Appendix 2-5: Data Gaps and Monitoring Plan

1.0 Introduction

The purpose of this appendix is to provide an overview of potential data gaps that may prevent the monitoring networks from collecting sufficient data to measure progress towards Plan management goals. The monitoring networks are designed to collect data to monitor the SV Subbasin's sustainability indicators which include the lowering of groundwater levels, reduction of groundwater storage, depletion of interconnected surface water (ISW), degradation of water quality, and land subsidence. Each of the five sustainability indicators is monitored by a dedicated monitoring network that should have sufficient spatial density and temporal resolution to evaluate the effects and effectiveness of Plan implementation and represent seasonal, short-term, and long-term trends in groundwater conditions and related surface conditions. The monitoring networks may have deficiencies that prevent them from collecting sufficient data to evaluate the SV Subbasin's conditions. Table 1 presents the monitoring network for each sustainability indicator and provides potential data gaps, as well as the plan to improve the network and overcome the data gap. In addition to the monitoring networks, the SV Subbasin's hydrogeologic model and water budget will be used to better understand the conditions of the aquifer, and track progress towards achieving sustainability. Potential data gaps associated with the hydrogeologic model and water budget, as well as plans to overcome the gaps, are presented in Table 2.

Table 1. Monitoring Networks, Potential Data Gaps, and Plans to Enhance Monitoring Network

Sustainability Indicator [1]	Overview of Planned Monitoring Network	Potential Data Gap	Plan to Overcome Data Gap
Groundwater Level	19 District Wells (measured at least 2x/year; additional measurements during the irrigation season) 17 CASGEM wells (measured at least 2x/year, continuous measurements in the latest multi-completion wells)	Seasonal fluctuations in groundwater level are not well characterized, and the impact of pumping and irrigation on groundwater levels is not well understood.	Subject to funding availability, sensors to measure groundwater level, and telemetry to remotely download the data, may be employed in groundwater level monitoring wells to increase data collection frequency and better understand seasonal patterns in groundwater level. Increased coordination between various groundwater level monitoring and reporting programs in the Subbasin aims to expand data gathering, sharing, and analysis
		Vertical coverage of shallow and deep aquifer units may potentially be inadequate.	As the hydrogeologic conceptual model is refined, shallow versus deep zones of the aquifer will be better characterized, and targeted monitoring of these zones will be possible. Obtaining construction information (depth and screened interval) for wells in the Subbasin will allow for targeted placement of monitoring wells that provide increased vertical coverage of the aquifer.
		The potential impact of lowering groundwater levels on shallow domestic wells in the Subbasin is currently limited. Domestic well information (location, well depth, screened interval) is currently lacking.	An inventory and assessment of domestic wells, which will attempt to identify well construction information (well depth and screened interval) is expected to occur within two years of GSP adoption subject to funding availability. Utilizing this inventory, undesirable results based on well outage reports may be refined during the 5-year GSP update.
		General uncertainty in groundwater storage estimates.	Storage estimates to be refined by the updated regional groundwater flow model.

Sustainability Indicator [1]	Overview of Planned Monitoring Network	Potential Data Gap	Plan to Overcome Data Gap
Reduction of Groundwater Storage	Monitored using the same wells as the groundwater level monitoring network.	Seasonal changes in groundwater storage, and the impact of pumping and irrigation on groundwater storage are potential data gaps.	Level sensors and telemetry may be employed in groundwater level monitoring wells to increase data collection frequency and better understand seasonal patterns in groundwater level. Inventory of large-capacity wells is maintained by Sierra Valley Groundwater Management District (SVGMD), which includes active metered wells and inactive wells. Active large-capacity agricultural wells are fitted with flow meters owned and read by SVGMD. Enhancement to this program includes potential expansion to all types of wells subject to funding availability, including domestic and municipal, especially in critical locations where minimum thresholds are in jeopardy of being reached.
Interconnected surface water (ISW) and Groundwater Dependent Ecosystems (GDEs)	Groundwater levels from 13 wells (used as a proxy for ISW depletion).	Monitoring of shallow groundwater is lacking near locations critical to characterize ISW (current wells are a subset of shallow groundwater wells in the levels monitoring network). The relationship between pumping and ISW depletion is also lacking.	Instrument at least 4 existing shallow wells near ISW and GDE with continuous pressure transducers. During the GSP's 5-year implementation period, data from shallow wells will be correlated with flow and/or stream gauge data to better characterize ISW. This information, in conjunction with updates to the Subbasin groundwater model, will allow for refined estimates of spatial and temporal ISW depletion.

Sustainability Indicator (1)	Overview of Planned Monitoring Network	Potential Data Gap	Plan to Overcome Data Gap
	Stream flow and stream stage sites. Integrated hydrologic model estimates (based on available data and tools).	The absence of continuous streamflow or stage gauges in the Subbasin is a data gap that prevents understanding of vertical hydraulic gradients that determine flux between surface water and groundwater (particularly in the central and eastern portions of the Subbasin). This inhibits estimates of ISW depletion as a rate or volume. Lack of continuous gauge data prevents estimates of seasonal changes in hydraulic gradients; additionally, the potential effects of pumping on surface water critical to beneficial users needs to be enhanced. Limited data on the extent of perched aquifers prevents ISW classification.	Evaluate possible locations and design of up to 10 stream flow gauges and up to 8 stream stage gauges to be paired with the continuous groundwater level measurements. Continuous streamflow monitoring stations are proposed as upgrades to the existing DWR stations, and other locations where measurement of streamflow is feasible. Telemetry may be employed at gauges to increase data collection frequency. Future updates to the regional groundwater flow model will enable more accurate estimates of ISW depletion rates. Water Master data will continue to be obtained from the area Water Master and will continue to be incorporated in water budget refinement and groundwater management decision making.
		Ecosystem reliance and connection to groundwater is uncertain throughout the Subbasin. This is due to uncertainties in the source of water used by vegetation and aquatic organisms, limited shallow groundwater data, and relatively old vegetation maps (vegetation maps lack sufficient detail to determine the rooting depth of vegetation to compare with groundwater depth).	In response to relatively old vegetation maps, an updated and more detailed vegetation map was started by CDFW (awaiting additional funding to complete). If this map is completed by the 5-year update, it can be used to better assess the species assemblages, the source of water, and their maximum rooting depth. Instrument at least 4 existing shallow wells near ISW and GDE with continuous pressure transducers (see above).

Sustainability Indicator (1)	Overview of Planned Monitoring Network	Potential Data Gap	Plan to Overcome Data Gap
		Lack of Normalized Difference Vegetation Index (NDVI, or vegetation indices derived from satellite imagery) values near representative monitoring points (RMPs) and insufficient spatial characterization of NDVI. This data gap prevents the use of NDVI for accurate characterization of ISW and GDE.	Changes to average NDVI values near RMPs and spatial pattern changes of NDVI will be evaluated during the GSP's 5-year implementation period. Historical NDVI data collected in the Subbasin will be examined in relation to groundwater elevation data
		Lack of established correlation between groundwater levels, NDVI, and the health of GDEs.	Changes to summer NDVI will be used in coordination with groundwater levels and interconnected surface discharge to monitor the health of GDEs in the SV Subbasin (assuming that declines in vegetation greenness will correspond to changes in water availability for special status species). Historical NDVI data collected in the Subbasin will be examined in relation to groundwater elevation data. Changes to average NDVI values around RMPs and the spatial pattern changes of NDVI throughout the Subbasin will be evaluated in updates to the GSP.
Groundwater Quality	17 GAMA wells Community Volunteer Wells (up to five; to be finalized at a future time) 1 DWR well (to be installed at a future time)	GAMA wells are monitored at irregular frequency and over extended time intervals incapable of determining temporal trends. Additionally, constituents listed in the GSP are not analyzed at every GAMA well. Lack of coverage to identify areas where septic tanks may impact groundwater quality, or to identify areas impacted by boron or arsenic. Existing wells used to monitor groundwater quality in the Subbasin are primarily located within and near the semi-urban areas of the Subbasin.	6 new wells are being selected and added to the network (5 domestic, 1 DWR). During the GSP's 5-year implementation period, the new wells will be monitored once every 2 years for TDS, nitrate, boron, and arsenic. If no problems are observed, the monitoring frequency will decrease to once every 3 years. Monitoring will be augmented as needed if constituents exceed criteria or if specific increasing trends in the constituent's concentration are observed. Additionally, during the 5-year implementation period, communication with existing monitoring programs in the Subbasin will aim to coordinate data collection and reporting.

Sustainability Indicator [1]	Overview of Planned Monitoring Network	Potential Data Gap	Plan to Overcome Data Gap
		Potentially inadequate vertical coverage of the shallow and deep zones of the aquifer.	As the hydrogeologic conceptual model is refined, shallow versus deep zones of the aquifer will be better characterized, and targeted monitoring of these zones will be possible. Obtaining construction information (depth and screened interval) for wells in the Subbasin will allow for targeted placement of monitoring wells that provide increased vertical coverage of the aquifer.
		The majority of existing wells in the Subbasin have not regularly been monitored for water quality, and it is uncommon for a well to be tested consistently between 1990 - 2020 for multiple constituents. Based on the water quality assessment, and public input, constituents of concern in the SV Subbasin were deemed to include nitrate, TDS, arsenic, boron pH, iron, manganese, and MTBE.	Evaluation of MTBE established that reported concentrations have diminished substantially over the last 10 years, and therefore monitoring will not be conducted as part of GSP efforts. SMCs are defined for nitrate and TDS. In addition to these constituents, the GSA will monitor arsenic, boron, and pH to track any potential mobilization of elevated concentrations or exceedances of the Maximum Contaminant Levels.
Land Subsidence	Groundwater levels from the groundwater level network will be used as proxy for the first two years (currently, groundwater levels and the correlations established by Poland and Davis (1969) offer the	Groundwater levels are the only long-term measure of land subsidence for the Subbasin at the time of GSP writing. No known Continuous Global Positioning System (CGPS) stations or extensometers are installed in Sierra Valley. Although satellite-based Interferometric Synthetic Aperture Radar (InSAR) measures of land subsidence are available for the SV Subbasin, these data are relatively recent, do not show long-term trends, and indicate total subsidence which represents a combination of	Groundwater level data will be augmented with annual estimates of land elevation change provided by DWR InSAR data, and ground-based surveys conducted every 5 years (ground-based monument installation and monitoring is detailed below). The ground-based surveys will be used to gauge the accuracy of future InSAR data processing. Additionally, throughout the 5-year implementation period, the correlation between the change in groundwater levels and the change in the amount of land subsidence (factoring in that total land subsidence is a composite of elastic and inelastic land subsidence) will be refined.

Sustainability Indicator [1]	Overview of Planned Monitoring Network	Potential Data Gap	Plan to Overcome Data Gap
	best-available information to estimate potential land subsidence for the Subbasin).	elastic (reversable) subsidence and inelastic (irreversible) subsidence. As such, adequate Subbasin-specific information correlating the detailed long-term connection between land subsidence and groundwater levels is lacking.	Installation of 4 monument-based land surface elevation stations will occur within the primary geographic area where subsidence is documented by DWR from InSAR data processing for 2015-2019. Geologic uncertainties, such as the Grizzly Valley Fault Zone, will also be considered when placing the monuments. Monuments will be surveyed every 5 years. Additional surveys will be conducted if InSAR subsidence increases by 50% of the average annual subsidence from baseline period (2015-2019).
		InSAR data processing may be inaccurate as it has not been compared to vertical displacement point time series data from CGPS stations.	Comparison of InSAR data processing to 4 monument-based land surface elevation stations will be conducted (detailed above).

1. This table only includes monitoring networks used to measure sustainability indicators. It does not include additional monitoring necessary to monitor the various water budget components of the Subbasin, described in Chapter 2, or to monitoring the implementation of projects and management actions, which are described in Chapter 4.

Table 2. Hydrogeologic Model and Water Budget: Potential Data Gaps and Plans to Overcome Data Gaps

Potential Data Gap	Plan to Overcome the Data Gap
Estimates of streamflow entering the Subbasin are incomplete due to lack of continuous data. Because of the discontinuous nature and infrequency of streamflow measurements (weekly at best, and mostly only during the irrigation season), the data collected by the DWR Watermaster cannot be used for more in-depth analysis such as volume calculations or flood-frequency analysis. Surface water flows entering the groundwater basin are estimated with the PRMS model (Appendix 2-7) due to the lack of observed flows (i.e., gauging stations) for the majority of streams.	Installation of near-continuous streamflow gaging stations, or upgrades to the existing DWR stations, can measure flow entering the Subbasin and calibrate model estimates of total surface inflows. These data can be used to refine the basin-wide water budget. Water Master data will continue to be obtained from the area Water Master and will continue to be incorporated in water budget refinement and groundwater management decision making.
Potential data gaps exist for aquifer characterization, structure, and hydrogeologic and transport properties. SV Subbasin numeric model requires updating to better represent and evaluate the Subbasin's existing hydrogeologic conditions. Delineation of shallow and deep aquifer units has not been completed for the Subbasin. Additionally, parts of a deep aquifer zone may be pressurized by confining low-permeability layers, although extent and isolation between shallow and deep aquifer zones likely vary throughout the Sierra Valley subbasin. Few pumping test data are available for the basin fill unit.	Robust aquifer characterization analysis. This effort would include efforts to coordinate with parties that have large-capacity wells to conduct aquifer characterization studies throughout the SV Subbasin. Typically, these studies would include collection of one week of baseline data including static water level of the pumping well and static water level and water level trends of nearby wells, spring discharge measurements of any nearby springs, and upstream and downstream flow measurements of any nearby streams. These data will be critical to better understand the geology and hydrogeology of the SV Subbasin. Siting of future monitoring wells will prioritize areas with limited subsurface characterization to the fullest extent possible. Well logs provided to SVGMD from new wells drilled within the groundwater basin will have the lithology added to the DMS so their data can be incorporated into future model updates.
Pumping data is not available at the same time interval as the model stress periods.	Per SVGMD Ordinance 82-03, continued monitoring of agricultural extraction wells is required in the SV Subbasin. Implementation of a voluntary pumping data collection program where growers record groundwater extraction volumes at the beginning or end of each month. SVGMD will still be responsible for meter reads at the beginning and end of the irrigation season.

Potential Data Gap	Plan to Overcome the Data Gap
The relative contribution of mountain-front recharge is largely unknown.	Reduction of uncertainty in other areas of the model (e.g., ET, pumping, GW-SW exchange) will improve estimates of mountain-front recharge entering the basin. Further exploration of mountain-front recharge parameterization in the integrated hydrologic model is recommended.