with the SGMA regulations §354.38 (assessment and improvement of monitoring network) to comply with 5-year update requirements pertaining to SGMA regulations §356.4 (periodic evaluation by agency).

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1.2 PROPOSED GSU22 COMMITTEE STATEMENT

This monitoring plan will be presented to the Ad Hoc Sustainable Groundwater Committee (GSU22 Committee) at its September 9, 2021 meeting. Consistent with GSU22 Committee advisement on how other DWR Recommended Actions are addressed, the following statement is proposed for the GSU22 Committee to consider at its meeting:

> *The Monitoring Plan represents PV Water's most current monitoring networks and protocols. It describes future improvements to the network to facilitate improved basin management as the GSP Alternative is implemented.*
>
> *The priorities for future improvements to the network are improvements that will be directly used to assess conditions with respect to sustainable management criteria (SMC)*
>
> - *Wells added to the water quality monitoring network along the seawater intrusion SMC chloride isocontour inland of SC-A4A and between PV6 and the Hudson wells.*
> - *Representative monitoring points for chronic depletion of groundwater levels in the south of Watsonville, Las Lomas, and east of Watsonville areas.*
> - *A representative monitoring point for depletion interconnected surface water along Carneros Creek.*

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2 MONITORING OBJECTIVES

SGMA requires monitoring networks be developed to promote the collection of data of sufficient quality, frequency, and spatial distribution to characterize groundwater and related surface water conditions, and to evaluate changing conditions that occur during implementation of PV Water's GSP Alternative. The monitoring networks are intended to:

- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.
- Demonstrate progress toward achieving measurable objectives.
- Monitor impacts to the beneficial uses or users of groundwater.
- Quantify annual changes in water budget components.

The Basin's existing monitoring networks have been used for many decades to collect information to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface water conditions. The existing networks will be used to collect data relevant to the Basin's applicable groundwater sustainability indicators (Table 1). Land subsidence is currently found to be inapplicable because of a lack of observed permanent or inelastic subsidence in the Basin (Brandt et al., 2021).

Table 1. Applicable Sustainability Indicators in the Pajaro Valley Subbasin

Sustainability Indicator	Data Used to Evaluate Sustainability Indicator	Metric Evaluated Against Sustainable Management Criteria (SMC)
Chronic Lowering of Groundwater Levels	Groundwater level	Data at Representative Monitoring Points (RMPs)
Reduction of Groundwater in Storage	Groundwater level	Change of groundwater in storage calculated based on contoured data
Seawater Intrusion	Chloride Concentration	Data mapped vs. SMC chloride isocontour
Degraded Groundwater Quality	Total Dissolved Solids, Chloride, and Nitrate Concentrations	Data spatially averaged by zone
Depletion of Interconnected Surface Water	Groundwater level	Data at RMPs

The monitoring networks described in this report are based on existing monitoring wells. There are 2 monitoring networks referred to in this monitoring plan:

- The full **PV Water monitoring network** includes both public and confidential privately-owned wells.
- The **GSP Alternative monitoring network** is a subset of only the monitoring features collecting data that are publicly available used for Basin management.

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Data collected from privately-owned wells are confidential and therefore those wells are not part of the GSP Alternative monitoring network unless the property owner provides explicit consent in writing to PV Water that the data may be shared publicly. Confidential wells are monitored by PV Water and the data are used in hydrogeologic analyses; results are presented in an aggregated form or if identifying information about the well including name and exact location can remain confidential. To honor confidentiality, privately-owned wells are not part of the GSP Alternative monitoring network because data collected from that network are required to be uploaded to the Department of Water Resources (DWR) SGMA online data portal for public access.

Representative monitoring points (RMPs) are selected from the GSP Alternative monitoring network because information from RMPs is required to be uploaded to the DWR SGMA Portal. RMPs are established for the chronic lowering of groundwater levels and depletion of interconnected surface water SMC. Groundwater level SMC are assigned to these RMPs and groundwater levels measured in the RMPs are directly compared to the SMC to evaluate the sustainability status of the indicator.

Representative monitoring points are not established for the 3 other applicable sustainability indicators for the Basin: reduction of groundwater in storage, seawater intrusion, and degraded groundwater quality. Sustainability status for these indicators is evaluated based on mapping of data from the full PV Water monitoring network.

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3 DESCRIPTION OF MONITORING NETWORK

DWR's review of PV Water's GSP Alternative monitoring network concluded that the PV Water monitoring network generally has a sufficient density of monitoring wells, measured at sufficient intervals, to capture the spatial and temporal variability of groundwater levels and storage changes in the Basin. (DWR, 2019). This monitoring plan brings all the elements of the GSP Alternative monitoring network into 1 document, incorporate monitoring sites constructed or added since 2016, describes monitoring protocols, identifies remaining monitoring data gaps, and recommends improvements to the networks. Surface water data used for evaluation of depletion of interconnected surface water for GSU22 (cbec, 2021a) as well as Pajaro Valley Hydrologic Model (PVHM) model development, updates, and calibration (Hanson et al., 2015 and M&A, 2021), are part of the surface water monitoring network, which continues to assess interconnected surface water.

PV Water's monitoring network has been used for several decades to collect information to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and to enable PV Water and community stakeholders to be adequately informed when making management decisions. The monitoring networks include features for the collection of data to monitor the 6 groundwater sustainability indicators applicable to the Basin: chronic lowering of groundwater levels, reduction of groundwater in storage, seawater intrusion, degraded groundwater quality, land subsidence, and depletion of interconnected surface water.

The groundwater monitoring program is designed to measure changes in storage and quality within the Basin through the collection and analysis of metered groundwater extractions, groundwater levels, and groundwater quality. Data collected from this program enable PV Water staff to track the effects of groundwater extraction and water resource management activities, which include water supply facility operations and conservation programs. The surface water monitoring program has been designed to track fluctuations of water quality, volume, and water levels in both streams and other water bodies. Groundwater level data obtained from the monitoring network track changes in groundwater storage, impacts of water management projects, and are also used in the development and refinement of the PVHM. Groundwater quality data assists in tracking trends in groundwater both spatially and temporally, the progression of seawater intrusion (SWI), and the impacts of projects and management actions.

The total number of wells in the full PV Water monitoring network, including destroyed, collapsed, no longer accessible, and wells outside the Basin is 1,281 (Table 2). From this greater network, there are 264 active dedicated monitoring wells and production wells mostly within the Basin that monitor groundwater levels and/or groundwater quality. Twenty-five of those wells are outside but close to the Basin boundary. Destroyed or collapsed wells are kept in the network as their historical data are still used for basin management. The majority of the wells are inherited from existing groundwater monitoring networks established by the state of California,

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the County of Monterey, and the County of Santa Cruz. The monitoring network is composed of predominantly privately owned wells, municipal supply wells, and a series of dedicated monitoring wells.

Almost all of the wells in the PV Water network monitor groundwater levels with most capable of producing groundwater quality samples. Twenty water supply wells used for monitoring groundwater levels and quality are constructed with the intention of obtaining the maximum yield are screened across more than 1 aquifer unit (i.e., alluvium and Aromas, and Aromas and Purisima) . Wells screened across multiple aquifers cannot provide aquifer specific data, but can still be used to evaluate composite groundwater conditions for the two units screened. A small subset of 54 wells in the network are monitored by other entities that share the data with PV Water. These partnering entities include Soquel Creek Water District (SqCWD), Central Water District (CWD), the Monterey County Water Resources Agency (MCWRA), Aromas Water District (AWD), the County of Santa Cruz, and an unnamed public agency that has agreed to have its data and well information uploaded to DWR but not otherwise identified. Twenty-five of the wells in PV Water's network are outside the Basin and are used as control points when preparing groundwater elevation contours and to develop boundary conditions in the PVHM. Data from these wells can be made publicly available and uploaded to DWR portal, with a subset requesting that well ownership, site identification, and use not be disclosed in GSU22 reports and SGMA reporting.

Table 2. Summary of Agencies Contributing to the PV Water Groundwater Monitoring Network

Monitoring Agency	Production Wells	Dedicated Monitoring Wells	Wells with Use to be Disclosed to DWR	Total Number of Wells
PV Water				
Groundwater level and/or quality collected by PV Water	157	62	0	219
Production reported to PV Water	1,008	0	0	1,008
Central Water District*	6	3	0	9
Soquel Creek Water District**	0	18	0	18
Aromas Water District	3	1	0	4
Santa Cruz County	5	0	0	5
Monterey County Water Resources Agency*	0	4	0	4
Unnamed Public Agency	0	0	14	14
Total	1,179	88	14	1,281

* wells are outside the Basin

** 13 of 18 wells are outside the Basin

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A large portion of the monitoring network monitored directly by PV Water is broken down into sub-networks based on the frequency of data collection (monthly, semi-annually) or a specific project (supplemental, Harkins Slough Facility). These sub-networks are described below:

- PV Water's Monthly monitoring network consists of 53 wells distributed across the Basin. Groundwater levels are measured every month and groundwater quality samples are collected semi-annually. PV Water's 22 dedicated monitoring wells in this sub-network are known as the "PV" series are part of this sub-network but have groundwater quality samples collected 3 times a year. Wells in this sub-network with publicly available data are included in the GSP Alternative monitoring network.
- PV Water's Semi-Annual monitoring network consists of 98 wells distributed across the Basin. Groundwater levels are measured, and groundwater quality samples are collected twice a year in spring and fall. PV Water attempts to collect groundwater level measurements and groundwater quality samples semi-annually, but due to access and operational issues groundwater level measurements and water quality samples are not always collected. Wells in this sub-network with publicly available data are included in the GSP Alternative monitoring network.
- PV Water's Supplemental Well monitoring network consists of 37 wells and was created in 2004 for the purpose of monitoring groundwater conditions at 3 locations that at that time were potential sites for supplemental supply wells to the Coastal Distribution System (CDS). At present, only 1 (BW2) of the 3 supplemental supply wells has been constructed with a previously existing well (BW1) leased by PV Water. As this Supplemental Monitoring network was created to monitor a project and is composed of privately owned wells, only BW1 and BW2 are included in the GSP Alternative monitoring network.
- The Harkins Slough Managed Aquifer Recharge and Recovery Facility (HSF) diverts water from Harkins Slough and impounds it in a spreading basin located on the adjacent San Andreas Terrace. As part of the HSF, PV Water has installed 12 recovery wells and 16 monitoring wells to operate and observe project performance. These wells are monitored either monthly or continuously with dedicated data loggers. Groundwater quality samples are collected from 23 of these wells. As this sub-network was created to monitor conditions specific to project operations in the shallow terrace aquifer, only HSPDMW1 and PV11 are included in the GSP Alternative monitoring network because they have been included in CASGEM reporting.

- The PV Water extraction well network contains 1,008 wells that per PV Water ordinances are required to be metered because they pump 10 acre-feet or more annually. Extraction data is reported semi-annually to PV Water.

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The subsections below describe monitoring networks for groundwater levels, groundwater quality, groundwater extraction, land subsidence, and interconnected surface water.

3.1 GROUNDWATER LEVEL MONITORING NETWORK

The chronic lowering of groundwater levels, depletion of interconnected surface water, and reduction of groundwater in storage sustainability indicators are evaluated by monitoring groundwater levels (Table 1). GSP regulations require a network of monitoring wells of sufficient density to demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features.

Table 3 summarizes 61 groundwater level monitoring wells within the Basin that have publicly available data, including all wells part of PV Water's existing CASGEM reporting to DWR. The table includes the aquifer(s) and sustainability indicator(s) monitored, identifies whether it is an RMP, and monitoring frequency. There are 177 active wells not included in Table 3 either because they are confidential wells (152 wells) or outside the Basin (25 wells). Figure 1 shows the basin-wide distribution of the full PV Water groundwater level monitoring network. Confidential wells monitored by PV Water not included in Table 3 are plotted unlabeled on Figure 1 to show the distribution of the full monitoring network used to inform PV Water on Basin conditions. Monitoring network wells outside of the Basin monitored by other agencies are plotted and labeled on Figure 1 but are not part of the public GSP Alterative monitoring network summarized in Table 3.

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Table 3. Summary Wells in the GSP Alternative Public Groundwater Level Monitoring Network

Well	Aquifer	Well Type	Representative Monitoring Point	Measurement Frequency	Monitoring Agency
HSPDMW1*	Alluvial	MW	-	Monthly	PV Water
PV11*	Alluvial	MW	-	Monthly	PV Water
PV13*	Alluvial	MW	-	Monthly	PV Water
PV14	**Alluvial**	**MW**	**ISW**	**Monthly**	**PV Water**
PV20S	**Alluvial**	**Nested MW**	**ISW**	**Monthly**	**PV Water**
PV4MD*	**Alluvial**	**Nested MW**	**GWL**	**Monthly**	**PV Water**
PV4S*	**Alluvial**	**Nested MW**	**-**	**Monthly**	**PV Water**
Well 13	Alluvial	Unnamed	-	Monthly	Unnamed
Well 12	**Alluvial**	**Unnamed**	**-**	**Monthly**	**Unnamed**
782*	Alluvial, Aromas	Supply Well	-	Monthly	PV Water
PV6S*	Alluvial, Aromas	Nested MW	ISW	Monthly	PV Water
Well 1	Alluvial, Aromas	Unnamed	-	Monthly	Unnamed
Well 4	Alluvial, Aromas	Unnamed	-	Monthly	Unnamed
Well 6	Alluvial, Aromas	Unnamed	-	Monthly	Unnamed
Well 8	Alluvial, Aromas	Unnamed	-	Monthly	Unnamed
AWDAimee*	Aromas	MW	GWL	Monthly	PV Water
BW1	Aromas	Supply Well	-	Monthly	PV Water
BW2	Aromas	Supply Well	-	Monthly	PV Water
HudsonS	**Aromas**	**MW**	**GWL**	**Monthly**	**PV Water**
PV1D*	Aromas	Nested MW	-	Monthly	PV Water
PV1M*	Aromas	Nested MW	GWL	Monthly	PV Water
PV1S*	Aromas	Nested MW	-	Monthly	PV Water
PV1SA	Aromas	MW	-	Monthly	PV Water
PV20MD	Aromas	Nested MW	GWL	Monthly	PV Water
PV20SM	**Aromas**	**Nested MW**	**GWL; ISW**	**Monthly**	**PV Water**
PV3D*	Aromas	Nested MW	GWL	Monthly	PV Water
PV3M*	Aromas	Nested MW	-	Monthly	PV Water
PV3S*	Aromas	Nested MW	GWL	Monthly	PV Water
PV6D*	Aromas	Nested MW	-	Monthly	PV Water
PV6MD*	Aromas	Nested MW	GWL	Monthly	PV Water
PV6SM*	**Aromas**	**Nested MW**	**GWL; ISW**	**Monthly**	**PV Water**
PV8M*	Aromas	Nested MW	-	Monthly	PV Water
PV8S*	Aromas	Nested MW	GWL	Monthly	PV Water
SC-A4C	Aromas	MW	GWL	Quarterly	SqCWD
SC-A4D	Aromas	MW	-	Quarterly	SqCWD
SC-A9A	Aromas	MW	GWL	Quarterly	SqCWD
SCCo_Pt1	Aromas	Domestic Well	-	Semi-Annual	Santa Cruz County
SCCo_Pt2	Aromas	Domestic Well	-	Semi-Annual	Santa Cruz County
SCCo_Pt3	Aromas	Domestic Well	-	Semi-Annual	Santa Cruz County

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Well	Aquifer	Well Type	Representative Monitoring Point	Measurement Frequency	Monitoring Agency
SCCo_Pt4	Aromas	Domestic Well	-	Semi-Annual	Santa Cruz County
SCCo_Pt5	Aromas	Domestic Well	-	Semi-Annual	Santa Cruz County
Well 2	Aromas	Unnamed	GWL	Monthly	Unnamed
Well 3	**Aromas**	**Unnamed**	**GWL**	**Monthly**	**Unnamed**
Well 5	Aromas	Unnamed	GWL	Monthly	Unnamed
Well 7	Aromas	Unnamed	-	Monthly	Unnamed
Well 9	Aromas	Unnamed	GWL	Monthly	Unnamed
Well 10	Aromas	Unnamed	-	Monthly	Unnamed
HudsonD	Aromas, Purisima	MW	GWL	Monthly	PV Water
Well 11	Aromas, Purisima	Unnamed	-	Monthly	Unnamed
AWD Marshall	Purisima	MW	-	Monthly	Aromas Water District
PV20D	Purisima	Nested MW	-	Monthly	PV Water
SC-A4A	Purisima	MW	-	Quarterly	SqCWD
SC-A4B	Purisima	MW	-	Quarterly	SqCWD
Well 14	Purisima	Unnamed	-	Monthly	Unnamed
AirportD	Unknown	Nested MW	-	Monthly	PV Water
AirportMD	Unknown	Nested MW	-	Monthly	PV Water
AirportS	Unknown	Nested MW	-	Monthly	PV Water
AirportSM	Unknown	Nested MW	-	Monthly	PV Water
AWD Carpenteria	Unknown	Supply Well	-	Monthly	Aromas Water District
AWD Pleasant Acres	Unknown	Supply Well	-	Monthly	Aromas Water District
AWD San Juan	Unknown	Supply Well	-	Monthly	Aromas Water District

MW = monitoring well; GWL = Chronic Lowering of Groundwater Levels; ISW = Interconnected Surface Water
* CASGEM well; **Bold** indicates well is used to monitor groundwater dependent ecosystems

Of the 238 monitoring wells in the active groundwater level monitoring network, approximately 90 are equipped with pressure transducers to measure groundwater level data continuously at intervals as often as 15 minutes. Many transducers also record temperature and specific conductance. The frequency of groundwater level measurements varies but attempts to measure groundwater levels at all wells occurs at least twice a year.

As shown on Figure 1 the overall spatial distribution of groundwater level monitoring wells is extensive, both throughout the Basin including near the coast. The frequency and spatial distribution of wells is sufficient to evaluate short-term, seasonal, and long-term groundwater trends for groundwater management purposes. Nested monitoring wells completed in different aquifers at the same location are used to understand changes in vertical hydraulic gradients between the principal Aromas Red Sands aquifer, the overlying Alluvial/Marine Terrace deposits, and the Purisima Formation (Purisima) below. There is adequate vertical monitoring distribution for monitoring groundwater levels.

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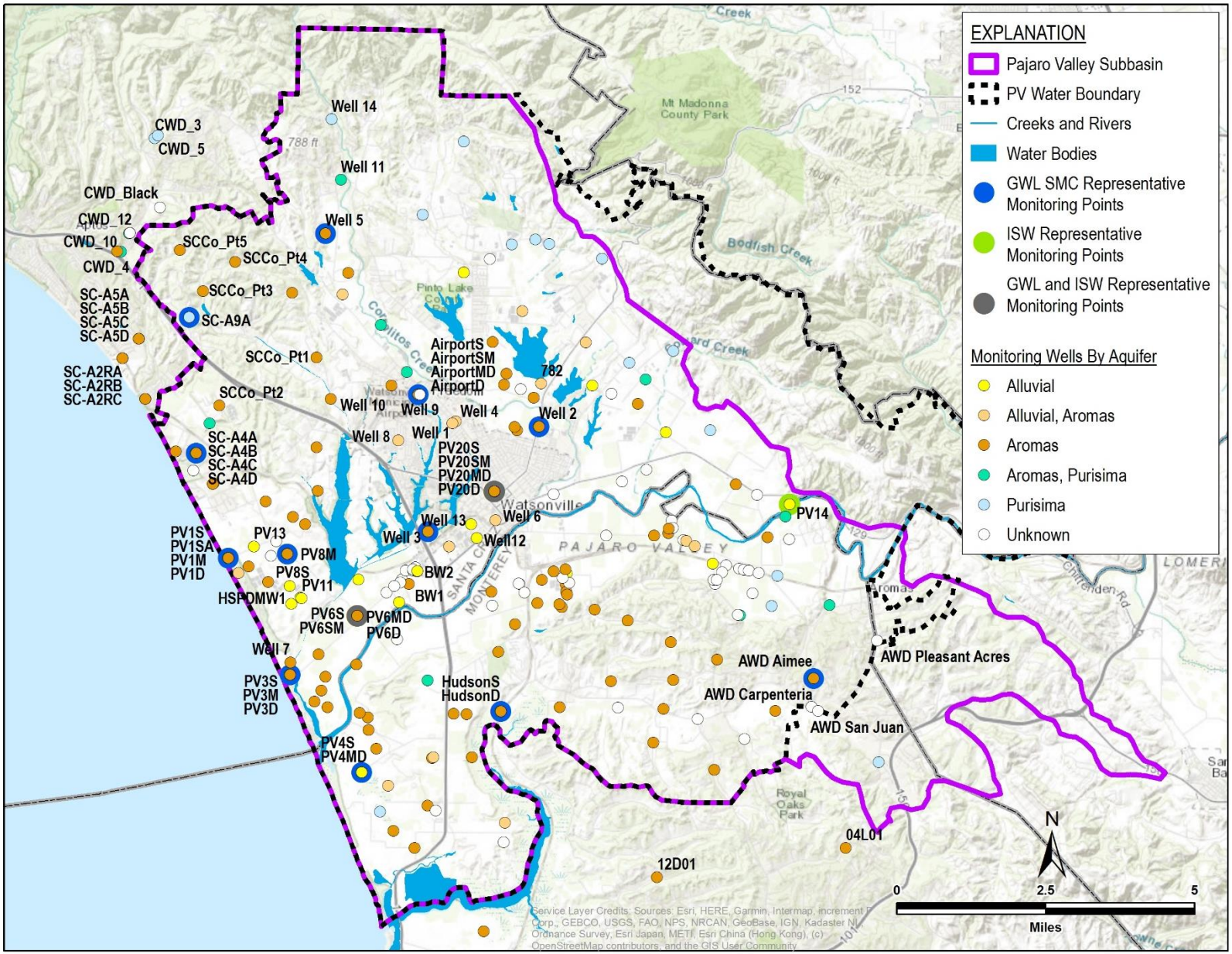

Figure 1. Distribution of Groundwater Level Monitoring Wells in the Groundwater Level Monitoring Network (Public Wells are Labeled)

3.2 GROUNDWATER QUALITY MONITORING NETWORK

3.2.1 BASIN-WIDE GROUNDWATER QUALITY MONITORING NETWORK

The sustainability indicator for degraded water quality is evaluated by monitoring groundwater quality at a network of 134 water supply wells and 59 dedicated monitoring wells. The GSP regulations require sufficient spatial and temporal data from the principal aquifer (Aromas Red Sands or Aromas) to determine groundwater quality trends for water quality indicators to address known groundwater quality issues.

Groundwater quality data are used by PV Water to support the Basin's Salt and Nutrient Management Plan (SNMP) by monitoring general water quality conditions and changes in these conditions throughout the Basin, both spatially and temporally. The data are used to assess seawater intrusion and to prepare maps showing its location.

The August 5, 2021 technical memorandum *Sustainability Status in Pajaro Valley Subbasin: Water* Quality(M&A, 2021) planned for incorporation into GSU22 evaluates current groundwater quality relative to the groundwater quality SMC. The evaluation relied on a compilation of groundwater quality datasets from PV Water's monitoring network, the State Water Resources Control Board (State Water Board) Groundwater Ambient Monitoring and Assessment Program (GAMA), SqCWD, MCWRA. The data were used to generate spatial representations of groundwater conditions for TDS, chloride, and nitrate (as NO_3) during the 5-year period of calendar years 2016 through 2020.

The majority of wells (122 wells) sampled by PV Water are confidential wells. These are excluded from Table 4 summarizing the public wells used for groundwater quality monitoring within the Basin. Figure 2 shows the spatial distribution of 47 public (labeled), 122 confidential, and 830 GAMA wells that are part of PV Water's groundwater quality network used to evaluate basin-wide groundwater quality.

As shown on Figure 2, the overall spatial distribution of groundwater quality monitoring wells is extensive, both throughout the Basin including near the coast. The frequency and spatial distribution of wells is sufficient to evaluate short-term, seasonal, and long-term groundwater trends for groundwater management purposes. Nested monitoring wells completed in different aquifers at the same location are used to understand vertical differences in groundwater quality between aquifer units. There is adequate vertical monitoring distribution for monitoring groundwater levels., although it could be improved along the coast to better understand where seawater intrusion is occurring within the Aromas Red Sands (Feeney et al., 2016). Improvements to the vertical distribution of monitoring are included in Section 5.4.

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Table 4. Summary Wells in the GSP Alternative Public Groundwater Quality Monitoring Network

Well	Aquifer	Well Type	Measurement Frequency	Monitoring Agency
HSPDMW1	Alluvial	Monitoring Well	Semi-Annual	PV Water
PV11	Alluvial	Monitoring Well	3 x year	PV Water
PV13	Alluvial	Monitoring Well	3 x year	PV Water
PV14	Alluvial	Monitoring Well	3 x year	PV Water
PV20S	**Alluvial**	**Nested MW**	**3 x year**	**PV Water**
PV4MD	**Alluvial**	**Nested MW**	**3 x year**	**PV Water**
PV4S	**Alluvial**	**Nested MW**	**3 x year**	**PV Water**
Well 12	Alluvial	Supply Well	Annual	City of Watsonville
Well 13	Alluvial	Supply Well	Annual	City of Watsonville
782	Alluvial, Aromas	Metered Well	Semi-Annual	PV Water
PV6S	Alluvial, Aromas	Nested MW	3 x year	PV Water
Well 1	Alluvial, Aromas	Unnamed	Annual	Unnamed
Well 4	Alluvial, Aromas	Unnamed	Annual	Unnamed
Well 6	Alluvial, Aromas	Unnamed	Annual	Unnamed
Well 8	Alluvial, Aromas	Unnamed	Annual	Unnamed
BW1	**Aromas**	**Supply Well**	**Monthly**	**PV Water**
BW2	**Aromas**	**Supply Well**	**Monthly**	**PV Water**
HudsonS	**Aromas**	**Monitoring Well**	**Annual**	**MCWRA**
PV1D	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV1M	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV1S	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV20MD	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV20SM	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV3D	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV3S	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV6D	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV6MD	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV6SM	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
PV8S	**Aromas**	**Nested MW**	**3 x year**	**PV Water**
SC-A4C	**Aromas**	**Monitoring Well**	**Quarterly**	**SqCWD**
SC-A4D	Aromas	Monitoring Well	Quarterly	SqCWD
Well 10	Aromas	Unnamed	Annual	Unnamed
Well 2	Aromas	Unnamed	Annual	Unnamed
Well 3	Aromas	Unnamed	Annual	Unnamed
Well 5	Aromas	Unnamed	Annual?	Unnamed

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Well	Aquifer	Well Type	Measurement Frequency	Monitoring Agency
Well 7	Aromas	Unnamed	Annual	Unnamed
Well 9	Aromas	Unnamed	Annual	Unnamed
HudsonD	**Aromas, Purisima**	**Monitoring Well**	**Annual**	**MCWRA**
Well 11	Aromas, Purisima	Unnamed	Annual	Unnamed
PV20D	**Purisima**	**Nested MW**	**3 x year**	**PV Water**
SC-A4A	Purisima	Monitoring Well	Quarterly	SqCWD
SC-A4B	Purisima	Monitoring Well	Quarterly	SqCWD
SC-A9A	**Purisima**	**Monitoring Well**	**Quarterly**	**SqCWD**
Well 14	Purisima	Supply Well	Annual	Unnamed
AWD Carpenteria	Unknown	Supply Well	Annual	Aromas Water District
AWD Pleasant Acres	Unknown	Supply Well	Annual	Aromas Water District
AWD San Juan	Unknown	Supply Well	Annual	Aromas Water District

Note. Wells in **bold** are those used to evaluate seawater intrusion, but only those primarily screened in the Aromas Red Sands are used to evaluate the chloride SMC isocontour.

PV Water developed a soil monitoring program in 2005, 4 years prior to deliveries of recycled water, in order to establish baseline soil quality. The baseline data provides a point of comparison for potential changes in soil chemistry following the delivery of blended, recycled water (PV Water, 2016).

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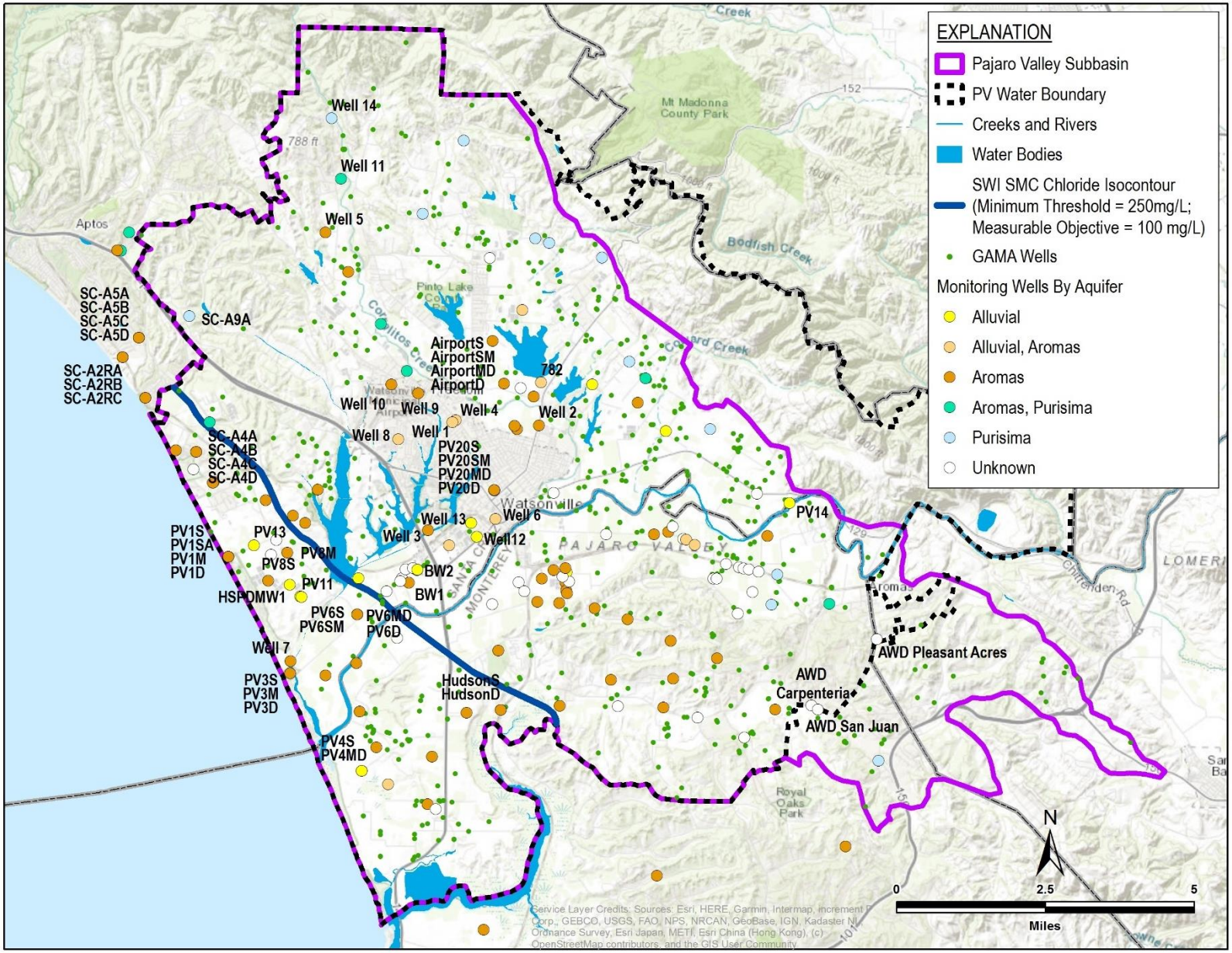

Figure 2. Distribution of Groundwater Quality Monitoring Wells in the PV Water Monitoring Network (Public Wells are Labeled)

3.2.2 SEAWATER INTRUSION MONITORING NETWORK

The sustainability indicator for seawater intrusion is evaluated using chloride concentration measured at an existing network of wells monitored for groundwater quality (Figure 2) compared to the location of the seawater intrusion (SWI) SMC isocontour. The March 9, 2021 technical memorandum *Proposed Sustainable Management Criteria for Seawater Intrusion* (M&A, 2021) planned for incorporation into GSU22 Section 2 describes use of the data from the groundwater quality monitoring network to establish the chloride isocontour SMC. Data from the groundwater quality monitoring network will be used to compare conditions to the chloride isocontour location set for the minimum threshold of 250 mg/L and measurable objective of 100 mg/L. Chloride concentrations observed in the Aromas Red Sands aquifer inland of the SWI SMC isocontour higher than 250 mg/L will be considered a minimum threshold exceedance. If chloride concentrations higher than 100 mg/L are observed in the Aromas Red Sands aquifer inland of the SWI SMC isocontour, measurable objectives are not achieved.

3.3 GROUNDWATER EXTRACTION MONITORING NETWORK

Groundwater extraction for the Basin must be included in annual reports on the GSP Alternative to DWR, Extraction data are also used by PV Water to evaluate changes in groundwater conditions that may be related to pumping stresses and groundwater management activities, as well as to provide the basis for groundwater augmentation fee charges, which support basin management activities .

The amount of groundwater extracted from the Basin is supported by the following sources:

- Municipal groundwater users and small water systems with at least 15 connections or serving at least 25 people are required to measure their groundwater usage and report it to the State of California. These data are available on the State's Drinking Water Information Clearinghouse website and will be used to quantify municipal and small system pumping.
- Agricultural and commercial wells extracting 10 acre-feet/year, or more are required to be metered, and the meters are read by PV Water staff quarterly. The majority of agricultural wells have flow meters installed to measure production with an accuracy of +/-5.0%. A small portion of agricultural wells are estimated due to access limitations. Estimates are based on the size of the use area and type of land use (crop type).
- Metering is not required for agricultural, commercial, and domestic wells if they produce less than 10 acre-feet/year. Those with meters in this groundwater use category are tracked by PV Water quarterly. Unmetered well estimated usage are based on the size of the use area and type of land use (crop type).

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- Private domestic extraction less than 10 acre-feet/year is not required to be metered and reported. Rural residential (domestic) groundwater wells have usage estimated at 0.5 acre-feet/year per connection based on a technical analysis of developed for the PV Water Proposition 218 Service Charge Report (2015), which evaluated annual consumption volumes from 2 local water districts, and 1 water mutual services company: Aromas Water District, Central Water District, and the San Andreas Water Mutual Company (PVWMA Service Charge Report, January 2015).

Groundwater extraction wells equipped with flow meters allow for the accurate measurement of the volume of water pumped. PV Water follows a meter maintenance program that includes routine accuracy tests to check that meters are working properly. Meter calibrations are conducted regularly by trained staff to verify accuracy.

All metered extraction wells and domestic unmetered wells are shown on Figure 3. Approximately 1,008 metered wells and 1,695 unmetered domestic wells are used to derive the total annual extraction reported to DWR in the annual report. The unmetered domestic wells, on Figure 3 are those that have their extraction estimated based on usage of 0.5 acre-feet/year. Figure 4 shows a subset of extraction wells that have groundwater levels monitored by PV Water.

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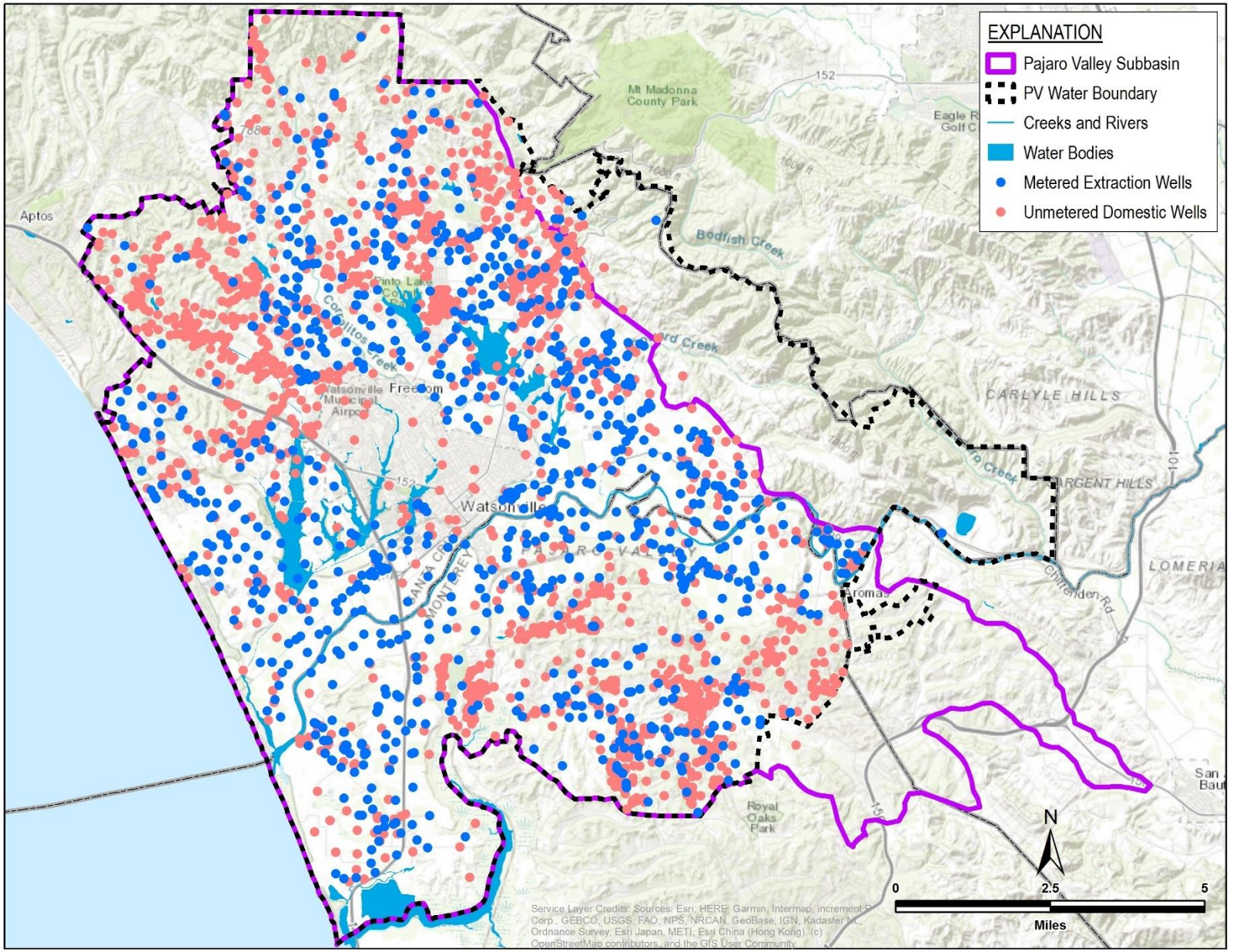

Figure 3. Metered and Unmetered Extraction Wells in the Pajaro Valley Subbasin

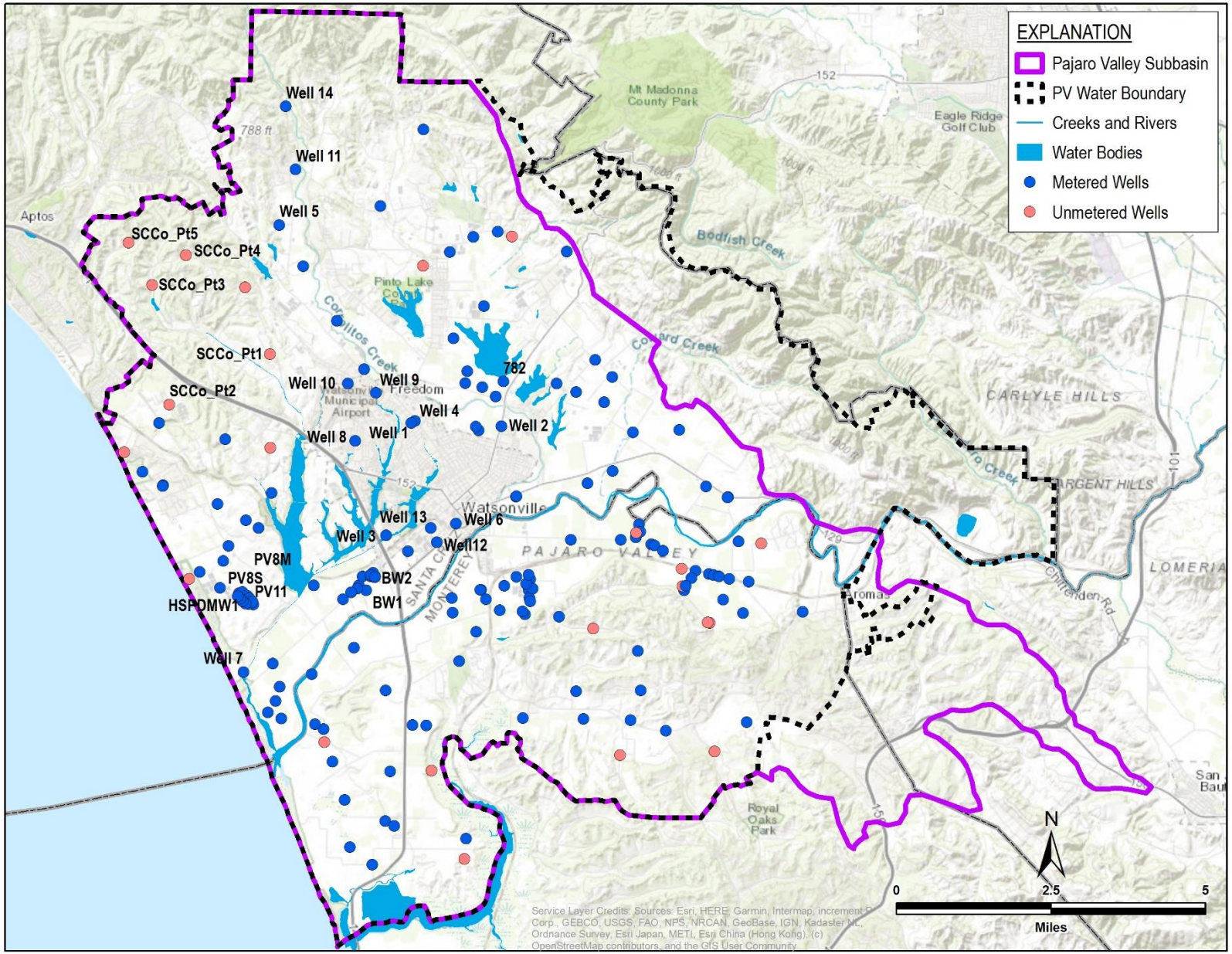

Figure 4. Metered and Unmetered Extraction Wells with Groundwater Level Monitoring (Public Wells are Labeled)

3.4 LAND SUBSIDENCE MONITORING NETWORK

Even though there are no SMC needed for land subsidence because of the United States Geological Survey's (USGS) evaluation of subsidence finding a lack of observed permanent or inelastic subsidence in the Basin (Brandt et al., 2021), periodic monitoring is needed to confirm land subsidence does not occur in the future.

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

In addition to the InSAR data, there are 3 Continuous Global Positioning System (CGPS) stations in the Basin that are part of the UNAVCO Plate Boundary Observatory network of CGPS stations that can be used to monitor land subsidence at the locations depicted on Figure 5. CGPS data are a subset of Plate Boundary Observatory GPS with near real-time data streams made available by UNAVCO. CGPS stations in the Basin are:

- Larkin Valley (P212)
  https://www.unavco.org/instrumentation/networks/status/nota/overview/P212
- Corralitos (P214)
  https://www.unavco.org/instrumentation/networks/status/nota/overview/P214
- Lewis Road (P211)
  https://www.unavco.org/instrumentation/networks/status/nota/overview/P211

The CGPS data and TRE ALTAMIRA InSAR subsidence dataset will be used by PV Water for every 5-year Update to compare measured land subsidence with groundwater extraction and groundwater elevations to confirm the land subsidence due to groundwater extraction is not occurring in the Basin.

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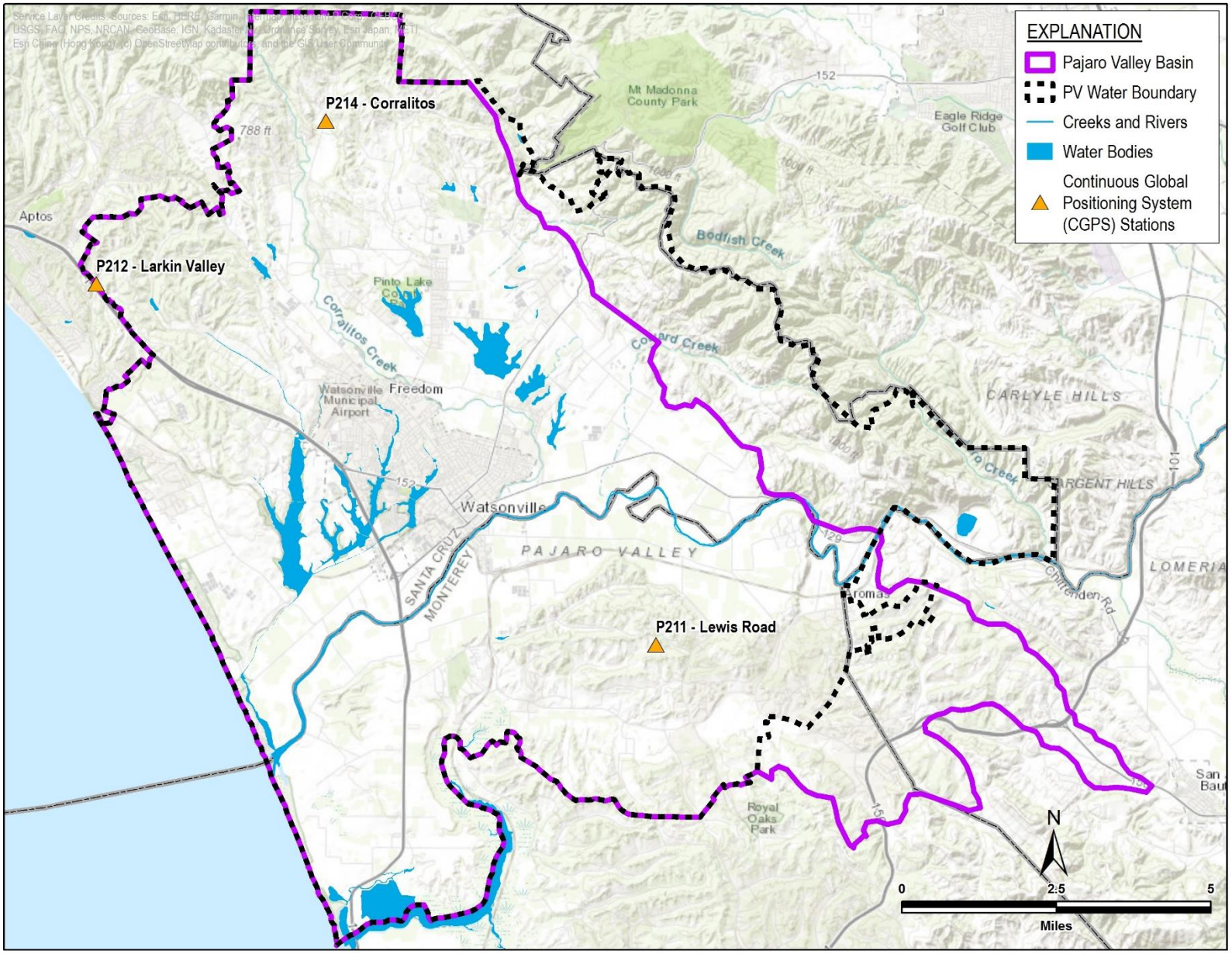

Figure 5. Continuous Global Positioning System Stations in the Pajaro Valley Subasin

3.5 SURFACE WATER MONITORING NETWORK

As described in cbec's January 8, 2021 technical memorandum *Quantify Depletions of Interconnected Surface Waters* (cbec, 2021a) to be incorporated into GSU22 Section 5, there is minimal connection between surface water and groundwater in the Aromas Red Sands in the Basin. However, measurable objectives have been set to increase the connection between surface water and groundwater. These measurable objectives have been set at wells in the groundwater level monitoring wells identified as RMPs for interconnected surface water identified in Table 3 and on Figure 1.

Continued evaluation of interconnected surface water will be based on the existing surface water monitoring network for the Basin. Data from the surface water monitoring network are also used to update the PVHM to estimate recharge from streams whether or not they are connected. The surface water monitoring network is maintained by the USGS, PV Water, and City of Watsonville:

- USGS publishes streamflow data from USGS stream gaging stations on Corralitos Creek at Freedom (11111592), Pajaro River at Chittenden (11159000), and Pajaro River at Watsonville (11159500). Locations of the gages are provided on Figure 6.
- PVWMA maintains a continuous stream flow gages on the Pajaro River at Murphy Crossing and Watsonville Slough (Figure 6).
- If the City of Watsonville continues to monitor flow at their 4 gages on Corralitos Creek (CW Site 1 through CW Site 4 on Figure 6), these data will also be used.

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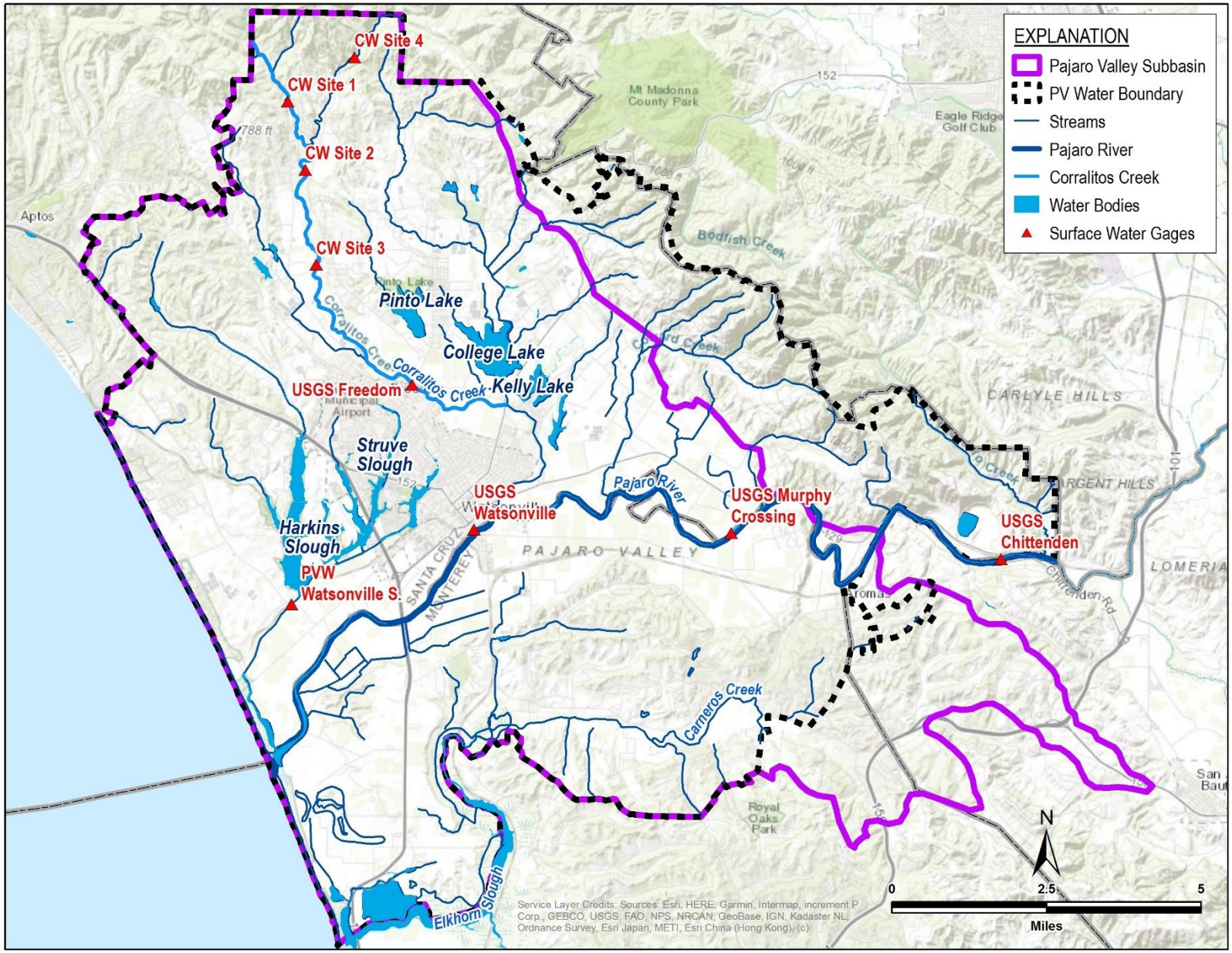

Figure 6. Surface Water Monitoring Gages in the Pajaro Valley Subbasin

4 MONITORING PROTOCOLS FOR DATA COLLECTION

4.1 GROUNDWATER LEVEL MONITORING PROTOCOLS

The groundwater level monitoring protocols established by PV Water in its Quality Assurance Project Plan (QAPP; 2016) were adopted by the GSP Alternative for groundwater level monitoring. The 2016 QAPP is included in Appendix A. Groundwater level measurements are collected at least twice a year to represent seasonal low and seasonal high groundwater conditions. Groundwater level data are currently collected both by manual sounding and using automated pressure transducers. Groundwater level monitoring protocols outline in the 2016 QAPP are consistent with data and reporting standards described in SGMA Regulation §352.4.

All groundwater level measurements are referenced to a consistent elevation datum, known as the Reference Point (RP). For monitoring wells, the RP consists of a mark on the top of the well casing. For most production wells, the RP is the top of the well's concrete pedestal. The standard vertical datum for RPs in the PV Water monitoring network is the North American Vertical Datum of 1988 (NAVD88). Wells have been surveyed or estimated to multiple vertical datums over time so RP elevations (RPEs) for RMPs and wells considered as RMPs (primarily wells screened in the Aromas with publicly available data) have been converted to NAVD88 as described in the August 5, 2021 technical memorandum *Pajaro Valley Hydrologic Model Updates Supporting GSU22 Analyses* to be included as a GSU22 appendix. The primary conversion was from mean sea level to NAVD88 is based on mean sea level being equivalent to 2.956 feet NAVD88 according to National Oceanic and Atmospheric Administration (NOAA) at its Monterey station. Conversion of the entire groundwater level monitoring network to NAVD88 will be necessary prior to upload of data to DWR. Where surveyed to a known datum, the elevation of the RP is accurate to at least 0.5 foot, and most PV Water well RPs are accurate to 0.1 foot or less. In cases where RPEs are estimated based on the NAVD88 Digital Elevation Model, RPEs are less accurate and correspond to the ground surface.

Depth to groundwater measurements are taken to the nearest 0.02 foot relative to the RP using procedures appropriate for the measuring device. Equipment is operated and maintained in accordance with manufacturer's instructions, and all measurements are in consistent units of feet, tenths of feet, and hundredths of feet.

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Groundwater elevation is calculated using the following equation:

GWE = RPE-DTW

where:

GWE = groundwater elevation

RPE = reference point elevation

DTW = depth to water

In cases where the official RPE is a concrete pedestal but the hand soundings are referenced off the top of a sounding tube, the measured DTW is adjusted by subtracting the sounding tube offset from the top of the pedestal.

4.1.1 MANUAL GROUNDWATER LEVEL MEASUREMENT

Manual groundwater level measurements are made with electronic sounders or oil tapes. All manual groundwater level measurements taken by agencies providing data to PV Water abide by the following protocols:

- Equipment usage follows manufacturer specifications for procedure and maintenance.
- Measurements are taken in wells that have not been subject to recent pumping. At least 2 hours of recovery must be allowed before a hand sounding is taken.
- For each well, multiple measurements are collected to ensure the well has reached equilibrium such that no significant changes in groundwater level are observed.
- Equipment is sanitized between well locations in order to prevent contamination and maintain the accuracy of concurrent groundwater quality sampling.

The majority of manual groundwater level measurements taken by those agencies monitoring groundwater levels that are part of PV Water's network use electric sounders. These consist of a long, graduated wire equipped with a weighted electric sensor. When the sensor is lowered into water, a circuit is completed and an audible beep is produced, at which point the sampler will record the depth to water.

Electric sounders and oil tapes are routinely cleaned to ensure operational integrity. To ensure the accuracy of each sounder and tape unit, a quarterly quality control check of all active sounders and tapes are performed by staff. The quality control check consists of staff measuring the depth to water of a single well with all active sounders to verify that all active sounders are

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within +/- 0.05 feet of the median measurement. Oil tape measuring instruments are measured against a new measuring tape to verify measurement accuracy. Any sounders or oil tapes deemed to be inaccurate in the quality control test are repaired if possible or disposed.

4.1.2 GROUNDWATER LEVEL MEASUREMENT WITH CONTINUOUS RECORDING DEVICES

In addition to manual groundwater level measurements, most public water supply wells are connected to SCADA and most PV Water dedicated monitoring wells are equipped with pressure transducers to collect more frequent data than manual measurements. Installation and use of pressure transducers abide by the following protocols:

- Prior to installation the sampler uses an electronic sounder or steel tape to measure and calculate the current groundwater level in order to properly install and calibrate the transducer. This is done following the protocols listed above.
- All transducer installations follow manufacturer specifications for installation, calibration, data logging intervals, battery life, and anticipated life expectancy.
- Transducers are set to record only measured groundwater level although some also have the capability of measuring temperature and specific conductance; groundwater elevation is calculated after downloading.
- In any log or recorded datasheet, the well ID, transducer ID, transducer range, transducer accuracy, and cable serial number are all recorded.
- The sampler notes whether the pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are used, data are properly corrected for barometric pressure changes.
- All transducer cables are secured to the well head with a well dock or another reliable method.
- Transducer data are periodically checked against manually measured groundwater levels to monitor instrument drift, highlight cable movement, and ensure the transducer is operating correctly.
- For wells not connected to SCADA systems, transducer data are downloaded as necessary to ensure no data are overwritten or lost. Data are entered into the data management system as soon as possible. When the transducer data are successfully downloaded and stored, the data are deleted or overwritten to ensure adequate data logger memory.

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4.2 GROUNDWATER QUALITY MONITORING PROTOCOLS

Groundwater quality samples are currently being collected according to SWRCB and ILRP requirements. Drinking water supply well water quality data from public systems are collected, analyzed, and reported in accordance with protocols reviewed and approved by the SWRCB and the Division of Drinking Water, in accordance with the state and federal Safe Drinking Water Acts. All groundwater quality analyses are performed by laboratories certified under the State Environmental Laboratory Accreditation Program. Laboratories must be able to provide a calibration curve for the desired analyte and are instructed to use reporting limits equal to or less than the applicable data quality objectives, regional water quality objectives/screening levels, or state detection limit for purposes of reporting.

Laboratory analytical services for water samples collected as part of the PV Water groundwater monitoring program analyze submitted samples in accordance with all method and quality assurance requirements specified in the 2016 Quality Assurance Project Plan (QAPP) contained in Appendix A and all subsequent regulations. Laboratory staff are trained to perform analytical testing and comply with quality assurance and quality control measures under the supervision of the Lab Director.

While specific groundwater sampling protocols vary depending on the constituent and the hydrogeologic context, the protocols contained here provide guidance which is applied to all groundwater quality sampling. The protocols listed below include specific protocols from PV Water's 2016 QAPP contained in Appendix A.

- Prior to sampling, the sampler contacts the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.
- Prior to any sampling, the sampler cleans the sampling port and/or sampling equipment so that it is free of any contaminants, and also decontaminates sampling equipment between sampling locations to avoid cross-contamination between samples.
- Prior to sample collection, the well is run long enough to purge all stagnant water in the pump casing, well, and/or pump tubing.
- Wells equipped with micropurge bladder pumps use the flow cell water quality sonde with stabilization criteria to determine when to collect the sample following the purging of stagnant water.
- At the time of sampling, the groundwater level in the well is measured following appropriate protocols described above in the groundwater level measuring protocols.

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- Each sample bottle is labeled with the site name, date of sample, time of sample, and the desired analyses.
- Wearing a new pair of nitrile or latex gloves for each site, the staff person triple rinses the bottle and cap with the water being sampled unless the sample requires use of a preservative.
- Routine samples are collected in a single HDPE plastic 1-liter bottle and capped. For specialized analyses, PV Water staff follow the appropriate protocol as directed by the laboratory.
- PV Water staff follow best practices regarding head space and preservatives when sampling.
- Once samples are collected, they are stored in a cooler with ice packs until the staff person returns to the PV Water office. The samples remain in the Hydrology Unit refrigerator at 4° C ± 2° C until being picked up by laboratory staff or a PV Water staff person delivers them to the laboratory for analysis. Water quality samples are typically picked up or delivered to the laboratory in less than 48 hours after sample collection to meet the hold time requirements for the shortest hold time analytes, turbidity, and nitrate. During transport to the laboratory by PV Water staff, the samples are once again placed in a cooler with ice packs.

4.3 GROUNDWATER EXTRACTION METERING PROTOCOLS

Groundwater extraction volumes used as the metrics for the reduction of groundwater in storage sustainability indicator are also collected to provide data for well field management and for assessment of the Basin's water budget. PV Water measures discharge from water supply wells pumping 10 acre-feet or more per year with calibrated flow meters as described in Section 3.3. It follows a meter maintenance program that includes routine accuracy tests to check that meters are working properly. Meter calibrations are conducted regularly by trained staff to verify accuracy.

4.4 LAND SUBSIDENCE MONITORING PROTOCOLS

Land subsidence monitoring is not performed by PV Water. By relying on InSAR data provided by DWR, protocols are the ones used by DWR for InSAR measurements and interpretation. If the 5-year review indicates permanent or inelastic subsidence in the Basin is occurring, additional investigation and routine monitoring may be warranted. Specifically, PV Water will conduct a study to assess if the observed subsidence is inelastic and can be correlated to groundwater extraction and lowered groundwater levels, and whether a reasonable causality can be established.

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4.5 SURFACE WATER MONITORING PROTOCOLS

All surface water-level and streamflow monitoring, reporting and delivery will be completed pursuant to the methods and protocols consistent with the USGS Groundwater and Streamflow Information Program.

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5 ASSESSMENT AND IMPROVEMENT OF MONITORING NETWORK

In 2016, a study to inventory, classify, and evaluate PV Water's groundwater monitoring network adequacy to develop data to understand and effectively manage the Basin's groundwater resources was completed (Feeney et al., 2016). Recommendations were made to improve the network's overall effectiveness and comply with the requirements of SGMA. Obvious shortcomings to the network were identified, with the most prominent of these being a lack of spatial coverage within the city limits of Watsonville. To address this data gap, PV Water constructed the PV20 nested monitoring wells comprising 4 wells in 2 boreholes targeting the Alluvium, Upper Aromas, Lower Aromas, and Purisima in the agency parking lot located in City of Watsonville's downtown in 2015.

5.1 EVALUATION BY AQUIFER UNIT

A group of 107 monitoring wells from the PV Water monitoring network consists of wells perforated solely in either the Upper or Lower Aromas units or a combination thereof. Of those wells, 76 can capture both water quality and groundwater level data, 31 can measure groundwater level only, and 5 have access restrictions for level measurements and can only by sampled for groundwater quality only.

The distribution of PV Water dedicated monitoring wells on the coastal side of the SWI SMC chloride isocontour is limited, but are supplemented by private wells to monitor seawater intrusion and groundwater quality. However, some previously monitored wells in the SWI area are no longer active due to poor groundwater quality and obtaining agreement to monitor additional wells is difficult. The data gap could be filled with dedicated wells designed for induction logging[1] to survey the entire depth of saturated sediment for changes in groundwater salinity in the coastal portion of the Basin. There are also some wells in the coastal portion of the Basin that are relatively closely spaced, and may be redundant.

The overall areal spatial distribution of monitoring wells in the Aromas Red Sands is adequate, both throughout the Basin and also in the SWI area though there are areas where additional monitoring would improve the spatial distribution. Vertical distribution of monitored zones is also adequate however, additional multi-aquifer monitoring wells should be considered.

The Purisima Formation (Purisima) is monitored by PV Water with 40 wells perforated in part or in whole within the Purisima. Of the 40 wells, 28 are perforated solely in the Purisima, 10 are

[1] Induction or electromagnetic-induction conductivity logging is a down-hole geophysical method of measuring the fluid conductivity within the formation up to a distance of 3 feet from the well casing. The method can be used as a cost-effective method of detecting seawater intrusion by measuring the electrical conductivity of the formation throughout the depth of the well. If over time, the conductivity increases relative to the baseline value, it could indicate seawater intrusion.

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perforated in both the Upper and Lower Aromas and the Purisima, and 8 are perforated in the Lower Aromas and the Purisima. Groundwater level and quality data is collected from 26 wells, 9 are measured only for water level, and 1 is strictly monitored for water quality. Spatially these wells are predominately located in the foothill areas where the Purisima is shallow or is exposed at the surface. There are several wells however, that extend through the shallow units in the area of SWI to the underlying Purisima.

5.2 ADEQUACY OF NETWORK TO COMPLY WITH SGMA

The PV Water monitoring network as currently developed and maintained has sufficient spatial density, temporal frequency, and vertical discretization to collect the data necessary to characterize the aquifer system. The network is able to track groundwater conditions for all sustainability indicators, with the exception of land subsidence which can be monitored with data provided by DWR and through the 3 CGPS stations in the Basin. The network can measure the achievement of measurable objectives and detect exceedances of minimum thresholds. Although there is sparse evidence that the differences in potentiometric surfaces between the principal aquifer system is significant, if future data suggest that it is, some additional effort to improve PV Water's ability to contour each aquifer unit would be appropriate. The existing network is adequate to prepare annual contour maps of the Aromas Red Sands, the principal aquifer for the GSP Alternative, and calculate changes of groundwater in storage.

Surface water monitoring by the USGS and PV Water on the Pajaro River and by the USGS and City of Watsonville on Corralitos Creek are sufficient to supplement the finding based on groundwater monitoring that interconnection between surface water and groundwater in the Aromas Red Sands is minimal (cbec, 2021a).

5.3 MONITORING DATA GAPS

Spatial data gaps in the monitoring networks are identified below. Spatial data gaps are areas where additional monitoring or reporting of monitoring, will improve management of the Basin under SGMA. Therefore, the data gaps focus on the Aromas Red Sands aquifer, the principal aquifer of the Basin. There are 3 categories of spatial data gaps corresponding to the monitoring networks and subsets of the networks described in this plan.

- A spatial data gap within the full **PV Water monitoring network** that includes both public and confidential privately-owned wells, i.e., there is no monitoring within this area of the Basin.
- A spatial data gap within the **GSP Alternative monitoring network** that is a subset of only the monitoring features collecting publicly available data used for Basin management. This includes areas where there is monitoring, but PV Water does not have

permission to publicly disclose data from identified wells and therefore cannot upload data to the DWR Portal.

- Areas where additional **representative monitoring points** with SMC for specific sustainability indicators are recommended. Some spatial data gaps within the GSP Alternative monitoring network are not represented by existing RMPs. Therefore, additional RMPs should be identified as spatial data gaps within the GSP Alternative monitoring network are filled.

Data gaps may occur within 1, 2, or all 3 categories. The category with the highest priority to address is where additional RMPs are recommended. The next highest priority to address is where there are spatial data gaps within the full PV Water monitoring network. The lowest priority to address are spatial data gaps that only occur within the GSP Alternative monitoring network. A lower priority is assigned because PV Water is still able to use confidential data from these areas to manage the Basin, but the data may not be publicly shared. Data gaps may be addressed by identifying an existing well to join the monitoring network, obtaining the necessary permission to publicly share data from an existing confidential well, or installing a new monitoring well.

5.3.1 GROUNDWATER LEVEL MONITORING DATA GAPS

Data gaps for groundwater level monitoring are identified in areas that have no or limited monitoring, but also in areas where monitoring impacts from groundwater extraction can be improved. Figure 7 shows domestic wells and agricultural wells to identify where pumping is occurring in comparison to the groundwater level monitoring networks.

5.3.1.1 PV WATER MONITORING NETWORK DATA GAPS

Based on the SGMA regulations and the Best Management Practices published by DWR on monitoring networks (DWR, 2016), an analysis of the existing monitoring network was performed by a certified hydrogeologist to evaluate whether there are data gaps in the groundwater level monitoring network.

The Basin encompasses 117 square miles and if the Best Management Practices guidance recommendations are applied to the principal aquifer in the Basin, the well network should include between 1 and 12 wells in the Aromas Red Sands aquifer. The current full network (public and confidential wells) includes 107 wells screen exclusively in the Aromas Red Sands, which far exceeds the Best Management Practices guidance. However, visual inspection of the geographic distribution of the network indicates that additional wells are necessary to better characterize portions the Basin. The most obvious data gaps in the PV Water's Figure 1 groundwater level monitoring network within the Aromas Red Sands Aquifer are as follows:

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- The area north of Pinto Lake where there are no public or privately owned wells monitored (area 7 on Figure 7)
- The portion of the Basin outside of PV Water's jurisdictional area (area 8 on Figure 7)

5.3.1.2 GSP ALTERNATIVE MONITORING NETWORK DATA GAPS

In addition to the 2 data gaps identified for the PV Water monitoring network, there are gaps in the GSP Alternative Monitoring Network for data that can be provided publicly. PV Water monitors groundwater levels in these areas but private well data cannot be disclosed publicly or uploaded to the SGMA Portal. Identification of wells in these areas for which data can be provided publicly will improve transparency of the data PV Water uses to manage the Basin. These areas include

- Moss Landing (area 1 on Figure 7)
- Las Lomas area (area 2 on Figure 7)
- South of Watsonville (area 3 on Figure 7)
- East of Watsonville (area 4 on Figure 7)
- East of Kelly Lake (area 5 on Figure 7)
- North of Ellicott Slough (area 6 on Figure 7)

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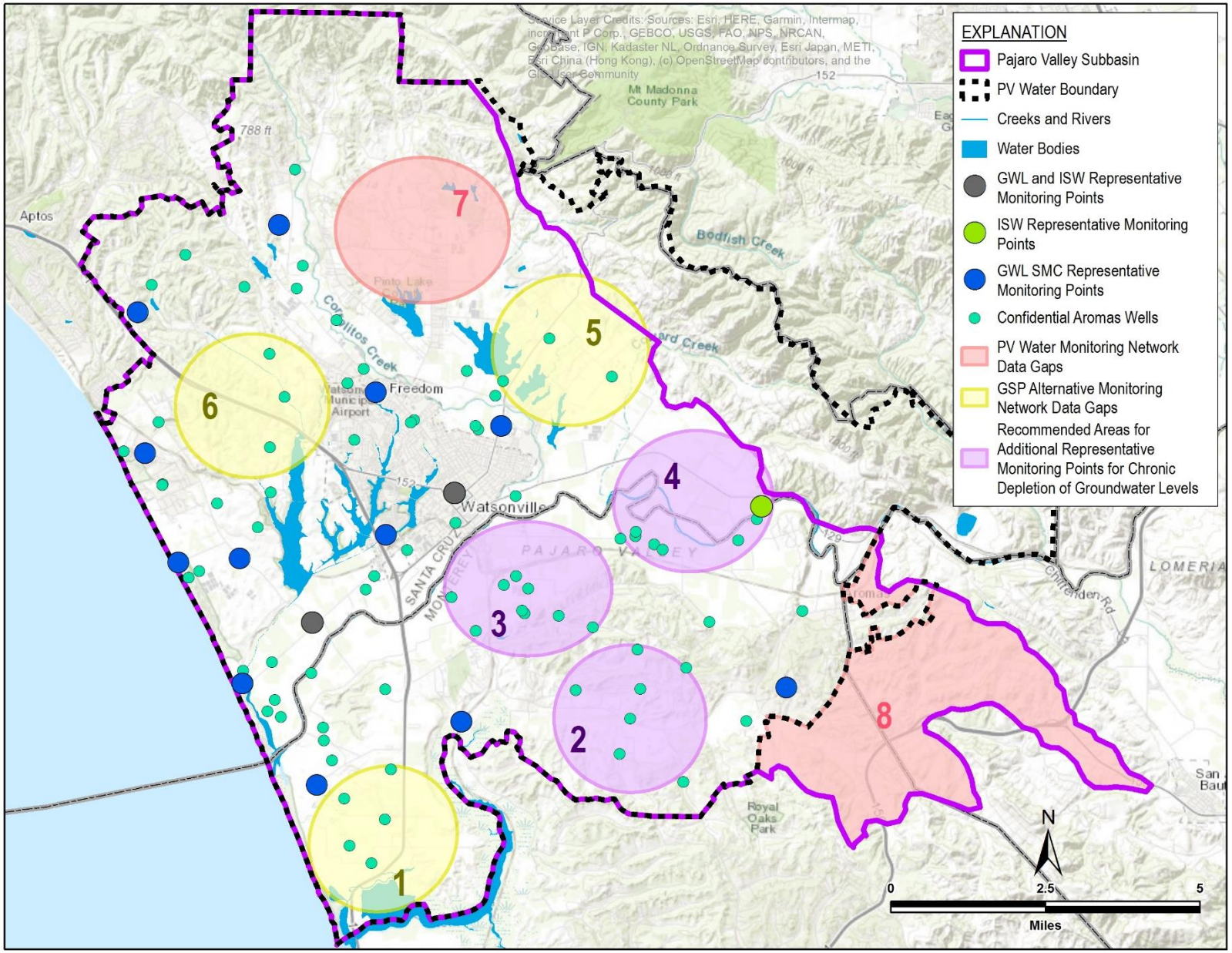

Figure 7. Groundwater Level Monitoring Networks and Identified Data Gaps

5.3.1.3 RECOMMENDED ADDITIONAL REPRESENTATIVE MONITORING POINTS FOR CHRONIC DEPLETION OF GROUNDWATER LEVELS

As described in the April 2, 2021 draft technical memorandum *Development of Sustainable Management Criteria for Chronic Lowering of Groundwater Levels* that will be incorporated into Section 3 of the GSU22 submittal, recommended additional GWL RMPs include the Las Lomas (area 2), south of Watsonville (area 3), and east of Watsonville (area 4). Appendix B includes supplementary information that will support development of GWL SMC when RMPs for these areas are established. As shown in Appendix B, the GWL SMC values are highly dependent on which well is used as an RMP or where a new well is located. Data from private wells in PV Water's network do represent groundwater level trends for the area.

The data gaps for the PV Water monitoring network, north of Pinto Lake and the non-jurisdictional areas, are not recommended for additional RMPs at this time. Monitoring in these areas should first be established and after serval years of data have been collected, the data can be evaluated to assess whether RMPs are needed for these areas. It is possible RMP Well 5 may be representative of the north of Pinto Lake area and AWD Aimee may be representative of the non-jurisdictional area.

New RMPs are not recommended for the remaining data gaps in the GSP Alternative monitoring network, Moss Landing, east of Kelly Lake, and north of Ellicott Slough. Data from these areas have been evaluated and existing RMPs are considered representative of these areas:

- **Moss Landing (area 1):** Groundwater elevations are represented by the nearby RMP well PV4MD (Figure 8). The hydrograph illustrates groundwater elevations at private wells in the Moss Landing area correlated with elevations at the PV4MD RMP. Although it appears to a lower degree of seasonal magnitude than the monitored private wells, groundwater elevations in PV4MD exhibit the same overall trends.
- **East of Kelly Lake (area 5):** Groundwater elevations are represented by the nearby RMP Well 2 (Figure 9). The hydrograph illustrates groundwater elevations at private wells in the East of Kelly Lake area correlate with elevations at the Well 2 RMP. Two of the wells (Well 2 and Well 3) exhibit similar baseline groundwater elevations, seasonal fluctuations, and inter-annual trends. A third well (Well 1) exhibits muted seasonal fluctuation but reflects similar inter-annual trends.
- **North of Ellicott Slough (area 6):** Groundwater elevations are represented by the nearby RMP Well 9 (Figure 10). The hydrograph illustrates groundwater elevations at private wells in the North of Ellicott Slough area correlate with elevations at the Well 9 RMP. Seasonal fluctuations, inter-annual trends, and baseline elevations, elevations in nearby private wells are consistent with Well 9.

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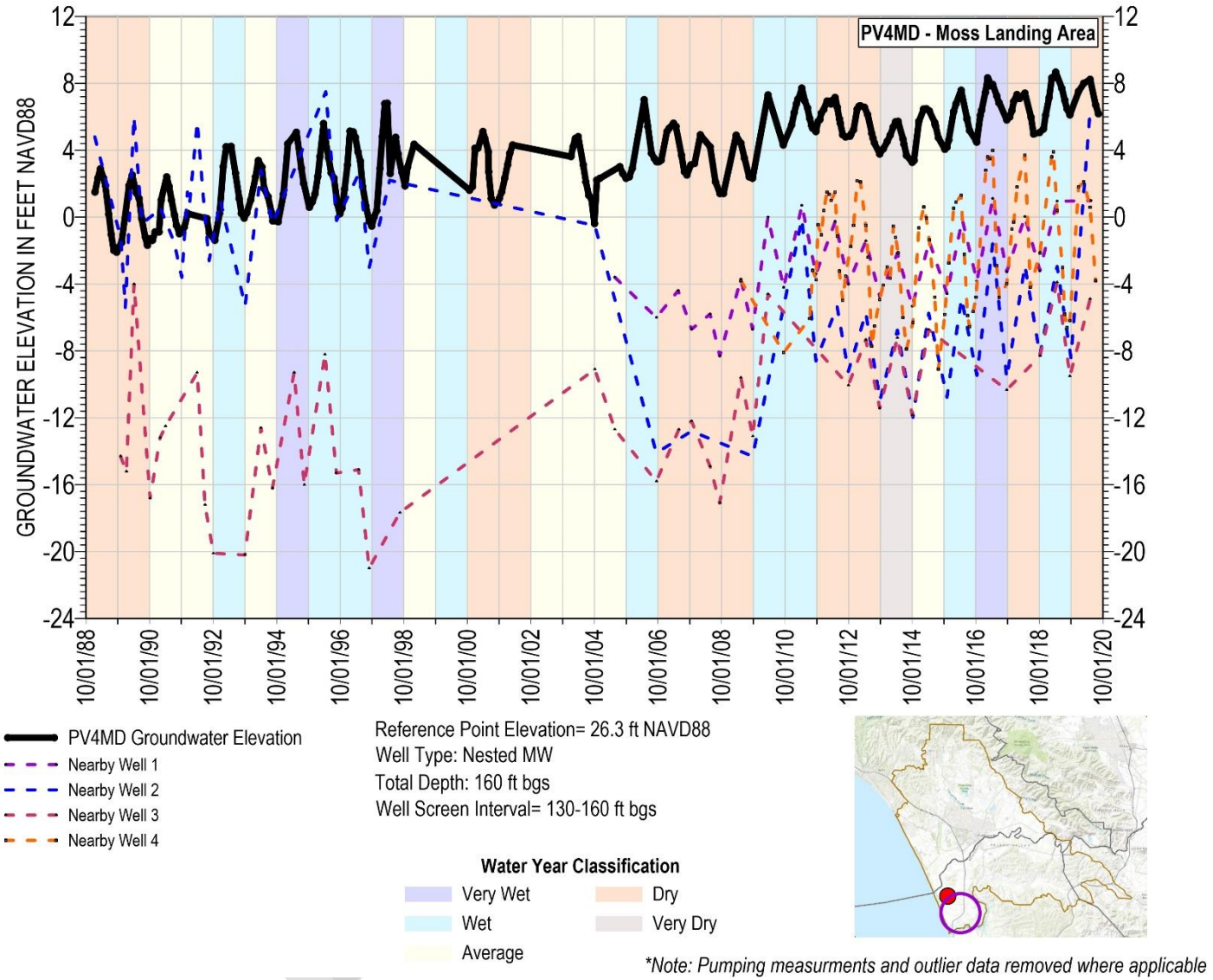

Figure 8. RMP PV4MD and Moss Landing Area Well Hydrographs

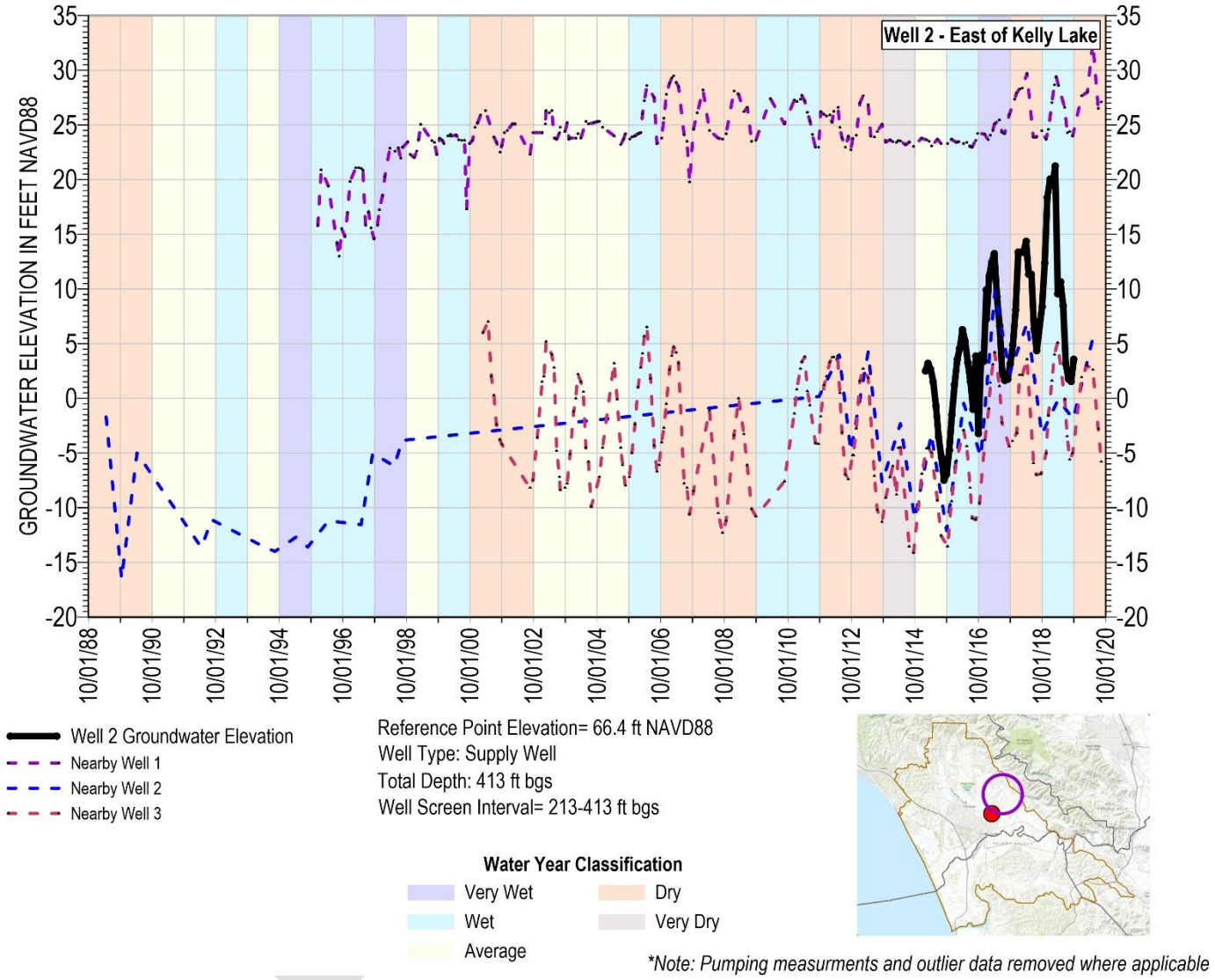

Figure 9. RMP Well 2 and East of Kelly Lake Area Well Hydrographs

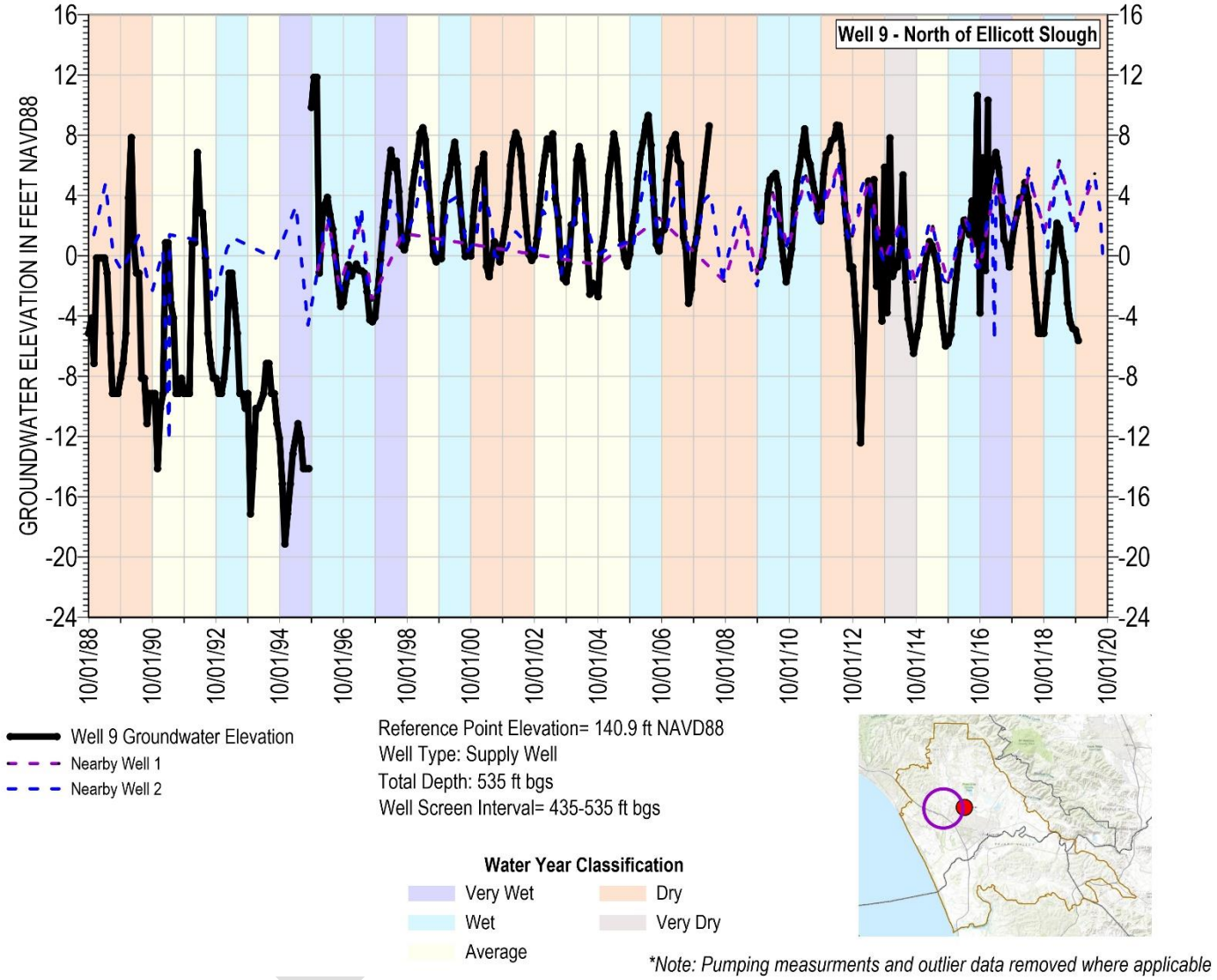

Figure 10. RMP Selection, Well 9 and North of Ellicott Slough Well Hydrographs

5.3.1.4 RECOMMENDED ADDITIONAL REPRESENTATIVE MONITORING POINTS FOR DEPLETION OF INTERCONNECTED SURFACE WATERS

As described in the May 7, 2021 technical memorandum *Sustainability Management Criteria for Depletions of Interconnected Surface Waters* (cbec, 2021b) to be incorporated as Section 5 of the GSU22 submittal, additional RMPs are recommended for ISW. These include the following recommended RMPs:

- A RMP in the Aromas Red Sands along Carneros Creek. The RMP would be in the Las Loma area (area 2 on Figure 7) with private wells Y and Z identified in the technical memorandum as potential RMPs. Private well Y is preferred over Z due to its closer proximity to Carneros Creek. This is the highest priority recommended RMP because there is no RMP to track interconnection between the Aromas Red Sands and Carneros Creek.

- A RMP in the Alluvium along Carneros Creek in the Las Lomas area co-located with the RMP in the Aromas described above.

- A RMP in the Aromas Red Sands near the Alluvium RMP PV14 (Figure 1) for the Murphy Crossing area of the Pajaro River. The RMP would be in the East of Watsonville area (area 4 on Figure 7) with private wells N and O identified in the technical memorandum as potential RMPs.

5.3.2 GROUNDWATER QUALITY MONITORING DATA GAPS

Identified data gaps in the Aromas Red Sands, the principal aquifer for the Basin, for the groundwater quality monitoring network are similar to gaps in the groundwater level monitoring network. There are no RMPs for the groundwater quality and seawater intrusion indicators because all available monitoring points are used collectively to evaluate SMC for those indicators. Available data are used to calculate average TDS, chloride, and nitrate concentrations over 2 groundwater quality zones in the Basin. For the SWI SMC, all available data are used to assess concentrations across the seawater intrusion SMC chloride isocontour. The spatial coverage of the network is adequate to evaluate SMC in this manner.

5.3.2.1 PV WATER MONITORING NETWORK DATA GAPS

To evaluate the groundwater quality indicator, there are spatial data gaps for groundwater quality monitoring of the Aromas Red Sands north of Pinto Lake (area 7) and in the non-jurisdictional portion of the Basin (area 8). Addressing these data gaps may be possible by identifying wells in those areas that can monitor both groundwater levels and quality.

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To evaluate seawater intrusion, there are 2 data gaps along the seawater intrusion SMC chloride isocontour. These data gaps are:

- The area inland of SC-A4A and the SWI SMC isocontour
- Along the SWI SMC isocontour between PV6SM and HudsonS.

Addressing these data gaps could provide important data for evaluating the SWI sustainability indicator, including potentially revising the location of the SWI SMC isocontour, and should be prioritized.

5.3.2.2 GSP ALTERNATIVE MONITORING NETWORK DATA GAPS

In addition to the 2 data gaps identified in the PV Water monitoring network, there are gaps in the GSP Alternative Monitoring Network for data that can be reported publicly. PV Water monitors these areas and uses the data to compare groundwater quality and seawater intrusion to SMC. However, private wells and their data cannot be publicly identified and shared in the SGMA Portal. Identification of wells in these areas that data can be provided publicly will improve documentation of the data PV Water uses to manage the Basin. These areas include:

- Moss Landing (area 1 on Figure 7)
- Las Lomas area (area 2 on Figure 7)
- South of Watsonville (area 3 on Figure 7)
- East of Watsonville (area 4 on Figure 7)
- East of Kelly Lake (area 5 on Figure 7)
- North of Ellicott Slough (area 6 on Figure 7)

As these are the same data gaps identified for this network for groundwater levels, efforts to address this data gap for groundwater quality should be concurrent to the effort for groundwater levels.

5.3.3 SUBSIDENCE MONITORING DATA GAPS

Because INSAR data used to evaluate subsidence covers the whole Basin , there are no data gaps for ongoing evaluation of subsidence. If UNAVCO considers adding CGPS stations in the Basin, PV Water would support adding a station in the City of Watsonville area where there is density of infrastructure that could be affected by subsidence.

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5.3.4 SURFACE WATER MONITORING DATA GAPS

The surface water monitoring network, used in part, to evaluate ISW includes multiple stream gages on the Pajaro River and Corralitos Creek to support continued evaluation of whether interconnected surface water is occurring (Figure 6). The technical memorandum quantifying depletions of ISW (cbec, 2021a) identified a gaining reach between the City of Watsonville's CW Site 3 streamflow gauge and the USGS gage at Freedom. Best available information indicates that the source of these gains is surface water though there is a possibility that the gains represent groundwater contributions. There is also a data gap in the understanding of dry season flow conditions along Pajaro River between Murphy Crossing and Watsonville.

Analysis of where surface water and groundwater are connected in the Basin identified the potential need to improve understanding of the frequency and duration of interconnected surface water along Carneros Creek. This can be adequately monitored by establishing groundwater level monitoring wells as RMPs along Carneros Creek as described in Section 5.3.1.4, but the lack of surface water gaging in this creek represents a data gap in the understanding of dry season flow conditions that might be affected by lowered groundwater levels (Figure 6).

5.4 RECOMMENDATIONS FOR GROUNDWATER MONITORING IMPROVEMENTS

Several spatial monitoring data gaps for the principal aquifer, the Aromas Red Sands, have been identified where there are either 1) no public or privately owned wells monitored, or 2) no public wells that can be used as RMPs because available private well data cannot be disclosed publicly or uploaded to DWR's SGMA Portal. Improvements to the network can be made by identifying an existing well to join the monitoring network, obtaining the necessary permission to publicly share data from an existing confidential well, or installing a new monitoring well. The priority order to address data gaps and improve groundwater monitoring are:

- The highest priority for improvements is adding monitoring of water quality of the Aromas Red Sands aquifer in the areas inland of SC-A4 and between PV6 and the Hudson wells to evaluate sustainability related to seawater intrusion, which is the primary adverse effect of critical overdraft conditions in the Basin.

- The 2nd highest priority for improvements is adding representative monitoring points in the Aromas Red Sands aquifer in the Las Lomas area, south of Watsonville, and east of Watsonville to evaluate sustainability related to chronic lowering of groundwater levels to better manage groundwater supply in those areas of the Basin.

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- The 3rd highest priority for improvements is adding a representative monitoring point in the Aromas Red Sands aquifer along Carneros Creek to evaluate the measurable objective of increasing the frequency and duration of interconnection between surface water and groundwater in the Aromas Red Sands.

- Medium priority for improvement is adding groundwater level and groundwater quality monitoring in the north of Pinto Lake and non-jurisdictional area where there are spatial data gaps in the PV Water monitoring network.

- Lower priority areas are the Moss Landing, east of Kelly Lake, and north of Ellicott Slough areas where there are spatial data gaps in the GSP Alternative monitoring network.

Additional recommendations from Feeney et al., 2016 will also be considered for improving the groundwater monitoring network.

- Constructions details for some of the wells are unknown because driller logs are not available. PV Water should obtain permission from property owners to seek well construction information from local pump/drilling contractors. Many of the network wells lacking construction details have years of data which is valuable.

- Reducing the number of wells in the Supplemental sub-network in the central portion of Basin would provide cost savings. The producing intervals are not precisely known and significant redundancy likely exists. Currently, monitoring is performed twice a year for 25 wells for which the construction is unknown. The Supplemental sub-network wells were added when the 2000 Basin Management Plan was proposing supplemental supply wells for the Coastal Distribution System at 3 locations. The purpose of the sub-network wells was to quantify water level or water quality impacts that might occur from the operation of the supplemental supply wells. Ultimately, PV Water only built supplemental supply wells at 1 location and are leasing another well. The Supplemental network could be refined to provide information adequate to support current basin management and projects.

- Study evaluate whether within the network there are subsets of wells that can be used to better understand the depth/aquifer-specific nature of SWI. Alternatively, a useful tool would be the installation of “Sentinel Wells” that would allow periodic induction logging of the entire saturated thickness of sediments (at least to top of the Purisima) to detect changes in pore-fluid resistivity.

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5.5 RECOMMENDATIONS FOR INTERCONNECTED SURFACE WATER AND GROUNDWATER DEPENDENT ECOSYSTEM MONITORING IMPROVEMENTS

To facilitate improved assessment of interconnected surface water and groundwater dependent ecosystems beyond the best available information used to support GSU22, additional studies are recommended:

- Retain a botanist/ecologist to complete a field survey to verify wetland and vegetation types within Potential Additional GDE areas to validate/refine GDE determination and delineation.
- Retain an aquatic ecologist and/or fisheries biologist to identify and prioritize GDE use by sensitive species.
- In order to address data gaps identified for surface water monitoring, design and implement a flow seepage/accretion monitoring along specified reaches of Corralitos Creek and Pajaro River as well as Carneros Creek to better determine and delineate the spatial and temporal variability in gaining and losing creek conditions to improve ISW assessment. The seepage/accretion monitoring plan includes completing monthly field surveys and mapping of observed hydrology over the dry season to determine changes in the extent of flowing surface water and determination of streamflow duration. The occurrence, change in flow magnitude and calculation of flow duration will inform identification of gaining or losing reaches and likely sources of flow (i.e., groundwater vs. surface water). Monitoring methods will be derived from the EPA's streamflow duration assessment method for the Pacific Northwest (Nadeau, 2015).

Table 5 details existing (1-3) and recommended (4-9) monitoring for groundwater dependent ecosystems and interconnected surface water.

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Table 5. Summary of Existing and Recommended Monitoring for Groundwater Dependent Ecosystem and Interconnected Surface Water

No.	Feature Monitored	Action/Description	Location	Parameter	Period	Sample Interval
1	GDE/ISW	Continue PV Water's annual monitoring program (existing)	PV Water monitoring well network	Groundwater level	All year	Biannually (spring and fall)
2	ISW	USGS stream flow gages (3 on Pajaro R.; 1 on Corralitos Ck (existing)			Continuous (all year)	
3	ISW	Monitor existing RMP well pairs to evaluate and quantify hydraulic connection between upper Alluvial and Aromas aquifers.	Lower Pajaro R. near PV6: (PV6S [alluvium] and PV6SM[Aromas]) Middle Pajaro R. at confluence of Corralitos Cr. and Pajaro R.: (PV20S [Alluvium] and PV20SM[Aromas]) Upper Pajaro R. near Murphy Crossing: (PV14 [alluvium] and a nearby Aromas well)	Groundwater level	Continuous (all year)	15- to 30-minute interval
4	ISW	Establish new RMPs	Aromas well near Carneros Creek (highest priority), Alluvium well near Carneros Creek,, Alluvium well near PV14	Groundwater level	Continuous (all year)	15- to 30-minute interval
5	GDE	Botanist/ecologist to field verify wetland and vegetation types within Potential Additional GDE areas to validate GDE determination.	Potential Additional GDE areas	Vegetation survey	Spring	n/a
6	GDE	Aquatic ecology analysis/synthesis to identify and prioritize GDE use by sensitive species.	All GDE areas	Fish and wildlife surveys	Winter, spring, summer & fall	Quarterly
7	ISW	Stream flow seepage/accretion monitoring	Corralitos Creek between the City of Watsonville's CW Site 3 streamflow gauge and the USGS gage at Freedom on	Distribution of wetted channel	All year	Monthly
8	ISW	Stream flow seepage/accretion monitoring	Pajaro River between Murphy Crossing to Watsonville	Distribution of wetted channel	All year	Monthly
9	ISW	Stream flow seepage/accretion monitoring	Carneros Creek	Distribution of wetted channel	All year	Monthly

GDE = groundwater dependent ecosystem
ISW = interconnected surface water

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6 DATA MANAGEMENT SYSTEM AND DATA REPORTING

PV Water uses Microsoft Access and Springbrook software as Data Management Systems (DMS) to store and review all groundwater level, quality, and extraction data collected from its monitoring network. The DMS is used to export groundwater level data to prepare for SGMA Monitoring Network Portal upload. Data are regularly entered into the DMS soon after the data are collected. Field water quality, laboratory water quality, and water level measurements collected by individuals other than PV Water staff are incorporated into the DMS if comparable measures of precision and accuracy are used in obtaining the data. Data added to PV Water DMS identify the supplying source in the notes field of each record. Data from external entities that are not collected with comparable accuracy and precision are included in the PV Water DMS but are flagged.

Records generated by PV Water's data collection are stored at PV Water's office in electronic format on agency owned server(s) or a subscribed cloud data service. PV Water's DMS is located on the agency's servers which are backed up to tape on a nightly basis. Backup tapes are taken offsite daily and retained for a period of 3 weeks. Access to PV Water's DMS is limited to appropriate staff. Access to the agency servers is limited to users with administrator authority only.

DWR confirmed that PV Water was in compliance with the requirements of CASGEM prior to evaluating the GSP Alternative and the Basin remained in compliance with CASGEM through the last reporting deadline of January 1, 2019 prior to issuing its assessment on the GSP Alternative. PV Water has continued to submit groundwater level data for CASGEM wells to the County of Santa Cruz, the "Monitoring Entity" under CASGEM for submittal as required no later than January 1st and July 1st each year. PV Water will be transitioning to report CASGEM well data in the newly released Monitoring Network Module for alternative submittal SGMA reporting for the fall 2021 groundwater level data and all subsequent data uploads.

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