DRAFT

Chapter 7 - Monitoring Networks

San Luis Obispo Valley Basin Groundwater Sustainability Plan

Available for viewing in the December 9, 2020 Agenda Packet:	**Dec 2, 2020**
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Available for public comments on www.slowaterbasin.com:	**Dec 11, 2020**
Close of public comment period:	**Jan 30, 2021**

Per the GSC's recommendation on December 9, 2020, the Draft Chapter 7- Monitoring Networks will be distributed to the City and County GSAs to receive and file. This Draft document is also posted on the online portal: www.slowaterbasin.com for public comments. Comments from the public are being collected using a comment form available at www.slowaterbasin.com by clicking on "Submit Comment". If you require a paper form to submit by postal mail, please contact your local Groundwater Sustainability Agency (GSA).

DRAFT

Groundwater Sustainability Plan
Chapter 7 – Monitoring Networks

for the

San Luis Obispo Valley Groundwater Basin Groundwater Sustainability Agencies

Prepared by

12/2/2020

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The grey highlighted sections in the Table of Contents (TOC) indicate that the section has been previously released (Chapters 1 through 6) or will be released in the future (Chapters 8 through 14). The complete list of the anticipated TOC is presented to give the reader context as to how Chapter 7-Monitoring Network, connects with the complete Groundwater Sustainability Plan.

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LIST OF TERMS USED

Abbreviation	**Definition**
AB	Assembly Bill
ADD	Average Day Demand
AF	Acre Feet
AFY	Acre Feet per Year
AMSL	Above Mean Sea Level
Basin Plan	Water Quality Control Plan for the Central Coast Basin
BMP	Best Management Practices (DWR)
Cal Poly	California Polytechnic State University
CASGEM	California State Groundwater Elevation Monitoring program
CCR	California Code of Regulations
CCRWQCB	Central Coast Regional Water Quality Control Board
CCGC	Central Coast Groundwater Coalition
CDFM	Cumulative departure from the mean
CDPH	California Department of Public Health
CIMIS	California Irrigation Management Information System
City	City of San Luis Obispo
County	County of San Luis Obispo
CPUC	California Public Utilities Commission
CPWS-52	Cal Poly Weather Station 52
CRWQCB	California Regional Water Quality Control Board
CWC	California Water Code
DDW	Division of Drinking Water
Du/ac	Dwelling Units per Acre
DWR	Department of Water Resources
EPA	Environmental Protection Agency
ERMWC	Edna Ranch Mutual Water Company
ET_0	Evapotranspiration
EVGMWC	Edna Valley Growers Ranch Mutual Water Company
°F	Degrees Fahrenheit
FAR	Floor Area Ratio
FY	Fiscal Year
GAMA	Groundwater Ambient Monitoring and Assessment program
GDE	Groundwater Dependent Ecosystem
GHG	Greenhouse Gas
GMP	Groundwater Management Plan
GPM	Gallons per Minute
GSA	Groundwater Sustainability Agency
GSC	Groundwater Sustainability Commission
GSP	Groundwater Sustainability Plan
GSWC	Golden State Water Company
IRWMP	San Luis Obispo County Integrated Regional Water Management Plan
ILRP	Irrigated Lands Regulatory Program
kWh	Kilowatt-Hour
LUCE	Land Use and Circulation Element

Abbreviation	Definition
LUFTs	Leaky Underground Fuel Tanks
MAF	Million Acre Feet
MCL	Maximum Contaminant Level
MG	Million Gallons
MGD	Million Gallons per Day
Mg/L	Milligrams per Liter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MWR	Master Water Report
NCDC	National Climate Data Center
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information System
RW	Recycled Water
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SGMA	Sustainable Groundwater Management Act
SGMP	Sustainable Groundwater Management Planning
SGWP	Sustainable Groundwater Planning
SLO Basin	San Luis Obispo Valley Groundwater Basin
SLOFCWCD	San Luis Obispo Flood Control and Water Conservation District
SCML	Secondary Maximum Contaminant Level
SOI	Sphere of Influence
SNMP	Salt and Nutrient Management Plan
SWRCB	California State Water Resources Control Board
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
USFW	United States Fish and Wildlife Service
USTs	Underground Storage Tanks
UWMP	Urban Water Management Plan
UWMP Act	Urban Water Management Planning Act
UWMP Guidebook	Department of Water Resources 2015 Urban Water Management Plan Guidebook
VRMWC	Varian Ranch Mutual Water Company
WCR	Well Completion Report
WCS	Water Code Section
WMP	Water Master Plan
WPA	Water Planning Areas
WRF	Water Reclamation Facility
WRCC	Western Regional Climate Center
WRRF	Water Resource Recovery Facility
WSA	Water Supply Assessment
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This section to be completed after GSP is complete.

7 MONITORING NETWORKS (§ 354.32 AND § 354.34)

This chapter describes the proposed monitoring networks for the GSP in accordance with SGMA regulations in Subarticle 4: Monitoring Networks. Monitoring is a fundamental component of the GSP necessary to identify impacts to beneficial uses or Basin users, and to measure progress toward the achievement of any management goal. The monitoring networks must be capable of capturing data on a sufficient temporal and spatial distribution to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface water conditions, and to yield representative information about groundwater conditions for GSP implementation. There are three monitoring networks for the Basin: a groundwater level network, a groundwater quality network, and a surface water flow network.

Chapter 7 describes the monitoring objectives, rationale, protocols, and data reporting requirements of the monitoring networks. Monitoring requirements for sustainability indicators are presented, and data gaps are identified, along with steps to be taken to fill the data gaps before the first five-year assessment. The following is a list of applicable SGMA sustainability indicators that will be monitored in the Basin:

- Chronic lowering of groundwater levels.
- Reduction in groundwater storage.
- Degradation of groundwater quality.
- Land subsidence.
- Depletion of interconnected surface water (includes GDE sustainability).

Sustainability indicators are discussed in detail in Chapter 8. This monitoring networks chapter focuses on the monitoring sites and data collection needed to support the evaluation of each sustainability indicator.

7.1 MONITORING OBJECTIVES

The proposed monitoring network must be able to adequately measure changes in groundwater conditions to accomplish the following monitoring objectives:

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

The monitoring network must provide adequate spatial resolution to properly monitor changes to groundwater and surface water conditions relative to measurable objectives and sustainability indicators within the Basin. The network must also provide data with sufficient temporal resolution to demonstrate short-term, seasonal and long-term trends in groundwater and related surface conditions.

7.1.1 Management Areas

Although there are differences in land use and associated water budgets between the San Luis Valley and Edna Valley subareas, as described in Chapter 6, separate management areas have not been formally established. The monitoring network includes representative wells across the Basin for which minimum thresholds and measurable objective have been selected based on local conditions, as described in Chapter 8.

7.1.2 Representative Monitoring Sites

Monitoring sites are the individual locations within a monitoring network and consist of groundwater wells and stream gages. While a monitoring network uses a sufficient number of sites to observe the overall groundwater conditions and the effects of Basin management projects, a subset of the monitoring sites may be used as representative for meeting the monitoring objectives for specific sustainability criteria.

Representative monitoring sites are the locations at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined. The criteria that were used to determine which wells to utilize are as follows:

- A minimum 10-year period of record of historical measurements spanning wet and dry periods.
- Available well information (well depth, screened interval).
- Access considerations.
- Proximity and frequency of nearby pumping wells.
- Spatial distribution relative to the applicable sustainability indicators.
- Groundwater use.
- Impacts on beneficial uses and Basin users.

7.1.3 Scientific Rationale

GSP monitoring program development is based on a combination of SGMA monitoring networks best management practices (BMPs), local hydrogeology, and the monitoring requirements for individual sustainability criteria. Some of the SGMA monitoring network BMPs implemented for this GSP include the following:

- Defining the monitoring objectives.
- Utilizing existing monitoring networks and data sources to the greatest extent possible to meet those objectives.
- Adjusting the temporal/spatial coverage to provide monitoring data consistent with the need.
- Efficient use of representative monitoring sites to provide data for more than one sustainability indicator.

County monitoring programs that existed before SGMA include sites that do not meet SGMA monitoring network BMPs with respect to known construction information, such as wells with no available Well Construction Report (WCR) and active wells that are used for groundwater supply. While not prohibiting the use of these wells as a monitoring site, SGMA regulations require that the GSP identify sites that do not meet BMPs and describe the nature of the divergence. If the monitoring network uses wells that lack construction information, the GSP shall include a schedule for acquiring monitoring wells with the necessary information or shall demonstrate that such information is not necessary to understand or manage groundwater in the Basin.

As discussed in Chapters 4 and 5, information from available boring logs indicates that there is no regional or laterally extensive aquitard separating the Alluvial aquifer, Paso Robles Formation aquifer, and Pismo Formation aquifer in the Basin. In the San Luis Valley, a physical distinction between Alluvium and Paso Robles Formation sediments is often not apparent, and information from WCRs indicates that wells are regularly screened across productive strata in both formations, which effectively function as a single hydrogeologic unit. DWR (1997) also concluded that there are no continuous confining layers, and unconfined groundwater table conditions essentially prevail throughout the Basin, including the Edna Valley. A minor exception is recognized in Chapter 6 (Section 6.3.5) near the intersection of Biddle Ranch Road and Edna Road, where there is a shallow (semi-perched) alluvial aquifer tapped by a former windmill well. Therefore, with respect to groundwater level monitoring, data collected from wells completed in one or more of the three principal aquifers (Alluvium, Paso Robles Formation, and Pismo Formation) can be used collectively for groundwater elevation contouring and storage estimates. Obtaining well construction information for all monitoring network wells is not an immediate necessity and will be addressed (see Section 7.6).

7.1.4 Existing Monitoring Programs

Existing monitoring programs are discussed in Chapter 3. Figure 3-9 (Chapter 3) shows the locations of monitoring wells identified in the GAMA program (publicly available groundwater quality data), the SLOFCWCD semi-annual groundwater level program, and the CCRWQCB Irrigated Lands Regulatory Program (groundwater quality data). There are also groundwater level and quality data collected for various contaminant investigations and monitoring programs that are publicly available from the SWRCB Geotracker website.

7.2 MONITORING NETWORKS

This section introduces the proposed GSP monitoring networks and describes the networks in relation to the following SGMA sustainability indicators applicable to the Basin:

- Chronic lowering of groundwater levels.
- Reduction of groundwater in storage.
- Groundwater quality degradation.
- Land subsidence.
- Depletion of interconnected surface water (includes GDE sustainability).

The GSP monitoring program consists of three separate networks, one for groundwater levels, one for groundwater quality, and one for surface water flow. Each network is described below.

7.2.1 Groundwater Level Monitoring Network

Groundwater level monitoring is a fundamental tool in characterizing Basin hydrology. Groundwater levels (often reported as elevations relative to a reference point) in wells are measures of the hydraulic head in an aquifer. Groundwater moves in the direction of decreasing head (downgradient), and groundwater elevation contours can be used to show the general direction and hydraulic gradient associated with groundwater movement. Changes in the amount of groundwater in storage within an aquifer can also be estimated based on changes in hydraulic head, along with other parameters.

There are 40 monitoring wells in the GSP groundwater level monitoring network, 22 wells in the San Luis Valley and 18 wells in the Edna Valley (Figure 7.1 and Table 7-1). Construction information is available for 31 of the 40 wells. Based on the available information, 16 of the wells are interpreted to be alluvial wells, while the remaining 24 wells tap into the Paso Robles Formation, Pismo Formation, or are mixed aquifer wells that utilize groundwater from more than one aquifer. Half the wells are used for irrigation, seven are private domestic wells, and 13 are dedicated monitoring wells.

Groundwater levels may be used as a proxy for monitoring other sustainability indicators (besides chronic lowering of water levels) provided that significant correlation exists between groundwater elevations and the sustainability indicator for which the groundwater elevations serve as a proxy. Ten of the groundwater level monitoring network wells are representative monitoring site wells used for evaluating sustainability criteria. Six representative monitoring site wells are used for evaluating chronic lowering of groundwater level and reduction of groundwater in storage, which is correlated with groundwater levels (Chapter 6, Section 6.3.5). Two wells are used for evaluating subsidence, which is correlated with groundwater levels in the area being monitored (Chapter 4, Section 4.7), and three wells are used to evaluate depletion of interconnected surface water, which is correlated with groundwater levels (Chapter 5, Section 5.7). One of the wells used to evaluate depletion of interconnected surface water is also a representative monitoring site for subsidence. The sustainability criteria and associated minimum thresholds and measurable objectives are presented in Chapter 8.

7.2.1.1 ***Groundwater Level Monitoring Data Gaps***

SGMA regulations do not require a specific density of monitoring wells, other than being sufficient to represent groundwater conditions for GSP Implementation. The monitoring network well density is roughly 20 wells per 10 square miles, which is 10 times greater density than guidelines for the statewide CASGEM program. There are currently sufficient wells in the network to provide information for overall sustainable management of the Basin, although some local data gaps have been identified that will be addressed during GSP implementation.

A groundwater level monitoring well is recommended in the Foothill Boulevard/O'Conner Way area to improve groundwater level contour control and associated groundwater storage estimates in the Los Osos Valley within the Basin. Other groundwater level monitoring locations are recommended for GDE indicator evaluation and are in the vicinity of existing or proposed stream gage locations. The background and rationale for the GDE indicator monitoring sites are presented in a separate technical memorandum (Appendix 7A).

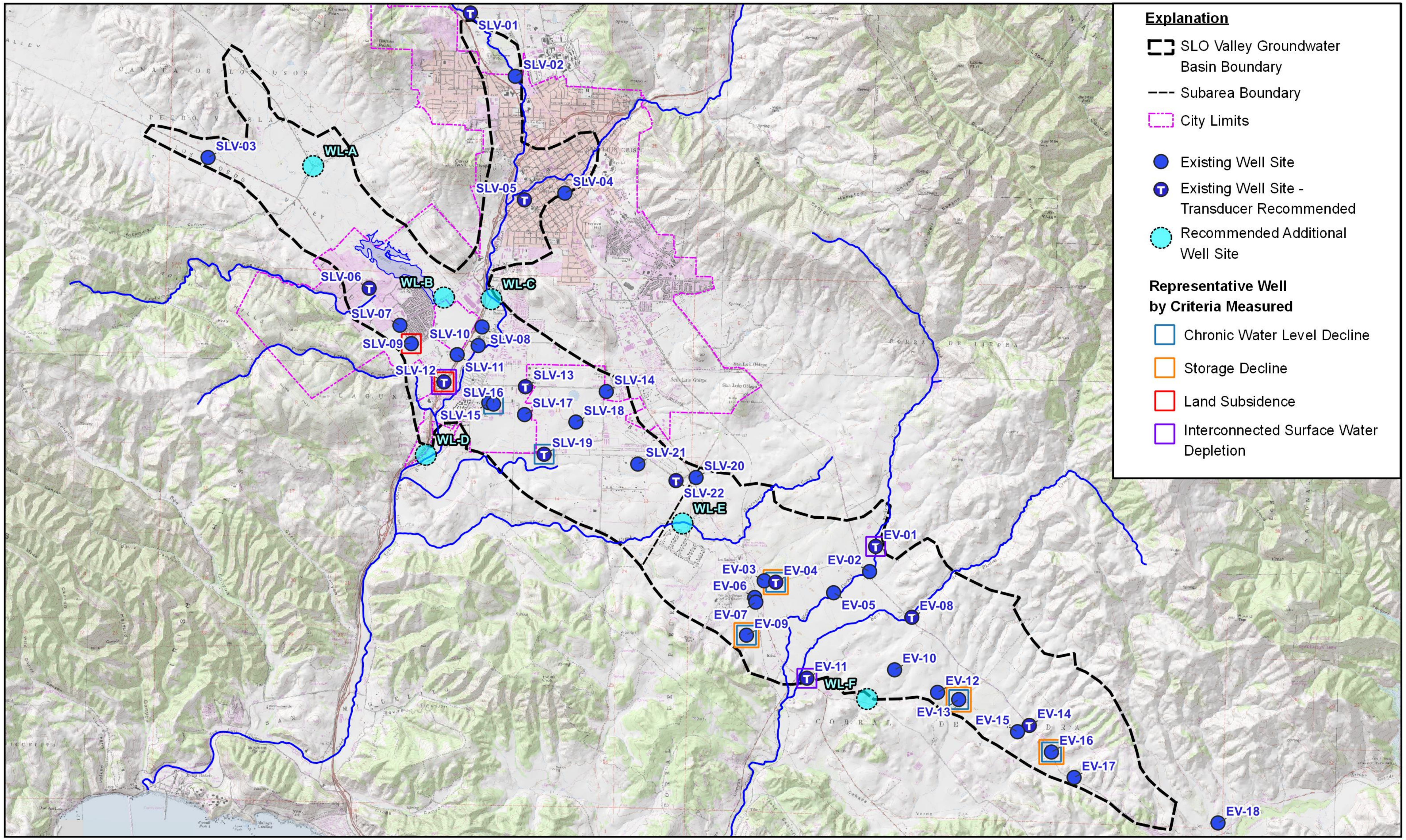
Table 7-1 presents the GSP groundwater level monitoring network wells. Table 7-2 presents additional areas recommended for groundwater level monitoring. Figure 7-1 shows the location of the existing groundwater level monitoring wells and the recommended additional monitoring areas.

Table 7-1
Groundwater Level Monitoring Network

Local ID[1]	TRS / **State ID**[2]	Well Depth (feet)	Screen Interval (feet)	RP Elev.[3] (feet AMSL)	First Data Year	Last Data Year	Data period (years)	Data Count	Aquifer[4]	Well Criteria[5]	Well Use[6]	GSA
SLV-01	30S/12E-23E	(pending)	(pending)	304			(pending)		Qa	GDE, T	MW	County
SLV-02	30S/12E-22G	(pending)	(pending)	276			(pending)		Qa		MW	City
SLV-03	30S/12E-30P			153					Qa		IRR-I	County
SLV-04	**30S/12E-35B1**	48	28-48	215.6	1991	2020	29	38	Qa		IRR-A	City
SLV-05	30S/12E-35D	52	32-52	187	1990	2018	28	7	Qa	GDE, T	IRR-A	City
SLV-06	31S/12E-04D	85	45-85	150	1989		1	1	Qa	T	MW	City
SLV-07	31S/12E-04K	125	55-125	139.5	1992	2000	8	46	Qpr		PS-I	City
SLV-08	31S/12E-03K	70	50-70	128	1988	2020	32	2	Qpr		IRR-A	City
SLV-09	**31S/12E-4R1**	130	40-130	129.5	1988	2020	32	48	Qa/Qpr	SUB	PS-I	City
SLV-10	31S/12E-3Q	48		131	2017	2020	3	82	Qa		MW	City
SLV-11	**31S/12E-3P1**	61		119	1990	2006	16	31	Qa		MW	City
SLV-12	**31S/12E-10D3**	175	50-90; 150-170	109.2	1992	2020	28	72	Qa/Qpr/Tps	ISW, SUB, T	IRR-A	City
SLV-13	31S/12E-11D	40	5-40	121.75	1996	2020	24	49	Qa	T, GDE	MW	City
SLV-14	31S/12E-12E	20	5-20	144.68	1990	2020	30	60	Qa		MW	County
SLV-15	**31S/12E-10G2**	190		122	1965	2020	55	90	Qpr		IRR-A	City
SLV-16	**31S/12E-10H3**	165	65-165	122	1984	2020	36	68	Qpr	WL	DOM-A	City
SLV-17	31S/12E-11M	100	60-100	119.78	1996	2020	24	73	Qpr		MW	County
SLV-18	31S/12E-11K	30	6-21	133.28	1990	2020	30	59	Qa		MW	County
SLV-19	**31S/12E-14C1**			128	1958	2020	62	98	Qpr	WL, GDE, T	IRR-A	County
SLV-20	31S/13E-18D			202					Qa		MW	County
SLV-21	31S/12E-13A	60	50-60	178.68	2018	2018	1		Qpr		MW	County
SLV-22	31S/12E-13C	100	11-100	178	2004	2020	16	2	Qpr/Kjf	T	IRR-I	County
EV-01	**31S/13E-16N1**	72		324	1958	2020	62	99	Qa	ISW, T	DOM-A	County
EV-02	31S/13E-20A	75		305					Qa	GDE	IRR-I	County
EV-03	**31S/13E-19H4**	250	178-250	254					Qpr/Tps		IRR-A	County
EV-04	**31S/13E-19H1**			262	1958	2020	62	100	Tps	WL, GWS, T	IRR-A	County
EV-05	31S/13E-20G	400	120-400	280					Tps		IRR-I	County
EV-06	**31S/13E-19J1**			251	1998	2020	22	44	Qpr		DOM-I	County
EV-07	**31S/13E-19J2**			250	1998	2020	22	45	Tps		DOM-A	County
EV-08	31S/13E-21L			350					Qa	GDE, T	IRR-A	County
EV-09	**31S/13E-19R3**	440	130-190; 290-430	239	1974	2020	46	45	Tps/Tm	WL, GWS	PS-A	County
EV-10	31S/13E-28F	340	200-330	344					Qpr/Tps		IRR-A	County
EV-11	**31S/13E-20F6**	150	55-150	230	2011	2020	9		Qpr/Tm	ISW, GDE, T	MW	County
EV-12	**31S/13E-28J3**	600		303	1993	2020	27	39	Qpr/Tps		IRR-A	County
EV-13	**31S/13E-27M3**	400	130-380	289	1993	2020	27	34	Qpr/Tps	WL, GWS	IRR-A	County
EV-14	31S/13E-27R	300	90-290	319	2017	2020	3	6	Qpr/Tps	T	MW	County
EV-15	31S/13E-27Q			307	1989	2020	31	9	Qpr/Tps		DOM-I	County
EV-16	31S/13E-35D	260	200-260	323	1988	2020	32	188	Tps	WL, GWS	PS-A	County
EV-17	31S/13E-35F	260	200-260	333	2014	2020	6	66	Tps/Kjf		PS-I	County
EV-18	**31S/13E-36R1**			327	1968	2020	52	99	(out of Basin)		IRR-A	County

Notes:

1- Representative Monitoring Sites are in **bold**. Wells with known State Well Completion Reports are underlined.
2- TRS = Township Range Section and ¼-¼ section listed, State Well ID bolded where applicable.
3- Reference Point elevations from various sources with variable accuracy.
4- Principal Aquifers are Quaternary Alluvium (Qa), Quaternary Paso Robles Formation (Qpr), and Tertiary Pismo Formation (Tps). Other bedrock aquifers (non-Basin sediments) are Tertiary Monterey Formation (Tm) and Cretaceous-Jurassic Franciscan Assemblage (KJf). Aquifers are inferred where construction information is not available.
5- Representative well criteria include Subsidence (SUB), Interconnected Surface Water Depletion (ISW), Chronic Water Level Decline (WL), and Groundwater Storage Decline (GSW). Other criteria are Transducer site (T), and Groundwater Dependent Ecosystem indicator evaluation site (GDE), which may be paired with nearby existing or proposed stream gage. Transducer installations are pending well owner authorization. Measurement frequency is semi-annual for all wells except Transducer sites (T), which are measured daily.
6- Well Use includes Monitoring Well (MW), Irrigation Well (IRR), Public Supply Well (PS), and Domestic Well (DOM). Modifiers are Active (A) or Inactive (I). Information for some wells inferred pending confirmation.



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Author: TK
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SAN LUIS OBISPO VALLEY BASIN GSP

N

0 0.25 0.5 0.75 1 mi
0 0.5 1 km

References:
1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Hirozontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: USGS 7.5' Topographic Map

Notes:
1.
2.
3.

Figure 7-1
Water Level Monitoring Network

Table 7-2
Recommended Groundwater Level Monitoring Network Additions

Water Level Data Gap ID	Location	Purpose
WL-A	Near Foothill Blvd. and O'Connor Way	Groundwater elevation contours and storage
WL-B	Madonna Road near Laguna Lake	GDE indicator evaluation
WL-C	Elks Lane south of SLO Creek Bridge	GDE indicator evaluation
WL-D	South Higuera near old Highway Bridge	GDE indicator evaluation
WL-E	Davenport Creek east of Crestmont Road	GDE indicator evaluation, groundwater elevation contours and storage
WL-F	Corbett Canyon Road near Canada Verde	GDE indicator evaluation

7.2.2 Groundwater Quality Monitoring Network

Groundwater quality monitoring refers to the periodic collection and chemical or physical analysis of groundwater from wells. As discussed in Chapter 5 (Section 5.9), the quality of groundwater in the Basin is generally good. Groundwater quality trends in the Basin are stable, with no significant trends of ongoing deterioration of groundwater quality based on the Central Coast Basin Plan.

Groundwater quality networks should be designed to demonstrate that the degraded groundwater quality sustainability indicator is being observed for the purposes of meeting the sustainability goal (DWR Monitoring Networks BMP, 2016). In other words, the main purpose of the groundwater quality monitoring network is to support the determination of whether the degradation of groundwater quality is occurring at the monitoring sites, based on the sustainability indicator constituents and minimum thresholds selected. This GSP groundwater quality network is also designed to use existing monitoring programs to the greatest degree possible (DWR Monitoring Networks BMP, 2016).

Sustainability indicator constituents selected for groundwater quality are Total Dissolved Solids (TDS), Nitrate, and Arsenic. These constituents were introduced in Chapter 5 (Section 5.9.3) as diffuse or naturally occurring in the Basin and are further discussed in relation to sustainability indicators in Section 7.3.4 and in Chapter 8. Two other water quality constituents associated with notable contaminant plumes in the South San Luis Obispo and Buckley Road areas (Figure 7-2 and Section 7.3.4) will also be monitored within the GSP water quality network, but not as sustainability indicators.

The groundwater quality network consists of nine sites (Figure 7-2), which are all are Public Water System supply wells. Water quality for these wells can be accessed using the GAMA Groundwater Information System. Wells in the Irrigated Lands Regulatory Program were evaluated for potential inclusion in the GSP monitoring program, however, the irrigation wells have not historically been sampled for groundwater quality at regular intervals, therefore no historical record of groundwater quality data exists. In addition, Agricultural Order 4.0 of the Irrigated Lands Regulatory Program is currently in draft form and under review. Selection of specific wells regulated under that program would not be recommended until the program is implemented and monitoring data is available for review. By comparison, the public water system wells have a history of groundwater quality data and specific wells are sampled at regular intervals for the three indicators recommended for groundwater quality monitoring in Chapter 8 – TDS, Nitrate, and Arsenic.

*7.2.2.1 **Groundwater Quality Monitoring Data Gaps***

Current groundwater quality monitoring within the Basin is sufficient to collect the spatial and historical data needed to determine groundwater quality trends for groundwater quality indicators. The GAMA database includes 120 wells within the Basin boundaries that have been monitored for groundwater quality in the last three years. The nine wells selected (Figure 7-2) provide representative Basin coverage but can be supplemented with other data if needed to support sustainability indicator evaluation. The water quality network wells will be used collectively to provide the metric for use with the groundwater quality degradation sustainability indicator (Chapter 8). No data gaps in groundwater quality monitoring are currently identified.

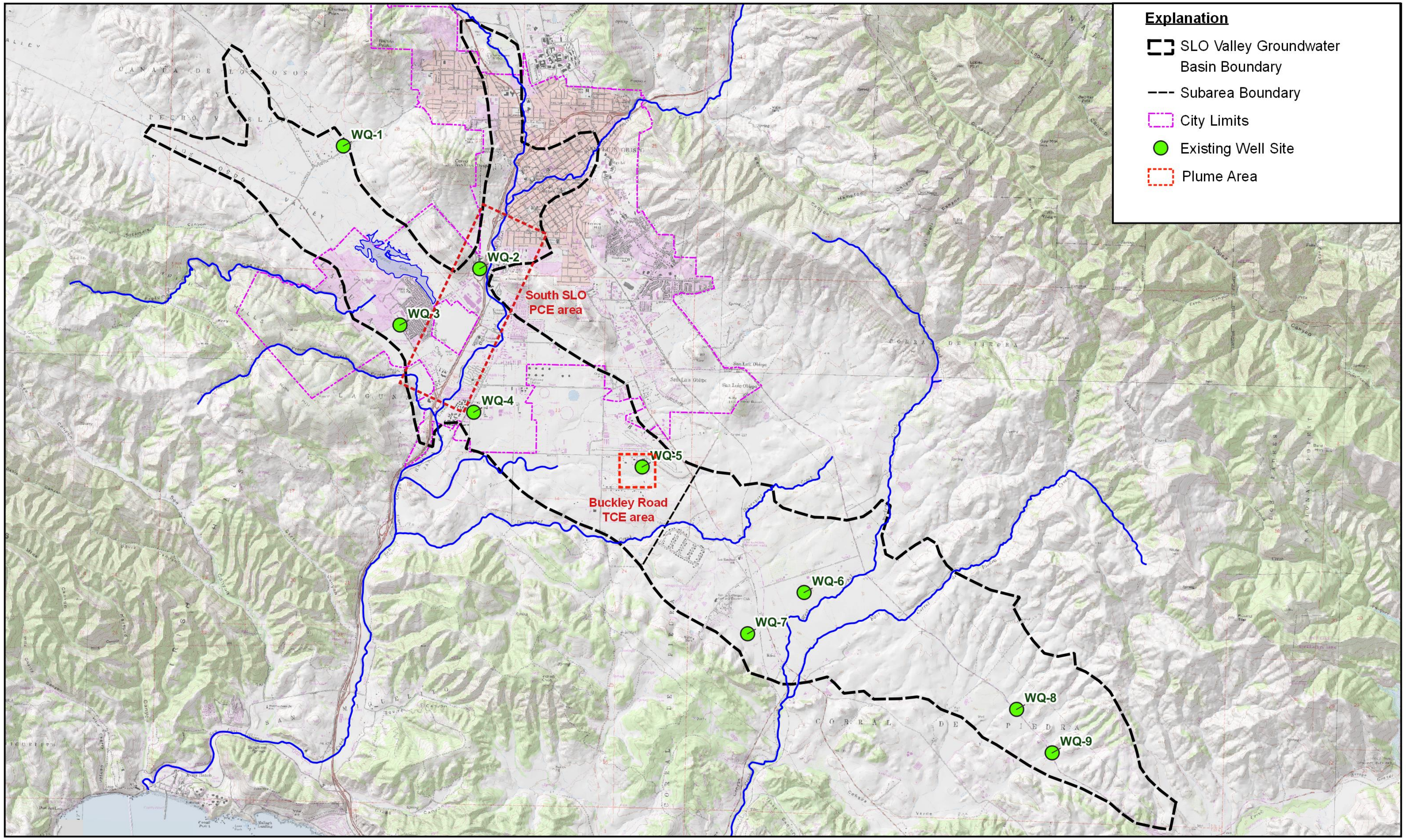
Table 7-3 presents the GSP groundwater quality monitoring network. Figures 7-2 show the locations of the groundwater quality monitoring wells.

Table 7-3
Groundwater Quality Monitoring Network

Local ID	State ID[1]	First Data Year	Last Data Year	Data period (years)	Data Count (TDS)[2]	Data Count (N)[3]	Data Count (As)[4]	GSA
WQ-1	4000206-003	2003	2019	16	4	12	5	County
WQ-2	4000780-001	2002	2019	17	5	21	6	City
WQ-3	4010009-004	1989	2019	30	8	42	8	City
WQ-4	4000604-001	2002	2020	18	6	69	6	City
WQ-5[5]	4000734-001	2004	2020	16	4	21	6	County
WQ-6	4000819-001	2017	2020	3	3	4	1	City
WQ-7	4010023-008	1992	2020	28	19	142	148	County
WQ-8	4000202-001	2003	2018	15	5	23	27	County
WQ-9	4000765-001	2002	2019	17	7	19	36	County

Notes: Data accessed on GAMA Groundwater Information System

1- State ID for public water system
2- TDS = Total Dissolved Solids – typically measured every three years
3- N = Nitrate-Nitrogen – typically measured every year or quarterly
4- As = Arsenic – variable from monthly to every three years
5- WQ-5 also used to track TCE (see Section 8.2.4)



Prepared For:

Author: TK
Date: 11/24/2020

SAN LUIS OBISPO VALLEY BASIN GSP

N

0 0.25 0.5 0.75 1 mi
0 0.5 1 km

References:
1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Hirozontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: USGS 7.5' Topographic Map

Notes:
1.
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3.

Figure 7-2
Water Quality Monitoring Network

7.2.3 Surface Water Flow Monitoring Network

Surface water flow monitoring can provide valuable information for the Basin model and for evaluating potential depletion of interconnected surface water for groundwater dependent ecosystems (GDEs), which is one of the sustainability indicators. The evaluation of surface water connectivity with the Basin and relevance to GDEs is described in a technical memorandum (Appendix 7A) that includes recommendations for the surface water flow monitoring sites identified in this chapter.

As summarized in Chapter 3, there are six permanent stream gages in or adjacent to the Basin, all within the San Luis Valley subarea watershed (Figure 7-3). The existing gaging stations only provide stage data, and not actual stream flow data. Stream stage is the height of water level in the stream above an arbitrary point, usually at or below the stream bed. Stage data can be useful for identifying flow and no-flow conditions, flood stage alerts, and analyzing the timing of precipitation and runoff in watersheds. Streamflow data is critical for quantifying Basin recharge from stream seepage as part of the water budget/model and for addressing sustainability indicators related to GDEs and depletion of interconnected surface water.

Stage data can be converted to streamflow through the use of a rating curve, which incorporates information that is specific to each site, including the cross-sectional area of the channel and the average surface water velocity for a given flow stage. A description of the methodology for monitoring surface water flow in natural channels is presented in Appendix 7B. There are partial rating curve approximations for three of the sites based on actual streamflow measurements (Section 3.6.1.3). A modeling approach to estimating rating curves was performed by Questa Engineering (2007), but the results of that study have not been validated with field measurements.

*7.2.3.1 **Surface Flow Monitoring Data Gaps***

The existing gages are all in the San Luis Valley subarea watershed, where the majority of potential GDEs have been identified (Figure 5-15; Chapter 5). There are no surface flow monitoring sites in the Edna Valley subarea, which is the subarea subject to overdraft (Chapter 6). Data gaps for surface water flow monitoring with respect to interconnected surface water depletion, GDEs, and the water budget are identified on Stenner Creek near the upstream Basin boundary, on San Luis Obispo Creek near the downstream Basin boundary, and on Pismo Creek near the downstream Basin boundary (Appendix 7A). Three stream gages are recommended for installation to fill these data gaps adjacent to the Basin boundaries. In addition, two more stream gage sites are recommended on East Corral de Piedra Creek and West Corral de Piedra Creek at Orcutt Road to fill a data gap in the water budget in the Edna Valley. Stream gages on these two principal drainages, along with a gage downstream of their confluence on Pismo Creek, will provide important information on stream seepage in the Edan Valley for the water budget/Basin model, and will allow a direct comparison of streamflow between the two watersheds, one of which has a permitted reservoir upstream of Orcutt Road (Chapter 6, Section 6.3.3.1). Rating curve development is recommended for all stream gages to provide the stream flow information needed for the water budget/model and sustainability indicator evaluation.

Table 7-4 presents the GSP surface water flow monitoring network. Table 7-5 presents recommended sites for additional stream gages. Figure 7-3 shows the locations of the existing gages, recommended gages, and the nearby groundwater level monitoring sites (both existing and recommended) that can be used to evaluate interconnected surface water depletion and GDE indicators (see Section 7.3.6 and Appendix 7A).

Table 7-4
Existing Surface Water Flow Monitoring Network

Local ID	Water Course	Location	First Data Year	Data Interval	Data period (years)	GSA
SG-745	San Luis Obispo Creek	Andrews St. Bridge	2006	15-minutes	14	City
SG-781	Stenner Creek	Nipomo Street	2005	15-minutes	15	City
SG-790	San Luis Obispo Creek	Marsh Street	2019	15-minutes	1	City
SG-740	San Luis Obispo Creek	Elks Lane	2005	15-minutes	15	City
SG-778	Prefumo Creek	Madonna Road	2005	15-minutes	15	City
SG-783	East Fork Creek	Jesperson Road	2005	15-minutes	15	County

Table 7-5
Recommended Surface Water Monitoring Network Additions

Surface Water Flow Gap ID	Location	Purpose
SG-A	Stenner Creek at Stenner Creek Road	Water Budget, Surface water connectivity, GDE indicator evaluation
SG-B	San Luis Obispo Creek at Old Highway Bridge	Water Budget, Surface water connectivity, GDE indicator evaluation
SG-C	West Corral de Piedra Creek at Orcutt Road	Water Budget
SG-D	East Corral de Piedra Creek at Orcutt Road	Water Budget
SG-E	Pismo Creek at Railroad Crossing	Water Budget, Surface water connectivity, GDE indicator evaluation

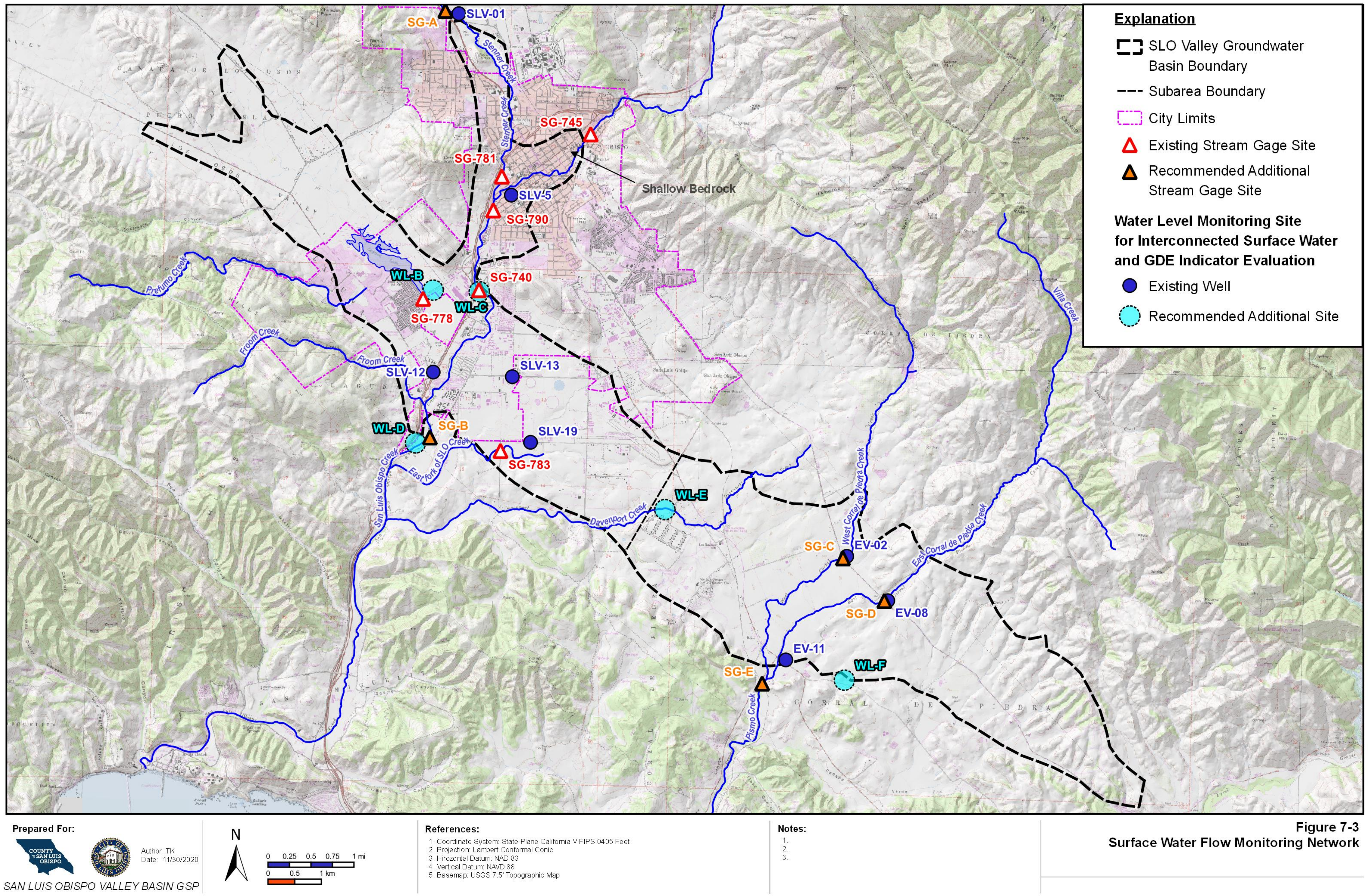

Figure 7-3
Surface Water Flow Monitoring Network

7.3 SUSTAINABILITY INDICATOR MONITORING

Sustainability indicators are the effects caused by groundwater conditions occurring throughout the Basin that, when significant and unreasonable, become undesirable results. The SGMA sustainability indicators for GSP implementation are as follows:

- Chronic lowering of groundwater levels.
- Reduction in groundwater storage.
- Seawater Intrusion (this indicator is not applicable to Basin).
- Degraded groundwater quality.
- Land subsidence.
- Depletion of interconnected surface water (includes GDE sustainability).

7.3.1 Chronic Lowering of Groundwater Levels

Chronic lowering of groundwater levels can lead to a significant and unreasonable depletion of the water supply. All of the groundwater level monitoring network wells can be used for evaluating chronic lowering of groundwater levels, with a selected subset of six representative wells formally assigned to assess Minimum Thresholds and Measurable Objectives (Chapter 8). Groundwater monitoring network wells not included in the subset of representative wells are included in the network primarily for preparing groundwater level contour maps, which are used for evaluating hydraulic gradient and groundwater flow direction. Groundwater level contour maps can reveal groundwater pumping depressions that result from lowering of groundwater levels and can also be used to calculate change in groundwater storage. The area where chronic lowering of water levels has been occurring is in the Edna Valley (Chapter 5; Figure 5-11). Four of the six representative wells focus on this area (Figure 7-1).

Static groundwater level measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions. Historically, the semi-annual groundwater level program conducted by SLOFCWCD has measured groundwater levels in April and October of each year. This schedule will be maintained for the GSP.

In addition, 12 wells have been recommended (based on spatial distribution, equipment access, and interconnected surface water/GDE applications; Figure 7-1) for pressure transducer installation to automatically record groundwater levels on a daily basis, providing more detailed information on short-term trends, seasonal high and low conditions, and on potential GDEs and interconnected surface water depletion. Pressure transducers are instruments that record water levels automatically at pre-determined intervals. They are installed below the water surface in a well and use the pressure of the overlying water column to produce a depth to water measurement. Pressure transducers are a very efficient means of collecting groundwater level data at frequent intervals. The recommended transducer locations are listed in Table 7-1.

7.3.2 Reduction of Groundwater Storage

Groundwater storage and water levels are directly correlated, and chronic lowering of water levels also leads to a reduction of groundwater storage. Change in groundwater storage will be monitored using the overall monitoring network, while selected representative wells will track reduction of groundwater storage as the sustainability indicator.

The comprehensive 40-well monitoring network will be used to contour groundwater elevations for seasonal high conditions, from which annual spring groundwater storage estimates will be estimated and the annual change in storage reported as required for Annual Reports. Groundwater storage will be calculated using the specific yield method, which is the product of total saturated Basin volume and average specific yield. The saturated Basin volume is the volume between a groundwater elevation contour map for a specific period (such as Spring 2019) and the base of permeable sediments (Chapter 6; Section 6.3.5). Representative wells that will be used for monitoring reductions in groundwater storage are listed in Table 7-1 and shown in Figure 7-1. Chapter 8 discusses the Minimum Thresholds and Measurable Objectives assigned to the representative wells.

7.3.3 Seawater Intrusion

The Basin is not susceptible to seawater intrusion and will not be monitored for that indicator.

7.3.4 Degraded Groundwater Quality

The significant and unreasonable degradation of water quality would be an undesirable result. As discussed in Section 7.2.2, groundwater quality constituents in the Basin that have been selected for groundwater quality indicator monitoring include TDS, Nitrate, and Arsenic. Selenium has been observed at concentrations that affect well operations at individual wells in the Basin, but it does not appear to be a widespread issue (Chapter 5; Section 5.9.3.5). The selected water quality indicators represent common constituents of concern in relation to groundwater production for domestic, municipal and agricultural use that will be assessed by the monitoring network. TDS is selected as a general indicator of groundwater quality in the Basin. Nitrate is a widespread contaminant in California groundwater and selected due to its presence across the Basin associated with agricultural activities, septic systems, landscape fertilizer and wastewater treatment facilities. Arsenic is selected to represent naturally occurring contaminants in the Basin. Other constituents of concern may be added to the list during GSP implementation. The sites currently best suited for evaluating trends over time are public supply wells. Sampling intervals vary by well and by constituent, ranging from every three years to monthly, but longer historical records are available, compared to other types of wells.

The significant and unreasonable degradation of water quality includes the migration of contaminant plumes that impair water supplies. There are two anthropogenic contaminant plumes that underly multiple properties and are under investigation within the Basin. These include a tetrachloroethylene (PCE) plume, also known as the South SLO PCE Plume, and a trichloroethylene (TCE) plume, also known as the Buckley Road Area plume (Figure 7-2).

7.3.4.1 South SLO PCE Plume

PCE is primarily used as a solvent at dry cleaning establishments and has a maximum contaminant level in drinking water of 5 micrograms per liter. Dissolved PCE in groundwater has been detected underlying portions of the City of San Luis Obispo, mainly south of the confluence of San Luis Obispo Creek and Stenner Creek. There have been several site investigations and documented PCE releases at various locations within the City. Historical site investigations date to the early 1990's, with regional investigations in 2005 (QPS, 2005) and 2013-2015 (URS, 2013), (URS, 2015). The Department of Toxic Substance Control (DTSC) and the Regional Water Quality Control Board (RWQCB) have provided most of the regulatory oversight related to site investigations and clean-up efforts since the early 1990's. Currently, the City has initiated a comprehensive PCE investigation, including monitoring well constructions, with Proposition 1 grant funding. Representative wells from the future PCE monitoring well network will be selected for inclusion with the GSP groundwater quality network specifically for tracking PCE in the Basin.

7.3.4.2 Buckley Road Area TCE Plume

TCE has a variety of uses, typically as an industrial solvent/degreaser. The maximum contaminant level for TCE in drinking water is 5 micrograms per liter. In 2013, the RWQCB initiated an investigation into the source of TCE detected in two supply wells in the industrial area of Buckley Road and Thread Lane. County of San Luis Obispo Environmental Health Services also began a sampling program following TCE detection above the maximum contaminant level in groundwater from a residential supply well in 2015. Information from these and subsequent investigations, including investigation at the San Luis Obispo County Airport north of Buckley Road, indicated that the likely source of TCE was the industrial area of Buckley Road and Thread Lane. These investigations were summarized in a public notice from the RWQCB dated January 15, 2019. One of the supply wells selected for the groundwater quality network (WQ-5) is in the industrial area and both historically and currently reports TCE concentrations above the maximum contaminant level (24 micrograms per liter TCE reported in April 2020). Currently, the RWQCB is enforcing a replacement water program to provide treatment for wells impacted by the TCE plume. A web page has been established by the Water Board to provide the latest information to the public and can be accessed here: https://www.waterboards.ca.gov/centralcoast/water_issues/hot_topics/tce_pce_info/tce_pce_index.html. The TCE plume will be monitored for the GSP through tracking the concentration reported at WQ-5 and observing published plume maps over time. A general trend of decreasing TCE concentration, along with plume containment, would be measures of success in plume management.

7.3.5 Land Subsidence

Land subsidence can lead to undesirable results when it interferes with surface land uses. Land subsidence is frequently associated with groundwater pumping and has been documented in the San Luis Valley subarea (see Chapter 4; Section 4.7 and Chapter 6; Section 6.7.3). The purpose of land subsidence monitoring is to identify the rate and extent of land subsidence and to provide data for sustainability criteria thresholds. DWR maintains a land subsidence dataset derived from Interferometric Synthetic Aperture Radar (InSAR) data from satellite imagery. InSAR is a remote sensing method used to measure land-surface elevations over large areas, with accuracy on the order of centimeters to millimeters. InSAR uses satellites that emit and measure electromagnetic waves that reflect off of the earth's surface to produce synthetic aperture radar images with a spatial resolution of about 100 meters by 100 meters. Vertical displacement values associated with land subsidence can be estimated by comparing these images over time.

The DWR land subsidence dataset shows vertical displacement from 2015-2019 in California groundwater basins. The raster GIS dataset covers the entire Basin, with no data gaps. The dataset shows minimal vertical displacement of less than an inch from 2015-2019 throughout the Basin (Chapter 8). Continued evaluation of Basin land subsidence through monitoring the available InSAR data is planned. In addition, two representative monitoring site wells have been identified for land subsidence monitoring based on the historical area of land subsidence in the Basin (Chapter 4; Section 4.7) and are included in Table 7-2. Groundwater level can be a proxy for land subsidence because the process is typically not reversible, and maintaining groundwater levels above historic lows in areas susceptible to land subsidence can protect against future undesirable results (see Chapter 8).

7.3.6 Depletion of Interconnected Surface Water

Surface water provides beneficial uses, and depletion of interconnected surface water due to groundwater pumping can result in undesirable results by impacting these beneficial uses. The purpose of monitoring for depletion of interconnected surface water is to characterize the following:

- Flow conditions including surface water discharge, surface water head, and baseflow contribution.
- Identifying the approximate date and location where ephemeral or intermittent flowing streams cease to flow.
- Historical change in conditions due to variations in stream discharge and regional groundwater extraction.

- Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

One of the beneficial uses of surface water is the environmental water demand which supports riverine, riparian, and wetland ecosystems. Locations where surface water is interconnected with groundwater have the potential for creating GDEs, which are ecological communities or species that depend on groundwater emerging from aquifers (rising into streams or lakes) or on groundwater occurring near ground surface where it may be used by riparian vegetation, wetland vegetation, or oak woodlands.

Depending on location and time of year, GDEs that overlie the Basin can be supported by a range of water sources including direct precipitation, surface runoff, shallow subsurface flow, and groundwater. Shallow subsurface flow can vary from short-term precipitation and runoff driven flow (e.g. bank storage and other macro-pores filled during a precipitation event that drain on the order of days to weeks) to flow that is directly connected to groundwater (e.g. baseflow as groundwater discharge into streams during the dry season). Because GDEs overlying the Basin are supported by a wider range of surface and groundwater hydrological processes in the wet season, monitoring of GDEs for sustainability indicators will focus on the late spring baseflow period and summer/early fall dry season. Primary groundwater dependence for GDEs is more likely during the late spring, summer, and early fall dry season, although in some reaches irrigation return flow may also be a factor. If the GDE indicators are met in the late spring and dry summer and fall seasons, sufficient groundwater is more likely also be available in the wet season to sustain GDEs (see Appendix 7A).

There are six existing County stream gages within, or adjacent to the SLO Valley Groundwater Basin (Table 7-4, Figure 7-3). The existing gages only report stage, as discussed in Section 7.2.3. An additional five stream gages are proposed, both for water budget and interconnected surface water flow data gaps (Table 7-5). Rating curves, which correlate stage with stream flows, should be developed for all 11 sites. In addition, groundwater level monitoring is recommended near the stream gages sites, and at additional sites for riparian and wetland/marsh GDE types (Figure 7-3). Table 7-6 shows the pairing between the stream gages and the nearby water level monitoring sites for interconnected surface water and GDE indicator evaluation (both existing and recommended).

Table 7-6
Interconnected Surface Water and Associated GDE indicator Monitoring Locations

Stream Gage	Monitoring Well	Area
SG-745	(none - bedrock)	SLO Creek near upstream Basin boundary
SG-781	SLV-5	Stenner Creek above SLO Creek confluence
SG-790	SLV-5	SLO Creek below Stenner Creek confluence
SG-740	WL-C	SLO Creek at Elks Lane
SG-778	WL-B	Prefumo Creek at Laguna Lake outlet
SG-783	SLV-19	East Fork SLO Creek at Jesperson Lane
SG-A	SLV-01	Stenner Creek near upstream Basin boundary
SG-B	WL-D	SLO Creek near downstream Basin boundary
SG-C	EV-2	West Corral de Piedra at Orcutt Road
SG-D	EV-8	East Corral de Piedra at Orcutt Road
SG-E	EV-11	Pismo Creek at downstream Basin boundary
(none)	SLV-12	Calle Joaquin
(none)	SLV-13	Tank Farm Road
(none)	WL-E	Davenport Creek near Crestmont Road
(none)	WL-F	Corbett Canyon Road near Canada Verde

The wells in Table 7-6 used for GDE monitoring need to be in locations that are representative of groundwater levels in the riparian zones. A few of the existing wells (SLV-5, SLV-19, EV-11) are not immediately adjacent to their paired stream gage, but may have a sufficient hydraulic connection to local riparian conditions to be useful for GDE indicator evaluation. The data for each paired monitoring well and stream gage would be supplemented with field surveys (discussed below), to evaluate the suitability of the GDE indicator monitoring sites.

In addition to streamflow and groundwater level monitoring, streamflow surveys are recommended across a range of seasons and water year types to identify losing and gaining reaches with the Basin. Identifying losing and gaining reaches is fundamental to understanding surface water-groundwater connectivity. Losing reaches occur in Basin recharge areas that are typically dry during the summer and late fall. Gaining reaches occur in Basin discharge areas where groundwater is contributing to surface water flow. Groundwater pumping that lowers groundwater levels in an aquifer beneath a creek channel may deplete surface water by either expanding a losing reach or contracting a gaining reach, depending on the depth of the water table and the permeability of the stream bed. The streamflow surveys characterize the extent of gaining and losing reaches and help evaluate depletion of interconnected streamflow. This type of data collection is conducted by measuring instream flow in multiple locations along a reach of creek in a short period of time and examining the loss or gain of stream flow rates along the length of the stream channel.

7.4 MONITORING TECHNICAL AND REPORTING STANDARDS

Monitoring technical and reporting standards include a description of the protocols, standards for monitoring sites, and data collection methods.

7.4.1 Groundwater Levels

Monitoring protocols and data collection methods for groundwater level monitoring and reporting are described in the attached Appendix 7C, and are based on SGMA monitoring protocols, standards and sites BMPs, USGS data collection methods, and practical experience. Wells used for monitoring program sites have been constructed according to applicable construction standards, although not all the information required under the BMPs is available for every site. Table 7-2 lists the pertinent information available for the monitoring sites.

7.4.2 Groundwater Quality

Monitoring protocols and standards for groundwater quality sampling sites are those required for public water systems from which the groundwater quality data is obtained. Sample collection and field tests shall be performed by appropriately trained personnel as required by California Code of Regulations Title 22, Section 64415. All wells used for public supply are expected to meet applicable construction standards.

7.4.3 Surface Water Flow

As previously discussed, the existing gaging stations only provide stage data, and not actual stream flow data. Stage data can be converted to streamflow through the use of a rating curve, which incorporates information that is specific to each site, including the cross-sectional area of the channel and the average surface water velocity for a given flow stage. These rating curves are developed using depth profiles and flow velocity measurements during storm-runoff events (Appendix 7B). Rating curves may need to be revised periodically as they can shift due to changes in channel geometry. Protocols and data collection methods will be based on applicable USGS standards and SLOFCWCD standards.

7.4.4 Monitoring Frequency

Monitoring frequency is the time interval between data collection. Seasonal fluctuations relating to groundwater levels or quality are typically on quarterly or semi-annual cycles, correlating with seasonal precipitation, recharge, groundwater levels, and well production. The monitoring schedule for groundwater levels collected under the GSP groundwater level monitoring program will coincide with seasonal groundwater level fluctuations, with higher levels (i.e. elevations) in April (Spring) and lower levels in October (Fall). A semi-annual monitoring frequency provides a measure of seasonal cycles, which can then be distinguishable from the long-term trends. At the transducer-monitored locations, groundwater level measurements will be recorded automatically on a daily basis and downloaded during the regular semi-annual groundwater level monitoring events. Daily measurements provide the same time-step as the Basin model, and will also allow direct correlation with daily stream flow data.

The monitoring frequency for groundwater quality sampling is variable and based on the schedule determined by the regulating agency (County Environmental Health Services for small public water systems and the State Division of Drinking Water for large public systems). TDS is typically monitored every three years, while nitrate and arsenic may be monitored annually, quarterly, or even monthly at vulnerable systems. The frequency selected for monitoring individual constituents at each system is sufficient to protect public health, and therefore considered sufficient for Basin management purposes.

Surface monitoring network frequency is a near-continuous record of flow stage, collected at 15-minute intervals. The stage data can then be converted to average daily flow (cubic feet per second) using a rating curve. Automatic gaging equipment (e.g. radar sensors or bubbler gages) at proposed flow monitoring locations will maintain the near-continuous monitoring frequency. Rating curves are needed at all gage sites, which requires manual flow measurements over a range of stream stages. New and existing wells listed in Table 7-6 used for interconnected surface water and GDE indicator evaluation may also be equipped with groundwater level transducers, either upon construction (for network additions) or when the recommended nearby stream gage is installed.

7.5 DATA MANAGEMENT SYSTEM

SGMA requires development of a Data Management System (DMS). The DMS stores data relevant to development of a groundwater Basin's GSP as defined by the GSP Regulations (California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2). To comply with SGMA, the Basin DMS was developed in this GSP and will store data that is relevant to development and implementation of the GSP as well as for monitoring and reporting purposes. Appendix 7D describes the data management plan associated with the DMS.

7.6 ASSESSMENT AND IMPROVEMENT OF MONITORING NETWORK

The current assessment of the monitoring networks has identified data gaps that will be filled during the implementation phase of the GSP and prior to the first five-year assessment. These data gaps, consisting of six groundwater level monitoring sites and five surface water flow monitoring sites, are listed in Tables 7-2 and 7-4 and shown in Figures 7-1 and 7-3.

As previously mentioned, obtaining well construction information for all monitoring network wells is not an immediate necessity or a requirement for Basin management purposes, provided the lack of information does not affect the usefulness of the monitoring results toward Basin management. Over time, wells for which construction information is not known will be inspected with a video camera to document construction, either within the next five years or at the earliest practical opportunity, such as when the well pump is being serviced. The monitoring networks will be re-evaluated at each five-year assessment.

7.7 ANNUAL REPORTS AND PERIODIC EVALUATION BY THE GSAs

Reporting requirements for the Annual Report and for periodic evaluation of the GSP are contained in Article 7 of the GSP regulations. The GSAs will submit an Annual Report that meets Article 7 regulations by April 1 of each year following adoption of the GSP, with the first Annual Report anticipated in 2022. Periodic evaluations of the GSP, including the monitoring networks, will be performed at least every five years and whenever the GSP is amended, with the first written evaluation anticipated no later than 2027.

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8 APPENDICES

APPENDIX 7A - GROUNDWATER-DEPENDENT ECOSYSTEMS IN THE SAN LUIS OBISPO VALLEY GROUNDWATER BASIN

(Will be included with the release of Chapter 8 – Sustainable Management Criteria)

APPENDIX 7B - GROUNDWATER LEVEL MEASUREMENT PROCEDURES FOR THE SAN LUIS OBISPO VALLEY GROUNDWATER BASIN GSP

Groundwater Level Measurement Procedures for the San Luis Obispo Valley Groundwater Basin GSP

Introduction

This document establishes procedures for measuring and recording groundwater levels for the SLO Basin Groundwater Monitoring Program, and describes various methods used for collecting meaningful groundwater data.

Static groundwater levels obtained for the groundwater monitoring program are determined by measuring the distance to water in a non-pumping well from a reference point that has been referenced to sea level. Subtracting the distance to water from the elevation of the reference point determines groundwater surface elevations above or below sea level. This is represented by the following equation:

$$E_{GW} = E_{RP} - D$$

Where:

E_{GW}	=	Elevation of groundwater above mean sea level (feet)
E_{RP}	=	Elevation above sea level at reference point (feet)
D	=	Depth to water (feet)

References

Procedures for obtaining and reporting water level data for the SLO Basin Groundwater Monitoring Program are based on a review of the following documents.

- State of California, Department of Water Resources, 2016, *Best Management Practices for the Sustainable Management of Groundwater: Monitoring Protocols, Standards, and Sites*, December 2016.
- State of California, Department of Water Resources, 2014, *Addendum to December 2010 Groundwater Elevation Monitoring Guidelines for the Department of Water Resources' California Statewide Groundwater Elevation Monitoring (CASGEM) Program,* October 2, 2014.
- State of California, Department of Water Resources, 2010, *Groundwater Elevation Monitoring Guidelines*, prepared for use in the California Statewide Groundwater Elevation Monitoring (CASGEM) program, December 2010.
- U.S. Geological Survey, 2011, *Groundwater Technical Procedures of the U.S. Geological Survey*, Techniques and Methods 1-A1, compiled by William L. Cunningham and Charles W. Schalk.
- U.S. Geological Survey, 1977, *National Handbook of Recommended Methods for Water-Data Acquisition*, a Unites States contribution to the International Hydrological Program.

Well Information

Table 1 below lists important well information to be maintained in a well file or in a field notebook. Additional information that should be available to the person collecting water level data include a description of access to the property and the well, the presence and depth of cascading water, or downhole obstructions that could interfere with a sounding cable.

Table 1
Well File Information

Well Completion Report	Hydrologic Information	Additional Information to be Recorded
Well name	Map showing basin boundaries and wells	Township, Range, Section and ¼-¼ Section
Well Owner	Name of groundwater basin	Latitude and Longitude (Decimal degrees)
Drilling Company	Description of aquifer	Assessor's Parcel Number
Location map or sketch	Confined, unconfined, or mixed aquifers	Description of well head and sounding access
Total depth	Pumping test data	Reference point elevations
Perforation interval	Hydrographs	Well use and pumping schedule if known
Casing diameter	Water quality data	Date monitoring began
Date of well completion	Property access instructions/codes	Land use

Reference Points and Reference Marks

Reference point (RP) elevations are the basis for determining groundwater elevations relative to sea level. The RP is generally a point on the well head that is the most convenient place to measure the water level in a well. In selecting an RP, an additional consideration is the ease of surveying either by Global Positioning System (GPS) or by leveling.

The RP must be clearly defined, well marked, and easily located. A description, sketch, and photograph of the point should be included in the well file. Additional Reference Marks (RMs) may be established near the wellhead on a permanent object. These additional RMs can serve as a benchmark by which the wellhead RP can be checked or re-surveyed if necessary. All RMs should be marked, sketched, photographed, and described in the well file.

All RPs for Groundwater Monitoring Program wells should be reported based on the same horizontal and vertical datum by a California licensed surveyor to the nearest tenth of one foot vertically, and the nearest one foot horizontally. The surveyor's report should be maintained in the project file.

In addition to the RP survey, the elevation of the ground surface adjacent to the well should also be measured and recorded in the well file. Because the ground surface adjacent to a well is rarely uniform, the average surface level should be estimated. This average ground surface elevation is referred to in the USGS Procedural Document (GWPD-1) and DWR guidelines as the Land Surface Datum.

Water Level Data Collection

Prior to beginning the field work, the field technician should review each well file to determine which well owners require notification of the upcoming site visit, or which well pumps need to be turned off to allow for sufficient water level recovery. Because groundwater elevations are used to construct groundwater contour maps and to determine hydraulic gradients, the field technician should coordinate water level measurements to be collected within as short a period of time as practical. Any significant changes in groundwater conditions during monitoring events should be noted in the Annual Monitoring Report. For an individual well, the same measuring method and the same equipment should be used during each sampling event where practical.

A static water level should represent stable, non-pumping conditions at the well. When there is doubt about whether water levels in a well are continuing to recover following a pumping cycle, repeated measurements should be made. If an electric sounder is being used, it is possible to hold the sounder level at one point slightly above the known water level and wait for a signal that would indicate rising water. If applicable, the general schedule of pump operation should be determined and noted for active wells. If the well is capped but not vented, remove the cap and wait several minutes before measurement to allow water levels to equilibrate to atmospheric pressure.

When lowering a graduated steel tape (chalked tape) or electric tape in a well without a sounding tube in an equipped well, the tape should be played out slowly by hand to minimize the chance of the tape end becoming caught in a downhole obstruction. The tape should be held in such a way that any change in tension will be felt. When withdrawing a sounding tape, it should also be brought up slowly so that if an obstruction is encountered, tension can be relaxed so that the tape can be lowered again before attempting to withdraw it around the obstruction.

Despite all precautions, there is a small risk of measuring tapes becoming stuck in equipped wells without dedicated sounding tubes. If a tape becomes stuck, the equipment should be left on-site and re-checked after the well has gone through a few cycles of pumping, which can free the tape due to movement/vibration of the pump column. If the tape remains stuck, a pumping contractor will be needed to retrieve the equipment. A dedicated sounding tube may be installed by the pumping contractor at that time.

All water level measurements should be made to an accuracy of 0.01 feet. The field technician should make at least two measurements. If measurements of static levels do not agree to within 0.02 feet of each other, the technician should continue measurements until the reason for the disparity is determined, or the measurements are within 0.02 feet.

Record Keeping in the Field

The information recorded in the field is typically the only available reference for the conditions at the time of the monitoring event. During each monitoring event it is important to record any conditions at a well site and its vicinity that may affect groundwater levels, or the field technician’s ability to obtain groundwater levels. Table 2 lists important information to record, however, additional information should be included when appropriate.

Table 2
Information Recorded at Each Well Site

Well name	Changes in land use	Presence of pump lubricating oil in well
Name and organization of field technician	Changes in RP	Cascading water
Date & time	Nearby wells in use	Equipment problems
Measurement method used	Weather conditions	Physical changes in wellhead
Sounder used	Recent pumping info	Comments
Reference Point Description	Measurement correction(s)	Well status

An example of a field log sheet from DWR is attached.

Measurement Techniques

Four standard methods of obtaining water levels are discussed below. The chosen method depends on site and downhole conditions, and the equipment limitations. In all monitoring situations, the procedures and equipment used should be documented in the field notes and in final reporting. Additional detail on methods of water level measurement is included in the reference documents.

Graduated Steel Tape

This method uses a graduated steel tape with a brass or stainless steel weight attached to its end. The tape is graduated in feet. The approximate depth to water should be known prior to measurement.

- Estimate the anticipated static water level in the well from field conditions and historical information;
- Chalk the lower few feet of the tape by applying blue carpenter's chalk.
- Lower the tape to just below the estimated depth to water so that a few feet of the chalked portion of the tape is submerged. Be careful not to lower the tape beyond its chalked length.
- Hold the tape at the RP and record the tape position (this is the "hold" position and should be at an even foot);
- Withdraw the tape rapidly to the surface;
- Record the length of the wetted chalk mark on the graduated tape;
- Subtract the wetted chalk number from the "hold" position number and record this number in the "Depth to Water below RP" column;
- Perform a check by repeating the measurement using a different RP hold value;
- All data should be recorded to the nearest 0.01 foot;
- Disinfect the tape by wiping down the submerged portion of the tape with single-use, unscented disinfectant wipe, or let stand for one minute in a dilute chlorine bleach solution and dry with clean cloth.

The graduated steel tape is generally considered to be the most accurate method for measuring static water levels. Measuring water levels in wells with cascading water or with condensing water on the well casing causes potential errors, or can be impossible with a steel tape.

Electric Tape

An electric tape operates on the principle that an electric circuit is completed when two electrodes are submerged in water. Most electric tapes are mounted on a hand-cranked reel equipped with batteries and an ammeter, buzzer or light to indicate when the circuit is completed. Tapes are graduated in either one-foot intervals or in hundredths of feet depending on the manufacturer. Like graduated steel tapes, electric tapes are affixed with brass or stainless steel weights.

- Check the circuitry of the tape before lowering the probe into the well by dipping the probe into water and observe if the ammeter needle or buzzer/light signals that the circuit is completed;
- Lower the probe slowly and carefully into the well until the signal indicates that the water surface has been reached;
- Place a finger or thumb on the tape at the RP when the water surface is reached;
- If the tape is graduated in one-foot intervals, partially withdraw the tape and measure the distance from the RP mark to the nearest one-foot mark to obtain the depth to water below the RP. If the tape is graduated in hundredths of a foot, simply record the depth at the RP mark as the depth to water below the RP;
- Make all readings using the same needle deflection point on the ammeter scale (if equipped) so that water levels will be consistent between measurements;

- Make check measurements until agreement shows the results to be reliable;
- All data should be recorded to the nearest 0.01 foot;
- Disinfect the tape by wiping down the submerged portion of the tape with single-use, unscented disinfectant wipe, or let stand for one minute in a dilute chlorine bleach solution and dry with clean cloth;
- Periodically check the tape for breaks in the insulation. Breaks can allow water to enter into the insulation creating electrical shorts that could result in false depth readings.

The electric tape may give slightly less accurate results than the graduated steel tape. Errors can result from signal "noise" in cascading water, breaks in the tape insulation, tape stretch, or missing tape at the location of a splice. All electric tapes should be calibrated annually against a steel tape that is maintained in the office and used only for calibration.

<u>Air Line</u>

The air line method is usually used only in wells equipped with pumps. This method typically uses a 1/8 or 1/4-inch diameter, seamless copper tubing, brass tubing, stainless steel tubing, or galvanized pipe with a suitable pipe tee for connecting an altitude or pressure gage. Plastic (i.e. polyethylene) tubing may also be used, but is considered less desirable because it can develop leaks as it degrades. An air line must extend far enough below the water level that the lower end remains submerged during pumping of the well. The air line is connected to an altitude gage that reads directly in feet of water, or to a pressure gage that reads pressure in pounds per square inch (psi). The gage reading indicates the length of the submerged air line.

The formula for determining the depth to water below the RP is: **d = k – h** where d = depth to water; k = constant; and h = height of the water displaced from the air line. In wells where a pressure gage is used, h is equal to 2.31 ft/psi multiplied by the gage reading. The constant value for k is approximately equivalent to the length of the air line.

- Calibrate the air line by measuring an initial depth to water (d) below the RP with a graduated steel tape. Use a tire pump, air tank, or air compressor to pump compressed air into the air line until all the water is expelled from the line. When all the water is displaced from the line, record the stabilized gage reading (h). Add d to h to determine the constant value for k.
- To measure subsequent depths to water with the air line, expel all the water from the air line, subtract the gage reading (h) from the constant k, and record the result as depth to water (d) below the RP.

The air line method is not as accurate as a graduated steel tape or electric and is typically accurate to the nearest one foot at best. Errors can occur from leaky air lines, or when tubing becomes clogged with mineral deposits or bacterial growth. The air line method is not desirable for use in the Groundwater Monitoring Program.

<u>Pressure Transducer</u>

Electrical pressure transducers make it possible to collect frequent and long-term water level or pressure data from wells. These pressure-sensing devices, installed at a fixed depth in a well, sense the change in pressure against a membrane. The pressure changes occur in response to changes in the height of the water column in the well above the transducer membrane. To compensate for atmospheric changes, transducers may have vented cables or they can be used in conjunction with a barometric transducer that is installed in the same well or a nearby observation well above the water level.

Transducers are selected on the basis of expected water level fluctuation. The smallest range in water levels provides the greatest measurement resolution. Accuracy is generally 0.01 to 0.1 percent of the full scale range.

Retrieving data in the field is typically accomplished by downloading data through a USB connection to a portable computer or data logger. A site visit to retrieve data should involve several steps designed to safeguard the stored data and the continued useful operation of the transducer:

- Inspect the wellhead and check that the transducer cable has not moved or slipped (the cable can be marked with a reference point that can be used to identify movement);
- Ensure that the instrument is operating properly;
- Measure and record the depth to water with a graduated steel or electric tape;
- Document the site visit, including all measurements and any problems;
- Retrieve the data and document the process;
- Review the retrieved data by viewing the file or plotting the original data;
- Recheck the operation of the transducer prior to disconnecting from the computer.

A field notebook with a checklist of steps and measurements should be used to record all field observations and the current data from the transducer. It provides a historical record of field activities. In the office, maintain a binder with field information similar to that recorded in the field notebook so that a general historical record is available and can be referred to before and after a field trip.

Quality Control

The field technician should compare water level measurements collected at each well with the available historical information to identify and resolve anomalous and potentially erroneous measurements prior to moving to the next well location. Pertinent information, such as insufficient recovery of a pumping well, proximity to a pumping well, falling water in the casing, and changes in the measurement method, sounding equipment, reference point, or groundwater conditions should be noted. Office review of field notes and measurements should also be performed by a second staff member.

All field tapes (both steel and electric) used for the monitoring program should be calibrated annually against another acceptable steel tape. An acceptable steel tape is one that is maintained in the office for use only in calibrating the field tapes. Adjustments for tape calibration should be applied and noted.

STATE OF CALIFORNA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WELL DATA

STATE WELL NUMBER	COUNTY	REFERENCE POINT ELEV.	MEASURING AGENCY
			DWR

NO MEASUREMENT	QUESTIONABLE MEASUREMENT
0. Measurement discontinued	0. Caved or deepened
1. Pumping	1. Pumping
2. Pump house locked	2. Nearby pump operating
3. Tape hung up	3. Casing leaky or wet
4. Can't get tape in casing	4. Pumped recently
5. Unable to locate well	5. Air or pressure gauge measurement
6. Well has been destroyed	6. Other
7. Special	7. Recharge operation at or nearby well
8. Casing leaky or wet	8. Oil in casing
9. Temporarily inaccessible	

DATE	N M	Q M	TAPE AT RP	TAPE AT WS	RP to WS	OBSR VR	COMMENTS

DWR 1213

Figure 4 – Example of Water Level Well Data Field Collection Form

APPENDIX 7C - STREAMFLOW MEASUREMENT IN NATURAL CHANNELS

Streamflow Measurement in Natural Channels

The most practical method for measuring streamflow in natural channels is the velocity-area method, which has the following computation[1]:

$$Q = \sum_{i=1}^{n} (a_i v_i)$$

where:

Q = total discharge (reported in cubic feet per second).

a_i = cross-sectional area of flow for the *i*th segment of the *n* segments into which the cross section is divided (square feet), and

v_i = the corresponding mean velocity of flow normal to the *i*th segment (feet per second).

The conceptual model for the velocity area-method is shown below. A stream is divided into segments, each with an individual area and velocity, which are then multiplied and summed using the above equation.

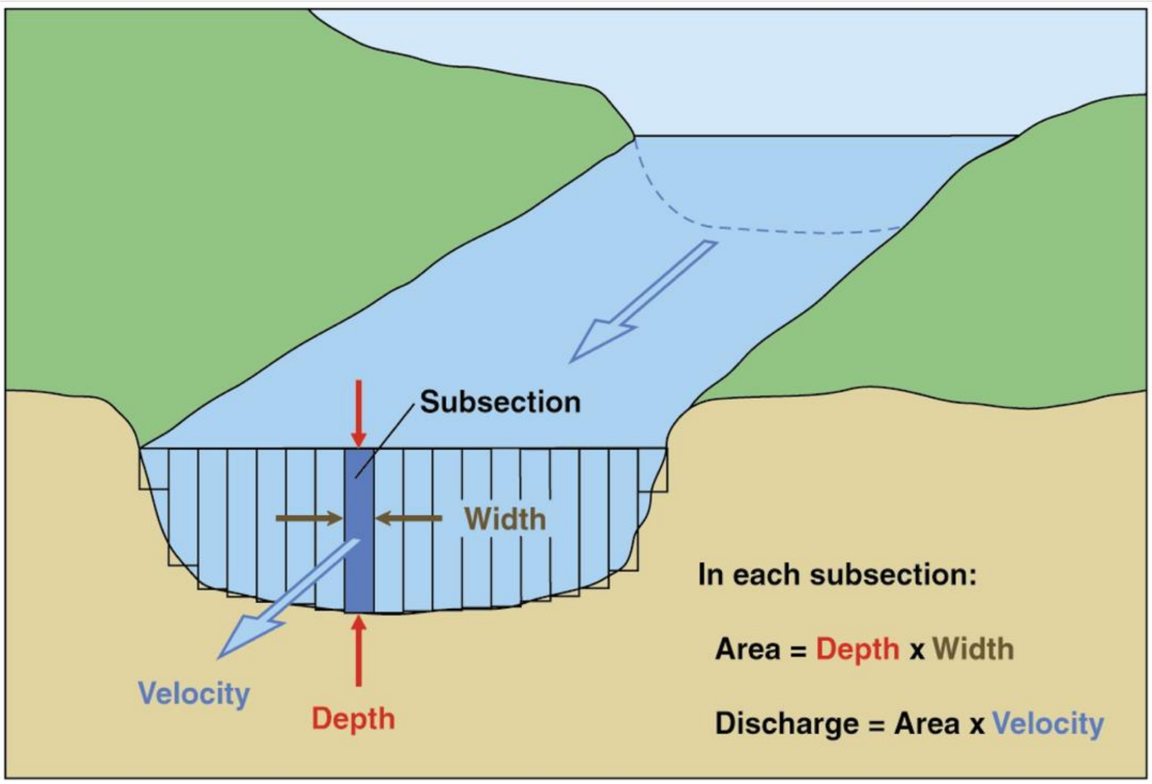

Diagram of Channel cross-section with segments for discharge computation (USGS)

In natural channels, stream gages are used to record stage (feet), which is the height of water in the stream above an arbitrary point, usually at or below the stream bed. The stage is then converted to streamflow through the use of a rating curve, or stage-discharge relation. A rating curve incorporates information collected that is specific to each site, including the cross-sectional area of

[1] Turnipseed, D.P. and Sauer, V.B., 2010. Discharge Measurements at Gaging Stations, USGS Techniques and Methods 3-A8.

the channel and the average velocity for a given flow stage. These rating curves are developed using depth profiles and average flow velocity measurements during storm-runoff events. Rating curves may need to be revised periodically as they can shift due to changes in channel geometry. Measuring average flow velocity across a channel at different stream stages is the most challenging part of developing a rating curve.

APPENDIX 7D – DATA MANAGEMENT PLAN

(Draft Data Management Plan was released for public comment following the September 9th GSC Meeting and may be found at https://www.slowaterbasin.com/review-documents)