SIERRA VALLEY GROUNDWATER SUSTAINABILITY PLAN
CONCEPT DOCUMENT

Prepared for:

Sierra Valley Groundwater Management District

Sierra Valley Groundwater Management District
Groundwater Sustainability Agency for the Sierra Valley Groundwater Basin
PO Box 88
Chilcoot, CA 96105
http://www.sierravalleygmd.org/

Last Revised: June 1, 2020

Prepared by:
Greg Hinds, Hinds Engineering
Email: greg@hindsengineering.com
Phone: 530-401-0000

Author's Notes:
This document is a compilation of available and relevant information assembled for the purpose of streamlining the development of the Sierra Valley Subbasin Groundwater Sustainability Plan (SV GSP). This document also includes draft text for GSP components that are required to be developed through the stakeholder engagement process. Such text is suggested for use as a starting place for said process.

This document was originally being prepared as a draft GSP beginning in early 2018 when the prospect of obtaining grant funding for GSP development was uncertain. In early 2019, after a second round of SGMA grant funding was announced and the Sierra Valley Groundwater Management District (SVGMD) began to feel confident they would be able to apply for and receive funding for GSP development, the document title was changed and the approach to the development of this document evolved.

It was decided by the SVGMD Directors that continuing to develop this document would be worthwhile, given the uncertainty associated with the timeline of the grant award and the likelihood that the time remaining for GSP development after receiving the award would be relatively limited. It was also decided that the format should be kept consistent with GSP formatting for ease of use of this document in the development of the actual SV GSP.

The preparer of the SV GSP may use any of the content herein as they see appropriate, taking into account the following:

- Much of the content in this document (especially within Chapters 1 and 2) is objective information from existing referenced documentation and from correspondences with various local individuals and entities. Such objective information is considered reliable, but should not be assumed to be 100% accurate or up-to-date or assumed to be "best available information".
- A certain portion of the content of this document (especially within Chapters 3 and 4) is draft text for GSP components that are required to be developed through the stakeholder engagement process and should be used only to supplement that process. Such content was drafted with the intention to reflect the perspective of the SVGMD Directors to the best ability of the author based on experiences/interpretations while attending monthly SVGMD Board of Director Meetings from 2016 to present. The resulting approach can be summarized as prioritizing clear compliance with SGMA while working toward an effective Plan that will not be overwhelming or cost-prohibitive to implement and will employ adaptive management to achieve sustainability.

It is my sincere hope that this document will prove useful in the development of a SGMA-compliant, effective GSP for the SV Subbasin which reflects public values and ensures protection of the resources of the Sierra Valley while preserving the local way of life.

Sincerely,

Greg Hinds, PE

Table of Contents

List of Appendices

List of Attachments

List of Tables

List of Figures

List of Abbreviations

Placeholder

Executive Summary *(Reg. § 354.4)*

ES 1.0 Introduction Summary

This Groundwater Sustainability Plan (GSP or Plan) Concept Document was developed under the direction of the Sierra Valley Groundwater Management District (SVGMD) and Plumas County, the Groundwater Sustainability Agencies (GSAs) for the Sierra Valley Groundwater Subbasin (SV Subbasin, Groundwater Basin Number 5-12.01), in accordance with the Sustainable Groundwater Management Act (SGMA) of 2014. This Plan Concept Document was developed using the Groundwater Sustainability Annotated Outline developed by the California Department of Water Resources (DWR).

Per Reg. § 354.4(a), an executive summary written in plain language that provides an overview of the GSP and description of groundwater conditions in the basin is provided here.

ES 1.1 Purpose of the Groundwater Sustainability Plan

In accordance with SGMA, this Plan Concept Document is intended for implementation beginning in year 2022 and continuing through the 50-year planning and implementation horizon (until 2072). The purpose of this Plan Concept Document is to ensure "sustainable groundwater management" in the SV Subbasin by SVGMD is achieved by 2042, as required by SGMA, and maintained at least until 2072. To understand what this purpose really means, some definitions are required.

Sustainable groundwater management, as defined by SGMA, is the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing "undesirable results".

Undesirable results, as defined by SGMA, are one or more of the following effects caused by groundwater conditions occurring throughout the basin:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion (*not applicable in the SV Subbasin).
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

To complete the above definition of undesirable results, the SV Subbasin GSAs have engaged stakeholders to come up with a description of what would be considered "significant and unreasonable" impacts associated with each of the undesirable results categories, a.k.a. "sustainability indicators" as referred to in SGMA. These descriptions are summarized in Section ES 3.4 of this Executive Summary and described in detail in Chapter 3 of this Plan Concept Document.

Commented [GH1]: This is an example of content which refers to future efforts in the past-tense – see additional comment below for more information on this.

Commented [GH2]: Suggestions for such descriptions and associated minimum thresholds and measurable objectives are provided in subsequent sections of this document – see additional comments below for more information on this.

Hence, the purpose of this Plan Concept Document as stated above can be re-phrased as follows: to facilitate groundwater management in the SV Subbasin by SVGMD which will by 2042 eliminate any and all impacts associated with groundwater level declines, groundwater storage reductions, water quality degradation, land subsidence, and/or surface water depletions which result from groundwater extraction and are locally considered to be significant and unreasonable, and to prevent any such impacts from occurring thereafter at least until 2072. This more precisely worded purpose serves as the basis of the intention of the Sustainability Goal described below.

ES 1.2 Sustainability Goal

Commented [GH3]: This is an example of a section with content that is meant to be a suggestion to use as a starting place for development of SV GSP components which are required to be developed through the stakeholder engagement process. It is important to understand that this content and other similar subsequent content, including content which refers to future efforts in the past-tense, is theoretical/hypothetical/suggestive content and must be revised as the stakeholder engagement/SV GSP development process continues to progress in accordance with the outcomes of the stakeholder engagement process and the direction of the SV Subbasin GSAs.

SGMA defines "Sustainability Goal" as the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield. The development and implementation of this GSP thus constitutes the Sustainability Goal for the SV Subbasin.

Additionally, per Reg. § 354.24 of the California Code of Regulations, the GSP must establish a sustainability goal, including a description of the goal, information from the basin setting used to establish the goal, discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon. The required sustainability goal information is covered comprehensively in Chapter 3 of this Plan Concept Document. The primary take-aways are summarized here.

As mentioned in Section ES 1.1 above, the intention of the Sustainability Goal is to accomplish the following: groundwater management within the SV Subbasin by SVGMD which by 2042 eliminates any and all impacts associated with groundwater level declines, groundwater storage reductions, water quality degradation, land subsidence, and/or surface water depletions which result from groundwater extraction and are locally considered to be significant and unreasonable, and to prevent any such impacts from occurring thereafter at least until 2072.

An essential step toward achieving the sustainability goal is the development and implementation of a long-term strategy for management of the groundwater. Some of the basic components of the Districts long-term strategy, as described in the District's 2006 Draft Management Plan, are:

1. Making maximum beneficial use of the groundwater and all other reasonable sources of water to augment the water supply in the District,
2. Development and implementation of plan components and adoption of appropriate rules which;
    a. Require conservation and responsible management of water used,
    b. Regulate existing and new groundwater withdrawals to reduce, and eventually eliminate, damage from groundwater level changes, groundwater quality changes, land subsidence, and any other undesirable results.
3. Identification and completion of projects that foster groundwater recharge or reuse of water in the District, and
4. Identification and elimination of unreasonable institutional barriers to the sound management of water resources.

The most pressing challenge that must be overcome in the endeavor to achieve sustainable groundwater management in the SV Subbasin is to prevent further groundwater level declines while minimizing economic impacts to locals. Agriculture is a primary economic driver in Sierra Valley, providing jobs/livelihood for a significant portion of the local population. Agriculture is also responsible for the vast majority of groundwater extraction from the SV Subbasin and the associated decline in groundwater levels (described in greater detail in subsequent sections of this Plan Concept Document). While groundwater overdraft and associated impacts (i.e. reduced groundwater in storage, land subsidence, etc.) are less significant in Sierra Valley than in most other developed groundwater basins in the state, country, and world, impacts have been documented in recent decades which warrant corrective efforts, especially when considering the extraordinary value of the Sierra Valley to plant life, wildlife, and downstream water users.

To prevent future impacts, groundwater demand must be balanced with groundwater supply (e.g. pumping must be kept within the limits of the basin's sustainable yield). To accomplish this, the long-term SV Subbasin management strategy focuses on the following two key elements: (1) maximize groundwater recharge, and (2) minimize agricultural pumping demand.

To maximize groundwater recharge, a recharge study has been conducted (Bachand et al., 2020) and opportunities for enhancing recharge have been identified. Additional proposed studies, pilot projects, and other efforts are outlined in Chapter 4 of this Plan Concept Document. Through these efforts, groundwater recharge to the SV Subbasin is expected to be maximized to the greatest degree practicable over the next decade or two.

To minimize agricultural pumping demand, the following three core strategies have been developed:

1. Prevent construction of new agricultural (a.k.a. "high capacity") wells in the portion of the SV Subbasin in which groundwater level declines have been observed through the passage and enforcement of a local ordinance (SVGMD Ordinance 18-01 was passed by SVGMD on April 9, 2018 to accomplish this).
2. Optimize the sustainable use of surface water for agricultural irrigation thereby reducing agricultural groundwater demand (e.g. optimize conjunctive use); this strategy includes efforts to work with DWR/area water master to review water rights allocations and identify any opportunities for improved water rights use, water rights "banking"/sharing , surface water storage during wet season for irrigation use in the dry season, etc., and also includes efforts to work with DWR/State Water Project to review the Frenchman Dam Operating Policy and identify opportunities to better utilize surface waters stored in Frenchman Reservoir through revising the Policy.
3. Optimize irrigation efficiency through use of improved irrigation technologies/systems such as low-elevation sprinkler application (LESA) and low-elevation precision application (LEPA), for which a study designed by Bachand and Associates is ongoing and collaboration with USDA National Resources Conservation Service (NRCS) is being considered.

An additional strategy being explored by some of the agricultural residents of the Valley is the possibility of changing agricultural business frameworks to reduce water demand, i.e. by switching to production of crops with lower water demand, etc.

By focusing on these strategies, it is widely believed by Sierra Valley locals that groundwater overdraft and associated impacts, including all undesirable results defined by SGMA, can be eliminated by 2042 without significantly impacting the local economy, values, or way of life. It is relevant to note here, however, that changes to the extremely valuable and diverse habitat that the Sierra Valley offers may not stop as a result of sustainably operating the SV Subbasin within its sustainable yield, as the changing climate and other human impacts are likely to continue to widely influence hydrologic conditions, habitat, and plant and animal populations.

ES 1.3 Agency Information

SVGMD was authorized under State Senate Bill No. 1391 in 1980 to protect and oversee the management of the groundwater in the Sierra Valley and has been doing so ever since. In accordance with Water Code Section 10723(c)(1), SVGMD was deemed the exclusive GSA for the portion of the SV Subbasin that is within SVGMD's statutory boundary. SVGMD submitted notification to DWR to become the GSA for that area. A small area of the northwest corner of the SV Subbasin (approximately 100 acres, less than 0.1% of total basin area) falls outside of

SVGMD's jurisdictional boundary and therefore excludes SVGMD from eligibility to be the GSA for that area. Accordingly, Plumas County submitted notification and became the GSA for that area and in accordance with Water Code Section 10723.6, SVGMD and Plumas County developed a memorandum of understanding (MOU) to establish their respective roles in GSP development and implementation. The MOU essentially states that the two entities will work together to develop and adopt a single SGMA-compliant GSP for the SV Subbasin using sound groundwater science and local expertise. Because SVGMD is the GSA for the vast majority of the SV Subbasin, SVGMD is considered the lead GSA.

PLACEHOLDER: Accordingly, Jenny Gant, the SVGMD Board Clerk, is the Plan Manager for this GSP. Her contact information is provided here:

Phone Number: (530) 428-5002

Mailing Address: PO Box 88, Chilcoot, CA 96105

Electronic Mail (email) Address: sierravalleygmd@sbcglobal.net

SVGMD was authorized under State Senate Bill No. 1391 in 1980 to protect and oversee the management of the groundwater within the Sierra Valley basin. SB 1391 defined the legal boundaries and regulatory authority of the District and authorized its creation by a joint exercise of powers agreement between Plumas and Sierra Counties. Senate Bill 1401, referred to as the "SB 1391 Clean-Up Bill", amended and repealed selected sections of SB 1391 and deleted specified provisions requiring the District to limit or suspend groundwater extractions for export before limiting extractions by overlying users (DWR, 1983). The bill also revised provisions of SB 1391 relating to the approval of proposed development projects within the District that propose to extract groundwater for water service (DWR, 1983).

The organization and management structure of SVGMD is as outlined in SVGMD's enabling legislation, which can be accessed here: https://svgmd.specialdistrict.org/enabling-act. SVGMD's Policies and Procedures Manual included as Attachment 2 provides additional information pertaining to SVGMD's organization and management structure.

ES 1.4 GSP Organization

This Plan Concept Document was developed using the DWR's Groundwater Sustainability Plan Annotated Outline and is therefore organized consistent with that Outline. DWR's Preparation Checklist for GSP Submittal was completed and added to this Plan Concept Document as Attachment 3 to provide a quick reference guide for reviewers to locate specific required information.

Commented [GH4]: It's expected that the checklist will be completed when the plan draft is completed. Including this is a nice way to ensure we don't miss anything and make things easier for reviewers.

ES 2.0 Plan Area and Basin Setting Summary

ES 2.1 Description of the Plan Area

The Plan Area is the area within the SV Subbasin as most recently defined in the Bulletin 118 February 2019 Update (following 2019 Basin Boundary Modification) and viewable on the SGMA Basin Prioritization Dashboard tool (available here: https://gis.water.ca.gov/app/bp-dashboard/final/). This area is the primary focus of this Plan Concept Document and is the area in which compliance with SGMA is required because the SV Subbasin was characterized as a medium priority basin by DWR. Although the Plan Area is technically the area within the SV Subbasin only, much of the descriptions, data assessment, monitoring, and management actions and projects included in this Plan Concept Document include areas beyond the SV Subbasin. The reasoning for this is that there are areas within SVGMD boundaries (but outside of the SV Subbasin boundary) which are significant from a groundwater sustainability perspective and for which SVGMD's enabling legislation gives legal authority to monitor and manage groundwater. For example, the northeastern corner of the valley (defined as the Chilcoot Subbasin - DWR Groundwater Basin Number 5-12.02) is within the SVGMD boundary but not within the SV Subbasin and has significant hydrologic connection with the SV Subbasin and critical recharge areas in the higher elevation areas surrounding Sierra Valley are within the SVGMD boundary but not within the SV Subbasin boundary. Additionally, watershed-scale information is relevant for recharge and hydrologic modeling consideration.

The Sierra Valley watershed is approximately 590 square miles in size and is the headwaters of the Middle Fork of the Feather River, which forms and exits the valley at its northwest corner, is a federally designated Wild and Scenic River, and drains to Lake Oroville, a keystone reservoir of the California State Water Project. The watershed is primarily in Plumas and Sierra Counties but extends slightly into Lassen County to the northeast. The watershed is bounded to the north by Miocene pyroclastic rocks of Reconnaissance Peak, to the west by Miocene andesite of Beckwourth Peak, to the south by Tertiary andesite, and to the east by Mesozoic granitic rocks (Saucedo, 1992). Annual precipitation varies spatially in the watershed from more than 30 inches in the mountains to the southwest to less than 12 inches in the valley to the northeast (Vestra, 2005). Several large meadows exist high in the watershed and numerous streams drain the mountains and flow into the Sierra Valley, playing an important role in the recharge of the groundwater in the valley (DWR, 1963 and 1983). The groundwater basins within the watershed are the SV Subbasin (primary) and the Chilcoot Subbasin in the northeast corner of the valley (hydrologically connected to the SV Subbasin). Neighboring groundwater basins, all of which were classified by DWR as very low priority basins, include the Long Valley Groundwater Basin to the east, the Clover Valley Groundwater Basin to the north, the Grizzly Valley Groundwater Basin to the northwest, the Humbug Valley Groundwater Basin to the west, and the Mohawk Valley Groundwater Basin to the southwest.

The SV Subbasin is located within the Sierra Valley, a valley renowned for its beauty, habitat (nationally designated Important Bird Area and largest wetland in the Sierra Nevada Mountains; FRLT, 2018), biodiversity (one of the most biodiverse landscape in the United States; FRLT, 2018), and size (commonly regarded as the largest high-alpine valley in the United States; Vestra, 2005). Sierra Valley is an irregularly shaped, complexly faulted valley located in eastern Plumas and Sierra Counties of northeastern California. The outer boundaries of the SV Subbasin and Chilcoot Subbasin (excluding the straight-line boundary held in common) approximately parallel the boundaries of Sierra Valley (defined by the interface of the valley floor and surrounding mountains), with some minor exceptions. Sierra Valley has a rich ranching heritage and abundance of ecological and cultural resources. A large portion of the valley is protected in perpetuity by conservation easements covering over 30,000 acres of private land.

There are several small communities in the Sierra Valley, mostly near the valley edges. The communities, clockwise (roughly) from northwest to southwest, are: Beckwourth, Vinton, Chilcoot, Sierra Brooks, Loyalton, Campbell Hot Springs (a.k.a. Sierra Hot Springs), Sierraville, Sattley, and Calpine. The cumulative population of these communities from the 2010 census comes to about 2,600 people. The remainder of the population in the valley (likely less than 500 people) is spread out on rural parcels, mostly R-20 (Rural Residence 20-acre), R-40 (Rural Residence 40-acre), and R-160 (Rural Residence 160-acre) zoned parcels, many of which are family ranches with ownership and operation carried through generations.

The primary existing land use designation is agriculture/cropland and grazing. A wide variety of crops are grown throughout Sierra Valley, including alfalfa, improved pasture, meadow pasture, grain, Christmas tree farms, and specialty crops, including hemp, which has gained attention and some popularity in the Sierra Values in recent years. The majority of crops grown in the Sierra Valley are for pasture/grazing and/or production of hay.

Water sources for domestic, commercial, industrial and irrigation water supply are both surface water and groundwater. DWR basin prioritization (DWR, 2019a) states that groundwater makes up 36% of the total water supply in the SV Subbasin. All of the communities within the Plan Area are to some extent groundwater dependent except for Campbell Hot Springs, which currently relies on a spring source, but has plans to expand and supplement their supply with water well(s) moving forward.

ES 2.1 Basin Setting

The SV Subbasin (DWR Groundwater Basin Number 5-12.01; DWR, 2019) lies at about 4,950 ft average elevation above mean sea level, covering an area of 184 square miles (DWR, 2004a), and is situated at the juncture between the Sierra Nevada and Cascade ranges. Surrounded by heavily faulted volcanic and granitic peaks, the SV Subbasin is a former lake basin filled with layers of lacustrine and upland sediments, capable of storing upwards of 7.5 million ac-ft (MAF) of groundwater in the top 1,000 feet of sediments (DWR, 1963) and 1.0 to 1.8 MAF in the top 200 feet of sediments (DWR, 1973).

DWR (2019) designated the SV Subbasin a medium priority basin due documented groundwater level declines, subsidence, surface water depletion, and special considerations including habitat value (largest fresh water marsh in Sierra Nevada Mountains) and pristine setting (headwaters of the Middle Fork of the Feather River, which is designated as a National Wild and Scenic River). The SV Subbasin received additional priority points for challenges to groundwater management outside the GSA's (SVGMD's) control (DWR 2019), including sensitivity to changing precipitation patterns/climate change and dependence on reservoir operations and upland watershed management. The following key SV Subbasin hydrologic findings presented in Bachand et al (2020) provide valuable context pertaining to the SV Subbasin setting and associated challenges:

- Greater water availability (groundwater, streamflow, rainfall and snowfall) occurs in the western and southwestern valley and less in the northern, northeastern and eastern valley. Irrigated agriculture is more prevalent in the latter regions.
- Deep groundwater is more sensitive and affected by agricultural pumping. Throughout the SV Subbasin, fine grained low permeability layers (aquitards) limit downward recharge flows to the deeper aquifer.
- Groundwater declines have occurred in the northern, northeastern and eastern portions of valley since the 1970s. Long-term groundwater declines have not occurred in deep and shallow groundwater elevations in the western and southwestern SV Subbasin.
- Faulting is limiting lateral groundwater flows and connectivity in the SV Subbasin, and may also act as conduits for groundwater flows in some areas; these effects are not well understood.
- Variances in seasonal and annual precipitation and evapotranspiration (including a gradient of less precipitation and greater ET from west to east) directly affect surface and subsurface flows into the valley and directly and indirectly affect annual groundwater pumping volumes.
- Climate change is expected to increase groundwater demand by decreasing late summer surface water availability, increasing crop ET, and reducing groundwater recharge.
- Frenchman Dam, constructed in the 1960s, has changed surface flow regimes in ways that likely reduce recharge opportunities. Leveling surface flow deliveries during irrigation season through spring impoundments has likely promoted agricultural growth.

Groundwater level monitoring in the SV Subbasin has been conducted since the 1950s. As described in DWR's basin prioritization reporting, (DWR, 2019a), DWR's interpretation of groundwater levels in SV Subbasin can be summarized as follows: the majority of long-term SV Subbasin hydrographs are relatively stable, with a few showing declining groundwater levels. The most significant groundwater level declines have occurred in the northern/northeastern/ eastern portions of the valley where the most agricultural pumping occurs and presumably the least amount of recharge occurs (significantly less precipitation and higher ET in the northern/eastern portions of the watershed) and during periods of drought when groundwater demand for agricultural irrigation spiked due to less availability of surface water.

These most significant periods of groundwater overdraft are believed to have also led to land subsidence in certain areas of the valley (DWR, 1983; Farr et. al, 2016). Direct measurements in the 1980s revealed subsidence corresponding with areas of overdraft and resulting in damage to private well infrastructure (DWR, 1983). A Caltrans survey of roads in Sierra Valley also found that up to 2 feet of subsidence occurred between 2012 and 2016 in the northeast portion of the valley, though no public infrastructure damage was reported (FRLT, 2019). Publicly available, DWR-funded, aerial Interferometric Synthetic Aperture Radar (InSAR) surveys show that six inches of subsidence occurred between April 2015 and 2016 in the northeast of Sierra Valley (Farr et. al, 2016), also spatially/temporally consistent with observed groundwater level declines. These surveys indicate Sierra Valley subsidence is linked with groundwater level declines and areas with high annual pumping are at risk for further subsidence if overdraft continues to occur in the future.

Data and documentation on water quality impacts, impacts to interconnected surface waters, and impacts to groundwater dependent ecosystems are lacking. Available data suggests that such impacts are relatively minimal, but additional monitoring and data evaluation are needed to further elucidate the correlations between current and historical groundwater management and observed trends with these sustainability indicators.

The total annual surface water input to the SV Subbasin is approximately 189,000 Acre-Feet (AF), (Dib et al., 2017). Bachand et al (2020) estimate Sustainable Yield for the northern to eastern valley to be in the range of 5,000 – 6,000 AF. The temporal and spatial variability of precipitation, as well as unquantified groundwater inflows, create uncertainty in this estimate. This uncertainty affects the utility of numerical models and other sophisticated modeling tools because errors associated with evaporation, precipitation, and subsurface flows are likely to exceed the magnitude of Sustainable Yield itself.

Given the hydrologic and geologic complexity found in Sierra Valley, the most promising strategy to estimate the sustainable yield of the SV Subbasin's is by comparing annual groundwater pumping totals with groundwater level monitoring observations. Based on SVGMDs groundwater level monitoring data and metered pumpage records dating back to the 1980s, the SVGMD's longtime consulting hydrogeologist estimated the sustainable yield to be about 6,000 acre-feet per year in the part of the SV Subbasin tapped by large-capacity agricultural supply wells (Schmidt, 2012). This is considered the most reliable sustainable yield estimate generated to date, though a recent assessment by Burkhard Bohm, Geohydrologist (unpublished) suggests that estimating sustainable yield from annual groundwater pumping totals and groundwater level monitoring observations alone is likely insufficient for achieving sustainable groundwater management.

Given the hydrologic and geologic complexity found in Sierra Valley, an adaptive management approach with well-defined protocols and methods to assess success is considered the most promising strategy to achieve sustainability. Built-in to this approach is an enforcement framework with a defined blueprint for corrective actions, including implementation of pumping restrictions as needed. To guide management decisions and strategies and provide sufficient and defensible (scientifically, legally) information, the SVGMD has developed a more comprehensive monitoring network and protocols for data collection, management and analyses, as described below.

ES 3.0 Sustainable Management Criteria Summary

ES 3.1 Sustainability Goal

The Sustainability Goal for the SV Subbasin is as summarized in Section ES 1.2.

ES 3.2 Measurable Objectives

The measurable objectives for the five applicable sustainability indicators for the SV Subbasin are the numeric values recorded during the spring of 2011 prior to the historic drought of 2011 – 2017, as displayed in Table ES 3.2-1 below. The groundwater conditions observed at the end of the historic drought, which lasted from December 2011 to March 2017 and was reportedly one of the most intense droughts in California history, with the period of late 2011 through 2014 being the driest in California history, were the worst on record in the SV Subbasin. However, no resulting impacts exceeded the standards of acceptability of impacts (i.e. what would be considered "significant and unreasonable") for the five applicable sustainability indicators described in Section ES 3.4, which if exceeded would constitute undesirable results, hence a failure to meet the Sustainability Goal for the SV Subbasin. It can thus be concluded that the conditions prior to this drought, e.g. those observed in the spring of 2011, provided a sufficient "margin of operation flexibility" (as referred to in SGMA) to enable continuation of typical agricultural activities and other groundwater dependent activities through a historic drought without causing impacts in excess of the standards of acceptability established for the SV Subbasin during the GSP development process, a.k.a. without causing undesirable results. As such, it was agreed upon during the GSP development process setting the measurable objectives values equal to the values observed during the spring of 2011 is a reasonable and safe means of ensuring that undesirable results within the SV Subbasin will be prevented.

Commented [GH5]: This is an example of future-tense language on a subject that has not occurred yet, hence it is theoretically/hydrostatical/suggestive, e.g. it is placeholder language that is included because it is anticipated that such language will be included in the actual SV GSP. The intent, as previously described, is to help accelerate development of the SV GSP. Including such content is per the direction of the SVGMD Directors, who decided at a Board Meeting in early 2020 that doing so is worthwhile due to the GSP development timeline being relatively tight.

Note, if a drought of equal magnitude were to again occur in the future while groundwater demand in Sierra Valley remains unchanged, no special groundwater management actions, i.e. restricting agricultural pumping, would be expected to be needed to avoid exceeding the minimum thresholds described below, based on available data. However, it is possible that a worse drought could occur and/or a similar drought could occur in combination with increased groundwater demand in the Sierra Valley. In such instances, special management actions such as implementing agricultural pumping restrictions would likely be required to present undesirable results, per the definitions provided in the subsequent sections of this document. Monitoring and management action implementation protocols have been developed accordingly, as outlined in subsequent sections of this document.

Table ES 3.2-1. Measurable Objectives (20-Yearr Milestones) – Spring 2011 Pre-Drought Conditions

(PLACEHOLDER)

ES 3.3 Minimum Thresholds

The minimum thresholds set for the five applicable sustainability indicators for the SV Subbasin are the numeric values recorded in the spring of 2016, as displayed in Table ES 3.3-1 below. At this time, the region was near the end of a historic drought and as such, groundwater conditions in the SV Subbasin were at or near the worst ever recorded. However, no resulting impacts exceeded the standards of acceptability of impacts for the five applicable sustainability indicators described in Section ES 3.4, which if exceeded would constitute undesirable results, hence a failure to meet the Sustainability Goal for the SV Subbasin. Because observed conditions in the SV Subbasin have never been worse than observed during the spring of 2016, it cannot be known how much worse conditions would have to become to exceed the standards of acceptability for impacts agreed upon by engaged stakeholders during the GSP development process. As such, it was agreed upon during the GSP development process that setting the minimum thresholds equal to the values observed during the spring of 2016 is a reasonable and safe means of ensuring that undesirable results within the SV Subbasin will be prevented, provided the minimum thresholds are not exceeded.

Table ES 3.3-1. Minimum Thresholds – Spring 2016 Worst Recorded Conditions

(PLACEHOLDER)

ES 3.4 Undesirable Results

As described in Section ES 1.1, definitions of undesirable results hinge upon descriptions of what would be considered "significant and unreasonable" impacts resulting from groundwater conditions throughout the SV Subbasin associated with each of the five applicable sustainability indicators, which per SGMA were required to be developed through the stakeholder engagement and decision making processes described in this document. The descriptions that resulted from this process are summarized here and described in greater detail in Section 3.4 of this Plan Concept Document.

Groundwater Levels: Groundwater level declines which result in increases in pumping costs and/or decreases in well production rates that prevent safe and economically feasible continuation of existing groundwater dependent activities within the SV Subbasin and/or declines which result in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Groundwater Levels sustainability indicator.

Groundwater Storage: Reduction in groundwater storage which results in increases in pumping costs and/or decreases in well production rates that prevent safe and economically feasible continuation of existing groundwater dependent activities within the SV Subbasin and/or reduction which results in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Groundwater Storage sustainability indicator.

Water Quality: Changes in water quality which prevent safe and economically feasible continuation of existing groundwater dependent activities within the SV Subbasin and/or which result in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Water Quality sustainability indicator.

Land Subsidence: Land subsidence which demonstrably results from groundwater level declines and demonstrably causes major damages to existing infrastructure and/or dwellings within the SV Subbasin and/or prevents the safe and economically feasible continuation of existing surface land uses within the SV Subbasin, and/or which results in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Land Subsidence sustainability indicator.

Interconnected Surface Water: Depletion of interconnected surface water which demonstrably results from groundwater level declines and demonstrably shrinks groundwater dependent ecosystems and/or prevents the safe and economically feasible continuation of existing beneficial uses of surface water within the SV Subbasin, and/or which results in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Interconnected Surface Water sustainability indicator.

ES 3.5 Monitoring Network

SVGMD maintains six sets of groundwater level monitor wells around the valley. Monitoring data was collected from these wells by SVGMD twice annually until late 2019, when monitoring frequency was increased to monthly throughout the agricultural season (from early spring to late fall). DWR monitors several other wells, also typically collecting data twice annually. Monitoring data dates back to the 1980s for most wells. Data for select wells extends back to the 1950s. Certain wells have significant data gaps, but monitoring data is generally sufficient to illuminate long-term groundwater level trends and spatial variances around the valley. SVGMD recently completed a multi-completion monitoring well through DWR's technical support services program and is in the process of planning another to expand their monitoring network. SVGMD also monitors agricultural groundwater pumping and has been doing so since 1989.

Groundwater quality monitoring is generally limited to monitoring performed by DWR. Groundwater quality monitoring by SVGMD has been conducted on few occasions to supplement DWR data during hydrogeologic investigations (Bohm, 2016a). Historic groundwater quality data includes 67 major ion and trace element groundwater chemistry data sets collected between 1981 and 1995 (from DWR), 27 data sets collected in 2002 (from DWR), 14 data sets from five of the six SVGMD monitoring wells sampled at shallow, intermediate, and deep levels in 2003, 2005, and 2015 (KDS, 2003; 2005), and 45 data sets from samples collected in 2014 (Bohm, 2016a), 12 data sets obtained from consulting reports, 13 geothermal water chemistry data sets, and an isotope data set collected from uplands springs and streams (Bohm, 2016a). SVGMD will likely incorporate regular groundwater quality testing as a part of their improvements to their monitoring protocol during GSP implementation.

No formal monitoring network protocol has existed historically in the SV Subbasin for groundwater storage, land subsidence, or interconnected surface water. Best available data has been acquired and assessed and associated monitoring networks and protocols have been developed as described elsewhere in this document. Moving forward, it is expected that groundwater storage monitoring will be via proxy groundwater level monitoring utilizing best available data to compute changes in storage associated with observed changes in groundwater levels. For land subsidence monitoring, SVGMD will rely partially on InSAR data for while developing and monitoring their own GPS-based land subsidence monitoring network during GSP implementation. LiDAR data is also expected to be utilized for land subsidence monitoring as data availability from other sources allows. For interconnected surface water monitoring, it is expected that periodic analyses of outflows through the Middle Fork of the Feather River at the Rocky Point streamgage in combination with groundwater level data, pumping data, climate/precipitation data, and flow data from the Lake Davis Dam (which releases water to the middle Fork of the Feather River upstream of Rocky Point – the only inflow that does not pass through the SV Subbasin) will be performed and that the Nature Conservancy's GDE Pulse tool will continue to be used to track changes to groundwater dependent ecosystems within the SV Subbasin.

Saltwater intrusion is not an applicable sustainability indicator in the SV Subbasin, due to its distance from saltwater sources.

ES 4.0 Summary of Management and Project Actions to Achieve Sustainability

Several management and project actions to achieve sustainability have been implemented prior to and during the development of the SV GSP. For example, SVGMD has developed and passed a number of ordinances which have successfully limited exploitation of groundwater resources in the SV Subbasin (Ordinance 82-01), achieved basin-wide monitoring of extraction from high capacity wells (Ordinance 82-03), limited new development where such development would likely impact groundwater resources (Ordinance 83-01, 84-02, and 00-02), generated revenue for groundwater management (Ordinance 17-01, 17-03, and 18-02), and limited construction of new high capacity wells where such construction would likely impact groundwater resources (Ordinance 18-01). Additional management action taken by the SVGMD to aid in achieving sustainable groundwater management in the SV Subbasin include:

- coordination of groundwater recharge study conducted by Bachand & Associates with funding from the Feather River Land Trust (FRLT), the results of which informed project/management action/policy development and land management strategies to be implemented by the FRLT on their conservation properties (Bachand et al., 2020).

- development and submittal of groundwater-related projects through the Upper Feather River Integrated Regional Water Management Plan (IRWM) Prop 1 grant funding process and additional projects (implementation subject to acquisition of funding);
- coordination of meetings and facilitation for generating public discussion and stakeholder input pertaining to development of groundwater projects and management actions and policies;
- development of corrective action policies for incorporation in this Plan Concept Document to respond to (correct) any observed undesirable results including a policy for limiting groundwater extraction from existing wells as may be needed to prevent undesirable results, per SB 1391, the SVGMD's enabling legislation, which outlined standards for limiting pumping in the event of chronically lowering groundwater levels or significant water quality impairment, as follows:

> Sec. 709.5. In the event that the District limits or suspends extractions by district users in order to eliminate existing or threatened conditions of overdraft, rights to the use of the available supply of ground water shall be allocated primarily on the basis of the number of acres overlying the basin or subbasin that a user owns or leases in proportion to the total number of acres overlying the basin or subbasin. The District may adjust any figure so arrived at up or down for any of the following factors:
>
> (1) the number of acres actually irrigated compared to the number of acres owned or leased
>
> (2) crop type
>
> (3) wasteful or inefficient use
>
> (4) reasonable need
>
> (5) any other factor that the District reasonably feels it should consider in order to reach an equitable distribution within the entire District.
>
> A benefit of this plan may be to encourage free-market trading
>
> of water by making clearer who owns what and how much. With lively

Through implementation of these and other policies, projects, and management actions and through monitoring, use of modeling, and adaptive management, SVGMD, Plumas County, and the public of Sierra Valley are confident that the SV Subbasin Sustainability Goal can and will be achieved

ES 5.0 Plan Implementation Summary

Plan implementation has already begun and will continue through the implementation horizon beginning with continued improvements to monitoring networks and protocol, continued collection, organization, and analysis of monitoring data, continued collaboration with land owners and other stakeholders, and implementation of special management actions as may be needed to meet the SV Subbasin Sustainability Goal.

1.0 Introduction

This Groundwater Sustainability Plan (GSP or Plan) Concept Document was developed under the direction of the Sierra Valley Groundwater Management District (SVGMD) and Plumas County, the Groundwater Sustainability Agencies (GSAs) for the Sierra Valley Groundwater Basin (SV Subbasin), in accordance with the California Department of Water Resources (DWR) Sustainable Groundwater Management Act (SGMA) of 2014 for the purpose of achieving sustainable groundwater management, as defined by SGMA, in the SV Subbasin.

SGMA is a three-bill legislative package comprised of Assembly Bill (AB) 1739 (Dickinson), Senate Bill (SB) 1168 (Pavley), and SB 1319 (Pavley) signed into law in 2014 and codified in Section 10720 of the California Water Code.

SGMA also expands the role of DWR to support local implementation of GSPs and allows for intervention by the State Water Resources Control Board (SWRCB) at discrete points throughout the process if local agencies are not willing or able to manage groundwater sustainably.

In addition to the three Assembly Bills, SGMA is partially defined by the "emergency regulations" (adopted by the DWR and incorporated into the California Code of Regulations, Sections 350 – 354.4) and a number of other documents. These documents and other information are available from the DWR's SGMA web page at: http://www.water.ca.gov/groundwater/sgm/

SGMA requires critically-overdrafted high and medium priority basins to be managed under a GSP by January 31, 2020, requires all other groundwater basins designated as high or medium priority basins to be managed under a GSP by January 31, 2022, requires demonstrated sustainability within 20 years of GSP implementation, and continued sustainability through the 50-year planning and implementation horizon. The GSP development and implementation process required by SGMA is summarized in Figure 1.1-1 (modified from DWR, 2016).

SV Subbasin boundary modifications were completed in early 2019 and basin prioritization for modified basins was revised by DWR in spring 2019. The SV Subbasin was characterized as a medium priority basin that is not critically overdrafted per DWR (2019). An eligible local agency was therefore required to develop and implement a GSP by January 31, 2022 and achieve demonstrated sustainability by January 31, 2042. SVGMD and Plumas County chose to pursue sustainability and compliance with the requirements of SGMA via a multi-GSA, single GSP approach, led by SVGMD with the support of Plumas County, in hopes that SVGMD can retain their authority to manage groundwater in the SV Subbasin into the indefinite future. It is the belief of SVGMD and Plumas County that groundwater management by a local entity will best ensure the local communities' needs are met and voices are heard while striving toward optimized groundwater management, consistent with the belief of former California Governor

Jerry Brown who emphasized in his signing statement that "groundwater management in California is best accomplished locally".

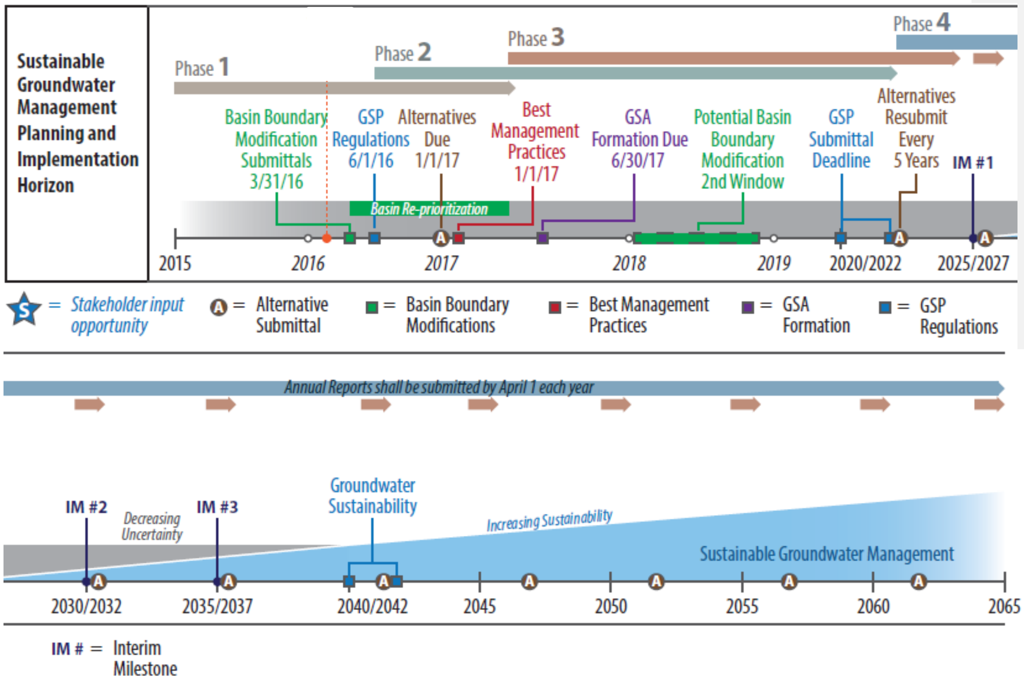


Figure 1.1-1. Phases of GSP Development and Implementation (DWR, 2016).

1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this Plan Concept Document is to ensure "sustainable groundwater management" in the SV Subbasin by the SVGMD is achieved by 2042, as required by SGMA, and maintained at least until 2072. To understand what this purpose really means, some definitions are in order.

Sustainable groundwater management, as defined by SGMA, is the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing "undesirable results".

Undesirable results, as defined by SGMA, are one or more of the following effects caused by groundwater conditions occurring throughout the basin:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion (*not applicable in the SV Subbasin).
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

To complete the above definition of undesirable results, the SV Subbasin GSAs engaged stakeholders to come up with a description of what would be considered "significant and unreasonable" impacts associated with each of the undesirable results categories (as described in Chapter 3 of this Plan Concept Document).

Hence, the purpose of this Plan Concept Document stated above can be re-phrased as follows: to facilitate groundwater management in the SV Subbasin by SVGMD which will by 2042 eliminate any and all impacts associated with groundwater level declines, groundwater storage reductions, water quality degradation, land subsidence, and/or surface water depletions which result from groundwater extraction and are locally considered to be significant and unreasonable (as described in this Plan Concept Document), and to prevent any such impacts from occurring thereafter at least until 2072. This more precisely worded purpose serves as the basis of the intention of the Sustainability Goal described below.

To facilitate such sustainable groundwater management, this Plan Concept Document provides:

- agency information and management structure (this Chapter);
- all pertinent background information (see Chapter 2) including description of the Plan Area and SV Subbasin setting, historical conditions, and current conditions;
- modeled water budget information (see Section 2.2.3.) including the estimated sustainable yield and discussion on how the value may change over time as a result of changes in climate;
- sustainable management criteria (see Chapter 3) that will serve as the basis for evaluation of the sustainability of groundwater management in the SV Subbasin and the efficacy of this Plan Concept Document;

- assessment of the sustainability of the existing condition (see Section 3.4) based on the sustainable indicators defined in SGMA and analysis of data collected over the past several decades, building upon the historic and existing conditions information provided in Section 2.2.2;
- description of the existing monitoring network and protocol (see Section 3.5), assessment of the existing network and protocol with respect to its ability to generate the data necessary to sufficiently evaluate the sustainability of groundwater management in the SV Subbasin, and planned improvements;
- projects and management actions planned to achieve sustainability, i.e. meet the sustainable management criteria (see Chapter 4); and
- GSP implementation information (see Chapter 5) including estimated cost, implementation schedule, annual reporting protocol, and periodic evaluation protocol for evaluating the Plan's efficacy and amending the Plan as needed to achieve sustainability.

1.2 Sustainability Goal *(Reg. § 354.24)*

Per Reg. § 354.24 of the California Code of Regulations, the GSP must establish a sustainability goal, including a description of the goal, information from the basin setting used to establish the goal, discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon. This information is detailed in Chapter 3 of this Plan Concept Document. The essence of the Sustainability Goal is provided here to provide context for any reader of this Plan Concept Document.

Sustainability Goal *(PLACEHOLDER – CONCEPT):* groundwater management within the SV Subbasin by SVGMD which by 2042 eliminates any and all impacts associated with groundwater level declines, groundwater storage reductions, water quality degradation, land subsidence, and/or surface water depletions which result from groundwater extraction and are locally considered to be significant and unreasonable (*as will be described in the SV GSP*) and to prevent any such impacts from occurring thereafter at least until 2072.

An essential step toward achieving the sustainability goal is the development and implementation of a long-term strategy for management of the groundwater. Some of the basic components of the Districts long-term strategy, as described in the District's 2006 Draft Management Plan, are:

1. Making maximum beneficial use of the groundwater and all other reasonable sources of water to augment the water supply in the District,
2. Development and implementation of plan components and adoption of appropriate rules which;

   a. Require conservation and responsible management of water used,
   b. Regulate existing and new groundwater withdrawals to reduce, and eventually eliminate, damage from groundwater level changes, groundwater quality changes, land subsidence, and any other undesirable results.
3. Identification and completion of projects that foster groundwater recharge or reuse of water in the District, and
4. Identification and elimination of unreasonable institutional barriers to the sound management of water resources.

In setting out to accomplish the sustainability goal, SVGMD has developed and passed a number of ordinances based on best available data, made improvements to the SV Subbasin monitoring network and protocol as described in Section 5.1, and developed additional projects, policies, and management actions for implementation over the course of the planning and implementation horizon as described in Chapter 5. Through monitoring per Section 3.5 and implementation of the projects, policies, and management actions per Chapter 4, undesirable results will be eliminated and the sustainability goal will be met.

1.3 Agency Information (*Reg. § 354.6*)

Per Reg. § 354.6 of the California Code of Regulations, the GSP must include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:

(a) The name and mailing address of the Agency.

(b) The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.

(c) The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.

(d) The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.

(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

The information provided pursuant to Water Code Section 10723.8 is included as Attachment 1. The name and mailing address of the lead Agency (SVGMD) is provided on the title page of this Plan Concept Document. The name and mailing address of Plumas County (the GSA for the small area of the SV Subbasin which is outside of the SVGMD boundary) is provided below. The other information (items b, c, d, and e) is provided subsequently in this Chapter.

Plumas County
520 Main St., Room 309
Quincy, CA 95971

1.3.1 Plan Manager

The Plan Manager is the individual point of contact for this Plan. The Plan Manager is responsible for submitting required documentation to DWR and reporting any comments, inquiries, and other Plan related correspondences to the SVGMD Board of Directors. If the Plan Manager is to change, the Plan Manager information below (*PLACEHOLDER*) will be updated.

Plan Manager Name: Jenny Gant

Phone Number: (530) 428-5002

Mailing Address: PO Box 88, Chilcoot, CA 96105

Electronic Mail (email) Address: sierravalleygmd@sbcglobal.net

1.3.2 Organization and Management Structure of the GSA

SVGMD was authorized under State Senate Bill No. 1391 in 1980 to protect and oversee the management of the groundwater within the Sierra Valley basin. SVGMD submitted notification to DWR in 2017 to become the GSA for the portion of the SV Subbasin that lies within their statutory boundary and thereby became the exclusive GSA for the majority of the SV Subbasin. A small area of the northwest corner of the SV Subbasin (100 acres or so, <0.1% of total basin area) falls outside of SVGMD boundary and therefore excludes SVGMD from eligibility to be the GSA for that area. Accordingly, Plumas County submitted notification and became the GSA for that area and in accordance with Water Code Section 10723.6, SVGMD and Plumas County established a memorandum of understanding (MOU) to establish their respective roles in GSP development and implementation. The MOU (see Appendix A) essentially states that the two entities will work together to develop and adopt a single SGMA-compliant GSP for the SV Subbasin using sound groundwater science and local expertise.

Because the sliver of the basin for which Plumas County is the GSA is managed by Plumas National Forest and is a tribally significant area, Plumas County has established coordination agreements with Plumas National Forest and area tribes. The coordination agreements (see Appendix A) state that (*PLACEHOLDER – these have not yet been finalized, to my knowledge)*.

Because SVGMD is the GSA for the vast majority of the SV Subbasin, SVGMD is considered the lead GSA. SVGMD monitors groundwater levels using monitoring wells located throughout the District, meters all active large-capacity wells (those capable of pumping 100 gallons per minute or more), prepares technical reports and evaluations on groundwater, reviews development project proposals within District boundaries and executes all other powers invested in the district by SB 1391 and SGMA. As the lead GSA for the SV Subbasin, SVGMD will be responsible for overseeing implementation of this Plan Concept Document, including monitoring and reporting.

The SVGMD Board of Directors holds public Board meetings monthly and publishes meeting minutes, ordinances, technical reports, and other information on their website (http://www.sierravalleygmd.org/). Plumas County representatives, representatives of affected agencies, and engaged community members regular attend SVGMD Board meetings and participate in discussions. The organization and management structure of SVGMD is as outlined in SVGMD's enabling legislation, which can be accessed here: https://svgmd.specialdistrict.org/enabling-act. SVGMD's Policies and Procedures Manual included as Attachment 2 provides additional information pertaining to SVGMD's organization and management structure.

The SVGMD Board of Directors and other individuals who attend meetings and participate in other ways all have a connection with the Sierra Valley and a genuine interest in ensuring environmental and public health and wellbeing in the Sierra Valley area are optimized in the present and in the future. The Board members and other participants have been living and working in the Sierra Valley area for generations and thus have a plethora of empirical knowledge and anecdotal data that are invaluable in informing the GSP development and implementation process.

1.3.3 Legal Authority of the GSA

SVGMD was authorized under State Senate Bill No. 1391 in 1980 to protect and oversee the management of the groundwater within the Sierra Valley basin. SB 1391 defined the legal boundaries and regulatory authority of the District and authorized its creation by a joint exercise of powers agreement between Plumas and Sierra Counties.

Senate Bill 1401, referred to as the "SB 1391 Clean-Up Bill", amended and repealed selected sections of SB 1391 and deleted specified provisions requiring the District to limit or suspend groundwater extractions for export before limiting extractions by overlying users (DWR, 1983). The bill also revised provisions of SB 1391 relating to the approval of proposed development projects within the District that propose to extract groundwater for water service (DWR, 1983).

In accordance with Water Code Section 10723(c)(1), SVGMD was deemed the exclusive GSA for the portion of the SV Subbasin that is within SVGMD's statutory boundary. In accordance with Water Code Section 10723.8, upon submitting notification to DWR to become the GSA for that portion of the SV Subbasin, SVGMD was authorized the legal powers of a GSA as described in Chapter 5 of SGMA (Water Code Sections 10725 - 10726.9).

In accordance with Water Code Section 10723(a), Plumas County was eligible to become the exclusive GSA for the portion of the SV Subbasin that is outside of the SVGMD's statutory boundary. In accordance with Water Code Section 10723.8, upon submitting notification to DWR to become the GSA for the small area of the SV Subbasin that is outside of the SVGMD boundary, Plumas County was authorized the legal powers of a GSA as described in Chapter 5 of SGMA (Water Code Sections 10725 - 10726.9).

1.3.4 Estimated Cost of Implementing the GSP and GSA's Approach to Meet Costs

The total estimated cost of GSP implementation over the next 50 years (2022 to 2072) is **$XXXX.XX** (*PLACEHOLDER*). Table 1.3-1 provides a cost breakdown.

Onetime costs include (*PLACEHOLDER*). Ongoing costs include (*PLACEHOLDER*) groundwater level monitoring costs ($X/year), water quality monitoring ($X/year), subsidence monitoring costs ($X/year), sensitive habitat monitoring ($X/year), continued management ($X/year), administrative costs ($X/year), data organization and analysis costs ($X/year), annual reporting costs ($X/year), and(*PLACEHOLDER*).

The funding for GSP implementation will come from a combination of local, state, and federal sources. Local sources include:

- SVGMD Management Charge (30 cents per acre, per year, with a total minimum charge of $10.00 per year on all parcels or lots of 40 acres or less, charged to all property owners within the District)
- SVGMD Large Capacity Well Management Charge ($200.00 per well per year charged to all owners of wells capable of pumping 100+ gallons per minute located within the District, all of which are metered and monitored by the District)
- Any SVGMD fines/fees/penalties for violations of SVGMD policies/ordinances.
- Feather River Land Trust Grants

Potential state and federal funding sources include, but are not limited to:

- California DWR – IRWM Grant Program
- California SWRCB – Clean Water State Revolving Fund (CWSRF)
- California SWRCB – Drinking Water State Revolving Fund (DWSRF)
- California SWRCB – Small Community Grant Fund
- California SWRCB – Groundwater Grant Fund (Chapter 10, Prop 1)
- California SWRCB – Parks and Water Bond (Chapter 11, Prop 68)
- California DFW Grant Programs

- California Legislative Appropriations
- Weyerhaeuser Family Foundation Sustainable Forests and Communities Initiative
- Nature Conservancy Natural Climate Solutions Accelerator Grant Program
- USDA/NRCS Grant Programs
- Water Infrastructure Financing and Integration Act (WIFIA)
- Reclamation Integration Financing and Integration Act (RIFIA)
- Water Resources Development Act (WRDA)
- Bureau of Reclamation – WaterSMART Program
- Department of Defense – Defense Communities Infrastructure Program
- Department of Defense – Readiness and Environmental Protection Integration Act
- U.S. Department of Agriculture – Community Facilities Program
- U.S. Department of Agriculture – Regional Conservation Program

1.4 GSP Organization

This Plan Concept Document was developed using the DWR's Groundwater Sustainability Plan Annotated Outline (December 2016) and is therefore organized consistent with that Outline. DWR's Preparation Checklist for GSP Submittal was completed and added to this Plan Concept Document as Attachment 3 to provide a quick reference guide for locating specific required information.

Commented [GH6]: It's expected that the checklist will be completed when the plan draft is completed. Including this is a nice way to ensure we don't miss anything and make things easier for reviewers.

2.0 Plan Area and Basin Setting

Commented [GH7]: This Chapter of this document includes a good amount of information, but I expect it will be greatly improved in the actual GSP through more comprehensive literature review, ground-truthing, additional investigations as needed and as budget/timelime allows, etc.

2.1 Description of the Plan Area (*Reg. § 354.8*)

Per Reg. § 354.8(a) of the California Code of Regulations, the GSP must include one or more maps of the basin that depict the following, as applicable:

(1) The area covered by the Plan ("Plan Area"), delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.

(2) Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.

(3) Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.

(4) Existing land use designations and the identification of water use sector and water source type.

(5) The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by DWR, as specified in Reg. § 353.2, or the best available information.

In accordance with § 352.4(d) of the California Code of Regulations, maps submitted to DWR shall meet the following requirements:

(1) Data layers, shapefiles, geodatabases, and other information provided with each map, shall be submitted electronically to DWR in accordance with the procedures described in Article 4.
(2) Maps shall be clearly labeled and contain a level of detail to ensure that the map is informative and useful.
(3) The datum shall be clearly identified on the maps or in an associated legend.

Figure 2.1-2 shows SVGMD's jurisdictional boundary, the boundaries of the SV Subbasin (Plan Area), the Chilcoot Subbasin, and adjacent groundwater basins.

Figure 2.1-2 identifies the one small area within the Plan Area for which SVGMD is not the exclusive GSA (the area for which Plumas County is the exclusive GSA).

Figure 2.1-3 shows the SV Subbasin, Chilcoot Subbasin, and adjacent basins more clearly and labeled.

The Plan Area currently has no adjudicated groundwater areas (source: Groundwater Information Center Interactive Map Application[1]) and there are no areas within the Plan Area that are covered by an Alternative. In the event that any groundwater areas become adjudicated in the future or any areas become covered by an Alternative, a figure will be added to this section and descriptions will be added to Section 2.1.1.2 of this Plan Concept Document. The only Agency (as defined in Reg. § 351. of the California Code of Regulations) within the Plan Area other than SVGMD is Plumas County. The area within the Plan Area for which Plumas County is the exclusive GSA is identified in Figure 2.1-2. SVGMD is the GSA for the remainder of the Plan Area.

Figure 2.1-4 shows the general location of the Plan Area and 2018 aerial satellite imagery of the Plan Area with state highways and county lines shown.

Figure 2.1-5 shows jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land) and also shows other land ownership, the state highways and locations of the communities within the Plan Area, and the Sierra Valley watershed

[1] Available from: https://gis.water.ca.gov/app/gicima/

Commented [GH8]: Many of the maps depicting groundwater data, etc., are to be developed using data provided by DWR or best available data, per SGMA emergency regs sections 353.2, 354.8, and 354.16. As such, much of the mapping can likely be accomplished using DWR online GIS tools. However, for instances when additional data is unavailable, new maps will likely need to be generated by a GIS tech. All data going into those maps (that isn't derived from DWR) should be organized in a folder for eventually turning over to DWR with the draft GSP.

Commented [GH9]: For maps included in this section from the watershed assessment (Vestra, 2005) I do not have the associated data, but can likely get it from Vestra. They gave permission to use their figures and also offered to help as needed.

Commented [GH10]: This is only applicable to maps showing elevation data, e.g. maps with contours or spot elevations.

boundary. The only community in the Plan Area that is an incorporated city is Loyalton. The boundaries of the City of Loyalton approximately match the Loyalton Water District boundaries as portrayed in Figure 2.1-7.

Figure 2.1-6 shows the counties within the Plan Area (Plumas and Sierra Counties), overlaid atop the groundwater basin boundaries.

Figure 2.1-7 shows agencies with water management responsibilities within the Plan Area, overlaid atop the groundwater basin boundaries. There are no tribal homelands or tribal land trusts based on data collected and mapped by DWR (2011). Should any new information change this determination in the future, a figure showing tribal lands will be added to this Section. Areas covered by relevant general plans are: 1) the portion of the Plan Area within Plumas County (Plumas County General Plan), 2) the portion of the Plan Area within Sierra County (Sierra County General Plan), and 3) the area within the City of Loyalton (City of Loyalton General Plan).

Figure 2.1-8. shows existing land use designations in the Plan Area. Data on water use sector and water source type associated with various land uses is portrayed in tabular form in Section 2.1.1.

Figures 2.1-9, 2.1-10, and 2.1-11 show the approximate number of domestic wells per square mile, production wells per square mile, and public wells per square mile, respectively (source: DWR Well Completion Report Map[2]). Figure 2.1-12 provides a clearer quantitative estimate of well density based primarily on well logs (Bohm, 2016a). Tables 2.1-1 provides a summary of the percent breakdown of the existing wells in Sierra Valley by types (Bohm, 2016a). The well inventory conducted by Bohm (2016a) also provides figures and tables showing the ages, depths, screened intervals, depth vs. type data, casing sizes, and additional data analysis.

All of the communities within the Plan Area are to some extent groundwater dependent except for Campbell Hot Springs, which relies on a spring source. Campbell Hot Springs has plans for expansion which may necessitate supplementing the spring source with groundwater.

Commented [GH11]: Likely need another map to include water use sector and water source type.

Commented [GH12]: We will probably have to do better than this. For all of these maps, what is shown here is a good starting place, but grant funds should be used for additional data collection/organization and map making.

[2] Available from: https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

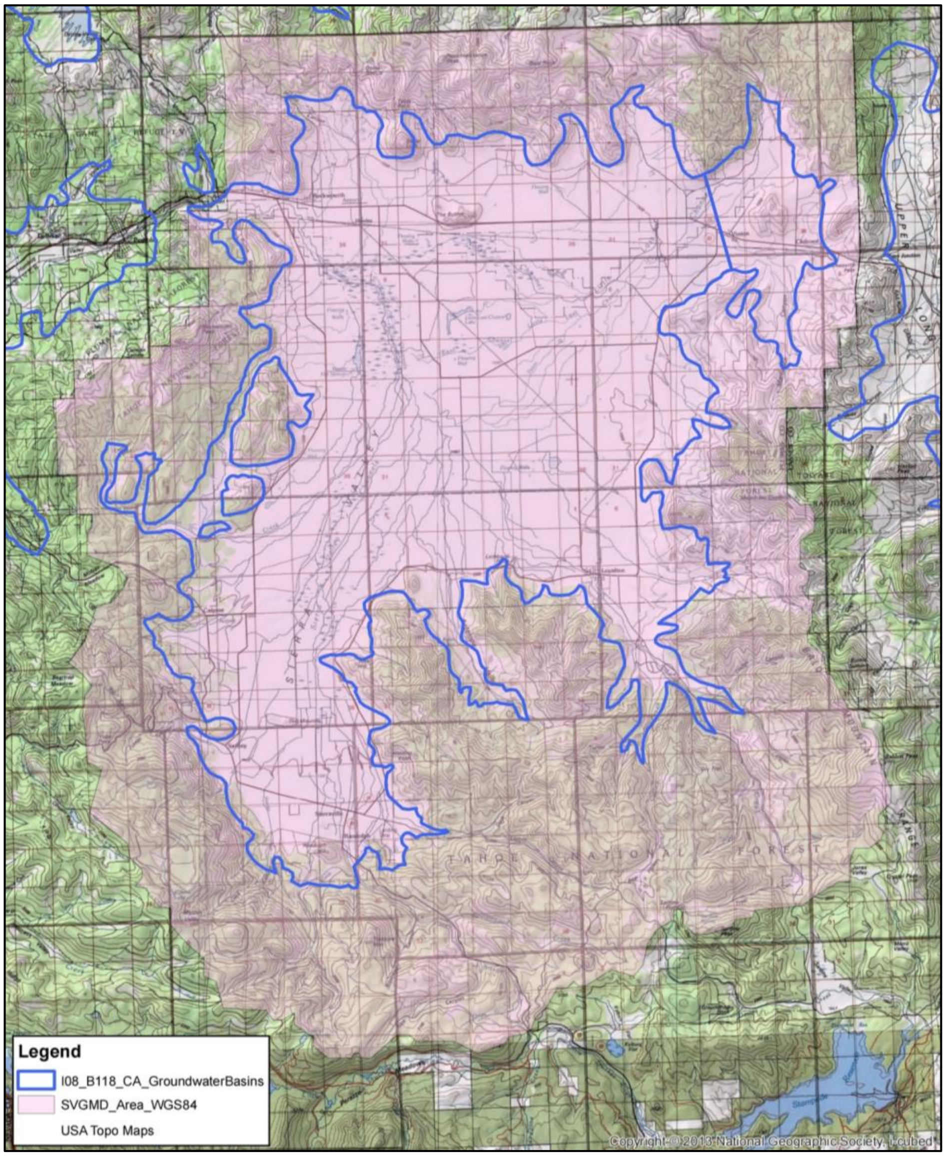


Figure 2.1-1. Plan Area (SVGMD jurisdictional area + small area within the SV Subbasin which is outside of the SVGMD jurisdictional area) and Groundwater Basin Boundaries.

Commented [GH13]: This figure and subsequent figures w/the SV Subbasin Boundary included need to be replaced with a new figures showing the new basin boundary resulting from the 2019 basin boundary modification.

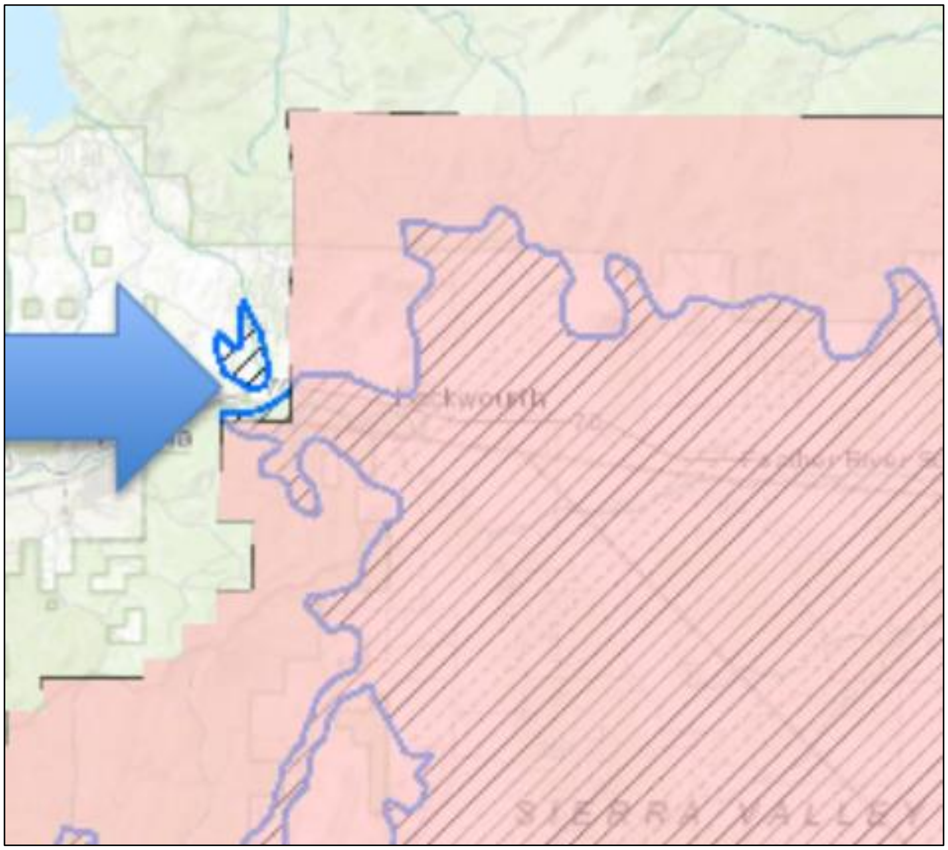


Figure 2.1-2. The small area (~100 acres) within the SV Subbasin for which Plumas County is the GSA (because it is outside of SVGMD's jurisdictional area).

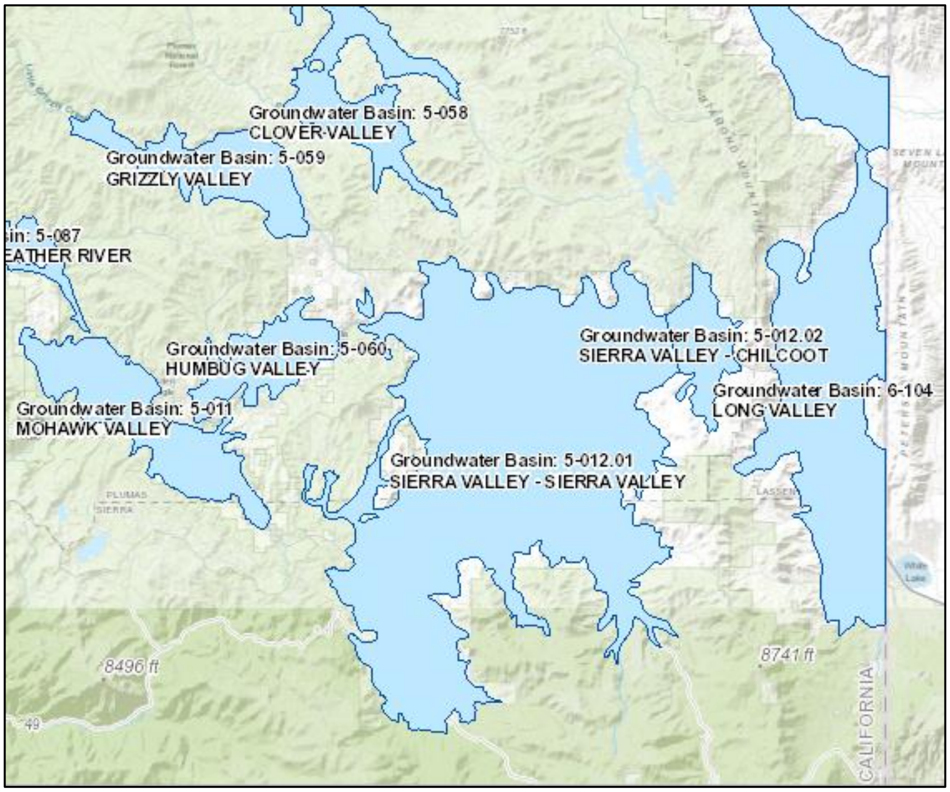


Figure 2.1-3. Sierra Valley Groundwater Basin (SV Subbasin) and Adjacent Groundwater Basins (source: Groundwater Information Center Interactive Map Application, 2019).

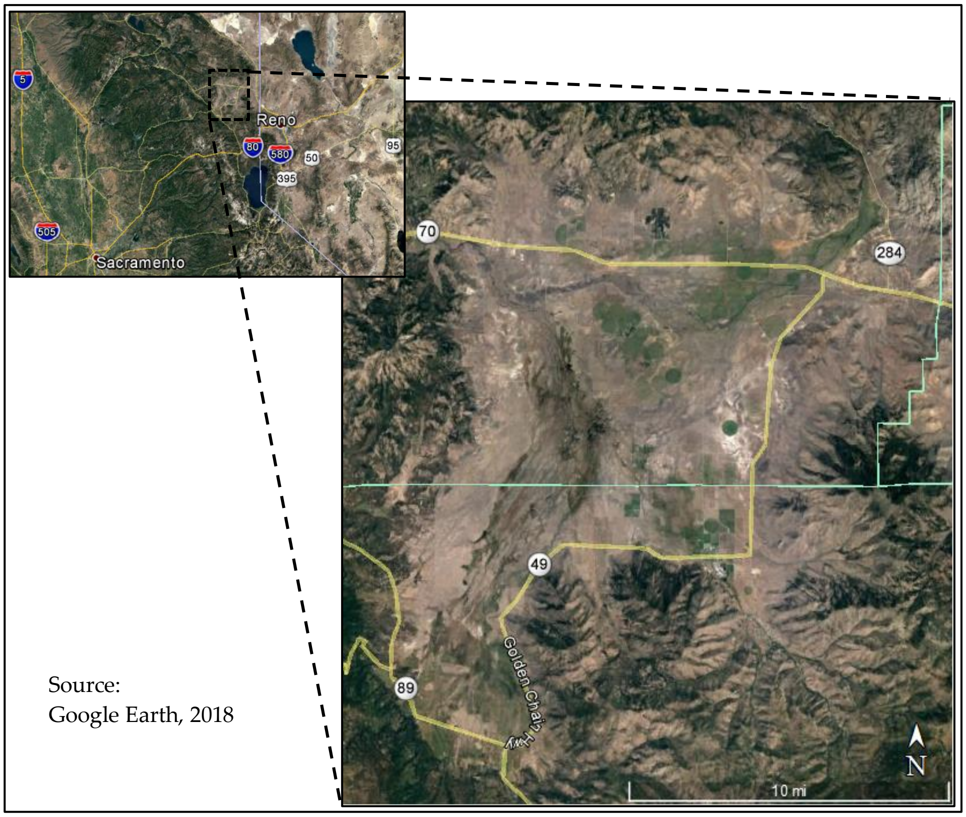
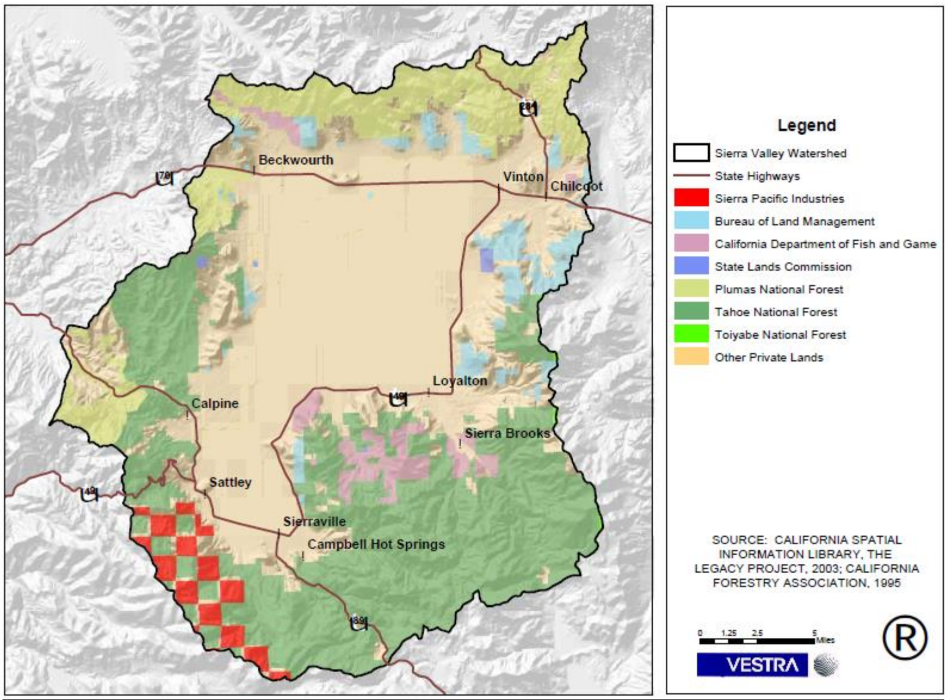


Figure 2.1-4. Location and 2018 Satellite Image of the Plan Area.



Owner	Total Acres	Percent of Watershed
Bureau of Land Management	11,733	3.9
California Department of Fish and Game	8,389	2.8
State Lands Commission	591	0.2
United States Forest Service	127,351	42.8
Plumas National Forest	*31,681*	*10.6*
Tahoe National Forest	*95,418*	*32.1*
Toiyabe National Forest	*252*	*0.1*
Subtotal Federal Acres	**148,064**	**49.7**
Unclassified Private Ownership	142,751	48.0
Sierra Pacific Industries	6,841	2.3
Subtotal Other Acres	**149,592**	**50.3**
Total	**297,656**	**100%**
Source: California Spatial Information Library, The Legacy Project, 2003 California Forestry Association, Private Timber Company Land Holdings Data, 1995		

Figure 2.1-5. Sierra Valley Watershed Boundary, State Highways, Locations of the Communities within the Plan Area, and Land Ownership (Vestra, 2005).

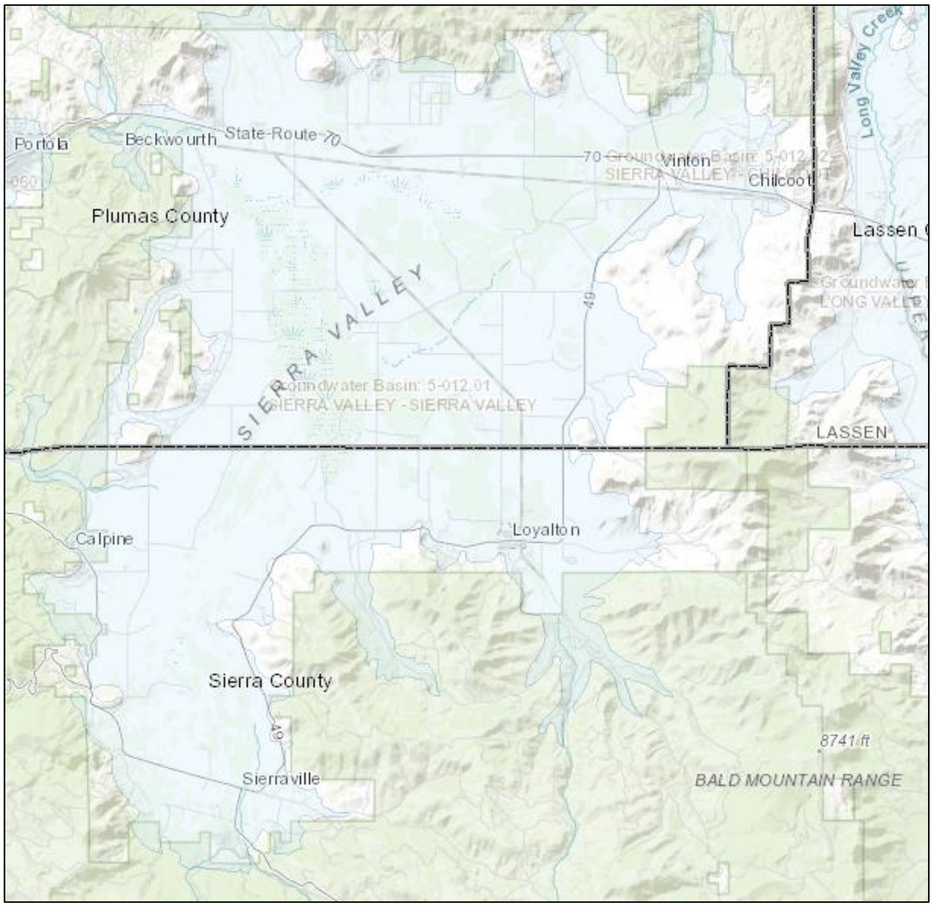


Figure 2.1-6. Plan Area Counties (Sierra and Plumas) shown atop Groundwater Basin Boundaries (source: Groundwater Information Center Interactive Map Application, 2019).

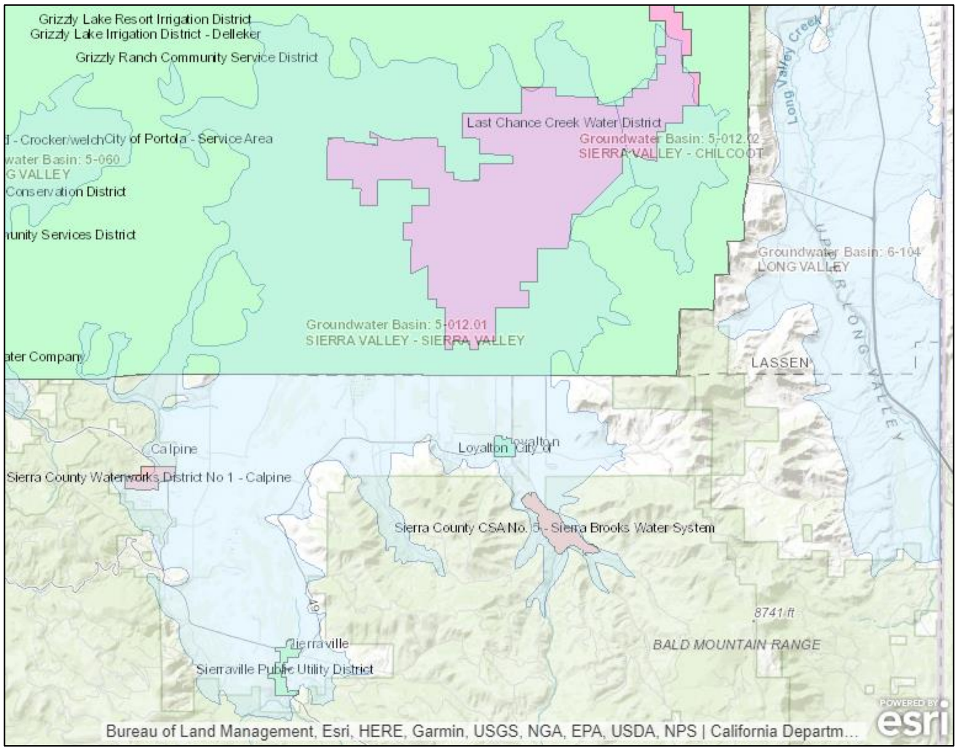


Figure 2.1-7. Plan Area Agencies with Water Management Responsibilities (Plumas County Flood Control and Water Conservation District – green, Last Chance Creek Water District shown – purple, City of Loyalton Water District – teal, Sierra Brooks Water System – pink/purple, Sierraville PUD – blue, Sierra County Waterworks District No. 1 Calpine - pink) shown atop Groundwater Basin Boundaries (source: Groundwater Information Center Interactive Map Application, 2019).

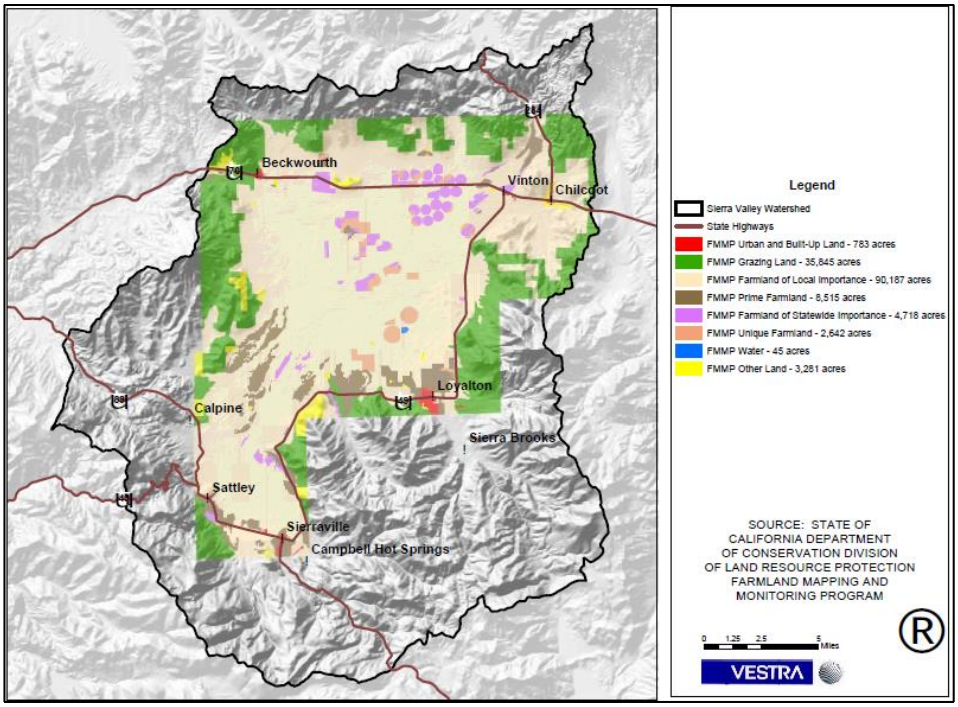


Figure 2.1-8. Existing Land Use Designations in the Plan Area (Vestra, 2005).

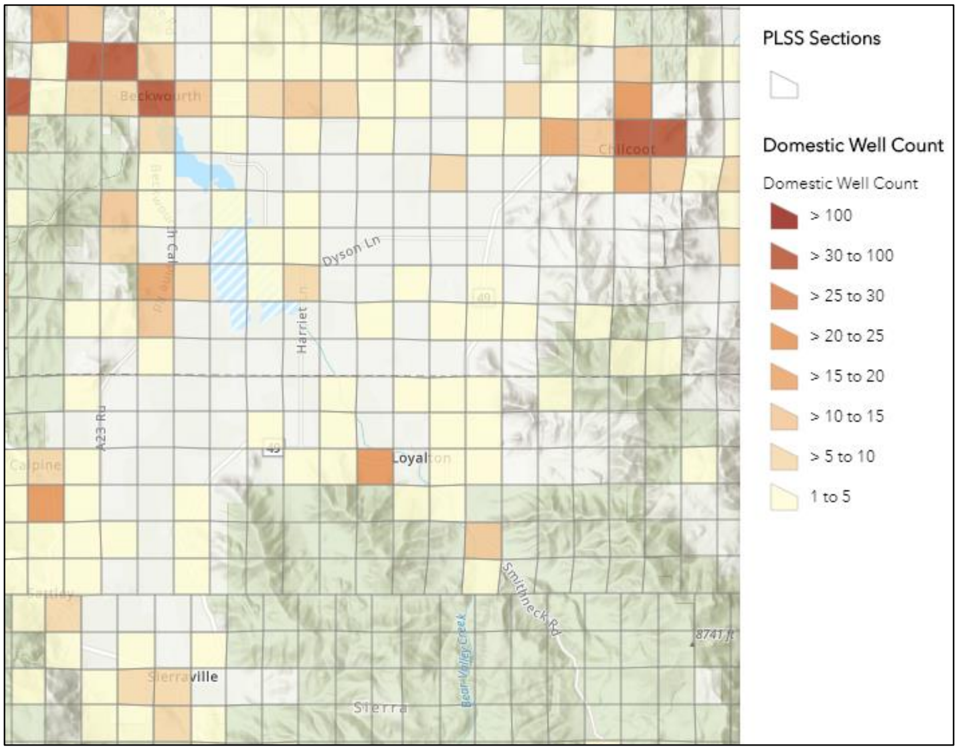


Figure 2.1-9. Approximate Number of Domestic Wells per Square Mile within the Plan Area (source: DWR Well Completion Report Map Application).

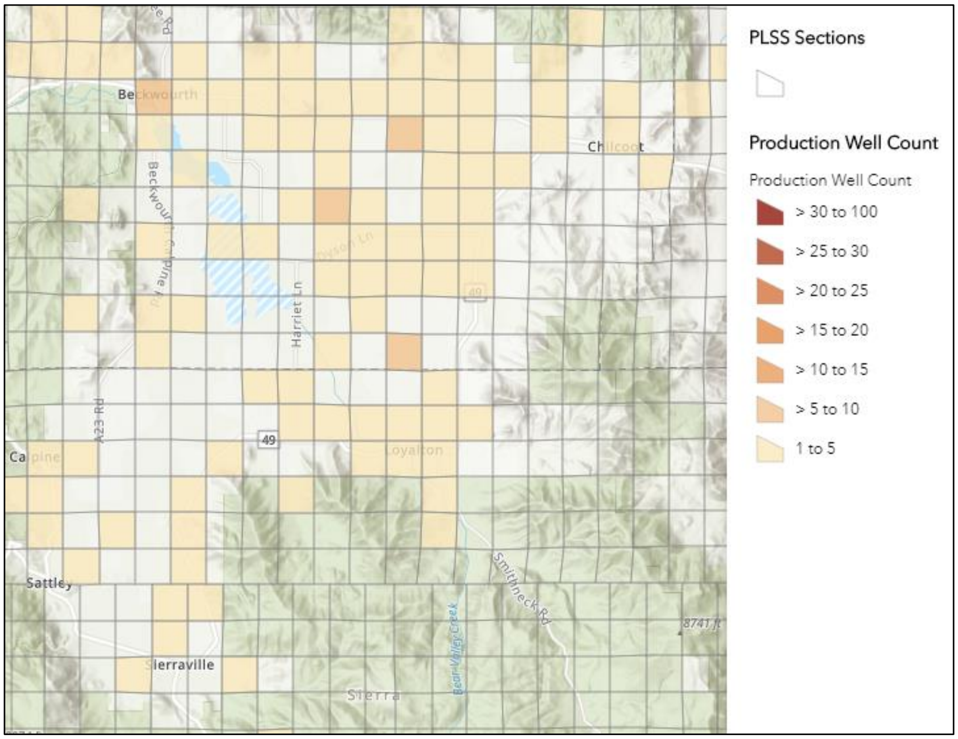


Figure 2.1-10. Approximate Number of Production Wells per Square Mile within the Plan Area (source: DWR Well Completion Report Map Application).

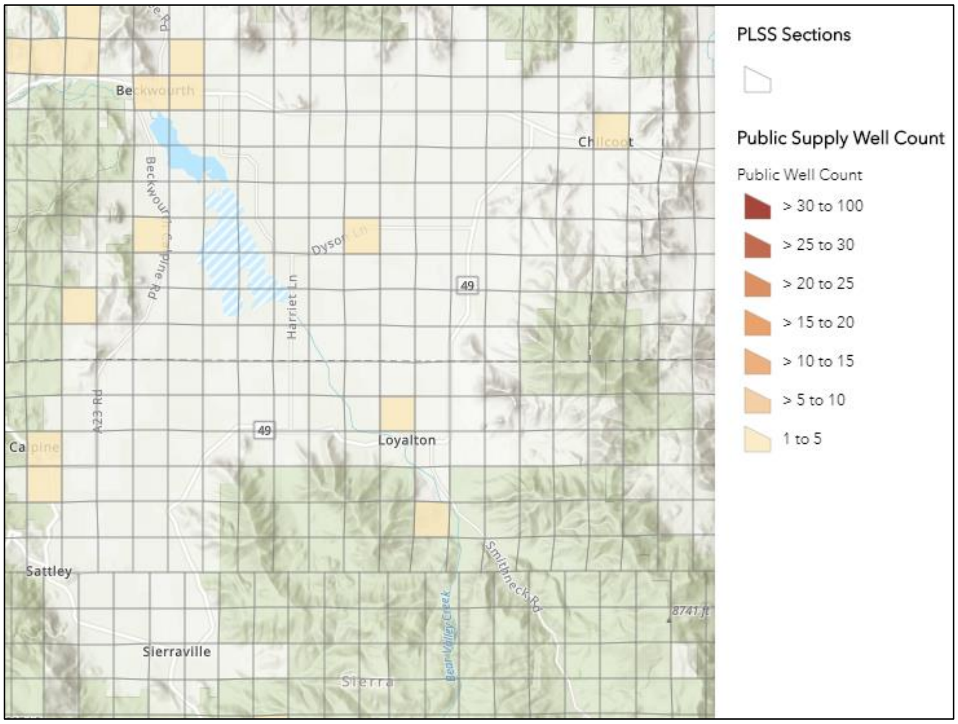


Figure 2.1-11. Approximate Public Wells per Square Mile within the Plan Area (source: DWR Well Completion Report Map Application).

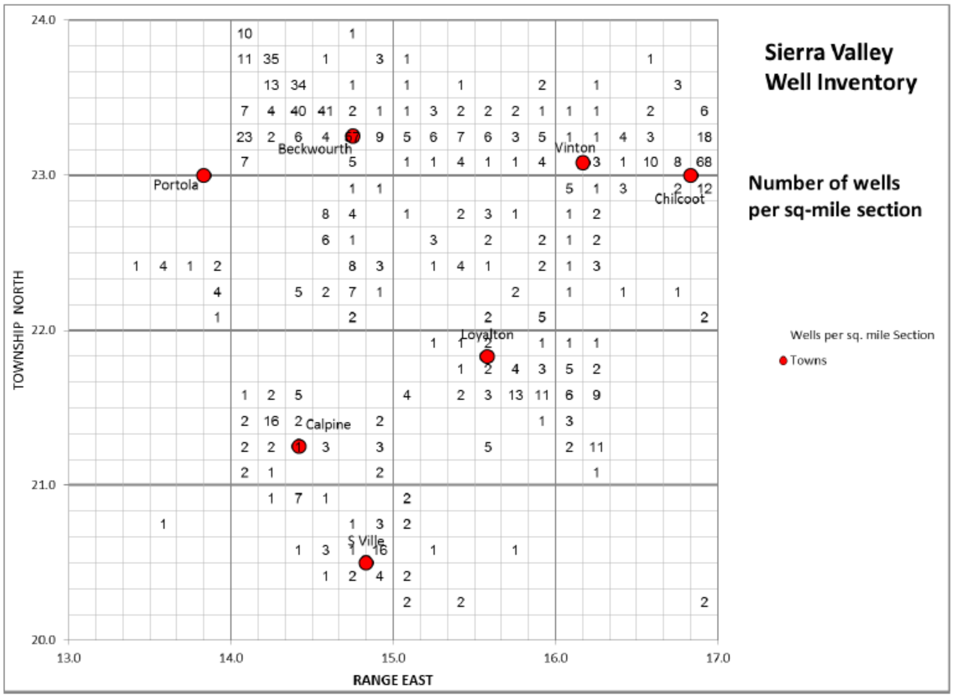


Figure 2.1-12. Total Number of Wells per Square Mile Section from Well Log Inventory (Bohm, 2016a).

Table 2.1-1. Percent Breakdown of Wells in Sierra Valley by Type (Bohm, 2016a).

type of use	number of wells		
domestic	636	74.3%	DOM
irrigation	53	6.2%	IRR
monitoring	42	4.9%	MON
stock	22	2.6%	STK
other	19	2.2%	OTH
public	19	2.2%	PUB
exploration & testing	26	3.0%	EXP &TES
destroyed	12	1.4%	DES
unknown	12	1.4%	UNK
unused	10	1.2%	Unused
industrial	4	0.5%	IND
municipal	1	0.1%	MUN
total	856	100.0%	

2.1.1 Summary of Jurisdictional Areas and Other Features (*Reg. § 354.8 b*)

Per Reg. § 354.8(b), the GSP must include a written description of the Plan Area, including a summary of the jurisdictional areas and other features depicted on the maps.

2.1.1.1 Plan Area, Exclusive Agencies, and Adjacent Basins

The Plan Area is the area within the SV Subbasin as most recently defined in the Bulletin 118 February 2019 Update (following 2019 Basin Boundary Modification) and viewable on the SGMA Basin Prioritization Dashboard tool (available here: https://gis.water.ca.gov/app/bp-dashboard/final/).This area is the primary focus of this Plan Concept Document and is the area in which compliance with SGMA is required because the SV Subbasin was characterized as a medium priority (DWR, 2018). Although the Plan Area is technically the area within the SV Subbasin only, much of the descriptions, data assessment, monitoring, and management actions and projects included in this Plan Concept Document include areas beyond the SV Subbasin. The reasoning for this is that there are areas within SVGMD boundaries (but outside of the SV Subbasin boundary) which are significant from a groundwater sustainability perspective and for which SVGMD's enabling legislation gives legal authority to monitor and manage groundwater. For example, the northeastern corner of the valley (defined as the Chilcoot Subbasin - DWR Groundwater Basin Number 5-12.02) is within the SVGMD boundary but not within the SV Subbasin and has significant hydrologic connection with the SV Subbasin. Additionally, critical recharge areas in the higher elevation areas surrounding Sierra Valley are within the SVGMD boundary but not within the SV Subbasin boundary. The "management areas" that arise from these and other distinctions are explicitly defined in Section 2.2.4 of this Plan Concept Document.

Because a small area (around 100 acres, < 0.1% of the SV Subbasin) of the SV Subbasin extends beyond the SVGMD statutory boundary, SVGMD cannot be the exclusive GSA for the entire Plan Area. Accordingly, Plumas County is the exclusive GSA for the small area identified in Figure 2.2 and SVGMD is the exclusive GSA for the remainder of the Plan Area. The two primary jurisdictional areas are therefore:

1. SVGMD's SGMA jurisdictional area, which is the portion of the Plan Area which is within the SVGMD boundary (see Figure 2.1-1), and
2. Plumas County's SGMA jurisdictional area, which is the portion of the Plan Area which is not within the SVGMD boundary (see Figures 2.1-1 and 2.1-2).

All groundwater basins adjacent to the SV Subbasin are very low priority basins, including the Chilcoot Subbasin (DWR, 2018). Adjacent groundwater basins, as shown in Figure 2.1-3, include:

- Long Valley Groundwater Basin (DWR Groundwater Basin Number 6-104) to the east,
- Clover Valley Groundwater Basin (DWR Groundwater Basin Number 5-058) to the north,

- Grizzly Valley Groundwater Basin (DWR Groundwater Basin Number 5-059) to the northwest,
- Humbug Valley Groundwater Basin (DWR Groundwater Basin Number 5-060) to the west, and
- Mohawk Valley Groundwater Basin (DWR Groundwater Basin Number 5-011) to the west south of the Humbug Basin.

The SV Subbasin is located within the Sierra Valley, a valley renowned for its beauty, habitat (nationally designated Important Bird Area and largest wetland in the Sierra Nevada Mountains; FRLT, 2018), biodiversity (one of the most biodiverse landscape in the United States; FRLT, 2018), and size (commonly regarded as the largest high-alpine valley in the United States; Vestra, 2005). Sierra Valley is an irregularly shaped, complexly faulted valley located in eastern Plumas and Sierra Counties of northeastern California. The outer boundaries of the SV Subbasin and Chilcoot Subbasin (excluding the straight-line boundary held in common) approximately parallel the boundaries of Sierra Valley (defined by the interface of the valley floor and surrounding mountains), with some minor exceptions, as evident in Figure 2.1-1. The SV Subbasin has a surface area of 184 square miles (DWR, 2004a) and the Chilcoot Subbasin has a surface area of 12 square miles (DWR, 2004b). The hydrologic connection between the Sierra Valley Subbasin and the Chilcot Subbasin is known to be significant, with some level of surface water hydrology and groundwater interaction, but is not well understood. According to DWR (2004b), the subbasins are to some extent discontinuous at depth due to a bedrock sill (DWR, 2004b).

2.1.1.2 Adjudicated Areas, Other Agencies, and Areas Covered by Alternative

As described above, the Plan Area currently has no adjudicated groundwater areas and there are no areas within the Plan Area that are covered by an Alternative. In the event that any groundwater areas become adjudicated in the future or any areas become covered by an Alternative, a figure will be added to Section 2.1 identifying such areas and descriptions will be added here. The only Agency (as defined in Reg. § 351. of the California Code of Regulations) within the Plan Area other than SVGMD is Plumas County. The area within the Plan Area for which Plumas County is the exclusive GSA is identified in Figure 2.1-2. SVGMD is the GSA for the remainder of the Plan Area.

2.1.1.3 Jurisdictional Boundaries

Other jurisdictional areas (federal, state, and water agencies) and areas covered by relevant general plans within the Plan Area include the following:

1. Bureau of Land Management lands, California Department of Fish and Wildlife lands, State Lands Commission lands, and National Forest lands (see Figure 2.1-5);
2. Tribal lands, the boundaries of which roughly match the boundaries of Plumas County's SGMA jurisdictional area (see Figure 2.1-2);

3. The portion of the Plan Area within Plumas County (Plumas County jurisdictional area – covered by Plumas County General Plan) and the portion of the Plan Area within Sierra County (Sierra County jurisdictional area – covered by Sierra County General Plan), and the area within the City of Loyalton (City of Loyalton jurisdictional area – covered by City of Loyalton General Plan), see Figures 2.1-6 and 2.1-7; and
4. The portion of the Plan Area within the following agencies with water management responsibilities: Plumas County Flood Control and Water Conservation District, Last Chance Creek Water District shown, City of Loyalton Water District, Sierra Brooks Water System, Sierraville PUD, and Sierra County Waterworks District No. 1 Calpine, see Figure 2.1-7.

As previously introduced, the only community in the Plan Area that is an incorporated city is Loyalton (boundaries approximately match the Loyalton Water District boundaries as portrayed in Figure 2.1-7), the counties within the Plan Area are Plumas and Sierra Counties as portrayed in Figure 2.1-6 (showing county boundaries overlaid atop the groundwater basin boundaries), and there are no tribal homelands or tribal land trusts based on data collected and mapped by DWR (2011). In the event that tribal lands are identified within the Plan Area in the future, a description of such lands will be added to this Section. Any other future changes to the information provided here will also be incorporated/the Plan will be revised accordingly within a reasonable timeframe.

2.1.1.4 Land Use and Water Sources

Land use is generally characterized by incremental intensities of human use by various types such as residential, commercial, industrial, agricultural, mineral resources, recreational, or natural resources and is typically controlled directly by local regulations and indirectly by other state and federal laws intended for public safety, public welfare, or to protect natural resources (Vestra, 2005). Demographics are often described in conjunction with land use to provide spatial information about population patterns in specific areas for factors such as density, race, age, and income. Demographics are generally reflective of current land use while land use plans, such as general plans, represent a desired blueprint for future development. Demographics and other land use data is described here. Land use elements of applicable general plans are described in Section 2.1.3. Much of the information provided here was excerpted from Vestra (2005) and is watershed-scale data.

There are several small communities in the Sierra Valley, mostly near the valley edges. The communities, clockwise (roughly) from northwest to southwest, are: Beckwourth, Vinton, Chilcoot, Sierra Brooks, Loyalton, Campbell Hot Springs (a.k.a. Sierra Hot Springs), Sierraville, Sattley, and Calpine. Figure 2.1-5 shows the Sierra Valley watershed boundary, which fully encompasses the Plan Area and extends slightly into Lassen County to the northeast, and the communities of Sierra Valley with state highways and county lines shown.

Beckwourth is a census-designated place (CDP) in Plumas County located near the northwest corner of the valley. The population of Beckwourth from the 2010 census was 432 at the 2010 census, up from 342 from the 2000 census.

Vinton is an unincorporated community in Plumas County located near the northeast corner of the valley. For census purposes, Vinton is included in the CDP of Chilcoot-Vinton.

Chilcoot is an unincorporated community in Plumas County located near the northeast corner of the valley, also included in the CDP of Chilcoot-Vinton. The population of the Chilcoot-Vinton from the 2010 census was 454, up from 387 from the 2000 census.

Sierra Brooks is a CDP community in Sierra County located near the southeast corner of the valley. The population of Sierra Brooks from the 2010 census was 478.

Loyalton is an incorporated city in Sierra County located near the southeast corner of the valley. The population of Loyalton from the 2010 census was 769, down from 862 from the 2000 census.

Campbell Hot Springs, also known as Sierra Hot Springs, is a small resort community located near the southern boundary of valley. There is no population data for the community of Campbell Hot Springs. The year-round population is minimal, but the community hosts a considerable number of tourists annually in its lodge, hotel, and camping area. Campbell Hot Springs is the only community in Sierra Valley with such accommodations for tourism.

Sierraville is a CDP community in Sierra County located near the southern boundary of the valley. The population of Sierraville from the 2010 census was 200.

Sattley is a CDP community in Sierra County located near the southwest corner of the valley. The population of Sattley from the 2010 census was 49.

Calpine is a CDP community in Sierra County located near the southwest corner of the valley. The population of Calpine from the 2010 census was 205.

The cumulative population of these communities from the 2010 census comes to about 2,600 people. The remainder of the population in the valley (likely less than 500 people) is spread out on rural parcels, mostly R-20 (20-acre), R-40 (40-acre), and R-160 (160-acre) parcels, many of which are family ranches. Based on population growth trends and anecdotal data, it is expected that the population of the communities of Sierra Valley will remain relatively stable, with the most significant changes expected to occur in the northeast and southeast portions of the valley (i.e. Chilcoot and Sierraville) as a side-effect of rapid population growth in the nearby Reno and Truckee areas.

Land ownership in the Sierra Valley Watershed is approximately 50 percent public and 50 percent private. The USFS, BLM, California Department of Fish and Game (CDFG), and State Lands

Commission hold approximately 58 percent of the watershed. Of the 50 percent of the land held by federal agencies, the USFS is the biggest landholder with approximately 43 percent. There are three national forests in the Sierra Valley Watershed. Approximately 32 percent of the USFS is in the Tahoe National Forest; 11 percent is in the Plumas National Forest, and less the one percent is in the Toiyabe National Forest.

The Sierra Valley Watershed is spread across three counties including: Plumas, Sierra, and a small portion in Lassen The Sierra Valley Watershed has one legislative district for the Assembly and the Congressional and is located in District 3 for the Assembly and District 4 for the Congressional.

The primary existing land use designation is agriculture/cropland and grazing. As shown in Figure 2.1-8, there are numerous farmland designations in the Sierra Valley defined by the California State Farmland Mapping and Monitoring Program. These include urban and built-up land (783 acres), grazing land (35,845 acres), farmland of local importance (90,187 acres), prime farmland (8,515), farmland of statewide importance (4,718 acres), unique farmland (2,642 acres), water (45 acres), and other land (3,281 acres). Although water makes up a relatively small portion of the estimated land use/cover, it should be noted that FEMA floodplain (area expected to be inundated by a 100-year flood event) comprises a significant portion of the valley.

A wide variety of crops are grown throughout Sierra Valley, including alfalfa, improved pasture, meadow pasture, grain, Christmas tree farms, and specialty crops. The majority of crops are pasture or production of hay. The top five crops in Plumas and Sierra County for 2002 listed by value were timber products, cattle, irrigated and dryland pasture and rangeland pasture, alfalfa hay, and other hay (CFBF, 2004).

Others land uses include various forms of recreation. Large areas of open space that are publicly and privately owned accompany relatively low density of human settlement in the Sierra Valley Watershed. Much of the land remains generally accessible for informal public recreational activities of a dispersed, low-intensity nature. These activities include camping, hunting, fishing, running, walking, mountain biking, cross-country skiing, snowmobiling, and nature study.

There are many existing laws governing land use in the Sierra Valley. For example, grazing allotments allow cattle ranchers to use public lands for three to six-month periods when it is necessary to have irrigated lands in hay production for winter-feeding. Allotments for USFS land total about 30 with approximately 133,259 acres, approximately 89 percent of the total USFS land. BLM allotments totals are about 20 with approximately 9,743 acres, approximately 83 percent of the total BLM land. Grazing legislation and allotment issues are a major concern in the Sierra Valley Watershed. There was a controversy in the mid-1970s over the grazing of public lands. BLM was charged with failing to consider the environmental impacts of their grazing program and failed to inform the ranchers of the proposed reductions. These actions resulted in many lawsuits filed by ranchers and an intense mistrust of the BLM. Responding to the turmoil, Congress passed the 1978 Public Rangelands Improvement Act (PRIA). This, and other laws including the Federal Land Policy and Management Act, the National Environmental Policy Act, and the Endangered Species Act, are just a few of the policies shaping the management practices in the Sierra Valley. Water Rights law and existing water rights in Sierra Valley (described in Section 2.1.2) also play a major role in dictating land use (crop production, grazing).

Water sources for domestic, commercial, industrial and irrigation water supply are both surface water and groundwater. DWR basin prioritization (DWR, 2019a) states that groundwater makes up 36% of the total water supply in the SV Subbasin. See Section 2.2.1.5 for additional information on water sources and delivery. Because of the surplus of surface water during the wet season and lack of surface water during the dry season, conjunctive use of surface and groundwater is a critical component of water supply management in Sierra Valley. Conjunctive use programs and practices are described in Section 2.1.2.3 of this Plan Concept Document.

2.1.1.5 Groundwater Well Density and Groundwater Dependent Communities

As described in Section 2.1, all of the communities within the Plan Area are to some extent groundwater dependent except for Campbell Hot Springs, which relies on a spring source. Campbell Hot Springs has plans for expansion which may necessitate supplementing the spring source with groundwater. In the event that such expansion occurs, this Section will be revised accordingly. Of the remainder of the communities, Sierraville and Calpine are the most likely to be capable of securing alternative water sources (i.e. springs, creeks) due to the relative wetness/higher precipitation averages and surface water inputs along the southern edge of the valley.

The density of wells per square mile, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, utilizing data provided by DWR, as specified in Reg. § 353.2, are shown in Figures 2.1-9, 2.1-10, and 2.1-11. As portrayed, the density of domestic wells, production (agricultural/industrial) wells, and public wells in the Plan Area range from 0 to 30-100, 0 to 10-15, and 0 to 1-5 per square mile, respectively, with the majority of domestic wells located around the communities of Sierra Valley, the majority of the production wells located in the central, northern, and eastern portions of the valley, and public wells primarily located within/around the communities of Beckwourth, Chilcoot, Loyalton, Sierra Brooks, and Calpine. A well inventory performed by Bohm (2016a), based primarily on well logs, provides perhaps the most comprehensive well dataset.

Commented [GH14]: We will probably need to do better than this. SVGMD has all well coordinates in speadsheets, including geothermal and inactive wells.

Agricultural wells make up the majority of pumping, as subsequently described (see Section 2.2). Industrial wells are limited to the SPI Biomass Power Plant Supply Well near Loyalton and a number of smaller wells providing water to industrial facilities near the towns of Sierra Valley, especially Beckwourth.

2.1.2 Water Resources Monitoring and Management Programs (*Reg. § 354.8 c, d, e*)

Per Reg. § 354.8(c), (d), and (e), this section includes description of water resources monitoring and management programs in the SV Subbasin, including:

- identification of existing water resources monitoring and management programs in the Sierra Valley, and description of any such programs SVGMD plans to incorporate in its monitoring network or in development of this Plan, (SVGMD may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan),
- a description of how existing water resource monitoring or management programs may limit operational flexibility in the SV Subbasin, and how the Plan has been developed to adapt to those limits, and
- a description of conjunctive use programs in the basin.

2.1.2.1 Existing Water Resources Monitoring Programs

Water resources have been monitored in the Sierra Valley in some fashion since the early days of settlers in the Valley. Documentation of water resources monitoring preceding the 1960's is relatively limited. Since then, formal and informal monitoring programs have generated a plethora of useful data. These programs and associated studies and findings are summarized below.

1) Groundwater Conditions Studies

   A key component of water resources monitoring in the SV Subbasin has been through the study of groundwater conditions and how they've changed over time. The SV Subbasin has been included in several geology and hydrogeology studies and has been the subject of numerous focused studies and monitoring projects. The first comprehensive study was by DWR (1983) and included review of all previous studies of the area geology, hydrogeology, and natural resources. Since 1983, DWR Northern District prepared eight annual updates on groundwater conditions in the Sierra Valley Basin extending through 1991 and Kenneth D. Schmidt and Associates prepared updates for the following time intervals: 1991-1994, 1994-1998, 1998-2003, 2003-2005, 2005-2011, 2011-2014, and 2014-2016. A comprehensive review of groundwater data was later prepared by Bachand and Associates (Bachand and Associated, 2019) which included data extending through 2018.

   Current and historic groundwater conditions as documented in the above-mentioned studies are described in detail in Section 2.2.2. of this Plan Concept Document. Studies and monitoring by SVGMD and DWR are ongoing, generating an increasingly complete picture of the water resources and hydrogeologic characteristic of the Sierra Valley, translating to reduced uncertainty and greater capacity for achieving sustainable management. Studies will be conducted and associated reports will be prepared annually throughout the implementation horizon of this Plan Concept Document, as described in Sections 5.3 and 5.4 of this Plan Concept Document.

2) Groundwater Level Monitoring

SVGMD has been monitoring groundwater levels in Sierra Valley since 1980. As of 2015, six District groundwater level monitoring wells were being monitored monthly as weather and access conditions allowed.

DWR has been monitoring groundwater levels since at least 1960. As of 2015, 51 wells in the main part of Sierra Valley and eight wells in the Chilcoot sub-basin were monitored. Monitoring frequency of DWR monitoring wells has typically been twice annually.

Other groundwater level monitoring includes piezometric monitoring of seasonal high groundwater levels in areas of proposed onsite wastewater treatment systems (OWTS) as required by the California Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy). Such monitoring typically takes place over one winter/spring at depth of approximately 8 feet and less. All associated data is filed through the Plumas and Sierra County Environmental Health Departments.

Current and historic groundwater level monitoring observations are described in detail in Section 2.2.2.1 of this Plan Concept Document. A detailed description of the groundwater level monitoring network and protocol and proposed improvements is provided in Section 3.5 of this Plan Concept Document.

3) Agricultural Groundwater Extraction Monitoring

SVGMD has been monitoring agricultural groundwater extraction using flowmeters since 1989. As of 2015, pumpage from 50 active agricultural wells was metered. Current and historic agricultural groundwater extraction data are depicted and trends discussed in Section 2.2.3 of this Plan Concept Document. Agricultural groundwater extraction monitoring is critical for water budget refinement and sustainable management of groundwater resources, as groundwater extraction for agriculture far exceeds groundwater extraction for municipal, industrial, commercial, and de minimum uses. As detailed in Section 2.2.3, having complete data records dating back to 1989 enables assessment of the dynamics of groundwater use and groundwater system response and the relation of weather patterns with groundwater use, positioning SVGMD to predict changes in demands and likely basin impacts on the basis on weather patterns. This is one significant advantage SVGMD has over most other basins in the state with regard to ability to sustainability manage groundwater. Per SVGMD Ordinance 82-03, continued monitoring of agricultural extraction wells is required in the SV Subbasin.

4) Stream and Channel Surface Water Flow Monitoring

   Stream and channel surface water flows have been and continue to be monitored by the area Water Master. Additionally, a stream gauge along the Middle Fork of the Feather River near the outlet from Sierra Valley (CDEC MFP; USGS 11392100) has been monitored and maintained since 1968. USGS monitored and maintained the gauge from 1968 to 1980 (data available from: https://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11392100) and DWR has monitored and maintained the gauge since 2006 (data available from: https://water.weather.gov/ahps2/hydrograph.php?wfo=rev&gage=mftc1). Available data include daily flow records for the water years 1969-1980 and 15-minute discharge records from 10/31/2006 to present. The gauge data was utilized to calculate surface water outflow in the water budget development (see Section 2.2.3) and will continue to provide critical information for water budget refinement and associated groundwater management decision making.

   Water Master data dating back to 2011 was obtained by SVGMD in 2018 for analysis to supplement water budget development/conjunctive use assessment (see Section 2.2.3). 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.

   Additional stream and channel surface water flow monitoring would be beneficial and is proposed as described in Section 3.5.

5) Water Quality Monitoring

   Sierra Valley groundwater chemistry data have been collected by DWR since the late 1950's and SVGMD has expanded the database through their monitoring efforts. The first comprehensive groundwater chemistry data was collected in 1981, including major ion chemistry and selected trace element data from 40 wells. Over the following 14 years DWR continued collecting data and by 1995 a total of 177 samples had been collected from 67 wells. This database was expanded with another 27 wells sampled in 2002 by a contractor working for the SVGMD (data in Schmidt, 2003). Fourteen chemistry data sets were later collected from the five District monitoring wells sampled at shallow, intermediate, and deep levels (Schmidt, 2003; 2005). These monitoring wells were resampled in the summer of 2015, including for light stable isotopes. A groundwater chemistry data base of 45 samples collected in 2014 from selected valley floor wells was developed as part of a SVGMD-funded study (Bohm, 2016a).

   Surface water quality has also been monitored. 48 surface water quality samples were taken between 1970 and 1980 at USGS Steamgage 11392100 (Middle Fork Feather River, a few miles downstream from Sierra Valley). Additionally, an isotope database was collected from upland springs and streams as part of the SVGMD-funded study (Bohm, 2016a).

Current and historic water quality observations are described in detail in Section 2.2.2.4 of this Plan Concept Document. A detailed description of the water quality monitoring network and protocol and proposed improvements is provided in Section 3.5 of this Plan Concept Document.

6) Weather Monitoring

Several weather stations exist in the vicinity of the SV Subbasin (Sierraville, Frenchman, Davis) and several relevant studies of precipitation and snow patters have been conducted (Dib et al., 2017; others). The data is important and useful for water budget development (see Section 2.2.3), understanding weather patterns and implications on groundwater use and associated impacts, and groundwater management decision making. However, as described in Dib et al., 2017, there is a lack of useful observation data Sierra Valley and a need for additional monitoring stations. Accordingly, steps have been made to increase weather data collection, as described in Section 3.5.

2.1.2.2 Existing Water Resources Management Programs

Several water resources management programs exist in the Sierra Valley, including surface water rights allocation management/tracking by the area water master, waterway preservation/restoration efforts by the Sierra Valley Resource Conservation District, groundwater management by SVGMD (including a well inventory and tracking program, with a database of coordinates of all agricultural, commercial, industrial, municipal, inactive, and geothermal wells).

2.1.2.3 Conjunctive Use Programs

According to the Water Education Foundation, Conjunctive Use is a catch-phrase for coordinated use of surface water and groundwater. In its passive form ("in-lieu conjunctive use"), surface water is used in wet years/during the wet season and groundwater is used in dry years/during the dry season. In active conjunctive use, groundwater recharge is actively enhanced during periods of abundant surface water ability via storing and injecting or flooding or other methods (known as "groundwater banking") to be used as needed during periods of limited surface water availability.

In the SV Subbasin, in-lieu conjunctive use plays a major role in optimizing management/use of water resources. It is common practice in the SV Subbasin to maximize surface water use for irrigation as water rights allow and switch to groundwater irrigation/supplement with groundwater irrigation only as needed (groundwater irrigation demand = total irrigation demand – surface water irrigation supply). The degree of such conjunctive use/opportunity for conjunctive use varies widely from ranch to ranch depending on water rights/availability, with some of the ranches in the valley able to meet irrigation demand entirely with surface water during typical water years and others depending on groundwater entirely even during wet years. Generally speaking, surface water is more abundantly and reliably available in the southern/western portions of the valley, where precipitation totals are high and the number of tributaries flowing down from the surrounding hills are greater in number relative to the northern/eastern portions of the valleys. As a result of years of decades of ranching, water rights allocations, etc., in-lieu conjunctive use is generally maximized in the Sierra Valley, with a wide array of diversions, conveyance channels, and irrigation ditches in existence throughout the valley, as described in Section 2.2.1.5 of this Plan Concept Document.

Opportunities for active conjunctive use in Sierra Valley, however, are somewhat limited. Existing active conjunctive use programs include the reuse of treated wastewater from the Loyalton wastewater treatment system (originates as GW from Loyalton's wells mostly), to irrigate alfalfa fields and reuse of wastewater generated at the biomass plant in Loyalton (also originating from well water) to irrigate fields. Construction of ponds on certain parcels and efforts to improve recharge by property owners (i.e. through construction of on-contour swales to infiltrate sheet flow runoff) are also somewhat prevalent in the valley and along the valley periphery. Work with US Forest Service to improve upland recharge through improved forest management is also an ongoing example of could be considered active conjunctive use.

Perhaps the greatest opportunity for conjunctive use in the SV Subbasin is optimization of storage of water in Frenchman Lake (reservoir)during the wet season and years of above-average precipitation and strategic use for surface irrigation and recharge in the SV Subbasin during the dry season, especially during years of below average precipitation. Such optimization would require the GSAs of the SV Subbasin to work together with DWR on revising the Frenchman Dam operating policy in a fashion that doesn't disrupt the State Water Project.

Over the course of the implementation of this Plan Concept Document, the GSAs of the SVGMD will be striving to optimize these conjunctive use strategies and merge them with conjunctive water management, which includes improving monitoring, evaluation of monitoring data, and use of monitoring data to establish and enforce local management policies, to contribute to the underlying strategy of maximizing groundwater recharge and minimizing agricultural groundwater demand.

2.1.2.4 Incorporating Existing Water Resources Monitoring and Management Programs to the GSP

The existing monitoring programs and networks provide a plethora of data elucidating the sustainability of the current condition in the Sierra Valley as described in Section 2.2.2. The existing monitoring programs and networks will be improved as described in Section 3.5.4 to ensure sustainability conditions can be adequately monitored and documented.

Existing water resources management programs will also be continued and strengthened in concert with the implementation of this Plan Concept Document through an integrated effort between local districts, agencies, etc., and relevant state entities.

No conflicts are expected to arise between monitoring and/or management programs as a result of the implementation of this Plan Concept Document.

2.1.2.5 Limits to Operational Flexibility from Existing Water Resources Monitoring and Management Programs

The existing monitoring and management programs described above are not expected to limit the operation flexibility of this GSP.

2.1.3 Land Use Elements/Topic Categories of Applicable General Plans (*Reg. § 354.8 f*)

Per Reg. § 354.8(f), this section includes:

- Summary of general plans and other land use plans
    - Information could include crop types and acreages, urban land designation, and identification of open spaces.
- Description of how implementation of the land use plans may change water demands or affect achievement of sustainability and how the GSP addresses those effects
- Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans
- Summary of the process for permitting new or replacement wells in the basin
- Information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management

2.1.3.1 Summary of General Plans and Other Land Use Plans

The primary land users on private property, excluding urban areas, are those associated with timber production, recreation, and agriculture (ranching, hay, alfalfa, and wild rice). The passage of the California Land Conservation Act of 1965, commonly known as the Williamson Act, enables local governments to enter into 10 or 20-year contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In exchange, landowners receive lower property tax assessments based upon farming and open space designation rather than current market value. The local government receives the lost property tax revenues from the state via the Open Space Subvention Act of 1971. All cities and counties are required by State law to prepare and periodically update general plans.

General plans are intended to guide growth in light of sensitive resources—both human and natural—and available services. Specifically, Government Code Section 65031.1 provides growth be guided by a general plan with goals and policies directed to land use, population growth and distribution, open space, resource preservation and utilization, air and water quality, and other physical, social, and economic factors. Sierra Valley Watershed is subject to county general plans, except the federally owned lands within the Sierra Valley Watershed. The process to update general plans involved extensive public review and environmental review under the California Environmental Quality Act (CEQA).

Plumas County's General Plan objectives are to identify and protect for present and future utilization of commercially viable resource production areas with safeguards for the surrounding lands and the environment. It is also used to establish land use patterns based on constraints and opportunities with intensity and density of development tied largely to the availability of public facilities and services.

Sierra County's General Plan objective is to protect existing qualities and address local concerns as Sierra County grows. Plan objectives and fundamental goals of the General Plan are as follows:

- It is the county's most fundamental goal to maintain its culture, heritage, and rural character and preserve its rural quality of life.
- It is the county's goal to defend its important natural features and functions; these have included and always will include scenic beauty, pristine lakes and rivers, tall mountain peaks and rugged forested canyons, abundant and diverse plants and animals, and clean air, water, and watershed values.
- It is the county's goal to foster compatible and historic land uses and activities which are rural and which contribute to a stable economy.
- It is the county's goal to direct development toward those areas already developed, where there are necessary public facilities, and where a minimum of growth inducement and environmental damage will occur. The pattern of land uses sought by the county is a system of distinct and cohesive rural clusters amid open land.
- It is the county's goal to provide a comprehensive plan for all lands and uses within the county regardless of ownership or governmental jurisdiction.
- The previous mentioned objectives are carried out in detailed policies, implementation measures, land use diagram, and the overall theme of the General Plan, which is as follows:
    - Direct growth of the community influence and community core areas;
    - Discourage development outside these communities;
    - Create Special Treatment Areas where a more detailed level of planning is needed due to resources or constraints in these areas;

- Utilize optional general plan elements to emphasize protection of the environment and economic value of the County's resources;
- Protect the county's natural resource-based industries; and
- Limit extension of county services outside the Community Core and Community Influences Areas to reduce fiscal impacts and protect the environment and economic value of the county's resources.

Other relevant General Plans and/or Land Use Plans likely exist, for example City of Loyalton General Plan and Feather River Land Trust Land Use Plan, but documentation on such Plans could not be obtained.

2.1.3.2 Description of How Land Use Plan Implementation May Change Water Demands or Affect Achievement of Sustainability and How the GSP Addresses Those Effects

No land use plans have been identified which are considered likely to significantly affect water demands or achievement of sustainability in the SV Subbasin. Should any such plans be identified in the future, they will be added to this Plan Concept Document here as well as discussion of coordination and other efforts that will seek to address such effects.

2.1.3.3 Description of How Implementation of GSP May Affect the Water Supply Assumptions of Relevant Land Use Plans

No land use plans have been identified which have water supply assumptions that are considered likely to be affected by implementation of this GSP. Should any such plans be identified in the future, they will be added to this Plan Concept Document here as well as discussion of coordination and other efforts that will seek to prevent such effects or adjust the land use plan water supply assumptions accordingly.

2.1.3.4 Summary of Processes for Permitting New or Replacement Wells in the SV Subbasin

The process for permitting new wells in the SV Subbasin is governed by SVGMD Ordinance 18-01, which requires that all applications to construct wells in the SV Subbasin be reviewed and approved by SVGMD prior to permit issuance by Plumas or Sierra Counties and limits construction of new high capacity wells where such construction would likely impact groundwater resources (e.g. within the "Restricted Area" as described in Section 2.2.4). SVGMD approved applications for which sufficient data is available which suggests construction and use of the proposed well will not adversely impact sustainability of groundwater management.

The process for permitting replacement wells is governed by the same ordinance. Replacement wells are typically permissible provided the proposed replacement well does not exceed the capacity of the well it is replacing, as documented by the well pumping rate capacity recorded on the well log by the well driller at the time of construction of the original well which is being replaced.

The aforementioned ordinance and a supplemental notice letter sent by SVGMD to the land owners of Sierra Valley shortly after passage of the ordinance addressed existing inactive wells in the valley. The ordinance/letter required resident to respond to the letter registering (i.e. providing the number of and information on) any existing inactive wells that may be present on their property, stated that failure to register inactive wells within the allotted timeframe would effectively forfeit the right for an owner to reactive an inactive well, and stated that reactivation of any inactive well would be subject to SVGMD approval. In doing so, SVGMD was able to complete their existing well database and bring the last remaining "unmanaged" potential groundwater extraction path under the control of the District (such that groundwater pumping capacity cannot be significantly increased without the knowledge and approval of SVGMD).

2.1.3.5 Information Regarding the Implementation of Land Use Plans Outside the SV Subbasin that could Affect the Ability of the GSAs to Achieve Sustainable

No land use plans outside the SV Subbasin have been identified which are thought to have the ability to significantly affect the GSAs ability to achieve sustainable groundwater management in the SV Subbasin. Should any such plans be identified in the future, they will be added to this Plan Concept Document here as well as discussion of coordination and other efforts that will seek to prevent such effects.

2.1.4 Additional GSP Elements *(Reg. § 354.8 g)*

Per Reg. § 354.8(g), this section includes information on:

- Control of saline water intrusion
- Wellhead protection
- Migration of contaminated groundwater
- Well abandonment and well destruction program
- Replenishment of groundwater extractions
- Conjunctive use and underground storage
- Well construction policies
- Groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects
- Efficient water management practices
- Relationships with State and federal regulatory agencies
- Land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity

- Impacts on groundwater dependent ecosystems

2.1.4.1 Control of Saline Water Intrusion

Control of saline water intrusion is not applicable in the Sierra Valley due to its elevation above and distance from saline water sources.

2.1.4.2 Wellhead Protection

Minimum wellhead protection requirements for wells in the SV Subbasin is as described in the California Well Standards (Bulletin 74).

2.1.4.3 Migration of Contaminated Groundwater

With the limited data available, it is difficult to characterize or quantify the migration of contaminated groundwater in the SV Subbasin. Based on the most recent and comprehensive study on groundwater quality in the SV Subbasin (Bohm, 2016b), it is apparent that faulting in the valley significantly affects groundwater flow in several areas, largely by creating northeast and northwest trending groundwater migration zones. Bohm (2016b) also elucidated the primary sources of contaminated groundwater as being thermal waters associated with this faulting, especially in the central west part of the valley. In the event of groundwater contamination, migration of that contaminated groundwater would therefore likely be the highest risk in the vicinity of these faults. See additional information and discussion on water quality in Sections 2.2.1.4 and 2.2.2.4.

2.1.4.4 Well Abandonment and Well Destruction Program

Well abandonment and well destruction in the Sierra Valley is per the requirements described in the California Well Standards (Bulletin 74). Sierra and Plumas Counties have well abandonment and destruction requirements included in their respective codes as well.

2.1.4.5 Replenishment of Groundwater Extraction

Replenishment of groundwater extraction is by efforts to improve recharge through various projects and measures, include restoration projects and erosion control measures. Other forms of replenishment include water conservation efforts which reduce groundwater pumping thereby contributing to replenishment of the SV Subbasin aquifer system. Subsequent sections of this Plan Concept Document discuss these various replenishment efforts in greater detail.

2.1.4.6 Conjunctive Use Programs and Underground Storage

Several conjunctive use programs exist in Sierra Valley, as described in Section 2.1.2.3. Underground storage also exists. Based on best available data, it is expected that the majority of underground water storage in the SV Subbasin is for domestic/fire purposes at private residences for which public water access is not available. Such storage is typically in poly or precast concrete tanks ranging in size from a few thousand to several thousand gallons.

Perhaps of more relevant to groundwater management, particularly from a groundwater quality perspective, is underground fuel storage. The existing permitted Underground Storage Tank (UST) facilitates within the District are as follows:

- Plumas County:
  - Chilcoot – Goodwin's General Store – One 20,000-gal double-wall UST – no active or historic groundwater monitoring
- Sierra County:
  - Loyalton – White's Sierra Station (508 Main Street) – One 12,000-gal double-wall UST – LUST case-closed (more information available from: https://geotracker.waterboards.ca.gov/profile_report.asp?global_id=T0609100006)
  - Loyalton – Sierra Energy (610 2nd st) – Three 20,000-gal single-wall* USTs - Cleanup Program Site case closed (more information available from: https://geotracker.waterboards.ca.gov/profile_report.asp?global_id=SL0609109274)
  - Sierraville – Sierraville Service and Country Store (126 S. Lincoln St) - One 13,000-gal double-wall UST – Active LUST (more information available from: https://geotracker.waterboards.ca.gov/profile_report.asp?global_id=T10000009540)

There are additional LUST cases in Loyalton and Sierraville that are not active UST facilities. These can be seen here: https://geotracker.waterboards.ca.gov/map/. All single-wall USTs (i.e. those at Sierra Energy in Loyalton listed above) are required to be removed by 12/31/2025.

2.1.4.7 Well Construction Policies

The well construction policy which governs well construction in Sierra Valley is the California Well Construction Standards (Bulletin 74). Sierra and Plumas Counties have well construction requirements included in their respective codes as well. Additionally, SVGMD passed an ordinance (Ordinance 18-01) requiring that all applications to construct wells in the SV Subbasin be reviewed and approved by SVGMD prior to permit issuance by the county and limiting construction of new high capacity wells where such construction would likely impact groundwater resources, as described in Sections 2.1.3.4 and 4.1.

2.1.4.8 Groundwater Contamination Cleanup, Recharge, Diversions to Storage, Conservation, Water Recycling, Conveyance, and Extraction Projects

A groundwater cleanup occurred at the Sierra Energy site in Loyalton, as listed in Section 2.1.4.6 above. No other information on groundwater contamination cleanup projects/efforts in the Sierra Valley could be found. Industry, fuel storage, and other activities that are likely to cause groundwater contamination requiring cleanup are relatively sparse in the Sierra Valley.

Recharge projects have been a primary focus of SVGMD since the start of implementation of SGMA in the SV Subbasin. A detailed study (Bachand and Associated, 2019) was conducted exploring opportunities for improving recharge, including potential for pilot studies, possibility of groundwater injection, and more. Recharge research and efforts to identify and leverage opportunities to improve recharge are ongoing, as described in Chapter 4 of this Plan Concept Document.

Diversion to storage in the Sierra Valley is limited. There are a handful of ranches on the periphery of the valley which have constructed ponds for various purposes, but none with significant storage capacity.

Conservation efforts in the Sierra Valley are extensive. Sierra Valley are extensive. Over 30,000 acres of private land in Sierra Valley are protected with conservation easements that conserve ranching and its culture and the valley's extraordinary ecological richness, primarily thanks to efforts by the Feather River Land Trust. Water conservation efforts include research on and support efforts for switching traditional irrigation systems to higher efficiency irrigation technologies (i.e. LESA/LEPA technologies). Other efforts for water conservation include agricultural residents of the Valley exploring possibilities for changing agricultural business frameworks to reduce water demand, i.e. by switching to production of crops with lower water demand, etc.

Water recycling projects include the Loyalton Wastewater Treatment Plant effluent recycling project and the Loyalton Biomass Plant effluent recycling project, as described in Section 2.1.2.3 of this Plan. The broad use of onsite wastewater treatment systems (a.k.a. septic systems) that exists in the Sierra Valley (only Loyalton has a sewer system and centralized wastewater treatment system, while the rest of the valley's population is on septic systems; Beckwourth also has a centralized wastewater treatment system, but no information on the system could be found) could also be considered a form of water recycling, given all domestic/commercial water that is used in the valley at properties with such systems is returned back into the groundwater system via leachfield dispersal. This practice also enables the recycling of nutrients in some circumstances (i.e. through nutrient uptake by plants from shallow groundwater with which leachfield percolate mixes), but is also a primary water quality impairment concern, as described in Section 2.2.2.4 of this Plan Concept Document.

Water conveyance in the Sierra Valley is via a series of channels, canals, and ditches, both natural and manmade, as described in detail in Section 2.2.1.1 of this Plan Concept Document.

No groundwater extraction projects, other than typical residential/commercial/public well drilling, are known to be occurring or expected to occur in the Sierra Valley.

2.1.4.9 Efficient Water Management Practices

Efficient water management practices in Sierra Valley include conjunctive use practices as described in Section 2.1.2.3, irrigation efficiency practices as described in Section 4.1, and typical water efficiency practices implemented in all new residential, commercial, and industrial construction throughout the valley as required by the California Plumbing, Building, and Residential Codes.

2.1.4.10 Relationships with State and Federal Regulatory Agencies

Relationships between SVGMD and state and federal regulatory agencies in Sierra Valley are relatively limited. The relationships are monetary (charging management charge to state/federal land owners) and managerial (ensuring groundwater extraction on federal and state lands comply with SVGMD management policies). Other aspects of the relationships include coordination as needed for property access, collaborative projects, etc.

2.1.4.11 Land Use Plans and Efforts to Coordinate with Land Use Planning Agencies to Assess Activities that Potentially Create Risks to Groundwater Quality or Quantity

Applicable land use plans are those described in Section 2.1.3. Efforts to coordinate with the planning agencies (Plumas and Sierra Counties, City of Loyalton) include the development of the SV GSP (SVGMD and Plumas County collective effort) and the Joint Powers Agreement between the counties and SVGMD.

2.1.4.12 Impacts on Groundwater Dependent Ecosystems

As described in DWR's reprioritization documentation (DWR, 2019a), several monitoring wells adjacent to wetlands and streams are showing significant declines that could be impacting the largest fresh water marsh in the Sierra Nevada Mountains. The dependence of the marsh ecosystems on the deep aquifer that is primarily being impacted by groundwater extraction is likely relatively minimal, however (based on past studies and knowledge of the aquifer system as described in Section 2.2). More information on impacts on groundwater dependent ecosystems is provided in Section 2.2.2.7 of this Plan Concept Document. More detailed studies on this topic are needed, as described in Sections 2.2.1.6 and 3.5.4 of this Plan Concept Document.

2.1.5 Notice and Communication *(Reg. § 354.10)*

Per Reg. § 354.10, this section includes:

- Description of beneficial uses and users in the basin
- A Communications Section that describes:
    - Decision-making processes
    - Public engagement opportunities
    - Encouraging active involvement
    - Informing the public on GSP implementation progress

Stakeholder communications and engagement have been carried out by SVGMD in accordance with the Stakeholder Communication and Engagement Plan (CE Plan) included as Appendix G in this Plan Concept Document. As described in the CE Plan, the central objective of the CE Plan is to provide a framework and identify tools to engage stakeholders in current and future SGMA activities in the SV Subbasin. A list of public meetings at which the Plan was discussed or considered by the GSA is included as Appendix C. A list of comments regarding the Plan received by the GSA and responses provided by the GSA is included as Appendix F. Beneficial uses and users of groundwater in the SV Subbasin, a description of the GSAs decision-making process, and additional communication information is provided below.

2.1.5.1 Beneficial Uses and Users

Per Reg. § 354.10(a), a description of the beneficial uses and users of groundwater in the basin is provided here, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

Beneficial uses of groundwater from the Basin include agricultural, municipal, industrial, public and environmental uses. Beneficial users include public, municipal, commercial, agricultural, county, state, federal, and tribal groundwater users. Such users include:

- Holders of overlying groundwater rights, including:
  - Agricultural users
  - Domestic Well owners
- Municipal well operators.
- Public water systems.
- Local land use planning agencies.
- Environmental users of groundwater.
- Surface water users, if there is a hydrologic connection between surface and groundwater bodies.
- The federal government, including, but not limited to, the military and managers of federal lands.
- California Native American Tribes.
- Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems.
- Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or part of a groundwater basin managed by the GSA.
- Plumas-Sierra Farm Bureau
- Plumas-Sierra Cattlemen’s Association
- Plumas Sierra Cattlewomen’s Association

- Sierra Valley Grange #466
- Sierra Valley Resource Conservation District (RCD)
- City of Loyalton
- Upper Feather River Integrated Regional Water Management (IRWM) group
- Feather River Land Trust
- Upper Feather River Watershed Group
- Plumas Audubon Society
- Rough list taken from CE Plan - To be continued…

Land uses and property interests potentially affected by the use of groundwater in the basin include all types of agriculture and agricultural interests, habitat and environmental interests, tribal/cultural interests, and infrastructure. Residents, landowners, tribal representatives, and government entities (i.e. USFS, BLM, DFW, etc.) are examples of the types of parties representing those interests. Participation in GSP development, implementation, and evaluation by all such parties has been encouraged by the GSAs of the SV Subbasin and ongoing communication and opportunity for engagement (via public workshops, SVGMD Board Meetings, and the SVGMD webpage) provide continued means of consultation with those parties.

2.1.5.2 Decision-Making Processes

The decision-making process used by SVGMD is as outlined below and was developed based on the input received from stakeholder engagement (*PLACEHOLDER-CONCEPT)*:

1. Develop a list of options and associated pros and cons for the decision at hand for presentation to the GSAs at SVGMD Board Meeting and/or GSP Workshop;
2. GSAs deliberate until decision consensus is gained (with assistance of a facilitator), then develop a description of the decision and justification;
3. GSAs provide the decision and justification description to engaged stakeholders for assessment and feedback to be provided prior to the subsequent SVGMD Board Meeting or GSP Workshop;
4. GSAs review stakeholder feedback and discuss and deliberate with engaged stakeholders at the subsequent SVGMD Board Meeting or GSP Workshop until overall consensus is gained (with assistance of a facilitator).

2.1.5.3 Public Engagement Opportunities

Public engagement opportunities include public workshops and SVGMD Board Meetings. Public workshops have been held as documented in the CE Plan and will continue to be held at least annually as described in the CE Plan. SVGMD meetings are held monthly and include an opportunity for public comment and often include significant discussion on GSP development and implementation measures.

Public input and responses have been used to guide the development of the SV GSP. Public input was used to establish the sustainable management criteria for the SV Subbasin (see Chapter 3), develop monitoring network improvements plans and protocol, and develop plans for projects and management action policies to achieve sustainability. Public input will continue to be used to shape adaptive management and refinement of this Plan throughout the implementation horizon.

Commented [GH15]: This is another example of future-tense language on a subject that has not occurred yet, hence it is theoretically/hydrostatical/suggestive, e.g. it is placeholder language that is included because it is anticipated that such language will be included in the actual SV GSP.

2.1.5.4 Encouraging Active Involvement

In order to encourage active involvement of diverse social, cultural, and economic elements of the population within the basin, SVGMD has utilized and will continue to utilize traditional and web-based communication tools to keep stakeholders informed and engaged. Such tools include:

- Print and on-line media/newspaper articles on:
    - Mountain Messenger: (Don Russell) mtnmess@cwo.com; (Jill) yesdearyousuck@yahoo.com,
    - Portola Reporter (Eva Small) esmall@plumasnews.com; (Debra Moore) Managing Editor, Feather Publishing dmoore@plumasnews.com,
    - Sierra Booster (Jan Buck) jbuck@psln.com,
    - http://www.sierraville.org;
- Outreach partners' newsletters, websites, and social media accounts, where applicable;
- GSA websites;
- Direct mailings (postcards); and
- Workshop flyers.

To ensure public engagement was maximized as much as possible within the power of SVGMD, a list of all relevant parties and stakeholders (Interested Parties List) was developed and regularly expanded (as applicable) during the GSP development process. The list is included with the CE Plan in Appendix G.

2.1.5.5 Informing the Public on GSP Implementation Progress

The public was kept informed on GSP development progress through progress summary presentations provided during public workshops as documented in the CE Plan. In order to keep the public informed on GSP implementation progress, including the status of projects and management actions, a GSP Implementation Assessment (*PLACEHOLDER-CONCEPT)* has been included as a required component of the annual evaluation and reporting to be facilitated by SVGMD and performed by qualified contractor(s) and an update based on said assessment will be presented annually in the fall or winter subsequent to completion of the annual reports, as described in the CE Plan. In the event of undesirable results occurring which necessitate timely implementation of management actions, notices will be distributed via the tools listed above and in accordance with the CE Plan.

2.2 Basin Setting

2.2.1 Hydrogeologic Conceptual Model *(Reg. § 354.14)*

Per Reg. § 354.14, this section includes:

- Graphical and narrative description of the physical components of the basin
- At least two scaled cross-sections
- Map(s) of physical characteristics
    - Topographic information
    - Surficial geology
    - Soil characteristics
    - Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas
    - Surface water bodies
    - Source and point of delivery for local and imported water supplies

In accordance with the requirement of § 354.14, the HCM narrative description includes:

1) The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.
2) Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.
3) The definable bottom of the basin.
4) Principal aquifers and aquitards, including the following information:
    a. Formation names, if defined.
    b. Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.
    c. Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.

   d. General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.
   e. Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.

5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model.

The HCM narrative description also provides climate data and recharge and water delivery descriptions.

In accordance with the requirement of § 354.14, the graphical representation of the HCM includes:

1) At least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.
2) Topographic information derived from the U.S. Geological Survey or another reliable source.
3) Surficial geology derived from a qualified map including the locations of cross-sections.
4) Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.
5) Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.
6) Surface water bodies that are significant to the management of the basin.
7) The source and point of delivery for imported water supplies.

As described in DWR's Hydrogeologic Conceptual Model BMP document, a hydrogeologic conceptual model (HCM) provides an understanding of the general physical characteristics related to regional hydrology, land use, geology and geologic structure, water quality, principal aquifers, and principal aquitards of the basin setting; provides the context to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks; and provides a tool for stakeholder outreach and communication. An HCM also serves as a foundation for understanding potential uncertainties of the physical characteristics of a basin which can be useful for identifying data gaps necessary to further refine the understanding of the hydrogeologic setting.

The HCM provided here is based on best available data at the time of the development of this Plan Concept Document and will be further developed and periodically updated as part of an iterative process as data gaps are addressed and new information becomes available.

The following are examples of anticipated used of this HCM:

- Develop an understanding and description of the basin to be managed, specifically the structural and physical characteristics that control the flow, storage, and quality of surface and groundwater
- Identify general water budget components
- Identify areas that are not well understood (data gaps)
- Inform monitoring requirements
- Facilitate or serve as the basis for the development, construction, and application of a mathematical (analytical or numerical) model
- Refine the understanding of basin characteristics over time, as new information is acquired from field investigation activities, monitoring networks, and modeling results
- Provide often highly-technical information in a format more easily understood to aid in stakeholder outreach and communication of the basin characteristics to local water users
- Help identify potential projects and management actions to achieve the sustainability goal within the basin

2.2.1.1 Physical Characteristics

This section includes the following:

- Summary of Physiography
- Topographic Information
- Soil Characteristics
- Surface Water Bodies and Waterways

Summary of Physiography

This information was extracted from DWR (1983). Sierra Valley is an irregularly shaped, complexly faulted valley in the northern portion of the Sierra Nevada geomorphic province. The valley floor, containing 130,000 acres, is relatively flat and lies about 4,900 feet above sea level. The surrounding rugged mountains rise to elevations ranging from 5,800 to nearly 8,000 feet. Around the borders of ' the valley, an alluvial apron of varying width slopes down from the adjacent highlands. At various locations around the valley, large masses of bedrock stand out of the valley floor either as inselbergs or as erosional remnants of volcanic flows.

Many streams enter the valley and join to form the Middle Fork Feather River, which drains the valley through a water gap in the northwestern corner near Beckwourth. These stream flows are fed by rainfall, snowmelt, and ground water discharge.

Vegetation in the valley is varied. On the valley floor there are agricultural crops, rangeland grasses, sagebrush and tules. Around the periphery, at slightly above the valley floor, sagebrush and rangeland grasses dominate. Forests of pine, fir, cedar, and hemlock grow in the mountains around the valley.

Topographic Information
This information was extracted from Vestra (2005). The USGS is the primary agency responsible for supplying data for this section.

The Sierra Valley Watershed topography is typical of former lake basins. A large portion of the watershed's 297,000 acres is part of the valley floor (approximately 130,000 acres; DWR, 1983). The low gradient of valley floor is a result of the Pleistocene lake that once occupied the valley. During this time, an abundance of glaciers could be found throughout the Sierra Nevada. Traces of these glaciers are found within the watershed today. The steep slopes of the surrounding Sierra Nevada still drain into the Sierra Valley, but now become the headwaters of the Middle Fork Feather River. Table 2.2-1 lists the sub-watersheds of the Sierra Valley.

The average elevation of the watershed is just below 5,000 feet, with the surrounding mountains including Beckwourth Peak, climbing steeply above 8,000 feet. The town with the highest population, Loyalton, sits at 4,985 above mean sea level (msl). Watershed topography with elevation bands is shown as Figure 2.2-1. A summary of USGS quadrangle maps within the watershed is included as Table 2.2-2. The slope gradient and aspect along the boundaries of the watershed vary significantly, but the valley floor is comparatively flat with a zero to five percent slope.

Soil Characteristics
This information was extracted from Vestra (2005). Data sources for this section include Soil Survey of Plumas National Forest Area published in 1985 by the United States Forest Service, Soil Survey of the Sierra Valley Area, California, Parts of Sierra, Plumas, and Lassen Counties published by the U. S. Department of Agriculture in 1975, and Soil Survey Geographic (SSURGO) database for Sierra Valley Area, California. The majority of the soils within the watershed, including those throughout the valley floor, are described in detail by the 1975 USDA soil survey. Northern portions of the watershed not included within USDA soil survey are included in the 1985 USFS soil survey. Areas included in the USFS survey include USGS quadrangles Crocker Mountain, Dixie Mountain, Frenchman Lake, Constantia, Portola, and the Calpine Area. Digital soils data is included in the SSURGO database available from the U.S. Department of Agriculture, Natural Resources Conservation Service, National Cartography and Geospatial Center. Areas included in the SSURGO database include USGS 7.5-minute quadrangles Portola, Reconnaissance Peak, Chilcoot, Beckwourth Pass, Calpine, Antelope Valley, Loyalton, Evans Canyon, Sattley, and Sierraville.

Soils within the Sierra Valley Watershed vary considerably in productivity, depth, and use. Primary conditions responsible for the diverse soil characteristics include parent material, topography, and precipitation. Parent material is the unconsolidated material from which soil develops; it may be deposited in place such as weathered rock, or it may be windblown, such as sands in more arid climates. Physical and chemical makeup of the parent material has a direct impact on soil chemistry and fertility, especially early in the development process. Topography is also a key factor in soil development. A steep slope will influence precipitation runoff and, depending on steepness, may inhibit sunlight affecting vegetative growth. Additionally, the amount of water increases along with velocity as it travels down slope, stripping developing soils from the source area. Entrained sediments are deposited in low-lying areas such as the valley floor as velocities decrease and sediment begins to fall out of suspension.

A brief description of common soil series present throughout the watershed is included below. The descriptions were obtained from the USDA Soil Survey of the Sierra Valley (USDA, 1975). Soil series have been subdivided based on their association with mountainous terrain, terrace and alluvial fan deposits, or valley floors. A summary of the soil series within the watershed along with percentage of mapped area is included in Table 2.2-3. Figure 2.2-2 provides a graphical depiction of the soils of Sierra Valley.

- Mountainous Soils – Soil series found primarily in mountainous regions surrounding the Sierra Valley include Trojan, Delleker, Portola, Toiyabe, Haypress, Aldax, and Basic Rock Land soils. These soils cover approximately 22 percent of the mapped area.
    - Trojan Series: The Trojan series consists of well-drained soils that form in place. These soils are derived from andesitic and basaltic conglomerates and breccias. Slopes range from nearly flat to steep, 2 to 50 percent, with elevations ranging from approximately 5,000 to 6,000 feet. The surface layer is dark brown, slightly acid stony sandy loam approximately 10 inches deep. The subsoil is light brown to reddish yellow, moderately acidic gravelly loam to gravelly clay loams to a depth of approximately 60 inches. Annual precipitation is 12 to 24 inches, supporting stands of Jeffrey pine, big sagebrush, bitterbrush, squirreltail, and cheat grasses. The soils are primarily used for timber production and livestock grazing.
    - Delleker Series: The Delleker series consists of well-drained to moderately well-drained soils that formed from volcanic tuffs. Slopes range from nearly flat to moderately sloping, 2 to 30 percent, with elevations ranging approximately 4,800 to 5,800 feet. The surface layer is light brown slightly acidic cobbly sandy loam and pale brown slightly acidic to medium acidic loams approximately 13 inches deep. The subsoil is pale brown to light yellowish brown moderately acidic sandy clay loams and clay loams to at least 60 inches. The annual precipitation is 14 to 24 inches, supporting stands of Jeffrey pine, ponderosa pine, white fir, and cedar, black oak, and manzanita. Sagebrush, bitterbrush, and annual grasses and forbs are also associated with the Delleker Series.
    - Portola Series: The Portola series consists of well-drained soils that are forming, at a depth of approximately 30 to 40 inches in mixed ashy material on the volcanic uplands (USDA 1975). These soils are found primarily in the foothills and mountainous uplands along the western rims of the watershed. Slopes range from moderately flat to steep, 9 to 50 percent, with elevations ranging

approximately 4,800 to 6,000 feet. The surface layer is light gray to light brownish gray, moderately acidic cobbly coarse sandy loam approximately 9 inches thick. The subsoil is very pale-brown to light-brown, moderately acidic coarse sandy loams approximately 40 inches thick. The annual precipitation is 14 to 24 inches, supporting stands of Jeffrey pine, cedar, sugar pine, white fir, and black oak. Bitterbrush, big sagebrush, manzanita, perennial and annual grasses and forbs are also associated with the Portola series.

- Toiyabe Series: The Toiyabe series consists of excessively well-drained soils that are forming in place in weathered granitic rock such as granodiorite, quartz diorite, and granite. These soils are found primarily in the mountainous uplands located in the northern and western regions of the watershed. Slopes range from flat to steep, 2 to 75 percent, with elevations ranging approximately 5,000 to 8,000 feet. The surface layer is grayish brown to light brownish gray, slightly acidic loamy coarse sands approximately 12 inches thick. The underlying parent material consists primarily of strongly weathered granodiorite. The annual precipitation is 10 to 24 inches, supporting stands of Jeffrey pine, ponderosa pine, black oak, mountain mahogany, brush, forbs, and minor grasses. Bitterbrush and big sagebrush are also associated with the Toiyabe series.
- Haypress Series: The Haypress series is similar to the Toiyabe series in that the Haypress series consists of excessively drained soils that are forming in place in weathered granitic rock such as granodiorite, quartz diorite, and granite. These soils are also found primarily in the foothills and mountainous uplands around the rims of the watershed with slopes ranging from near flat to steep, 2 to 75 percent, with elevations ranging from approximately 5,000 to 8,000 feet. The surface layer is grayish-brown moderately acidic loamy coarse sand approximately 14 inches thick. The subsoil is brown moderately acidic loamy coarse sands which grade to pale-brown loamy sands that further degrade to weathered granites at a depth of approximately 50 inches. The annual precipitation is 14 to 24 inches, supporting stands of Jeffrey and ponderosa pine, black oak, manzanita, serviceberry, ceanothus, and annual and perennial grasses and forbs. These soils found in lower elevations support big sagebrush and bitterbrush.
- Aldax Series: The Aldax series consists of excessively drained soils that are forming in material weathered from metamorphic rock or cobbly volcanic conglomerate and breccia. These soils are also found primarily in the foothills and mountainous uplands around the rims of the watershed with slopes ranging from near flat to steep, 5 to 75 percent, and elevations ranging approximately 4,500 to 8,000 feet. These soils are brown moderately acidic sandy loams to dark yellowish moderately acidic very gravelly loams. Bedrock is at a depth of approximately 12 inches. The annual precipitation is 10 to 20 inches. These soils primarily support big sagebrush and cheat grass.

  - Basic Rock Land: The Basic Rock Land consists of rough, rocky terrain. Rock outcrops and very shallow soils cover as much as 50 to 90 percent of the surface. These soils are also found primarily found in the foothills and steep mountainous uplands surrounding the watershed. The rock consists primarily of volcanics such as pyroclastic breccia, plugs, vents, flow rock, and tuff conglomerates. Basic Rock Land supports spotty cover of sagebrush, annual and perennial grasses, and minor stands of timber. These soils are relatively unproductive other than serving as part of a protected watershed and as part of the habitat and escape cover for wildlife.
  - Minor soil types but not described within the mountainous soils also include the Millich and Bonta Series soils. Descriptions of these soil types are included in the Sierra Valley Area Soil Survey (USDA, 1975).
- Terrace and Alluvial Fan Soils – Soil series found primarily on terraces and alluvial fans surrounding the Sierra Valley consist of the Mottsville, Dotta, Martineck, and Bieber soils. These soils cover approximately 13 percent of the mapped area.
  - Mottsville Series: The Mottsville series consists of excessively drained soils that are forming in course granitic alluvium. These soils are found on terrace deposits located in the northeastern regions of the watershed near Chilcoot. Slopes are generally flat, 2 to 9 percent, with elevations ranging approximately 4,800 to 5,200 feet. The surface layer is brown to dark brown moderately acidic loamy sands and loamy coarse sands approximately 10 inches thick. The subsoil is typically brown to yellowish brown, slightly to moderately acidic loamy sands that extend to a depth of more than 60 inches. The annual precipitation is 8 to 16 inches supporting big sagebrush, cheat grass, Indian ricegrass, scattered bitterbrush, and minor forbs and grasses.
  - Dotta Series: The Dotta series consists of well-drained soils forming in basic alluvium. These soils are found on lake terrace deposits around the rim of the valley, alluvial fans, foot slopes, and foothills surrounding volcanic uplands. Slopes are generally flat to moderately sloping, 0 to 30 percent, with elevations ranging approximately 4,800 to 5,200 feet. The surface layer is gray, slightly acidic sandy loam approximately 13 inches thick. The subsoils are generally gray to grayish brown moderately acidic heavy loams, sandy clay loams, and heavy sandy clay loams to a depth of at least 60 inches. The annual precipitation is 8 to 18 inches, supporting big sagebrush, annual and perennial grasses, scattered stands of pine, and juniper.
  - Martineck Series: The Martineck series consists of well-drained very stony soils forming in basic alluvium underlain by hardpan approximately 10 to 20 inches below ground surface. These soils are found on terrace deposits around the western and southern rims of the valley. Slopes are generally flat to moderately sloping, 2 to 30 percent, with elevations ranging approximately 4,500 to 5,200 feet. The surface layer is grayish brown and gray moderately acidic very stony

sandy loam approximately 6 inches thick. The subsoil is generally dark grayish brown to brown slightly to moderately acidic very stony clays to very stony sandy clay loams. The subsoil is generally underlain by pale yellow indurated hardpan. The annual precipitation is 12 to 18 inches, supporting sagebrush, grasses, forbs, and scattered stands of Jeffrey pine.

  - Bieber Series: The Bieber series consists of well-drained soils forming in mixed alluvium. These soils are found on terrace deposits on the valley floor and higher terraces such as those near Loyalton. Slopes are generally flat, 0 to 5 percent, with elevations ranging approximately 4,500 to 5,200 feet. The surface layer is gray moderately to slightly acidic sandy loams and heavy sandy loams approximately 6 inches thick. The subsoil is generally brown slightly acidic sandy clay loams and sandy clays approximately 11 inches thick. The subsoil is underlain by a very hard silica cemented hardpan at a depth of approximately 17 inches below ground surface. The annual precipitation is 12 to 18 inches, supporting sagebrush, silver sagebrush, and minor grasses and forbs.

- Valley Soils – Soil series found on the valley floor and shallow terraces include the Ramelli, Balman, Pasquetti, Beckwourth, Calpine, and Dotta soils. These soils cover approximately 61 percent of the mapped area.
  - Ramelli Series: The Ramelli series consists of poorly to very poorly drained soils that are forming in fine-textured mixed alluvium. These soils are commonly found in meadowlands throughout the watershed. Slopes are generally flat, 0 to 2 percent, with elevations ranging approximately 4,500 to 5,000 feet. The surface layer is dark gray to dark grayish brown slightly acidic silty clay and clay approximately 7 inches thick. The subsoil is generally dark gray to gray, slightly acidic to moderately basic clay and sandy clay loams approximately 20 inches thick. The subsoil is underlain by light brownish gray to gray moderately basic to slightly acidic sandy loam and gravelly coarse sands to a depth of at least 77 inches below ground surface. The annual precipitation is 12 to 18 inches, supporting wet meadow grasses and forbs, including sedges and wiregrass. The Ramelli series is closely associated with the Balman and Loyalton soils.
  - Balman Series: The Balman series consists of poorly drained soils that are formed from mixed valley alluvium. These soils are primarily found on the valley floor and alluvial fans. Slopes are generally flat, 0 to 5 percent, with elevations ranging approximately 4,000 to 5,000 feet. The surface layer is generally light brownish gray to gray highly basic and highly calcareous loams approximately 15 inches thick. The subsoils are gray to light gray moderately basic highly calcareous and stratified loams, sandy clay loam, sandy loam, and loamy coarse sands to a depth of more than 60 inches. The annual precipitation is 10 to 20 inches, supporting silver sagebrush, annual grasses, sedges, and herbs.
  - Pasquetti Series: The Pasquetti series consists of poorly drained to very poorly drained soils that are forming in ashy lake sediment. These soils are primarily

found in basins on slopes that are generally flat, 0 to 2 percent, with elevations ranging approximately 4,500 to 5,000 feet. The surface layer is generally very dark gray to dark gray moderately basic mucky silty clays and silty clays to a depth of approximately 20 inches below surface. The subsoil is generally dark gray moderately basic clay loam approximately 10 inches thick. The subsoil is underlain by light gray moderately basic clay loams and white or grayish brown very fine sandy loams and sandy loams to a depth of at least 60 inches below surface. The annual precipitation is 12 to 20 inches, supporting wet meadow plants such as wiregrass, sedges, moss, grasses, and forbs.

- Beckwourth Series: The Beckwourth series consists of poorly drained soils that are formed from mixed valley alluvium. These soils are primarily found on the plains between Vinton and Beckwourth. Slopes are generally flat, 0 to 2 percent, with elevations ranging approximately 4,000 to 5,200 feet. The surface layer is generally very dark gray to dark grayish brown moderately acidic loamy coarse sands approximately 15 inches thick. The subsoil is generally brown to pale brown slightly to moderately basic loamy coarse sands and coarse sandy loams approximately 20 inches thick. The subsoil is underlain by light yellowish-brown to pale brown loamy coarse sands and coarse sands that extend to a depth of at least 60 inches below ground surface. The annual precipitation is 12 to 18 inches, supporting silver sagebrush, annual grasses, dryland sedge, and forbs.
- Calpine Series The Calpine series consists of well-drained soils forming in granitic alluvium. These soils are primarily found on the western flats along the northern rim of the valley as well as low terraces and flood plains. Slopes are generally flat, 0 to 9 percent, with elevations ranging approximately 4,800 to 5,500 feet. The surface layer is generally dark grayish brown strongly acidic coarse sandy loam approximately 20 inches thick. The upper subsoil is brown moderately acidic sandy loam approximately 10 inches thick. The lower subsoil is light yellowish brown and yellow moderately acidic sandy clay loam. The subsoils are underlain by light yellowish brown moderately acidic stratified loamy sands to a depth of at least 60 inches below surface. The annual precipitation is 10 to 20 inches, supporting big sagebrush, silver sagebrush, bitterbrush, rabbitbrush, grasses, sedges, and forbs.
- Dotta Series: The Dotta series consists of well-drained soils forming in basic alluvium. These soils are found on lake terrace deposits around the rim of the valley, alluvial fans, foot slopes, and foothills surrounding volcanic uplands. Slopes are generally flat to moderately sloping, 0 to 30 percent, with elevations ranging approximately 4,800 to 5,200 feet. The surface layer is gray slightly acidic sandy loam approximately 13 inches thick. The subsoils are generally gray to grayish brown moderately acidic heavy loams, sandy clay loams, and heavy sandy clay loams to a depth of at least 60 inches. The annual precipitation is 8 to 18 inches, supporting big sagebrush, annual and perennial grasses, and scattered stands of pine and juniper.

Land capability and erosivity of soils are additional relevant components to soil assessments and descriptions. Land Capability Classification is a national system developed by the United States Department of Agriculture for primarily agricultural purposes. This classification groups farmable soils according to their potentialities and limitations for sustained production of commonly cultivated crops. This classification groups nonfarmable soils according to their potentialities and limitations for the production of permanent vegetation and risk of soil damage. Soils in Classes I through IV are classified according to their limitations for sustained production of cultivated crops. The majority of soils in Class VI and those in Class VII may be used for forestry, pasture, or range. Soils in Class VIII are suitable only for nonagricultural purposes.

Soils in Sierra Valley watershed area range from Land Capability Class III to Class VIII. Approximately half of the valley floor is a combination of Land Capability Class III and Class IV soils. These soils are spread throughout the valley and are predominantly where the cultivated crops are produced. Land Capability Class VI soils encompass approximately half of the Sierra Valley floor and are used primarily for livestock grazing. Soils in the Land Capability Class VII to VIII are used for limited livestock grazing and primarily timber production.

Four parameters, soil, slope, cover and climate, are considered when evaluating erosivity. Soil must be analyzed for detachability and permeability. Slope must be viewed for uniformity and steepness. Cover is important due to the density of both living and dead vegetation that shields the soil form the raindrop impacts. Climate is important in determining erosion hazards for the distribution of annual precipitation, intensity of storms, distribution of snowfall and snowmelt, and the freezing of the ground surface. All of these parameters are grouped together to provide a general sense of erosion potential of soils. Soils are designated as a “slight,” “moderate,” or “high” erosion hazard.

Soils on the Sierra Valley floor are classified primarily as a “slight” or “moderate” risk of erosion. The terrace and alluvial fan soils range from “slight” to “moderate” erosion risks. The mountainous soils are classified as “high” erosion hazards.

Surface Water Bodies and Waterways

There are many water bodies within and hydrologically connected to Sierra Valley and many waterways flowing into and through Sierra Valley. The waterways are displayed in Figure 2.2-3 and flow from the sub-watersheds listed in Table 2.2-1 and include:

- Little Last Chance Creek
- Smithneck Creek
- Bear Valley Creek
- Cold Stream
- Bonta Creek

- Perry Creek
- Berry Creek
- Turner Creek
- Hamlin Creek
- Fletcher Creek
- Carmen Creek
- Numerous unnamed intermittent and ephemeral streams
- Dyson Slough
- Numerous unnamed canals
- Sierra Valley Channels (flow paths through the valley floor generally from south to north)
- Middle Fork Feather River (only outlet)

Relevant surface water bodies include Frenchman Reservoir (outlets to Little Last Chance Creek) and Webber Lake (outlets to the Little Truckee River from which there is a diversion to the Sierra Valley). There are also several seasonal and perennial ponds on the valley floor and locations where standing water persists well into the dry season and sometimes year-round depending on the characteristics of the water year (see additional information in Section 2.2.1.5).

2.2.1.2 Climate

This climate summary is extracted from Vestra (2005) and includes the following:

- Historic Record
- Temperature and Growing Seasons
- Precipitation
- Snowfall
- Evaporation

The California Department of Water Resources, Desert Research Institute, and the Sierraville Ranger Station are the primary agencies responsible for contributing climate data.

Historical Record

Real-time climate data are not available before circa 1900. In order to evaluate historic climate trends, scientists use glacial cores, lakebed deposits, tree line inventory, and tree ring data. California has experienced a number of significant trends in both temperature and precipitation that are very different from what is today considered “normal.” In fact, around 1850, just as large numbers of Europeans entered western ecosystems, the region experienced a marked shift in climate from the abnormally cool and moderately dry conditions of the previous two centuries (the “Little Ice Age”), to the relatively warm and wet conditions that have characterized the past 145 years (Matthes, 1939).

This climactic shift is important to land managers for two interrelated reasons. First, the landscape and hydrologic changes that occurred since 1850 may not be entirely anthropogenic, but rather are attributable in part to the shift in climate. Second, the landscape of the immediate period should not be considered an exact model for what the watershed would be today had Europeans never colonized the region.

Scientists believe the dry period of the mid-1600s to the mid-1800s was preceded by several centuries of cool, wet conditions. This is documented from glaciers and tree rings as well as from lake deposits. Much of the data used to document historic climatic conditions for the watershed were extrapolated from data collected from the Sierra Nevada. Records show (Clark and Gillespie, 1995; Curry, 1969) that after thousands of years of little or no glaciation (adding ice), the high elevation areas of the Sierra Nevada experienced an accumulation of snow and ice for several hundred years prior to 1850. This accumulation corresponds to a period of cooling over much of the globe that began in the fourteenth or fifteenth century and continued through the middle of the nineteenth century (Grove, 1988).

Graumlich's tree ring record from the southern Sierra provides the most detailed view of variations in the latest Holocene climate. That record confirms the period from 1650 to 1850 was generally dry, although it shows an important exception not evident in the lake or glacial records: the interval 1713–32 was anomalously wet. The tree ring studies allow the temperature factor to be isolated from the precipitation factor, an advantage that neither the lake record nor the glacial record can provide. Graumlich stresses that the same inferred droughts and temperature variations are reflected in other tree-ring studies in and adjacent to the Sierra Nevada by others. Graumlich concluded that:

- Growing-season temperatures reached their lowest level of the past millennium around 1600 and then remained low by modern (1928–88) standards until around 1850.
- Although the period from 1713 to 1732 was by modern standards characterized by relatively wet conditions, it was preceded by a century dominated by low precipitation which was followed by 130 years (particularly the period 1764–61) of anomalous drought.
- The period from 1937 to 1986 was the third-wettest half-century interval of the past 1,000 plus years.

Temperature and Growing Seasons

Average annual temperatures within the watershed range from a low of approximately 30ºF to a high of 63ºF. Temperatures are typically warm in the summer months with average maximum monthly temperatures occurring in July at approximately 84ºF in Sierraville and 86ºF 3 miles to the northwest of the watershed boundary in Portola. Temperatures ranging from the high 70s to the mid-80s are common throughout the watershed from June through September. Maximum temperatures have been recorded in August at 104ºF and 107ºF in Sierraville and Portola.

Temperatures in winter months average 30ºF in Sierraville and 31ºF in Portola. Maximum temperatures from December through February range from the low to mid 40ºFs throughout the watershed. The lowest recorded temperature in Sierraville was –29ºF on December 9, 1972. Average monthly temperatures for Sierraville are included in Figure 2.2-4.

The first fall freeze generally occurs in September in Sierraville and the rest of the valley floor with May generally being the last month of freezing temperatures. At higher elevations in the watershed, it is not uncommon to experience freezing temperatures throughout the year. During January, Sierraville experiences daily temperature fluctuations of approximately 30ºF. In July, temperatures fluctuate nearly 40ºF. The growing season based on the freezing dates is approximately 60 to 90 days on the valley floor. The growing season typically shortens considerably in the mountainous regions to the west and south of the valley.

Precipitation

On average, most areas of the Sierra Valley Watershed receive approximately 15 to 20 inches of precipitation per year. Most precipitation falls during the winter months with 77 percent of the annual total received between November and March. Monthly averages are highest in January with 4.59 inches falling in Sierraville and 4.17 inches falling in Portola. Rainfall during the summer months is limited to thundershowers 5 to 10 days per year, accounting for less than 5 percent of the annual precipitation. Precipitation not only feeds the creeks and rivers of the region, but recharges the groundwater resource as well. An isohyetal map of the watershed is included as Figure 2.2-5.

Snowfall

Snowfall data collected at the Sierraville Ranger Station (elevation 4,190 ft above msl) show January as having the highest average snowfall at approximately 17.9 inches with average annual snowfall of approximately 71.8 inches. The highest total snowfall recorded at the Sierraville Ranger Station was 242.3 inches in 1952. In this high elevation valley, snow tends to stay on the ground for long periods. In January, the average snow depth in Sierraville is 5 to 6 inches, with snow depths consistently above two inches from December to April.

Evaporation

Evaporation is the amount of water lost from a system due to the sun's radiation, air temperature, wind speed, and vapor pressure (relative humidity). Evaporation data, although typically used to schedule irrigation events, closely reflect the evaporation rates of surface water and are used to help calculate water balance of the watershed. Data published by the DWR in 1979 indicate the average evaporation rates from 1960 to 1970 for the area around Vinton. Although this is the only evaporation data available for the watershed it is assumed that the evaporation rates would be similar for the rest of the valley floor. The evaporation rates recorded for Vinton between 1960 and 1970 are shown in Table 2.2-4.

2.2.1.3 Geology

This section includes the following:

- Geomorphic Province
- Geologic Setting
- Geologic Units
- Geologic Structure
- Faulting
- Seismicity

- Geologic History

The geology of Sierra Valley has been studied and reported on by many (Durrell, 1959; DWR, 1961; Jackson et al., 1961; DWR, 1963; Durrell, 1966; Oakshott, 1971; Berry, 1979; Guthe, 1981; Saucedo and Wagner, 1992; Sawyer, 1995; Grose et al., 2000a; Grose et al., 2000b; Vestra, 2005; Gold et al., 2013; Dib et al., 2017; Bachand and Associated, 2019; and others). The geology description provided below was excerpted from DWR (1983), which provides a comprehensive and groundwater-oriented summary of the valley and area geology.

Geomorphic Province
California may be divided into natural geomorphic provinces according to certain characteristic features--relief, landforms, geology, and landscapes--that distinguish each province. These provinces have developed their distinctive characteristics largely as the result of natural geologic processes acting on the rock types and structure over many millions of years.

The Sierra Nevada is a high, continuous mountain range that extends in a north-northwesterly direction for more than 400 miles. Geologically, the Sierra is a great block of granitic rocks and remnants of older metamorphic rocks that have been tilted westward. It is bounded on the east by the Great Basin province, which extends across Nevada into Utah and is characterized by many north and northwest-trending mountain ranges and intervening basins. To the west is the Great Valley province, consisting of the Sacramento and San Joaquin Valleys. To the north, the Sierra Nevada ends in the Lake Almanor/Honey Lake area, and its rock types and structure are thought to continue northward under the cover of the volcanic terrain of the Cascade Mountains province (Oakshott, 1971). The south end of the Sierra Nevada ends in the Tehachapi Mountains at the southern end of the San Joaquin Valley.

Geologic Setting
Sierra Valley is at the eastern edge of the Sierra Nevada geo-morphic province immediately west of the Great Basin geomorphic province. The rocks that underlie the valley are typical of the Sierra Nevada, but the deep alluvium-filled valley is characteristic of the Great Basin province. The geologic units in Sierra Valley can be divided into three main groups. The oldest are metamorphosed sedimentary and volcanic rocks intruded by Mesozoic granitic plutons which together are a basement to unconformably overlying Tertiary strata. These Tertiary continental rocks are largely volcanic in origin and include rhyolite, andesite, basalt, and pyroclastic rocks. Quaternary continental deposits of clay, silt, sand, and gravel unconformably overlie the older rock units and are their erosional products. Figure 2.2-6 displays the geologic timeline of the formations of Sierra Valley.

Geologic Units
The SV Subbasin contains the following geologic units:

- Basement Complex Rocks: The basement complex consists of pre-Tertiary rocks unconformably overlain by Tertiary volcanic strata and Quaternary sediments. Its rocks are therefore of two types: metamorphic and granitic.

- Metamorphic Rocks - A belt of metamorphic rocks is exposed on the east side of the valley and extends northward from east of Mount Ina Coolbrith (T21N, Rl6E, Sl, MDB&M} to an unnamed hill just north of Chilcoat. It is presumed that these rocks underlie some of the region now covered by Tertiary and Quaternary units. The metamorphic rocks consist of quartzite, slate, marble and metavolcanics of Paleozoic to Mesozoic age.
- Granitic Rocks - Exposures of granitic rocks occur along the northern and western edges of the valley, predominantly in the higher elevations. Granite underlies the basin and intrudes into the metamorphic rocks. One 2,231-foot exploratory drill hole (T22N/RlSE, S32Pl} in the middle of the valley encountered granitic rocks at a depth of 2,165 feet and helped to substantiate basement complex composition.

The granitic rocks range in composition from quartz diorite through true granite. They are usually massive, crystalline, and fractured; they present rounded outcrops, and are a portion of the Sierran batholith of Jurassic to Cretaceous age. There are also granitic pegmatite dikes.

- <u>Volcanic Rocks</u>: Volcanic rocks are mainly in the upland areas surrounding the valley or appear as isolated buttes and low hills in the valley. These Tertiary age rocks overlie or are faulted against basement complex rocks. Some drill-holes in the valley find volcanic rocks at depth, and a few penetrate to the underlying basement complex. The volcanics vary in composition and origin and are differentiated into four groups: rhyolite, andesite, basalt, and pyroclastic rocks.
  - Rhyolite -Light gray to white massive rhyolite occurs as isolated plugs and shallow intrusives northwest of Sattley. The rock is of undetermined age, but may be related to the rhyolitic pyroclastic rocks of Miocene age found elsewhere on the valley.
  - Andesite -Andesite occurs as plugs, flows, and tuff breccias at various locations around the valley. It is hard, gray, porphyritic, and in some places brecciated.
  - Basalt -Tertiary basalt caps many peaks in the area and is present both as remnants of flows and as volcanic "necks" that represent centers of eruptions. According to Durrell (1959), these rocks may be related to the Warner basalts further north. They are gray to black olivine basalt that typically shows columnar jointing.
  - Pyroclastic Rocks -Pyroclastic rocks consist of fragmental material ranging in size from fine ash to large boulders that have been blown into the atmosphere by volcanic explosion. Pyroclastic rocks in Sierra Valley range from pyroxene and hornblende andesitic mudflow breccia to rhyolite tuff. The mudflow breccias range in age from Oligocene to Pliocene (Durrell, 1959). The rhyolite tuff is Miocene age.

- Sedimentary Deposits: In Sierra Valley, the continental sedimentary deposits contain the primary aquifers, yield large quantities of water, and are the source of nearly all of the pumped ground water. These deposits range in age from Pleistocene to Recent and are differentiated according to their mode of deposition and particle-size distribution.
  - Pleistocene Lake Deposits - Lake deposits crop out at widely scattered localities around the basin perimeter, and occur throughout the valley beneath a thin cover of Recent sediments. They vary in thickness, with a maximum of about 2,000 ft. They consist of clay, silt, sand, and gravel, and although are all classified as lake deposits, they also include coarser-grained channel, near-shore, and deltaic sediments. The sediments are generally course-grained around the margins of the valley and grade to finer material toward the middle of the basin. The deposits are vertically stratified and show lateral facies changes. Probable reasons for this variability include diversity of lithology of highland rocks, sediment input from local tributaries, slow filling of the lake, lake level fluctuation corresponding to seasonal and longer-term climatic variations, and topographic changes caused by erosion and seismic activity.
  - Pleistocene Morainal Deposits - There are a few small glacial moraines around Sierraville. Moraines are a heterogeneous mixture of debris deposited during the Pleistocene glacial epochs. They include poorly sorted pieces and blocks of metamorphic and igneous rocks in a matrix of fine sand and rock flour.
  - Recent Alluvial Fan Deposits - Alluvial fan deposits occur around the margins of the valley next to highland areas. They are most developed at the mouths of streams entering the valley. In some areas, adjacent fans have coalesced to form alluvial aprons. Fan deposits are stratified, contain poorly sorted sand, gravel, and silt, with occasional clay lenses, and may be as much as 200 ft thick.
  - Recent Alluvium - Alluvium occurs along stream channels and on a slightly elevated area in the center of the valley. The deposits are up to 50 ft thick and, depending on their location in the valley, overlie Pleistocene lake deposits, basin deposits, fan deposits, volcanic rocks, or basement complex rocks. The alluvium consists of a heterogeneous mixture of poorly sorted sand and silt with some lenses of clay and gravel. Along active stream channels, sand, gravel, cobbles, and occasionally boulders are predominant.
  - Recent Basin Deposits - Extensive basin deposits are found throughout Sierra Valley. They are up to 35 ft thick and overlie the Pleistocene lake deposits. There are three types. The finest grained (Qb1) is found in poorly drained areas and consists of dark-gray clay containing some organic material. Because of poor drainage, certain alkali salts have accumulated. A coarser grained silt-to-clayey silt (Qb2), also containing organics, occurs in broad areas of the valley floor. Some alkali is also found in these sediments. A few areas of the basin are covered by freer draining material (Qb3) composed of sandy silt with very little alkali.

- Recent Sand Deposits - In the northeastern corner of the valley there are unconsolidated, fine-grained sand deposits. These represent an area of once active sand dunes that have stabilized and are now vegetated.

Figure 2.2-7 provides a spatial overview of Sierra Valley geology, and Figure 2.2-8 provides a graphic overview.

Geologic Structure

The geologic structure of Sierra Valley consists of a downdropped fault block, or graben, surrounded by uplifted mountains, or horsts. The primal valley floor was an irregular surface of basement rock, formed by steeply dipping to vertical, normal, and strike-slip faults. Northwest-trending faults are dominant and attendant branch faults offset and are occasionally offset by northeast-trending faults. The southern boundary of the valley, near Sierraville, may be formed by a complex pattern of faults, which included the Mohawk Valley Fault.

Relatively steep gravity gradients (from a 1959 DWR gravity survey) on the northwest and west margins of the valley suggest steep-bounding faults. The trend of these is slightly east of north and, near Beckwourth, trends northwest. Further towards the center of the valley are the most prominent faults. The first, the Grizzly Valley Fault, enters the valley via Mapes Canyon, north of Beckwourth, and extends southeast along Smithneck Creek. The Hot Springs Fault parallels the Grizzly Valley Fault three miles to the southwest. This fault's name refers to the Marble Hot Springs wells and other thermal artesian wells that are located along this trace. An unnamed fault diverges from the Hot Springs Fault near Beckwourth and connects with the Grizzly Valley Fault near Loyalton. Direction of movement and magnitude of vertical displacement along these faults are not known. South of Vinton, the valley is probably bounded by steeply dipping faults roughly parallel to those on the west side of the valley.

Figures 2.2-9 and 2.2-10 depict generalized cross-sections of the SV Subbasin prepared by DWR (1963). Figures 2.2-15 through 2.2-21 show detailed subsurface geologic cross-section prepared by Kenneth D Schmidt and Associates (Schmidt, 2003; Schmidt, 2005) using additional information, particularly electric logs. The locations of the subsurface geologic cross-sections, shown in Figures 2.2-11 through 2.2-14, are as follows:

- A-A′: north-south section extending from north of Highway 70 through Loyalton to Sierra Brooks
- B-B′: east-west section north of Highway 70 west of Vinton
- C-C′: east-west section south of Highway 70 extending from west of Highway 49 past the railroad
- D-D′: north-south section extending from near County Route A23 east of Calpine south to near Highway 89 west of Sierraville
- E-E′: east-west section south of Chilcoot
- F-F′: north-south section extending from north of Chilcoot through Chilcoot

- G-G': east-west section extending from Beckwourth to east of the airport near the railroad

Faulting

This section is excerpted from Vestra (2005). The Sierra Valley lies among one of the most faulted regions in California. Three primary faults that include Grizzly Valley Fault, Hot Springs Fault, and Mohawk Valley Fault trend northwest and are suspected to dissect the watershed.

Grizzly Valley Fault is located in the northern section of the watershed and can be traced from Mapes Canyon north of Beckwourth, extending along Smithneck Creek until it goes to Sardine Valley. The Fault zone is approximately 10 miles long and 1 to 2 miles wide. Movement along the fault zone consists of left lateral high angle normal faults of which a small right-slip component of movement is suspected (Grose, 2000b).

Hot Springs Fault parallels Grizzly Valley Fault and can be traced from Beckwourth southeast to where it intersects the Grizzly Valley Fault approximately 1 mile north of Sardine Valley. This fault's name refers to the hot spring wells and other thermal artesian wells located along this trace.

Mohawk Valley Fault trends northwest and is located throughout the Mohawk and Sierra Valleys southeast through Sierraville. The fault is a high angle normal fault with occurrences of dextral divergent movement. Vertical offset is estimated to be from 1,640 to 3,870 feet (Sawyer, 1995).

It is suspected that many of the normal faults have fractured the underlying basement rocks resulting in substantial variations in the depths of valley sediments. Some estimates are 800 feet belowground surface (bgs) up to 2,000 feet bgs (DWR, 1963).

According to a Sierra Valley aquifer delineation and groundwater flow analysis prepared by Plumas Geohydrology (Bohm, 2016b), Figure 2.2-22 shows the faults of Sierra Valley and a description of the faults and how they are expected to affect groundwater flow, excerpted from Bohm (2016b), is provided here:

- There are two faults striking about NNW, dissecting the basin into a southwestern one-third and a northeastern two-thirds. The western fault is called the "Hot Springs Fault" (HSF) "runs" from Antelope Valley NNW into Big Grizzly Canyon. The eastern fault (called the "Loyalton Fault") is traced from Smithneck Creek Canyon to a point west of Beckwourth, where it apparently merges with the HSF. Considering the regional geologic setting these two faults are mostly strike-slip faults and, given the significant west-to-east bedrock topography in Map 3-1, with a significant dip-slip component.
    - In a pumping test these faults would probable cause a barrier boundary effect.

- A major SW-to-NE striking fault zone was traced from east of Calpine to the Little Last Chance Creek Canyon (Adam's Neck) north of Vinton. For the purpose of this report this zone is referred to as the "Vinton-Calpine Fault Zone" (VCFZ). This feature is apparently more than a distinct fault, but a zone that is affected by a series of "normal faults", which create conspicuous linear ridges which can be readily identified on the aerial photos.
    - Apparently, this zone constitutes an important pathway for groundwater flow, evident in the linear stream channels referred to as the "Sierra Valley Channels".
    - A topographically low spot occurs where the VCFZ and the two NNW striking faults intersect. It is here where most high temperature wells are located.
- The VCFZ is apparently part of the Upper Long Valley fault zone identified on the Chilcoot geologic map quadrangle.
- The Mohawk Fault Zone apparently defines much of the topography of the uplands west Sierraville and Sattley, including Turner Creek Canyon and Chapman Saddle.

The fault system through the Sierra Valley was most recently studied by Gold et al. (2013) through analysis of LiDAR topographic data. This study elucidated a number of specifics regarding the locations, extents, and seismicity of faults in the Sierra Valley.

Seismicity

Faulting that began during the Sierra Nevada uplift (Miocene time) has continued intermittently to the present. Geochemical, geophysical, and geological evidence indicate that the Hot Springs and Grizzly Valley Faults may have been active during Quaternary time, and they are still considered active (Berry, 1979).

The region around Sierra Valley has a relatively high potential for seismic activity. Since 1932, 43 earthquakes with a Richter magnitude of 4.0 or greater have been recorded within 34 miles of Sierraville. A 5.6 Richter magnitude earthquake, centered near Loyalton in April 1959, caused about $5,000 worth of damage.

Gold et al. (2013) used high-resolution topographic data from airborne lidar and shallow seismic reflection imaging to demonstrate Quaternary deformation on the GVFS. The seismic reflection data image the Grizzly Valley fault system as a steeply dipping structure that vertically offsets the top of Tertiary volcanic rocks 70–80 m, southwest side up, to within 50m of the surface.

Geologic History

The geology of the Sierra Nevada reflects an extremely active margin between the North American continent and the ocean lithosphere. Most of the Tertiary-age and earlier rocks have their genesis in the resulting forces generated by this activity. The present study area has physical traces back to the Silurian period. At this time, a marginal sea apparently existed along the edge of the continent, receiving sediment from inland sources.

Probable subduction of the ocean lithosphere eastward under the continent began in the Devonian period. Regional overthrusting and volcanisim occurred in what is today called the Antler orogeny. Similar orogenic events involving western North America occurred during Permian-Triassic (Sonoma orogeny) and Late Triassic-Late Jurassic period (Nevadan orogeny). The metamorphic rocks of the basement complex represent volcanic rocks and sediments deposited as a result of these events.

During the Cretaceous-Early Tertiary period (Cordilleran orogeny), subduction moved westward and the Sierran granitic plutons were intruded into the existing country rock. Volcanic rocks were erupted periodically throughout the Mid-to-Late Tertiary as subduction continued in the area of the present-day Coast Ranges.

In Late-Pliocene time, faulting and erosion began to change the landscape toward its present shape (Berry, 1979). Lakes backed up in depressions (grabens) and received sediment from the surrounding highlands (horsts); Plio-Pleistocene Lake Beckwourth filled Sierra Valley to a probable elevation of 5,120 ft above sea level (Berry, 1979).

During the Pleistocene age, glaciers formed in the mountains south and west of Sierraville and contributed sediment and water to the la e. Draining to the west, the lake eroded a water gap and slowly emptied. Today, erosion, sedimentation, and faulting continue.

The history of the SV Subbasin can also be summarized as follows (Bohm, 2016b). The SVB is a fault bounded intermontane trough, filled with lacustrine and fluvial sediments. The trough was probably formed due to expansion in a limited section of the earth’s crust which leads to formation of steep normal faults and downward movement of one or several fault blocks. Throughout its geologic history, the fault trough floor gradually subsided while being occupied by one or several lakes (Durrell, 1986). Sediments eroded from the surrounding uplands and volcanic tuffs (mud-flows and volcanic "ash") where deposited in the lake while the fault trough floor continued to subside.

2.2.1.4 Principle Aquifers and Aquitards

This section includes:

- Formation names, if defined.
- Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.
- Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.

- General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.
- Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply
- Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.

<u>*Summary of Basin Boundaries*</u>
The SV Subbasin is bounded to the north by Miocene pyroclastic rocks of Reconnaissance Peak, to the west by Miocene andesite of Beckwourth Peak, to the south and east by Tertiary andesite, and to the east by Mesozoic granitic rocks (DWR, 2004a; Saucedo, 1992). Additional lateral boundaries and conduits are formed by faults across and around the SV Subbasin (see Figures 2.2-22 and 2.2-23 and additional discussion below and in Sectoin2.2.1.6).

Vertical boundaries are defined by the basin bottom (bedrock surface) and the tops and bottoms of aquitards. As indicated by well drilling records and a gravity survey conducted by DWR (1960), the SVB fault trough floor as defined by the bedrock surface buried under the sediments is not of uniform depth. Sediment thickness in the central basin as indicated by the geologic profile obtained from a geothermal exploration well and several deep water well drilling logs is at least 1500 ft, whereas in most peripheral areas depth to bedrock is no more than a hundred feet (Bohm, 2016b). Figure 2.2-23 shows the faults of Sierra Valley and the depth to bedrock within the SV Subbasin, as approximated by Bohm (2016b) based on well logs and other available data. In Figure 2.2-23, the deepest well total depths (TD's) for each section (square mile) are plotted as circles with a central dot, labeled with depth in ft below the 5000 ft level (negative numbers). The location plots and depth labels represent the following (Bohm, 2016b):

- Red - the deepest depth to BR (bedrock) measured in that particular section, i.e. only wells that did encounter bedrock.
- Dark green - the deepest TD of "deep aquifer" wells measured in that particular section, i.e. deep wells which did not encounter BR.
- Blue - the deepest TD of "shallow aquifer" wells measured in that particular section, i.e. shallow wells which did not encounter BR.
- Purple triangles - represent additional well data obtained from other sources, e.g. the five temperature gradient test holes drilled in 1985.

Additional data spatially-referenced data on the basin bottom and data on the lateral extents and tops and bottoms of aquitards and unconfined aquifers is best depicted in the subsurface cross-sections described below and graphically representation thereof (Figures 2.2-9 through 2.2-21) and is summarized in the descriptions of primary water-bearing formations provided below.

The complexly faulted nature of the SV Subbasin introduces additional barriers to the aquifers and aquitards of the SV Subbasin. Knowledge of the affects these faults have on groundwater flow in the SV Subbasin is limited (see Section 2.2.1.6 for additional data gap/uncertainty information).

Summary of Fault Boundaries/Conduits

The locations of faults within the SV Subbasin are well documented and the characteristics of the faults with regard to how they affect groundwater movement and recharge in the SV Subbasin is somewhat understood. This understanding is summarized from DWR (1983) here:

Fault zones may be separated into three general hydrogeologic categories: those which readily transmit ground water: those which act as ground water barriers: and those which do neither. When brittle, massive, or lithified rocks, such as the basement complex and volcanic rocks, are faulted, many fractures may develop along the plane of movement. This zone of fracturing varies in width and density of individual fractures, and may contain little or no fault gouge. Such fault zones will readily transmit ground water. The Hot Springs, Grizzly Valley, and Mohawk Valley Faults are believed to belong to this group (Grizzly Fault may not be, per analysis by Gold et al., 2013 summarized below).

Faults acting as ground water barriers are located within sedimentary deposits and certain water-yielding volcanic rocks. The barrier is formed by offset of permeable beds against less permeable beds, or the formation of fault gouge in the fault zone that transects and thus destroys the continuity of water-yielding materials. Such ground water barriers may not completely stop the flow of water but merely impede it. The Hot Springs Fault may also fall into this group where it extends into the sedimentary deposits of the valley. Faulting has no hydrologic effect when fault gouge forms in already impervious rock, or no barrier develops as the result of offset in pervious materials. Faults of this type have no known representatives in Sierra Valley. Using hydrologic data, they are difficult to detect because they produce no change in the movement of ground water.

Additional assessment of the effects of faults on groundwater movement and recharge in the SV Subbasin have been conducted. According to Bohm (2016b), available information suggests that faulting significantly affects groundwater flow in several areas of the Sierra Valley Basin, largely by creating NE and NW trending groundwater migration zones. Gold et al. (2013) concluded based on the abrupt change in hydrology coincident with the Grizzly Valley fault system (to the northeast, the ground surface is lower and is water saturated through much of the year; in contrast, the ground surface southwest of the GVFS tends to be dry through the majority of the year) that the fault may serve as a barrier to groundwater flow between the northeast and southwest portions of the valley where the Grizzly Valley Fault passes through. Analysis of groundwater level changes in close proximity to faults by Bachand and Associates (2019) suggests __________. Due to the significance of the effects of faults on groundwater movement in the SV Subbasin with respect to effective groundwater management, additional investigations should be conducted (see Section 2.2.1.6 for additional discussion).

Commented [GH16]: Placeholder; waiting for full report; recall from Phil's presentation that GW level data on either side of certain faults was similar enough to indicate that those faults aren't acting as barriers.

Summary of Primary Water-Bearing Formations
As summarized in DWR (2004a), the primary water-bearing formations in Sierra Valley are Holocene sedimentary deposits, Pleistocene lake deposits, and Pleistocene lava flows. The aquifers of the valley are mainly alluvial fan and lake deposits. The alluvial fans grade laterally from the basin boundaries into course lake and stream deposits. The deposits of silt and clay act as aquitards or aquicludes in the formation. Aquiclude materials are predominantly fine-grained lake deposits. In the central part of the basin, alluvial, lake and basin deposits comprise the upper 30- to 200-feet of aquitard material that overlies a thick sequence of interstratified aquifers and aquicludes. The following summary of water-bearing formations is from DWR (1963) and DWR (1983).

- Holocene Sedimentary Deposits: Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. These deposits are located at the perimeter of the valley to a thickness of 200 feet. The fan deposits coalesce or interfinger with basin, lake, and alluvial deposits. Specific yield ranges from 8- to 17-percent. The fans are a major source of confined and unconfined groundwater and also serve as important recharge areas. Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range between 5- to 25- percent. This unit is limited in extent and is found along streams and centrally in the basin. The deposits are up to 50 feet in thickness and yield moderate amounts of groundwater to shallow wells.
- Pleistocene Lake Deposits: Lake deposits underlie the majority of the valley and range in thickness to 2000 feet. These provide most of the groundwater developed in the valley. The deposits consist of slightly consolidated, bedded sand, silt, and diatomaceous clay with the sand beds yielding large amounts of groundwater to wells. Specific yield ranges from 1- to 25-percent. Well production reportedly ranges up to 3,200 gpm.
- Pleistocene Volcanic Rocks: Pleistocene volcanic rocks consist of jointed and fractured basalt flows ranging in thickness from 50- to 300-feet. These rocks are moderately to highly permeable and yield large amounts of groundwater to wells. They also serve as a recharge area and, where buried by lake deposits, form confined zones with significant artesian pressures.

Principle Aquifers and Aquitards Information Derived from Subsurface Cross-Sections
The principle aquifers and aquitards of the SV Subbasin are most comprehensively described via analysis of subsurface cross-sections by DRW (1983) and Kenneth D Schmidt and Associates (Schmidt, 2003; Schmidt, 2005), derived from drillers' well logs, E-logs of water wells and exploratory test holes. The descriptions below were therefore excerpted from those documents and include information on the definable bottom of the basin. For graphical representations of this information, see Figures 2.2-9 through 2.2-21.

Aquifers are geologic formations, groups of formations, or parts of formations that yield and transmit water in sufficient quantities to supply springs and wells. Finer material such as silt, or sand with silt or clay, may yield water, but only in minor amounts. However, they can transmit water from adjacent aquifers and constitute important ground water storage units. Geologic formations or parts of formations composed of these types of materials are called "aquitards". Materials composed of large amounts of clay are relatively imper-meable and are called "aquicludes"; these neither yield water to wells nor transmit water from adjacent sources. They are boundaries to aquifers and aquitards and confine ground water above and below them. In Sierra Valley, the aquifers are only parts of formations because none is composed entirely of water-yielding materials such as sand and gravel.

Cross-section A-A' from DWR (1963; see Figure 2.2-9), representing the basin from northwest of Vinton to south of Loyalton, shows aquifers at the surface and at depth interstratified with aquitards and aquicludes to the left (north) of the Lucky Hereford headquarters. These aquifers are mainly alluvial fan deposits where they are close to the basin-bounding granitic and volcanic rocks. Away from the basin boundary they grade laterally into coarse lake and stream deposits. The aquitard materials at the surface and at shallow depth are basin, alluvial, and lake deposits. Shallow wells (less than about 200 ft) completed in this area yield moderate amounts of unconfined water; deeper wells penetrating the confined aquifers can produce as much as 3,000 gpm, South of the Lucky Hereford headquarters, a thin layer of aquitard material overlies the aquifer. These are basin deposits and fine-grained alluvium overlying alluvial fan and coarse-grained stream deposits. Near Loyalton are lenses of fine-grained alluvial materials that locally confine some shallow ground water.

Cross-section B-B' from DWR (1963; see Figure 2.2-10) shows a general north-south section through the center of the valley. Basin, alluvial, and lake deposits comprise the upper 50 to 200 ft of aquitard material that overlies a thick sequence of interstratified aquifers and aquicludes. The aquifers consist of alluvial fan deposits near the basin boundaries and grade to alluvial and coarse-grained lake deposits towards the center of the basin. The aquicludes are predominantly fine-grained lake deposits. Shallow wells near this cross-section produce moderate quantities of unconfined ground water, usually sufficient for stock and domestic needs. Deep wells here can produce artesian flows of 20 to 100 gpm; when pumped, yields of 1,000 to 2,000 gpm are reported.

Subsurface Cross Section A-A' from Schmidt (2003; see Figure 2.2-15) shows the major confining bed in Sierra Valley. The bed is primarily clay, silty clay, or sandy clay. This bed thickens toward the center of the valley. Along this section, the clay is thickest at Lucky Herford Well No. 8, where it is about 600 feet thick. Above this bed, the coarse-grained deposits of the shallow water producing zone are generally less than 50 feet thick along much of the section. Near Loyalton and Sierra Brooks, in the alluvial fan of Smithneck Creek, the shallow coarse-grained deposits are much thicker, approaching 300 to 350 feet in thickness. Coarse-grained, highly productive deposits of the deep water-producing zone are present below an average depth of about 600 feet. These deposits are thickest and best developed along this section in the area north of Dyson Lane. Groundwater in the deep water-producing zone is confined by the over-lying major confining bed in the valley. Prior to the 1970's, many wells tapping the deep water-producing zone flowed. Thus, there was over 600 feet of hydraulic head or pressure in the deep zone at these wells.

Cross section B-B' from Schmidt (2003; see Figure 2.2-16) shows subsurface conditions in the area north of Highway 70. The shallow water-producing zone averages about 75 feet thick along the section. The confining bed averages about 500 feet thick along the section. Coarse grained deposits of the deep water-producing zone are well developed, particularly along the east part of the section, where stream channel deposits (coarser than sand) are present. These are probably associated with the alluvial fan of the Middle Fork of the Feather River.

Cross section C-C' from Schmidt (2003; see Figure 2.2-17) indicates a relatively thick (about 350 feet) shallow water producing zone along the central part of the section, which runs east/west south of Highway 70. This zone thins both to the west and east along the section. The confining bed is thickest along the west part of the section, where it is almost 500 feet thick. Beneath the central and east part of the section, the bed averages about 250 feet thick. The deep water-producing zone is shallower to the east along the section.

Cross section D-D' from Schmidt (2003; see Figure 2.2-18), which extends through the three new nested monitor wells constructed in 2002. The section extends from east of Calpine south to west of Sierraville. The southerly two District monitor wells (MW-2 and MW-3} along this section both encountered hardrock. The top of the hardrock was about 420 feet deep at MW-3 and 675 feet deep at MW-3. Because of the location of this section (in the extreme southwest part of Sierra Valley), the three major subsurface units shown in the other cross sections are more difficult to distinguish. The confining bed is indicated to be about 200 feet thick at MW-4, about 230 feet at MW-3, and about 400 feet thick at MW-2. The deep water-producing zone is not as well developed along this section as in much of the rest of the valley. At MW-2 and MW- 4, four sand layers were in this zone. At MW-3, there was only one sand layer in this zone, partly because of the shallow hardrock.

Subsurface Cross Section E-E' from Schmidt (2005; see Figure 2.2-19) shows the top of the hardrock, or base of the alluvial deposits, generally along Highway 70 in the Chilcoot area. Shallow coarse deposits are present at Well 35R, MW-5, and 36R above a depth of about 130 feet. Below this depth, the alluvial deposits are primarily fine-grained. MW-5 and Well 36P are believed to be located in the area where the bedrock is the deepest in the Chilcoot area. Depth to the hardrock changes substantially within relatively short distances in the area. The California Department of Water Resources (1983) indicated that a fault passed through the area just east of Well 34R. Depth to hardrock was about 350 feet at MW-5, about 200 feet at Well 1B, and less than 100 feet at Well 6D.

Cross Section F-F' from Schmidt (2005; see Figure 2.2-20) shows a highly variable depth to bedrock from north to south along the Frenchman Lake Road. The deepest hardrock is at MW-5, however to the north, another area of relatively deep bedrock (about 375 feet) is present at Well 25P. In the north part of the Chilcoot area, a thick weathered zone is present (almost 100 feet thick) above the top of the hardrock and below the alluvial deposits. Fine-grained alluvial deposits are predominant north of Well FLRE No. 3 along this section. A thin coarse-grained zone (boulders) appears to be present near the base of the alluvium in this part of the Chilcoot area. An area of relatively shallow hardrock (less than about 70 feet deep) was delineated by FLRE No. 3, and Wells 36C and 36M. To the south of that area, the hardrock becomes deeper within a relatively short distance.

Cross section G-G' from Schmidt (2005; see Figure 2.2-21), which extends from Beckwourth to the east, through MW-6. Coarse-grained deposits are predominant within the uppermost 120 feet or so, in the area west of MW-6. East ofMW-6, clay is predominant to a depth of about 150 feet. Coarse-grained strata are present at Well 26H2 from about 220 to 240 feet in depth. Coarse-grained strata are present from about 150 to 220 feet in depth at Well 25N. At MW-6, fine-grained deposits are predominant below a depth of about 130 feet.

The complexity and spatial variation of the SV Subbasin aquifers/aquitards is evident in the above cross-section descriptions. This complexity and associated quantitative uncertainty associated with the SV Subbasin groundwater system is exacerbated by the plethora of faults strewn across the valley and around the valley perimeter, as previously described.

<u>Properties of SV Subbasin Groundwater System</u>
As reported by Bohm (2016b), the SV Subbasin's aquifer properties are generally governed by:

- The basin's tectonic evolution,
- The former lake's sedimentary environment and history,
- The type of depositional conditions of the volcanic lava flows,
- The subsequent (post-sedimentary) geothermal alteration and lithification of the lacustrine tuffs, and
- The tectonic activity determining the distribution and degree of secondary permeability (joints and fracture zones) in the volcanic lavas and the granitic rocks of the Basin's floor and perimeter and in the geothermally lithified lacustrine tuffs.

As described by DWR (1983), except for shallow wells, the water-yielding characteristics and water quality of specific aquifers in Sierra Valley cannot be determined precisely due to the method of well construction. The typical large-capacity deep irrigation well penetrates four confined aquifers. The four aquifers may be contributing equally to the reported yield or one may be producing 50 percent of it. One aquifer may be producing poor quality water while the other three produce excellent water. Because of this mingling of effects from different aquifers in a single well, the determination of a particular aquifer's water-yielding properties and water quality cannot, from the available data, be determined. Accordingly, the properties of the SV Subbasin are described qualitatively and quantitively as conglomerate values, primarily from well pumping tests and bulk water level/pumping data. The properties and data, as summarized by Bohm (2016b), is summarized below and presented in Tables 2.2-5 and 2.2-6.

In general, the lake deposits within the SV Subbasin with a wide range of grain-sizes from silt to sand and gravel have primary (intergranular) permeability and porosity. Conversely, the bedrock units underlaying the SV Subbasin (fault-trough) are characterized by secondary (fracture) permeability and porosity. Most importantly, the bulk bedrock hydraulic conductivity is about seven orders of magnitude smaller than the average conductivity of the sedimentary basin fill.

DWR (1973, p. 153) reported specific capacities ranging between 0.7 and 6.9 gpm/ft, where the lowest value applies to shallow wells, and an anomalous high value of 19.9 gpm/ft is from a 426 ft deep irrigation well. DWR (1983) reported transmissivities between 17,900 (Lucky Herford R. well) and 110,900 gpd/ft (Genasci R. well). Due to difficulties with obtaining good observation well data, only one storativity value of 0.00031 was obtained.

The bedrock units may constitute several hydraulic units (HU's), with fairly low bulk hydraulic conductivities (K), interspersed, but well delineated fault-induced zones of high fracture permeability. Given the much lower bulk permeabilities in the bedrock units (compared to the sedimentary basin-fill formations), the bedrock units are deemed "impermeable" for all practical purposes – with the exception of highly permeable fault zones.

Additional properties and data are thoroughly covered in subsequent sections of this Plan Concept Document (Section 2.2.2 and 2.2.3).

General Water Quality of the Principal Aquifers

Water quality in the SV Subbasin has been studied and characterized on numerous occasions. DWR has collected groundwater chemistry data dating back to the late 1950's and SVGMD has expanded the database through their monitoring efforts. DWR (2004) summarized water quality in the SV Subbasin as follows:

A wide range of mineral type waters exist throughout the basin. Sodium chloride and sodium bicarbonate type waters occur south of Highway 49 and north and west of Loyalton along fault lines. Two well waters are sodium sulfate in character. In other parts of the valley the water is bicarbonate with mixed cationic character. Calcium bicarbonate type water is found around the rim of the basin and originates from surface water runoff (DWR, 1973). Total dissolved solids in the basin range in concentration from 110- to 1620-mg/L, averaging 312 mg/L (DWR unpublished data). The poorest quality groundwater is found in the central west side of the valley where fault-associated thermal waters and hot springs yield water with high concentrations of boron, fluoride, iron, and sodium. Several wells in this area also have high arsenic and manganese concentrations. Boron concentrations in thermal waters have been measured in excess of 8 mg/L. At the basin fringes, boron concentrations are usually less than 0.3 mg/L (DWR, 1983). There's also a sodium hazard associated with thermal waters and some potential for problems in the central portion of the basin (DWR, 1983).

Most of the early DWR datasets are incomplete and contain only a limited selection of water quality parameters according to Bohm (2016a). This, and the inconsistency of sampling frequency, wells sampled, and parameters analyzed, permits virtually no comparison between samples collected over time and unavailability of well log information for most of the DWR database precludes three-dimensional mapping of water quality parameters (Bohm, 2016a). As such, Bohm (2016a), supported and funded by SVGMD, set out to collect additional samples aiming to maximize the usefulness in understanding current groundwater chemistry and changes over time. The findings of the study are summarized below (Bohm, 2016a).

The Sierra Valley groundwaters cover a wide range of water types ranging from comparatively low percentages of chloride, sulfate, sodium, and potassium plotting in the lower left corner to high percentages of the same constituents in the upper right corner. The wide-ranging chemistry is a pattern that is symptomatic of groundwater chemistry evolution in silicate rocks and sediments under somewhat elevated groundwater temperatures (up to 40 degrees C). The variability appears to be more aerially than vertically. Vertical variability is evident in the southern monitoring wells and is expected to become more evident once we have been provided with the well log numbers for each of the wells that are part of DWR's groundwater quality monitoring network.

Total dissolved solids levels in Sierra Valley groundwaters range between about 100 and 1500 mg/l (or 160 to 2500 uS/cm). Chloride and sulfate range from 1 mg/L to 545 mg/L and from 1 to 370 mg/L, respectively. In Sierra Valley high boron levels correlate with groundwater temperature and TDS. However, the correlations are rather coarse, suggesting other unknown associations might be involved. For example, 30% of all wells sampled have boron levels greater than 1.0, and maximum boron levels can be greater than 5 mg/L (8.1 mg/L in the Filipini geothermal well). Among 122 samples taken, boron changes were observed in 80% of samples taken, of which 34% were increases, 46% were decreases and 20% showed no change. About 25% of all wells measured exceed the drinking water standard of 44 mg/L for nitrate. Figures 2.2-24 and 2.2-25 show the nitrate and boron concentrations in sampling wells throughout the valley (Bohm, 2016a).

In summary, groundwater quality is generally good in the SV Subbasin, but available data suggests potential for water quality impairment and issues. Monitoring (per Section 3.5) is thus a critical component of this Plan Concept Document.

Identification of the Primary Aquifer Uses

The quantitative breakdown of wells by type of use provided as Table 2.1 shows that domestic use is the primary aquifer use in Sierra Valley on a number-of-wells basis (approximately 74% of all wells are domestic). However, the high pumping capacity of irrigation/agricultural wells, which make up only approximately 6% of the total number of wells in Sierra Valley, make agriculture pumping the primary aquifer use in the SV Subbasin on a volume-of-water-pumped basis. Since 1989, agricultural groundwater extraction rates have been metered by SVGMD. The data are summarized in Table 2.2-8 and show an average annual groundwater extraction for irrigation of approximately 6,600 acre-feet per year (Schmidt, 2003), more than half of the total annual pumping estimate from DWR (2019a) of 12,480 acre-feet per year. It's important to note that agricltural pumping ranges substantially based on water year due to the conjuctive-use nature of agricultural irrigation in the Sierra Valley (e.g. years with high precipitation totals and good snow pack provide ample surface water for irrigation thereby reducing pumping totals; conversely, years with low precipication totals and poor snow pack yield limited availability of surface water for irrigation thereby requiring more groundwater pumping – see Sections 2.1.4 , 2.2.1.5, and 2.2.3 for additional information).

2.2.1.5 Recharge and Water Deliveries

This section includes:

- Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin
- Surface water bodies that are significant to the management of the basin
- The source and point of delivery for local and imported water supplies

Introduction to SV Subbasin Recharge

The content of this subsection was extracted from DWR (1983) to introduce recharge concepts in the SV Subbasin. The rate (gpd, ac-ft/yr, etc.) at which ground water flows through a particular section of the basin is a function of the hydraulic gradient, the transmissivity of the aquifer, and the width, measured perpendicular to the hydraulic gradient, of the portion of the aquifer under consideration. Rate of flow is expressed as: Q = TIL, where Q is the quantity of water flow in gallons per day, T is the coefficient of transmissivity in gallons per day per foot of width, I is the hydraulic gradient in feet per mile, and Lis the horizontal width, in feet, of the portion of the aquifer being considered.

The hydraulic gradient and width of the area being considered can be determined directly from groundwater level contour maps, while the estimation of transmissivity usually requires an aquifer test.

Total basin recharge, using transmissivity values calculated with data from three pump tests (see Appendix D of DWR, 1983) and average hydraulic gradients from the 1981 and 1983 spring water level elevation contour maps, is estimated to be about 70 ac-ft/day. Under existing conditions most of this (about 50 ac-ft/day) enters the eastern half of the basin from surrounding recharge areas. Elsewhere, recharge rates are considerably less because of generally lower hydraulic gradients. Unlike the eastern part of the basin, where large quantities of ground water are pumped during the summer and fall irrigation season {about 65 ac-ft/day), creating substantial changes in storage and thus room for recharge, the western half experiences only minor changes in storage and hence little recharge. Water available for recharge is rejected and runs off as streamflow out of the basin because of the absence of underground storage space.

A recharge rate of about 3 ac-ft/day is estimated to be entering the basin from the area north of Sierraville (T = 21,000 gpd/ft, I= 8 ft/mi, w = 3 mi) and 17 ac-ft/day (T = 30,000 gpd/ft, I= 20 ft/mi, W = 9 mi) from the rest of the recharge areas. Recharge in the confined aquifers of the basin comes from infiltration and percolation of rainfall and streamflow in areas where the confining bed rises to or near the surface (see Figure 3 of DWR, 1983). Recharge in the unconfined aquifer of the basin comes from infiltration and percolation of rainfall, streamflow, and applied irrigation water. The rate of recharge is influenced by: (1) the vertical permeability of the surface deposits, (2) vegetative cover, (3) frequency, intensity, and volume of precipitation, (4) topography, (5) temperature, and (6) available storage space. Water level measurements in the few wells that are drilled solely into the unconfined aquifer show that there is relatively little change in storage between spring and fall (fall water levels are about 2 to 7 ft below spring levels). This is because: (1) few wells draw from the aquifer, and (2) infiltration and percolation of applied irrigation water either provides recharge during the summer and fall or reduces natural discharge from the zone of saturation.

Recharge Areas
As summarized by Bohm (2016b), current thinking is that groundwater recharge enters the aquifers of Sierra Valley by:

- Stream infiltration in the alluvial fans at the periphery of the valley.
- Flow from the fractured bedrock in contact with shallow and deep aquifers.

It appears that some parts of the SVB aquifers may be connected to upland recharge areas via bedrock fault zones with enhanced permeability, zones that may provide significant recharge into limited portions of the SVB aquifer (Bohm, 2016b). Bohm (2016b) used isotope and water quality data and knowledge of the principles of groundwater recharge to identify the following "recharge centers" (areas which substantially contribute to the replenishment of the SV Subbasin) and their associated characteristics and discharge locations:

A. Dixie Mountain recharge center, elevation 8300 ft down to about 6300 ft. This is the entire area underlain by volcanic rocks, between Dixie Mountain peak and Frenchman Lake.
    1. Most groundwater discharge is to the north into Ramelli Creek and to the east into Little Last Chance Creek (now Frenchman Lake). (This is well supported by isotope data).
    2. Discharge through the deeper bedrock flowing south into the lacustrine valley aquifers. (This is supported by the isotope data).
    3. This is probably the second largest sub-basin in the Sierra Valley Basin, draining S and SW via Little Last Chance Creek (Adams Neck) into Sierra Valley.

B. Crocker Mountain, elevations 7500 down to 4900 ft.

1. Grizzly Valley (now filled by Lake Davis), underlain by fractured granite and volcanics. This area has little bearing on the Sierra Valley Basin hydrologic budget since Grizzly Creek flows out into the Middle Fork of the Feather River. (This is supported by isotope data).

C. Beckwourth Peak, elevations 7200 ft down to 5000, underlain by volcanics.

  1. Ross Meadows area on the N slope has no bearing on the Sierra Valley Basin hydrologic budget since it drains into the Middle Fork of the Feather River at the outflow from Sierra Valley. (No isotope data available).

  2. Carman Valley on the southern flank of Beckwourth Peak, with significant discharge areas draining south and east at low elevations (Knudson Meadows). Granite in the south. (So far this is not supported by isotope data, since access to Knudson Meadow has not been obtained).

D. Yuba Pass area, elevations 7400 ft down to 5000 ft.

  1. Watersheds drained by Fletcher, Turner, and Berry Creeks, draining E and SE, underlain mostly by granite.

  2. In tandem with the Cold Stream watershed this may be one of the major water sources of the Sierra Valley Basin, however, given the limited fracture permeability of the underlying granitic formations most of this may enter the Sierra Valley as groundwater. (This is supported by isotope data).

E. Truckee Summit area (Highway 89), elevations 8200 ft to 5400 ft.

  1. Cold Stream watershed, including Bonta and Cottonwood Creek watersheds, draining north into Sierra Valley near Sierraville.

  2. The area is underlain by volcanics, which is largely covered by colluvium and moraine deposits. These unconsolidated Quaternary formations are deemed unconfined upland aquifers which slowly release water to streams and underlying volcanics in the dry season.

  3. This is probably the largest sub-watershed in the Sierra Valley Basin, and given the high amount of precipitation here, may turn out to be the most significant groundwater recharge area. The underlying volcanic rocks (cropping out along Highway 89) are apparently well jointed to permit groundwater flow. (This is supported by isotope data).

F. Sardine Peak recharge center, elevations 7400 ft down to 5500 ft.

  1. Lemon Canyon watershed, E of Sierraville.

  2. Bear Valley Creek watershed, south of Loyalton, underlain by volcanics.

  3. Smithneck Creek watershed, including Dodge Canyon (E and SE of Loyalton), underlain by volcanics. (This is ambiguous based on the isotope data collected so far).

G. The Antelope Valley watershed takes on a unique position, being somewhat isolated from the surrounding Lemon Canyon watershed. (The isotope data do not suggest much of any contribution from Antelope Valley).

H. Mount Ina Coolbrith, elevations 8000 ft down to about 5700 ft, including three areas mostly underlain by volcanics and metavolcanics. The significance of these areas in terms of the total Sierra Valley Basin groundwater budget seems to be small, given their location on the eastern basin periphery. (Supported by isotope data). However, on the eastern Valley floor a number of irrigation wells have been identified with rather low TDS levels, suggesting close proximity to a groundwater recharge area. (The isotope data do not suggest Smithneck Creek as a source, but a so far unidentified second source). The second source(s) may be related to one or all of the following areas:

    1. A watershed drained by an unnamed stream, flowing west past Loyalton.
    2. A small watershed drained by an unnamed stream flowing NW, north of a knoll called "Elephant's Head".
    3. 3. A small watershed drained by several unnamed intermittent streams (Correco Canyon, et al.), flowing NW.

I. Diamond Mountains (DM) east of Frenchman Lake and NE of Chilcoot. Elevations 7700 ft down to about 5600 ft, predominantly underlain by granitics and contact metamorphic rocks:

    1. With its significant topographic relief this area appears to be significant but its location on the eastern periphery seems to imply only limited amounts of precipitation (and groundwater recharge).
    2. Groundwater studies conducted in the Chilcoot area suggest that significant groundwater recharge may flow (fault controlled) from the Diamond Mountains southwest into the Chilcoot sub-basin. (The isotope data interpretation is ambiguous).
    3. Based on the preceding observation, it may be justified to imply groundwater flow from the Chilcoot sub-basin into the larger Sierra Valley Basin via a set of SW striking faults.

<u>*Discharge Areas*</u>

The primary discharge area of surface water and groundwater from the SV Subbasin is through the Middle Fork Feather River outlet in the northwest corner of the valley. Discharge areas from upland recharge areas include springs, seeps, and wetlands, most of which exist along the periphery of the valley. These springs, seeps, and wetlands are generally more abundant in the southern/western portions of the valley, below the southern/western mountains/upland recharge areas of the watershed, which receive significantly more precipitation than the northern/eastern mountains/upland recharge areas, as summarized in Section 2.2.1.2, though many exist along the northern valley perimeter, likely fed by the relatively large upland recharge areas that exist north of the valley (i.e. Dixie Mountain and Diamond Mountains recharge centers). All such discharge locations could potentially be named, mapped, and monitored in the future as needed to reduce uncertainty and improve groundwater management sustainability. Anecdotal and written documentation (DWR, 1983) exists which suggests certain spring/seep discharge areas have gone dry in recent decades, as described in greater detail Sections 2.2.2.6 and 2.2.2.7.

Additional information on discharge from the SV Subbasin, extracted from DWR (1983) is provided here. Sierra Valley is a well-defined groundwater basin with a bedrock boundary. Subsurface inflow could enter only along pervious fault zones. Mineralized thermal water found in wells along the traces of Hot Springs, Grizzly Valley, and Mohawk Valley faults is evidence of water movement, but not necessarily of inflow from outside of the basin.

There are few data concerning subsurface outflow from the valley. A small amount of water seeps into the railroad tunnel east of Chilcoot, forms a small stream, and flows east out of the basin. Local residents say the tunnel intercepted the water table and caused a drop in water levels in surrounding wells. Evapotranspiration (ET), effluent (outflowing) reaches of streams, springs, and pumping and flowing wells are the main sources of groundwater discharge in the valley.

Effluent streams receive ground water discharge from unconfined aquifers where the water table is higher than the water surface of the stream. This discharge is greatest during the winter and spring and declines to almost nothing by fall.

Springs occur in the valley at or near the ground water basin boundary. They reveal areas where the groundwater surface intersects the ground surface or where a subsurface barrier to groundwater movement forces the water to the ground surface. Flow from springs vary; some flow year-round, while others dry up in the summer or fall.

Wells, by their general method of construction in Sierra Valley, are direct conduits for the discharge, and in some cases, recharge of ground water. A flowing well discharges confined groundwater and if it is open to more than one aquifer, as many wells in Sierra Valley are, conditions permit groundwater flow from one aquifer to another. This can work in both directions (deep aquifers supplying groundwater to shallower aquifers or shallow aquifers supplying deeper ones). The determining factor is the hydrostatic pressure differential in the individual aquifers. It is suspected that this condition may be partly responsible for the apparent changes in water quality in the valley, poor quality groundwater from one aquifer having a pathway to good quality groundwater in other aquifers.

Flowing artesian wells are present in many parts of the valley and discharge confined ground water at varying rates; flow during the winter and spring is usually greater than the summer and fall flows. When a well is not flowing or flowing at a rate less than that needed, it may be pumped. Pumping accelerates groundwater discharge and, depending on the rate of pumping and location in a basin, may affect (1) other wells, (2) the hydraulic gradient, (3) recharge rates, and (4) the physical characteristics of the aquifer itself.

Surface Water Bodies
Surface water bodies that are significant to the management of the SV Subbasin include Frenchman Reservoir (outlets to Little Last Chance Creek) and Webber Lake (outlets to the Little Truckee River from which there is a diversion to the Sierra Valley). There are also several seasonal and perennial ponds on the valley floor and locations where standing water persists well into the dry season and sometimes year-round depending on the characteristics of the water year. For example, the area of the valley surrounding Island Ranch (near the intersection of Harriet Lane and Dyson Lane, north of the channel through which Smithneck Creek flows through the southeastern portion of the valley) has been inundated well into the summer in recent years.

Water Supply Sources and Points of Delivery
Water supply sources include groundwater (36% of total according to DWR, 2019a) and surface water. Groundwater points of delivery are essentially the locations of groundwater wells as represented in groundwater well location maps included in this Plan Concept Document (see Figure 2.1-12 and other figures in Sections 2.1 and2.2.1.7). Surface water diversions are managed and monitored by the area watermaster. According to watermaster records obtained from DWR, points of delivery (using the watermaster's terminology) include the following:

- Cold Creek
- Fletcher Creek
- Hamlin Creek
- Lemon Creek
- Little Truckee
- Miller Creek
- Antelope Lake Dam outlet
- Frenchmen Dam outlet
- Lake Davis outlet
- Smithneck Creek
- Smithneck Creek East
- Smithneck Creek West
- Perry Creek
- Town Creek
- Turner Creek
- Webber Creek

- Pasquetti Ditch
- Pasquetti runoff
- Van Vleck
- West Creek
- SN31715
- SN31715A
- TP61215
- TP61215W
- Diversion 129
- Diversion 131
- Diversion 136 East
- Diversion 137
- Diversion 138
- Diversion 139
- Diversion 142
- Diversion 146
- Diversion 146A
- Diversion 147
- Diversion 148 East
- Diversion 148 West
- Diversion 150
- Diversion 150A
- Diversion 151
- Diversion 151A
- Diversion 152
- Diversion 154
- Diversion 158 East
- Diversion 202
- Diversion 222
- Diversion 225
- Diversion 225A

Files for many of these points of delivery are only provided for one or two of the years for which records are available. Much of the watermaster data could someday be used to fine-tune the water budget for the valley, to better understand conjunctive use opportunities and limitations, etc., but doing so would constitute a substantial effort which GSAs have thus far not initiated. This data gap is documented in this Plan Concept Document (see Section 2.2.1.6).

2.2.1.6 Identification of Data Gaps and Uncertainty within the HCM

Several data gaps have been identified which must be filled at least in part to reduce the uncertainty of groundwater dynamics in the SV Subbasin and improve the sustainability of groundwater management and to inform management actions during the implementation of this Plan Concept Document. These data gaps and proposals for filling them, as applicable, are summarized below.

Commented [GH17]: What is included thus far are ideas stemming from development of other sections. GSAs may or may not feel it is appropriate to include these and should definitely be consulted, as they will be with all contents of this plan. Also, there are surely plenty of potential data gap topics not yet listed here which perhaps could/should be.

Effects of Faults on Groundwater Movement and Recharge

As previously described, the locations of faults within the SV Subbasin are well documented and the characteristics of the faults with regard to how they affect groundwater movement and recharge in the SV Subbasin is somewhat understood. However, considering the significance of the conduits/barriers potentially formed by the many faults through Sierra Valley with regard to understanding the SV Subbasin groundwater system and making appropriate management actions accordingly, and the difficulty in understanding active faulting in low slip rate faults in low-relief settings as depicted by Gold et al. (2013), additional investigations are needed to better understand these affects and their dynamics (as governed by active faulting).

Stream-Aquifer Interaction and Groundwater Dependent Ecosystems

As previously described, the classification of the SV Subbasin as a medium priority groundwater basin was partially a result of DWR's interpretation of impacts in the SV Subbasin pertaining to stream-aquifer interaction and groundwater dependent ecosystems. Specifically, DWR (2019a) cited several monitoring wells adjacent to wetlands and streams showing significant declines that "could be impacting the largest fresh water marsh in the Sierra Nevada Mountains and the Middle Fork Feather River that is designated as a National Wild and Scenic River". The dependence of the marsh ecosystems on the deep aquifer that is primarily being impacted by groundwater extraction is likely relatively minimal (based on past studies and knowledge of the aquifer system as described in Section 2.2), but is not well understood. A monitoring network/protocol should therefore be designed to better understand which ecosystems in the Sierra Valley are dependent on the SV Subbasin groundwater system and to what extent, which are dependent on the deep aquifer vs. shallow groundwater and to what extent, how such ecosystems are or may be affected by groundwater management/pumping in the SV Subbasin, and how the Middle Fork of the Feather River (habitat, water quality, water quantity, etc.) is or may be impacted by groundwater management in the SV Subbasin.

Surface Water Diversions and Opportunities to Optimize Conjunctive Use

In the Sierra Valley, agriculture accounts for the majority of total water demand/use as well as being a primary economic driver and central component of the area culture. During wet years, surface water diversions provide the vast majority of water needed for agriculture irrigation, resulting in low pumping totals. However, during dry years, surface water volumes provided for irrigation are limited and the remaining demand must be supplied via groundwater pumping. Surface water diversion locations and characteristics are documented in watermaster records and water rights are publicly available records. Such information could be utilized to explore opportunities to optimize conjunctive use, e.g. to maximize the amount of surface water utilized for irrigation while ensuring impacts to downstream habitat and water users are minimized, thereby minimizing the amount of agricultural groundwater pumping required to sustain agriculture in the valley. To some extent, this has already been done through the allocation of water rights and is continuing to be done through watermaster efforts. However, there is likely room for improvement which could go a long way in assuaging groundwater concerns and potential sustainability issues in the valley, thus warranting the inclusion of this topic in the Section of this Plan Concept Document.

Enhanced Recharge Opportunities

Opportunities for enhanced groundwater recharge in the SV Subbasin has recently been studied by Bachand and Associated (2019) showing that such opportunities are limited. However, some possible pilot projects were identified including improving stormwater management in the watershed to maximize infiltration of runoff in the uplands and other potential options such as artificial recharge, stream restoration, and other innovated approaches to enhancing recharge were introduced which may be worth exploring. Given groundwater elevations is a key groundwater sustainability parameter and certain areas of Sierra Valley have shown decreasing groundwater elevation trends, and that essentially the only ways to prevent groundwater elevation decline where it is occurring is to either reduce pumping or increase recharge, working toward filling this data gap could significantly contribute to the overall effort of achieving sustainable groundwater management in the Sierra Valley.

Spatial and Temporal Understanding of Groundwater Quality and Pollutant Migration

As discussed in Sections 2.2.1.4 and 2.2.2.4, although a relatively large water quality database exists for SV Subbasin groundwater, the understanding of how water quality varies spatially (both vertically and laterally) through the aquifer system and temporally, and the directions and rates of pollutant migration, is limited. Accordingly, an improved monitoring network and protocol is needed (see Section 3.5.4).

Understanding Interconnected Surface Water Characteristics and Dynamics

The complexity of the Sierra Valley aquifer system and vast dynamic nature of surface water movement through the Sierra Valley make understanding the relationship between groundwater management and interconnected surface waters very difficult. The surface water that exists much of the year in the Sierra Valley floor offers critical habitat to birds and many other species of wildlife. This standing water, which exists throughout the winter and into the spring and summer, is seemingly unaffected by groundwater pumping in most locations, aside from possible impacts that could result (and may have already resulted) from subsidence. Flow out of the valley via the Middle

Fork of the Feather River, however, is likely affected to some extent by groundwater pumping, especially in the late summer and early fall when flow rates in the river are at a minimum and impacts on groundwater elevations from groundwater pumping are at a maximum. If groundwater pumping results in significantly less flow out through the river during this period, aquatic habitat in the reaches of the river downstream of the valley outlet, especially in close proximity to the valley outlet (upstream of the many perennial downstream tributaries), could be negatively impacted. To better understand this, streamgage data could be used to estimate late season flow rates and such estimates could be correlated to precipitation and groundwater pumping records for that year. Doing so for many years could enable better understanding of the relationship between precipitation totals/temporal distribution and river flow rates, and how groundwater pumping may be affecting the flow rates. Another approach to reducing uncertainty pertaining to this topic would be through fine-tuned integrated modeling and water budgeting, which could generate estimates for expected outflow totals vs. actual totals (which could be estimated from streamgage data). The proposed approach is described in detail in Section 3.5.4. of this Plan Concept Document.

Commented [GH18]: Just some ideas for discussion.

Understanding Groundwater-Dependent Ecosystem Characteristics and Dynamics

Similar to understanding the relationship between groundwater management and surface water interaction, and for the same general reasons, it is also very difficult to understand the relationship between groundwater management and the characteristics and dynamics of groundwater-dependent ecosystems. As described in this Plan Concept Document, much of the SV Subbasin contains confined and unconfined aquifers with varying degrees of interconnection and varying degrees of development (i.e. pumping capacity of wells tapping into them). Due to the limited understanding of the interconnection of the various aquifers of the SV Subbasin, it is difficult to ascertain to what extent groundwater pumping in a given location is affecting the shallow groundwater system upon which certain ecosystems of the Sierra Valley depend. To better understand this, the health of the ecosystems could be regularly monitored using best available technologies and practices and an attempt could be made to compare the results to groundwater elevation data (both deep and shallow) and pumping data. Current data availability is apparently too limited for such an exercise. A groundwater-dependent ecosystem monitoring network and protocol is therefore proposed per Section 3.5 of this Plan Concept Document.

Commented [GH19]: Another idea for discussion.

2.2.1.7 HCM Tables and Figures

This section provides the tables and figures referenced in the HCM narrative description.

Commented [GH20]: As with the tabled/figures of section 2.1, many of these should probably be recreated/updated; however, what we have here is a good start for meeting the req's of SGMA.

Table 2.2-1. Sub-Watersheds of the Sierra Valley Watershed (Vestra, 2005).

Alder Creek	Antelope Creek	Banta Creek	Bear Creek
Blatchley Creek	Carman Creek	Chilcoot	Correco Canyon
Cottonwood Creek	Dodge Canyon	E. Carman Creek	Franklin Cabin
Harding Point	Lemon Canyon	Martneck Canyon	Mt. Ina
Nichols Mill	Old Station	Palen Reservoir	Rock Creek
Rock Creek A	Ross Ranch Meadow	Sattley	Sierra Valley
S. Last Chance Creek	Turner Canyon	Upper Sulphur Creek	West Smithneck

Table 2.2-2. 7.5 Minute Quadrangles of the Sierra Valley Watershed (Vestra, 2005).

Antelope Valley	Beckwourth Pass	Calpine	Chilcoot
Clio	Constanta	Crocker Mountain	Dixie Mountain
Dog Valley	Evans Canyon	Frenchman Lake	Independence Lake
Loyalton	Portola	Reconnaissance Peak	Sardine Peak
Sattley	Sierraville	Webber Peak	

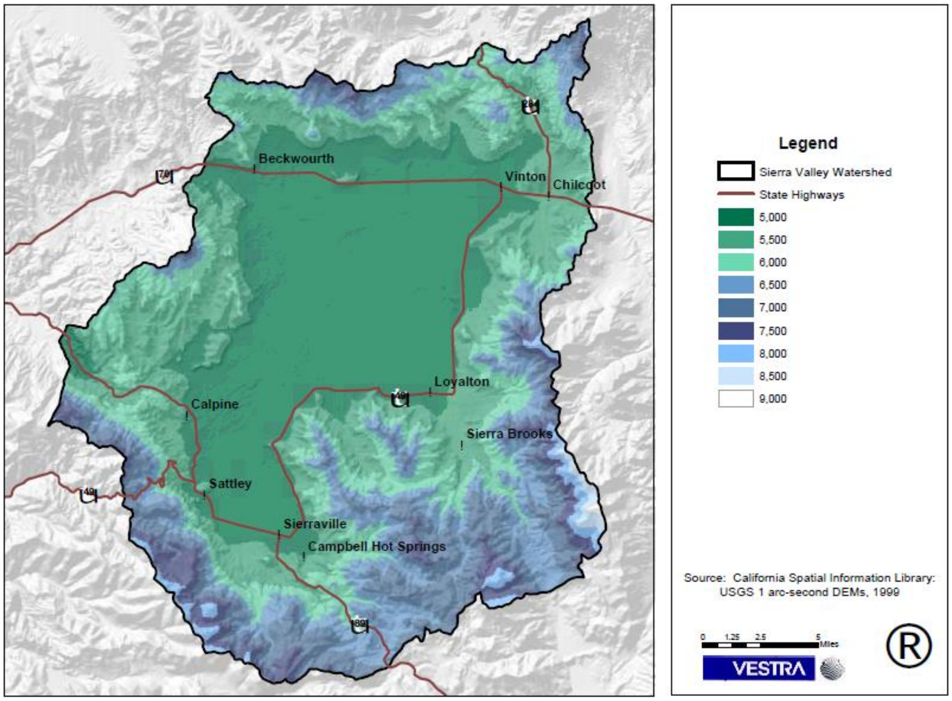


Figure 2.2-1. Sierra Valley Watershed Topography (Vestra, 2005).

Table 2.2-3. Sierra Valley Soils Summary (Vestra, 2005).

Soil Series	Total Acres	Mapped Area (%)
Acid Rock Land	3,791	2.59
Aldax	5,441	3.71
Badenaugh	1,948	1.33
Badenaugh P.D.V.	1,058	0.72
Balman	10,568	7.21
Basic Rock Land	9,246	6.31
Beckwourth	12,551	8.56
Bellavista	2,188	1.49
Bidwell	3,577	2.44
Bieber	3,268	2.23
Calpine	8,582	5.85
Coolbrith	4,843	3.30
Correlo	2,344	1.60
Delleker	3,835	2.62
Dotta	9,626	6.56
Galeppi	372	0.25
Glenbrook	1,054	0.72
Glenn	45	0.03
Haypress	1,451	0.99
James Canyon	3,702	2.52
Lovejoy	1,727	1.18
Loyalton	5,590	3.81
Martineck	3,782	2.58
Millich	298	0.20
Mottsville	2,137	1.46
Newland	1,348	0.92
Ormsby	5,062	3.45
Pasquetti	6,985	4.76
Portola	4,501	3.07
Quincy	558	0.38
Ramelli	15,844	10.81
Sattley	325	0.22
Sierraville	319	0.22
Smithneck	1,027	0.70
Toiyabe	3,708	2.53
Trojan	3,725	2.54
(not specified)	208	0.14
TOTAL	**146,633**	**100.00%**

NOTE: Percentages based on Soil Survey of the Sierra Valley Area (USDA 1975). Percentages do not represent percentage of watershed.

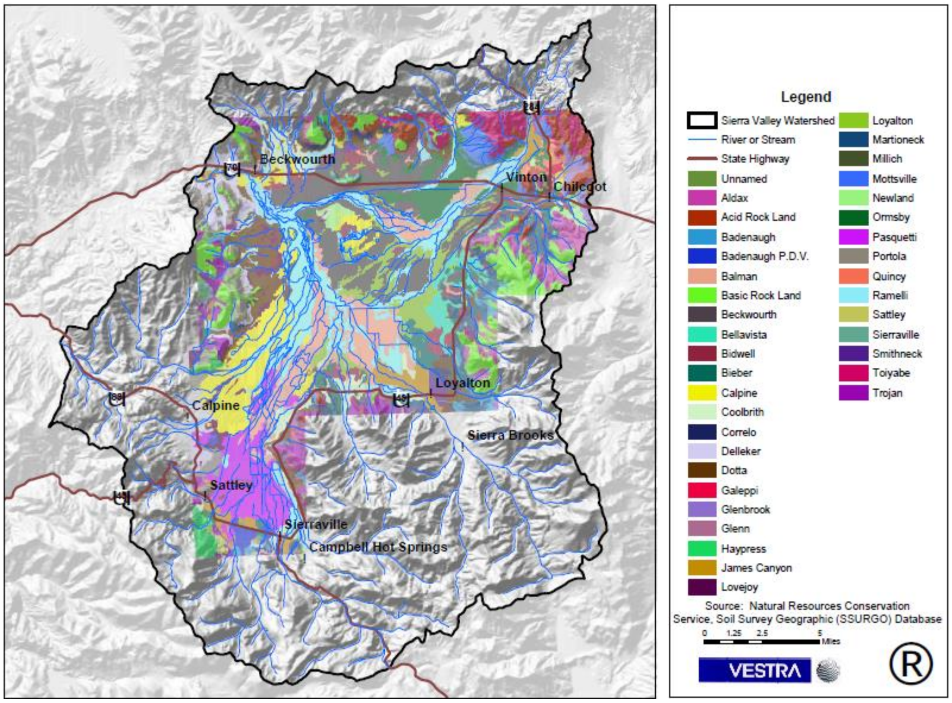


Figure 2.2-2. Sierra Valley Soils (Vestra, 2005).

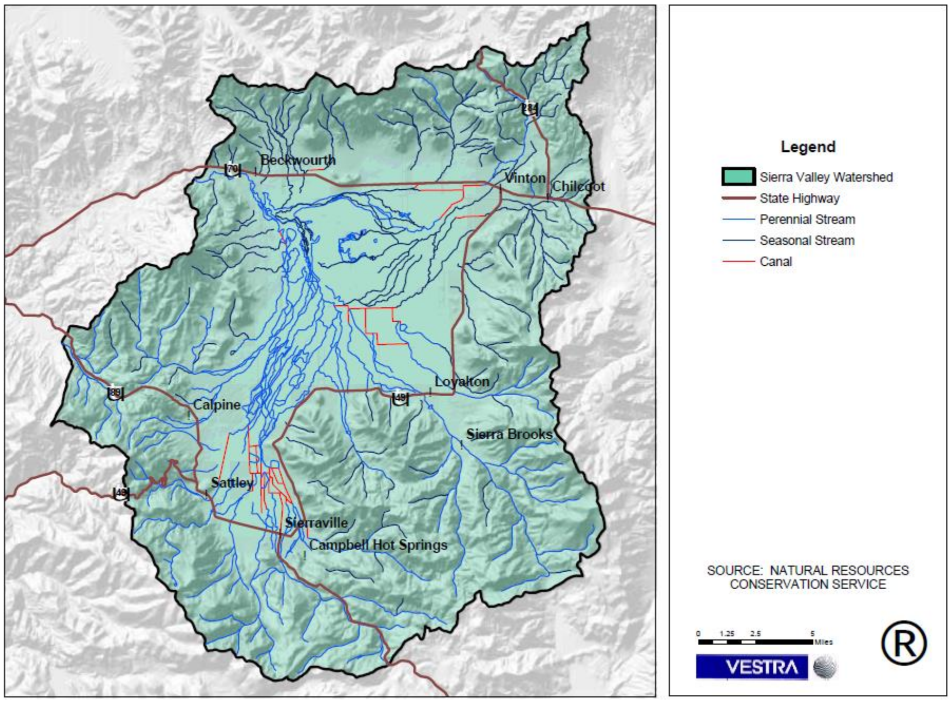
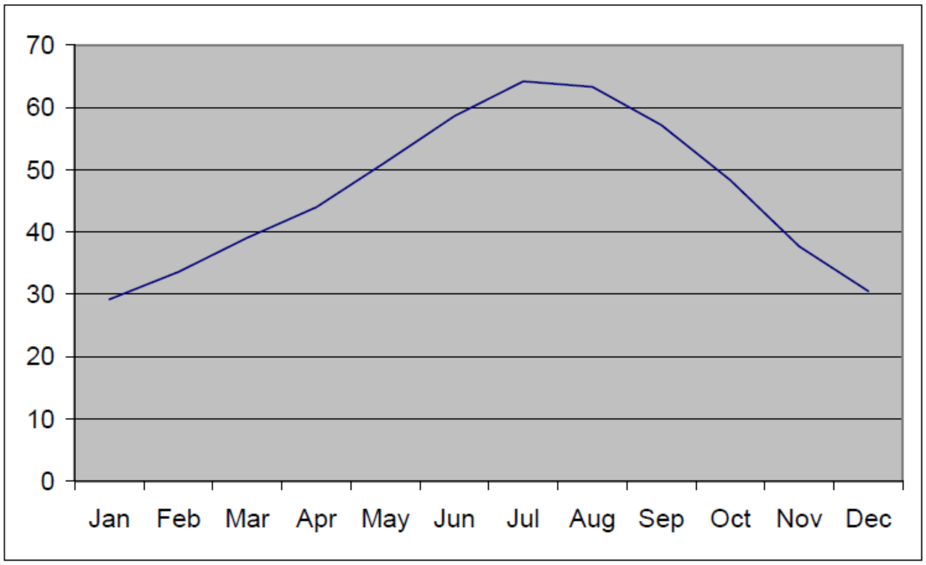


Figure 2.2-3. Sierra Valley Waterways (Vestra, 2005).



Source: Sierraville Ranger Station, California
NCDC 1971 - 2000 Monthly Normals

Figure 2.2-4. Average Monthly Temperatures for Sierraville (Vestra, 2005).

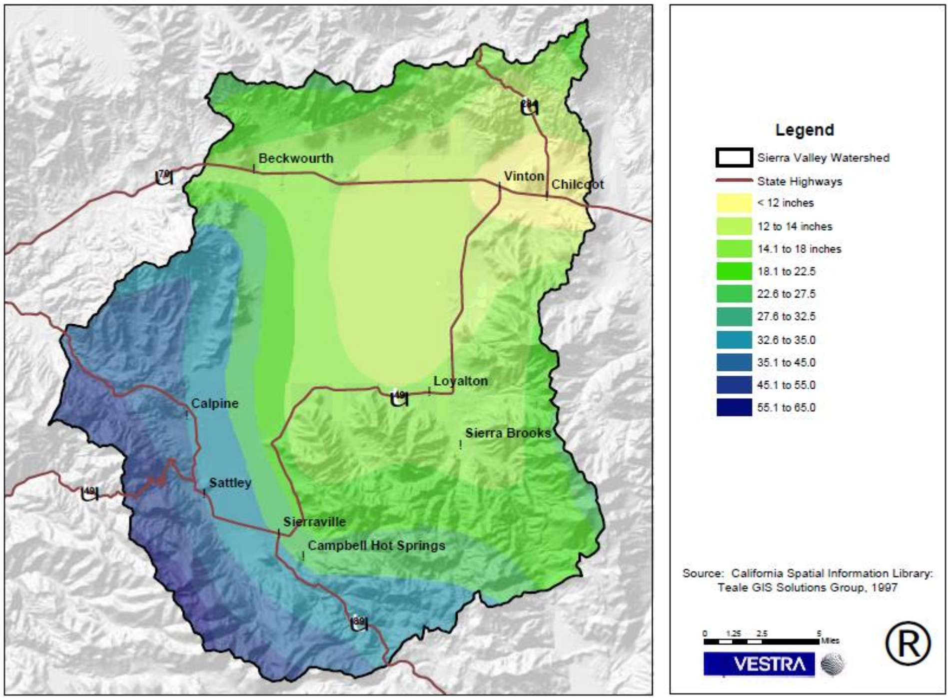


Figure 2.2-5. Sierra Valley Watershed Isohyetal Map (Vestra, 2005).

Table 2.2-4. Evaporation Rates for Vinton, 1960-1970 (Vestra, 2005).

Year	Total	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1960					44	49	106	228	215	266	267	283	206
1961		127	80	57				171	208	282	331	239	209
1962		141						180	166	203	225	247	206
1963		108	22					81	130	163	283	263	164
1964		117	35					137	169	187	257	259	212
1965		154							165	178	198	198	164
1966		134							208	232	279	252	188
1967		138								128	214	177	133
1968		98							225	289	349	243	223
1969									245	201	307	317	226
1970										214	321	321	
Mean	1,716	127	46	57	44	49	106	159	192	213	276	254	193
Source: California Department of Water Resources 1979.													

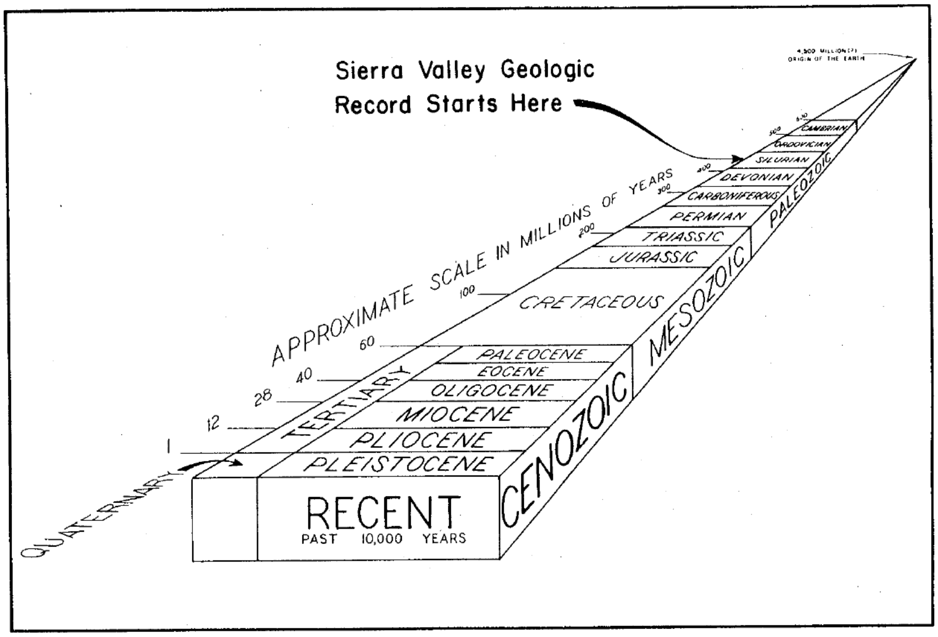


Figure 2.2-6. Sierra Valley Geology – Looking Back in Geologic Time (DWR, 1983).

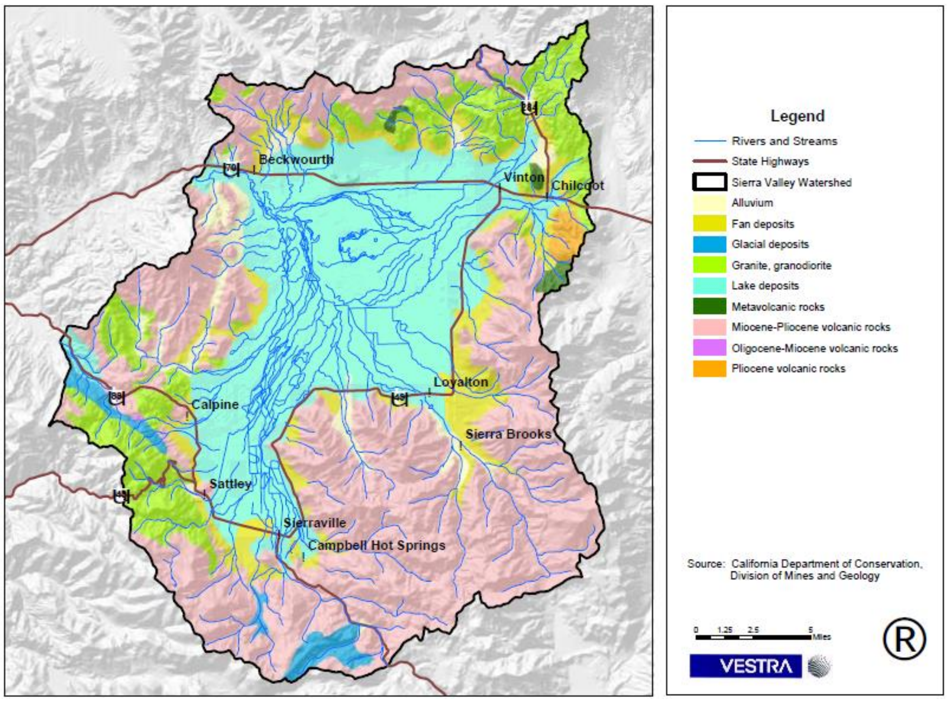
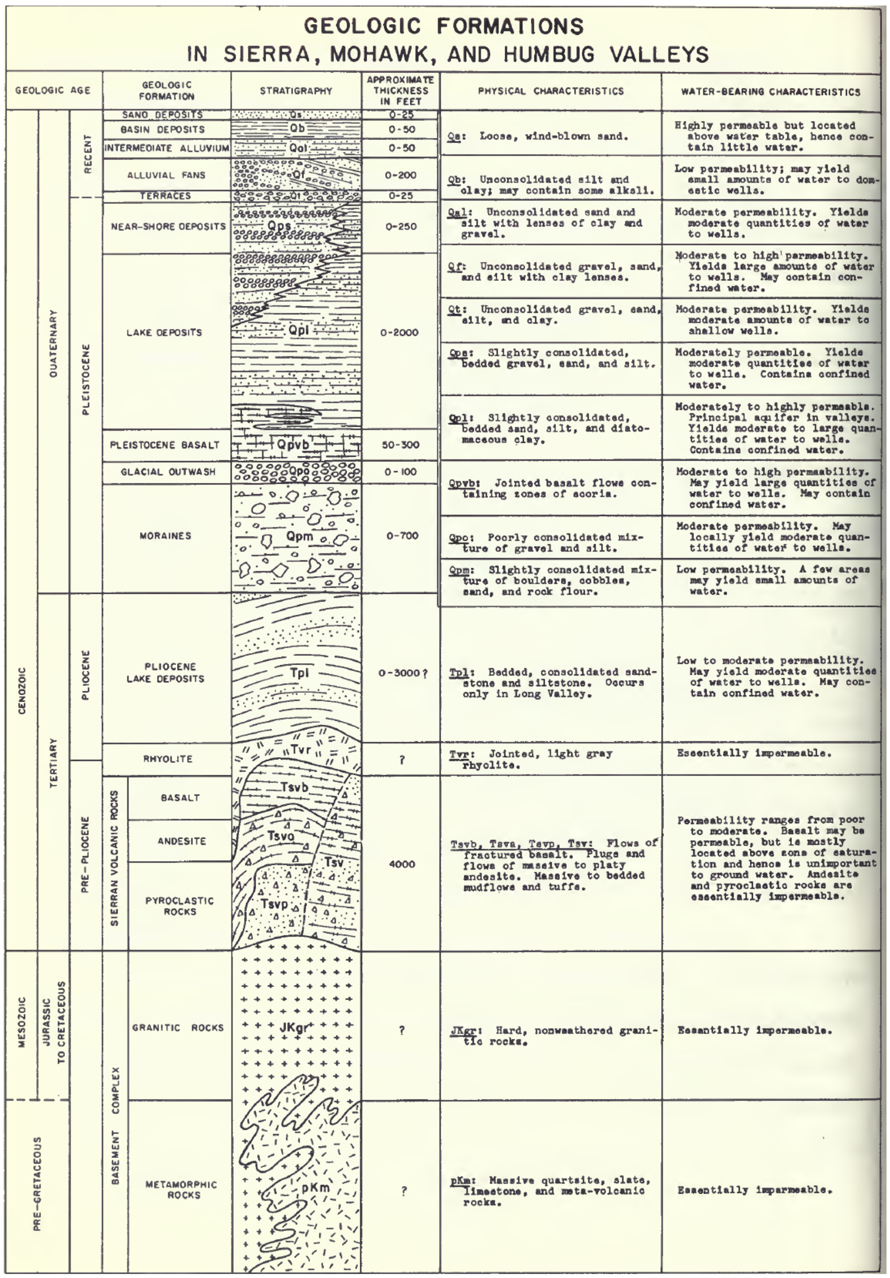


Figure 2.2-7. Sierra Valley Watershed Geology (Vestra, 2005).



GEOLOGIC FORMATIONS
IN SIERRA, MOHAWK, AND HUMBUG VALLEYS

Geologic Age				Geologic Formation	Stratigraphy	Approximate Thickness in Feet
Cenozoic	Quaternary	Recent		Sand Deposits	Qs	0-25
				Basin Deposits	Qb	0-50
				Intermediate Alluvium	Qal	0-50
				Alluvial Fans	Qf	0-200
				Terraces	Qt	0-25
		Pleistocene		Near-Shore Deposits	Qps	0-250
				Lake Deposits	Qpl	0-2000
				Pleistocene Basalt	Qpvb	50-300
				Glacial Outwash	Qpo	0-100
				Moraines	Qpm	0-700
	Tertiary	Pliocene		Pliocene Lake Deposits	Tpl	0-3000 ?
				Rhyolite	Tvr	?
		Pre-Pliocene	Sierran Volcanic Rocks	Basalt	Tsvb	4000
				Andesite	Tsva	
				Pyroclastic Rocks	Tsvp	
Mesozoic	Jurassic to Cretaceous		Basement Complex	Granitic Rocks	JKgr	?
Pre-Cretaceous				Metamorphic Rocks	pKm	?

Physical Characteristics	Water-Bearing Characteristics
Qs: Loose, wind-blown sand.	Highly permeable but located above water table, hence contain little water.
Qb: Unconsolidated silt and clay; may contain some alkali.	Low permeability; may yield small amounts of water to domestic wells.
Qal: Unconsolidated sand and silt with lenses of clay and gravel.	Moderate permeability. Yields moderate quantities of water to wells.
Qf: Unconsolidated gravel, sand, and silt with clay lenses.	Moderate to high permeability. Yields large amounts of water to wells. May contain confined water.
Qt: Unconsolidated gravel, sand, silt, and clay.	Moderate permeability. Yields moderate amounts of water to shallow wells.
Qps: Slightly consolidated, bedded gravel, sand, and silt.	Moderately permeable. Yields moderate quantities of water to wells. Contains confined water.
Qpl: Slightly consolidated, bedded sand, silt, and diatomaceous clay.	Moderately to highly permeable. Principal aquifer in valleys. Yields moderate to large quantities of water to wells. Contains confined water.
Qpvb: Jointed basalt flows containing zones of scoria.	Moderate to high permeability. May yield large quantities of water to wells. May contain confined water.
Qpo: Poorly consolidated mixture of gravel and silt.	Moderate permeability. May locally yield moderate quantities of water to wells.
Qpm: Slightly consolidated mixture of boulders, cobbles, sand, and rock flour.	Low permeability. A few areas may yield small amounts of water.
Tpl: Bedded, consolidated sandstone and siltstone. Occurs only in Long Valley.	Low to moderate permeability. May yield moderate quantities of water to wells. May contain confined water.
Tvr: Jointed, light gray rhyolite.	Essentially impermeable.
Tsvb, Tsva, Tsvp, Tsv: Flows of fractured basalt. Plugs and flows of massive to platy andesite. Massive to bedded mudflows and tuffs.	Permeability ranges from poor to moderate. Basalt may be permeable, but is mostly located above zone of saturation and hence is unimportant to ground water. Andesite and pyroclastic rocks are essentially impermeable.
JKgr: Hard, nonweathered granitic rocks.	Essentially impermeable.
pKm: Massive quartzite, slate, limestone, and meta-volcanic rocks.	Essentially impermeable.

Figure 2.2-8. Geologic Formation in Sierra, Mohawk, and Humbug Valleys (DWR, 1963).

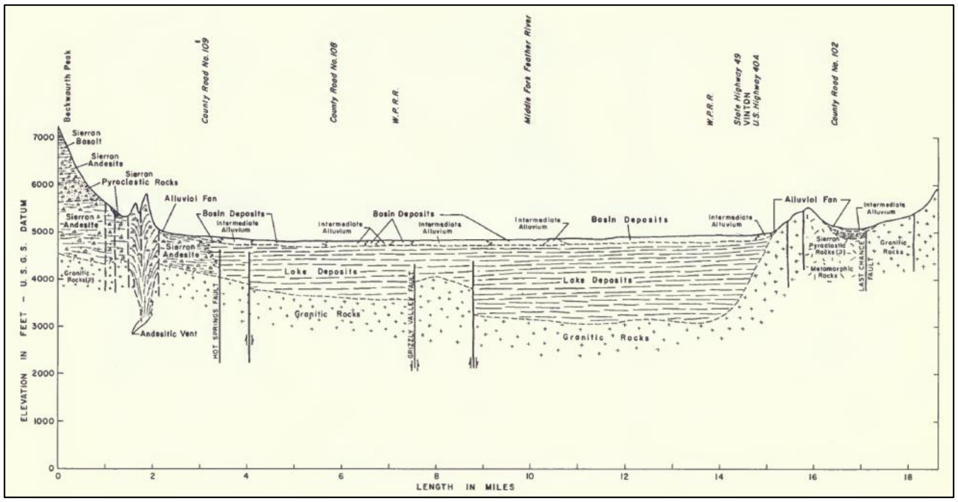


Figure 2.2-9. Generalized Cross-Section A-A′ of the SV Subbasin (DWR, 1963).

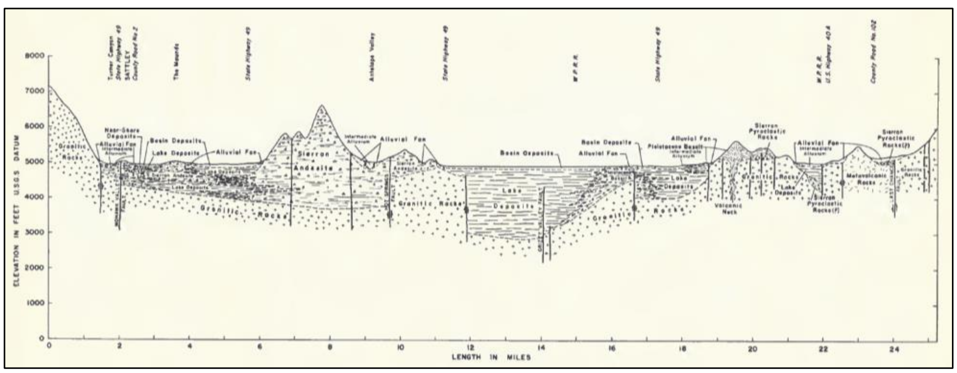


Figure 2.2-10. Generalized Cross-Section B-B′ of the SV Subbasin (DWR, 1963).

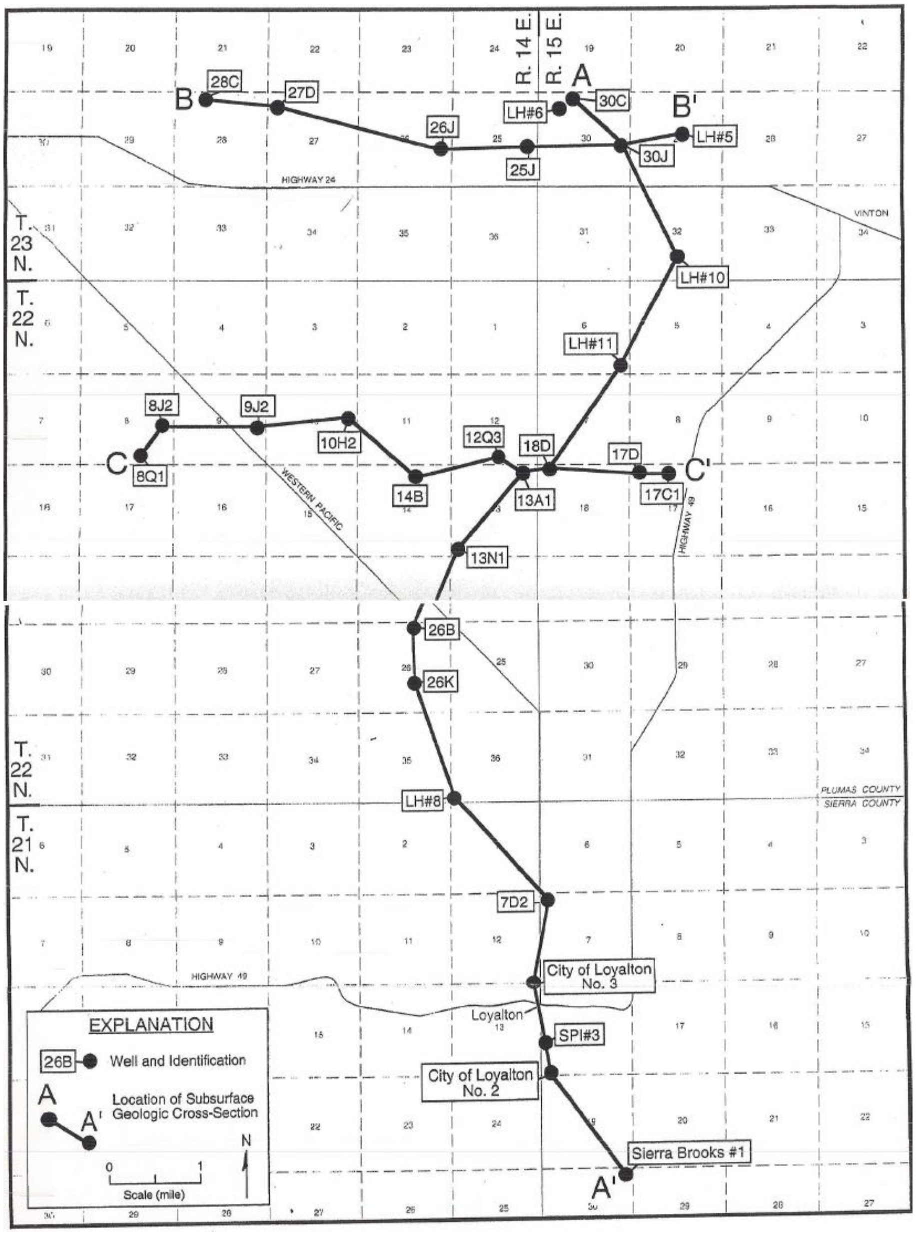


Figure 2.2-11. Locations of Subsurface Geologic Cross-Sections A-A′, B-B′, and C-C′ (Schmidt, 2003).

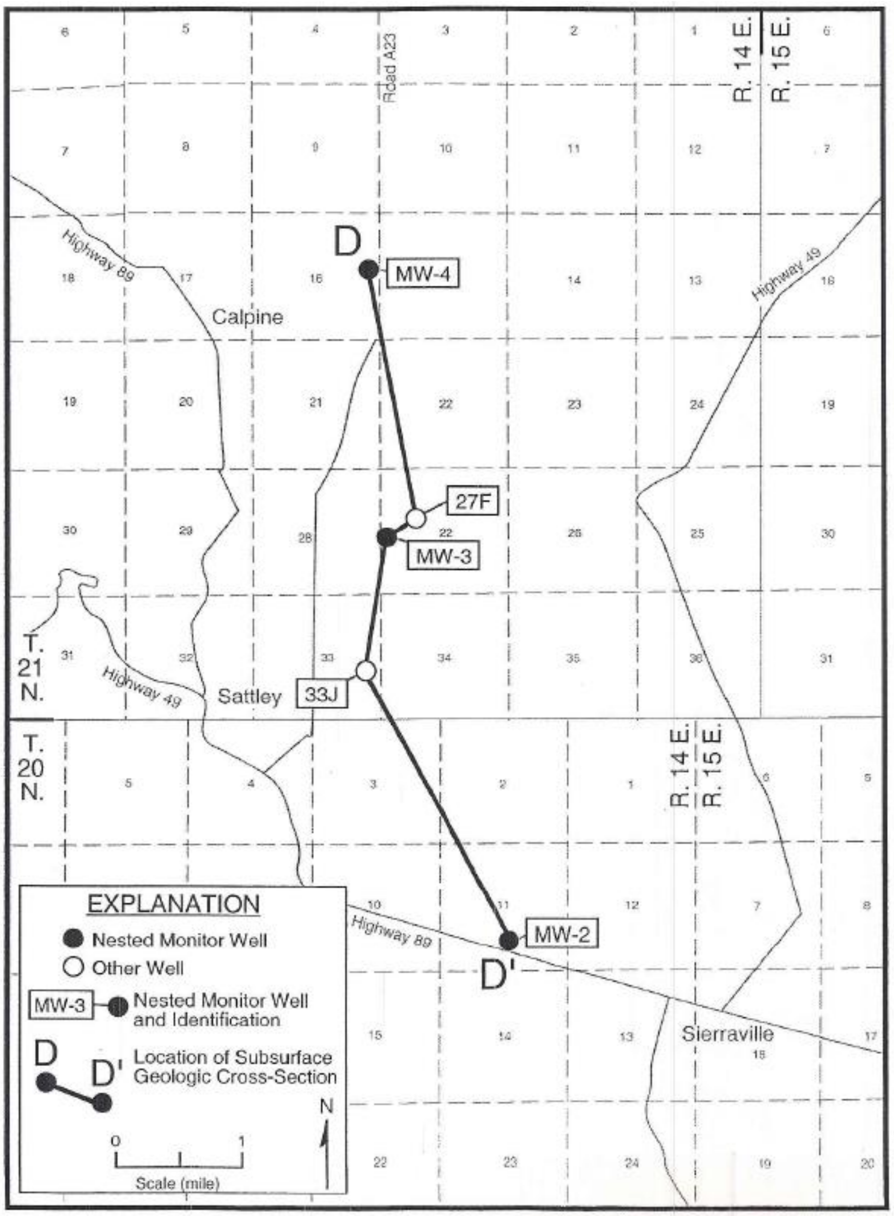


Figure 2.2-12. Location of Subsurface Geologic Cross-Section D-D′ (Schmidt, 2003).

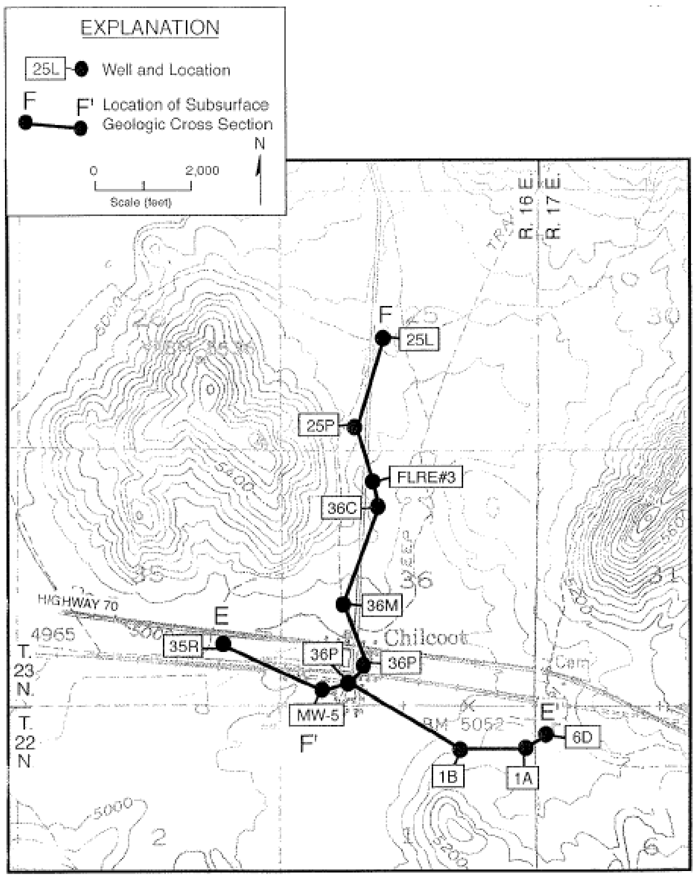


Figure 2.2-13. Locations Subsurface Geologic Cross-Section E-E′ and F-F′ (Schmidt, 2005).

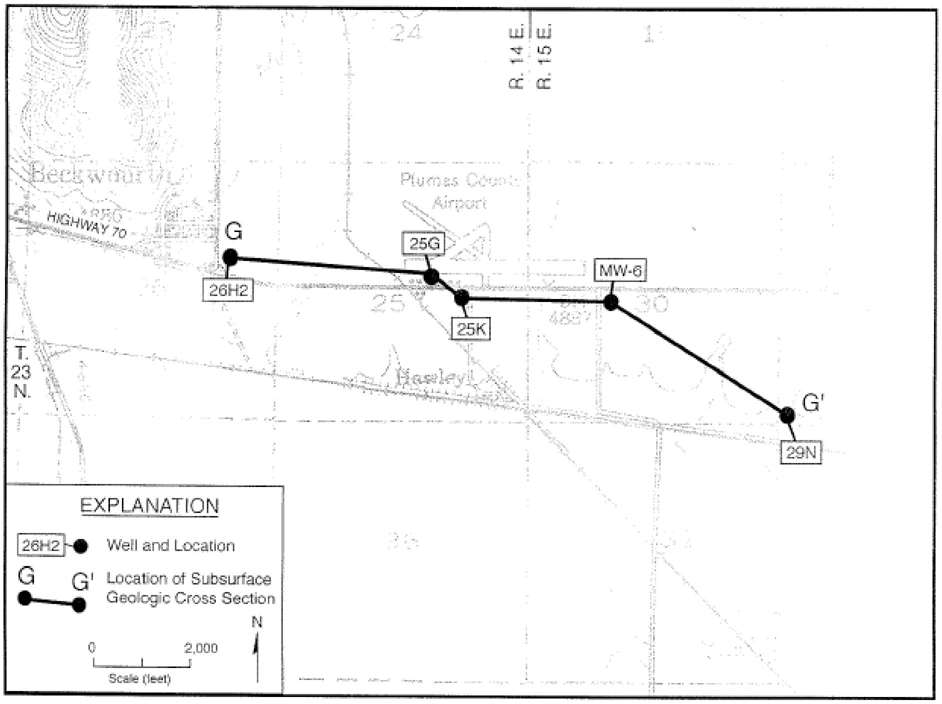


Figure 2.2-14. Location of Subsurface Geologic Cross-Section G-G' (Schmidt, 2005).

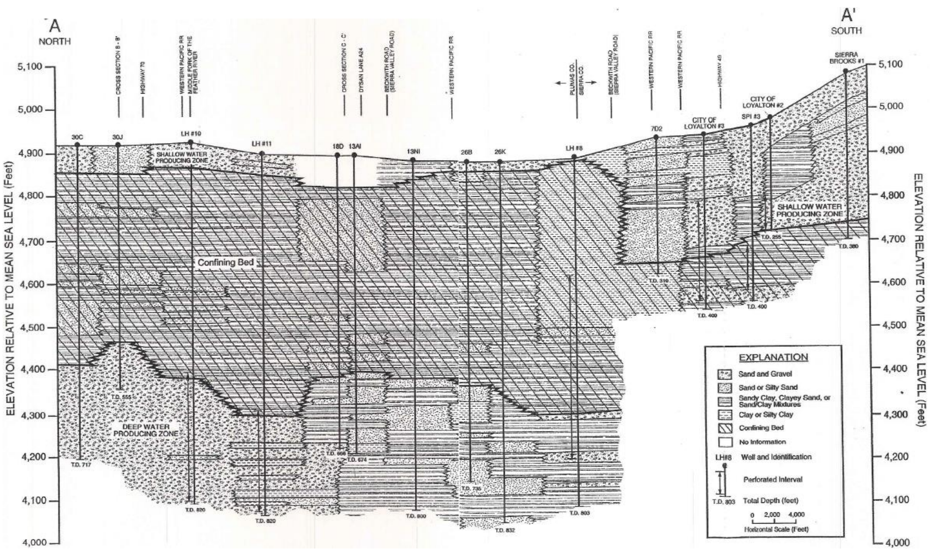


Figure 2.2-15. Subsurface Geologic Cross-Section A-A (Schmidt, 2003).

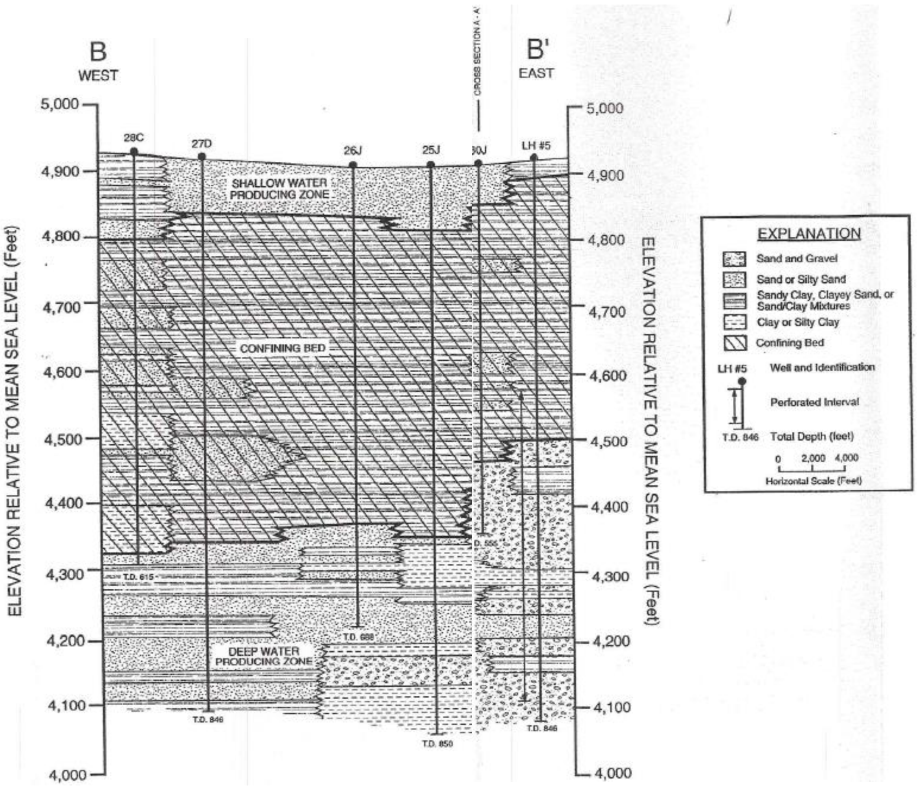


Figure 2.2-16. Subsurface Geologic Cross-Section B-B (Schmidt, 2003).

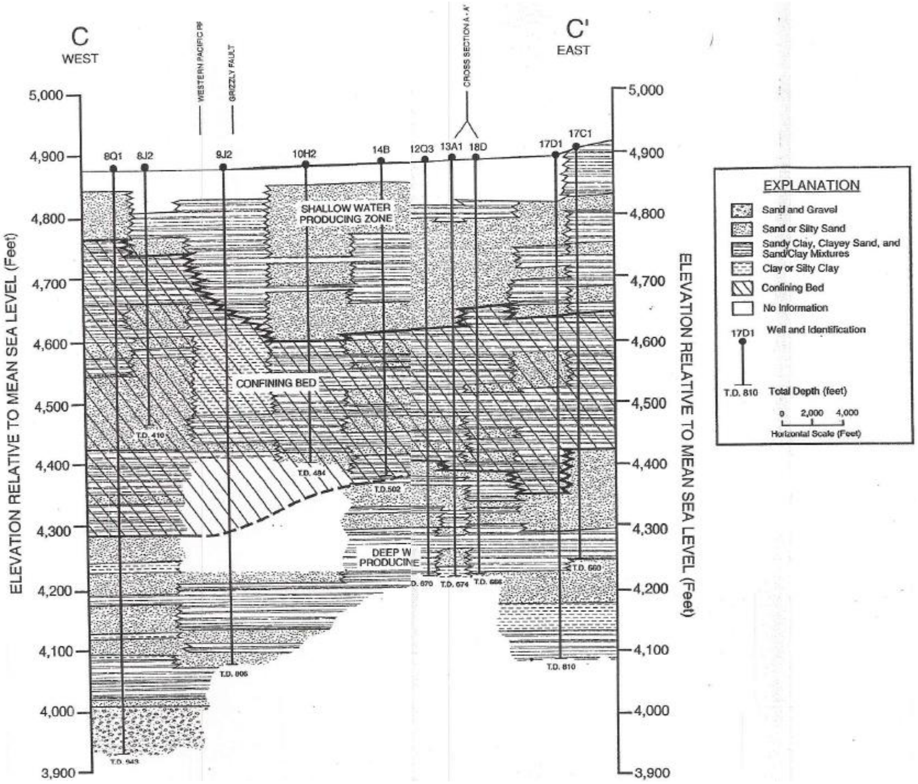


Figure 2.2-17. Subsurface Geologic Cross-Section C-C (Schmidt, 2003).

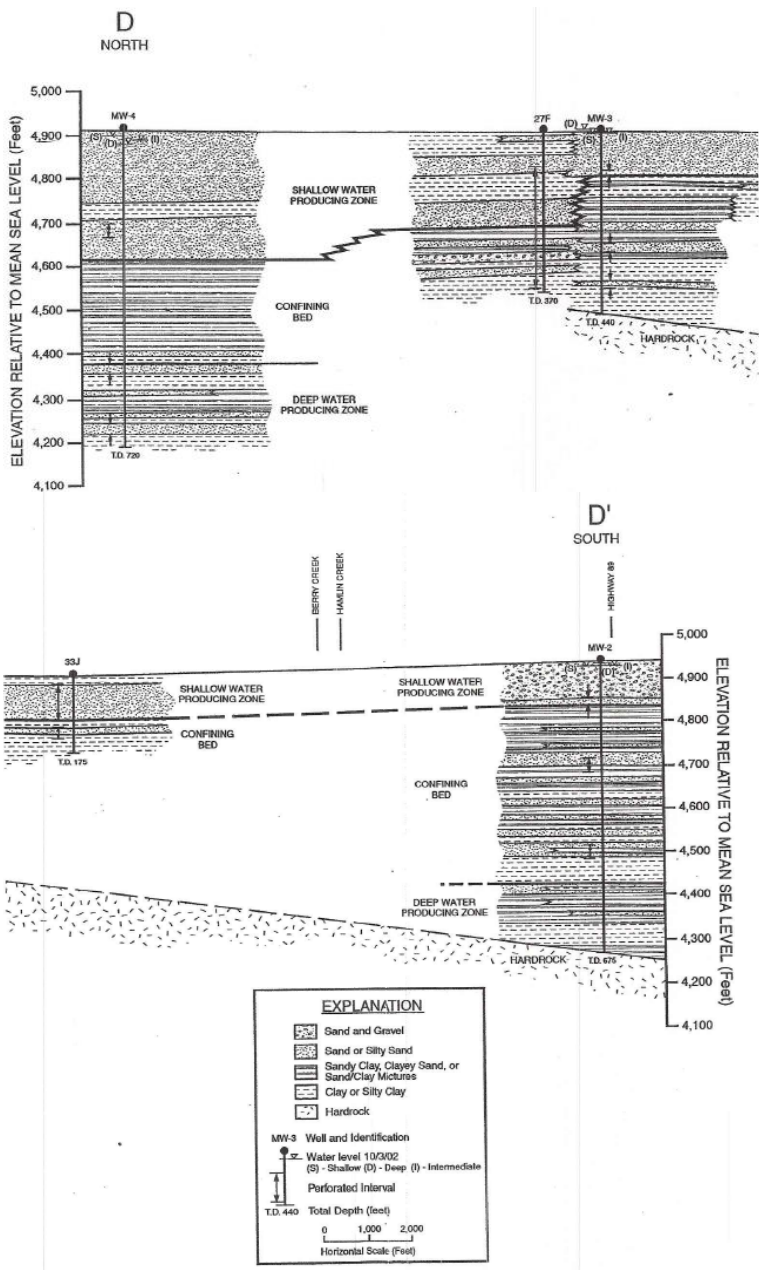


Figure 2.2-18. Subsurface Geologic Cross-Section D-D (Schmidt, 2003).

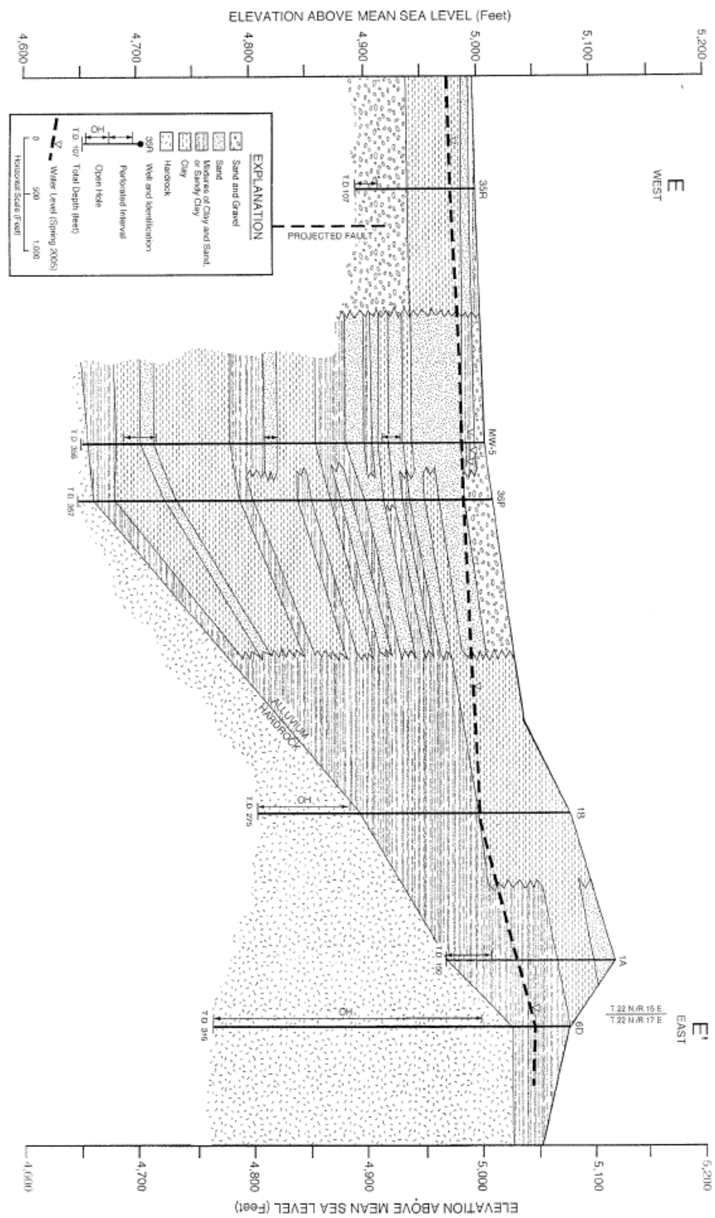


Figure 2.2-19. Subsurface Geologic Cross-Section E-E (Schmidt, 2005).

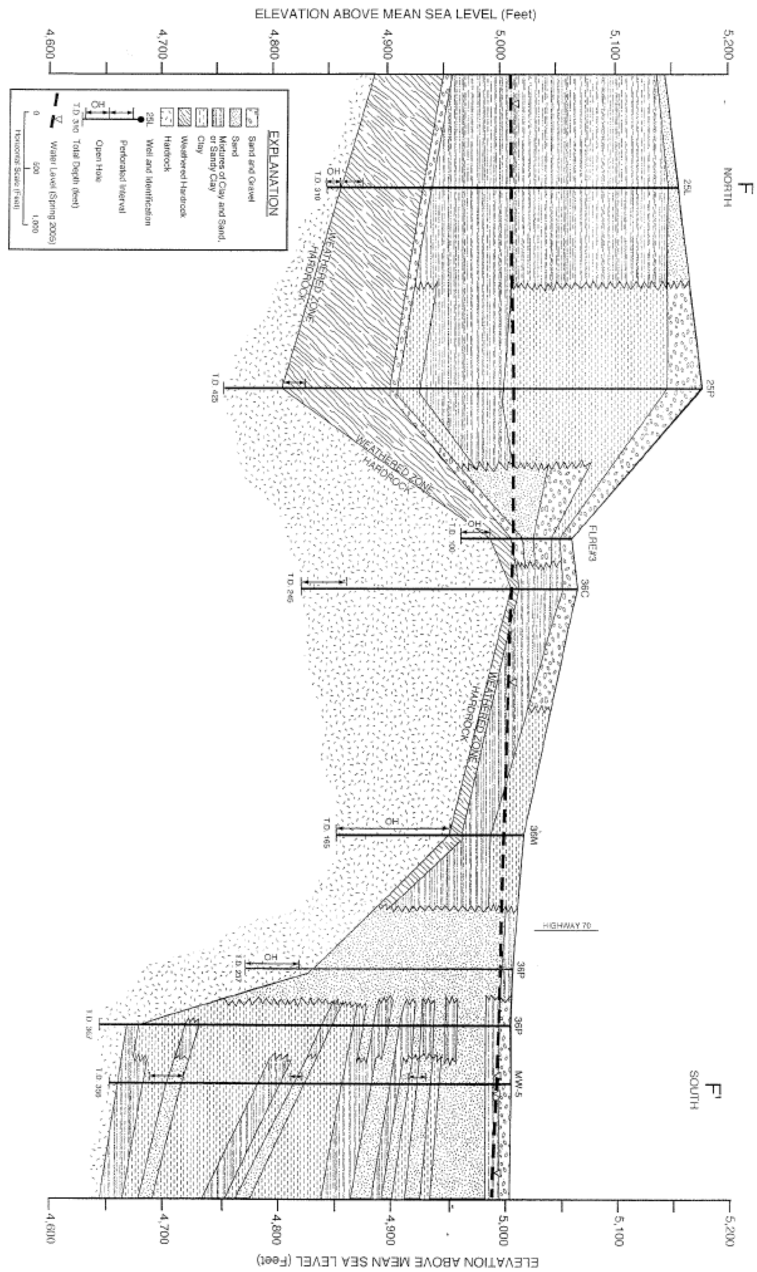


Figure 2.2-20. Subsurface Geologic Cross-Section F-F (Schmidt, 2005).

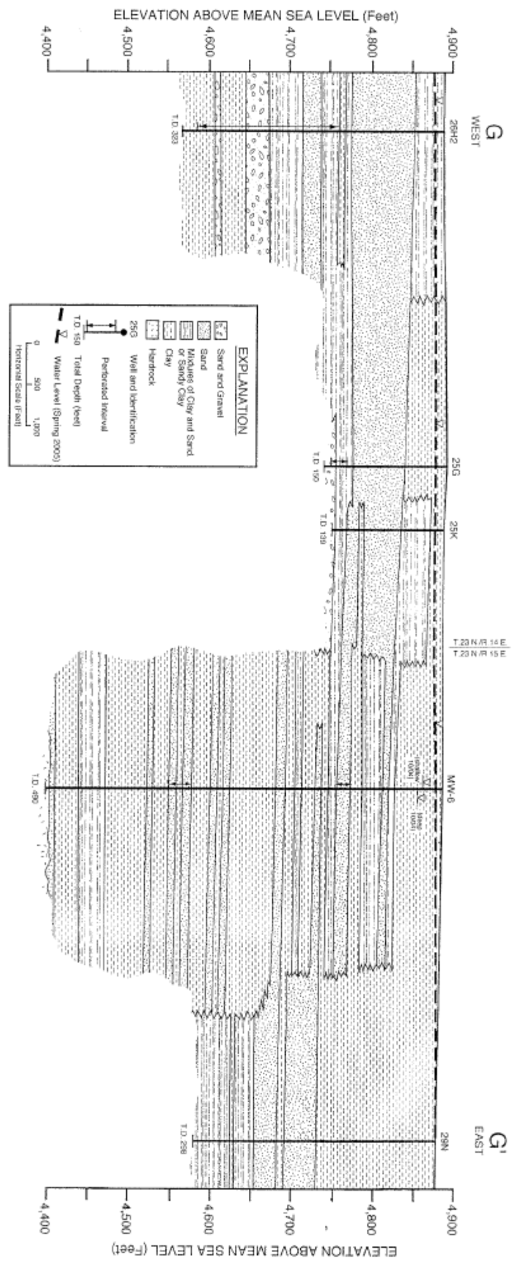


Figure 2.2-21. Subsurface Geologic Cross-Section G-G (Schmidt, 2005).

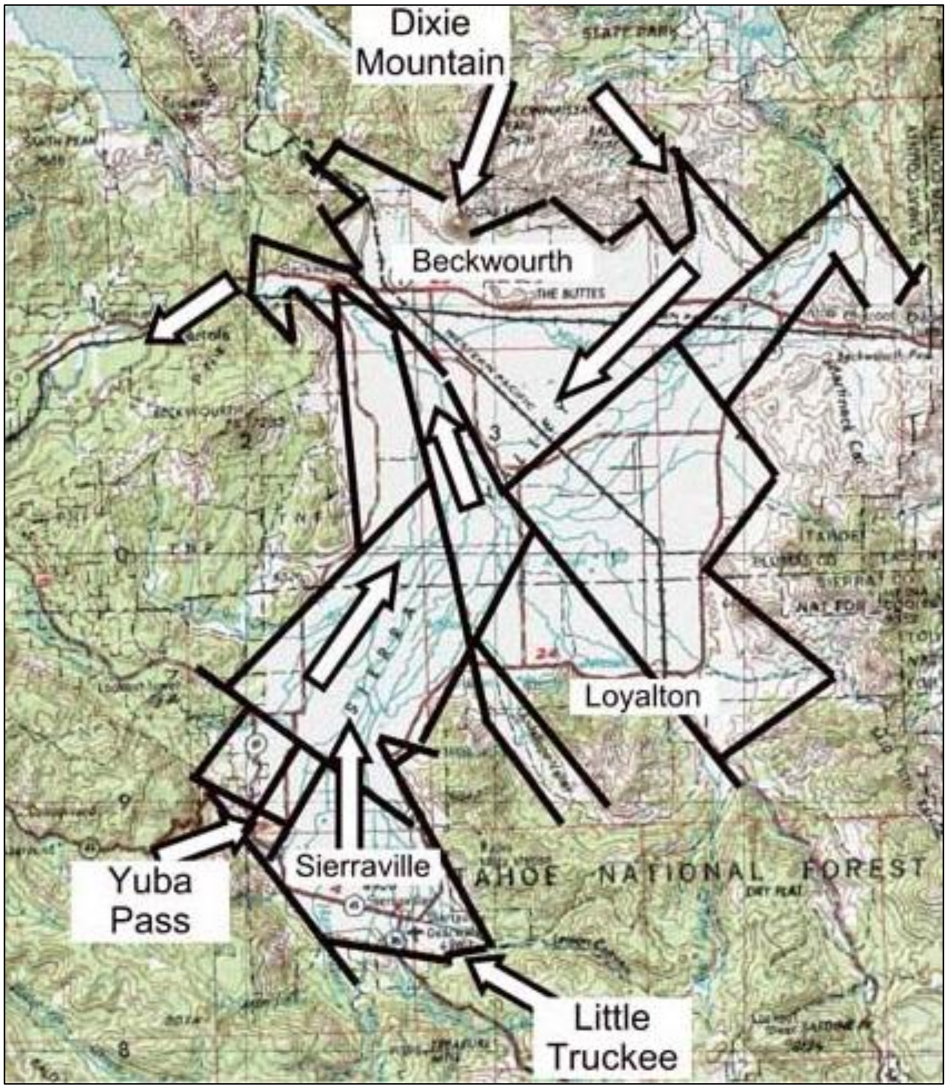


Figure 2.2-22. Faults of the Sierra Valley and Presumed Groundwater Flow Directions (Bohm, 2016b).

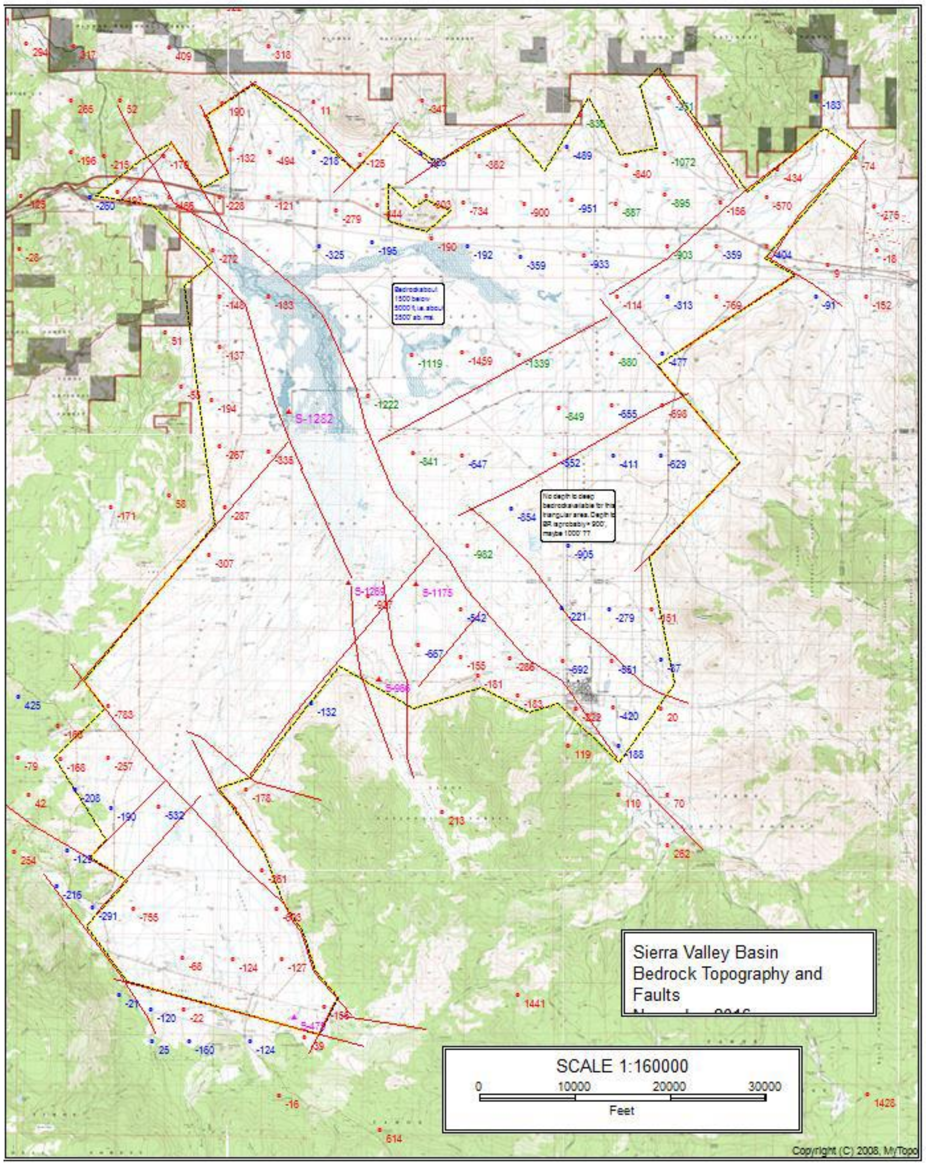


Figure 2.2-23. Faults and Depth to Bedrock within the SV Subbasin as approximated from Well Logs (Bohm, 2016b; see Section 2.2.1.4 for map data descriptions).

Table 2.2-5. Pumping Test Results/Aquifer Properties for Wells within the SV Subbasin (Bohm, 2016b).

Location	well #	T, gpd/ft	S	K, gpd/ ft2	t-max, hrs	Q, gpm	SWL, ft	h-max, ft	SPC	screen, ft	TD, ft	pw/ obs ?	comments
Lucky Herford Old Well #4	2215.36J1	17,900	nd	36	12	1,800	40	120	22	504	775	p	DWR (1983)
Genasci Well	2115.12P3	19,500	nd	69	23	1,330	35	153	11	284	514	p	DWR (1983)
Lucky Hereford #10	2316.32Q1	110,900	nd	375	20	3,150	69	126	55	296	820	p	DWR (1983)
		98,200	0.00031									o	DWR (1983)
Sposito resid. Well, Calpine		9,825	0.0051	68	72	119	9.8	119	1	145	145	o	Smith(2007)

Table 2.2-6. Pumping Test Results/Aquifer Properties for Wells on the Periphery of Sierra Valley Drilled into Bedrock (Bohm, 2016b).

			aquifer thickness b, ft	Transmissivity T		Hydraulic Conductivity, K:			
Well name/project:	location	aquifer formation		gpd/ft		gpd/sq-ft	m/day	m/s	Data Source
Calpine VFD well	Calpine	granite	single fracture	-----	K measured	4.2	0.172	2.0E-06	Bohm (2010)
Anderson test well	Sierraville	T. volcanics	210	1271	K measured	6.1	0.247	2.9E-06	Bohm(2006)
Amodei dom. Well	Sierraville	T. volcanics		1012	K measured	8.3	0.341	3.9E-06	Bohm(2006)
John Amodei, dom well	Sierraville	T. volcanics	50	1000	T measured	20.0	0.816	9.4E-06	Bohm(1998)
test well, "The Ridges"	Chilcoot	granite	185	1440	K measured	7.8	0.318	3.7E-06	Bohm(2006)
Test w. RH-2, Beckw. Pass	Chilcoot	granite	160	4911	T measured	30.7	1.252	1.4E-05	Bohm & Juncal (1989)
SPI well No. 3	Loyalton	T. volcanics	190	787	T measured	4.1	0.169	2.0E-06	Bohm (1997)
River valley Subd.	RV-1	T. volcanics	350	3440	T measured	9.8	0.401	4.6E-06	Bohm (2002)
River valley Subd.	RV-1	T. volcanics	350	6000	T measured	17.1	0.699	8.1E-06	Bohm (2002)
Frenchman Lake Road Esta	FLRE-1	granite	265	1162	T measured	4.4	0.179	2.1E-06	Juncal & Bohm, 1986)
Frenchman Lake Road Esta	FLRE-2	granite	254	27	T measured	0.1	0.004	5.1E-08	Juncal & Bohm, 1986)
Frenchman Lake Road Esta	FLRE-3	granite	96.74	13	T measured	0.1	0.005	6.3E-08	Juncal & Bohm, 1986)
Frenchman Lake Road Esta	FLRE-1	granite	265	2364	T measured	8.9	0.364	4.2E-06	Bohm (1995)
Well 1B, Cedar Crest, 14 day test		granite	433	1380	T measured	3.2	0.130	1.5E-06	Bohm (1997)
		maximum		6000		30.7	1.252	1.4E-05	
		minimum		13		0.1	0.004	5.1E-08	

Table 2.2-7. Summary of Metered Groundwater Pumpage for Irrigation in the Sierra Valley from 1989 to 2002 (Schmidt, 2003; Vestra, 2005).

Year	Beckwourth	Vinton	Loyalton	Other	Total
1989	668	3,574	2,798	616	7,656
1990	489	5,139	3,875	628	10,131
1991	289	3,607	3,486	935	8,317
1992	120	3,326	4,548	1,119	9,113
1993	83	1,226	2,066	719	4,094
1994	388	1,558	3,831	1,552	7,329
1995	533	973	1,964	630	4,100
1996	778	1,692	2,457	892	5,819
1997	932	1,685	2,242	457	5,316
1998	212	606	2,336	311	3,465
1999	385	1,350	2,333	797	4,865
2000	417	2,599	1,938	1,015	5,969
2001	809	2,641	2,824	1,217	7,491
2002	1,099	2,393	3,225	1,596	8,313
Average	514	2,312	2,852	892	6,570

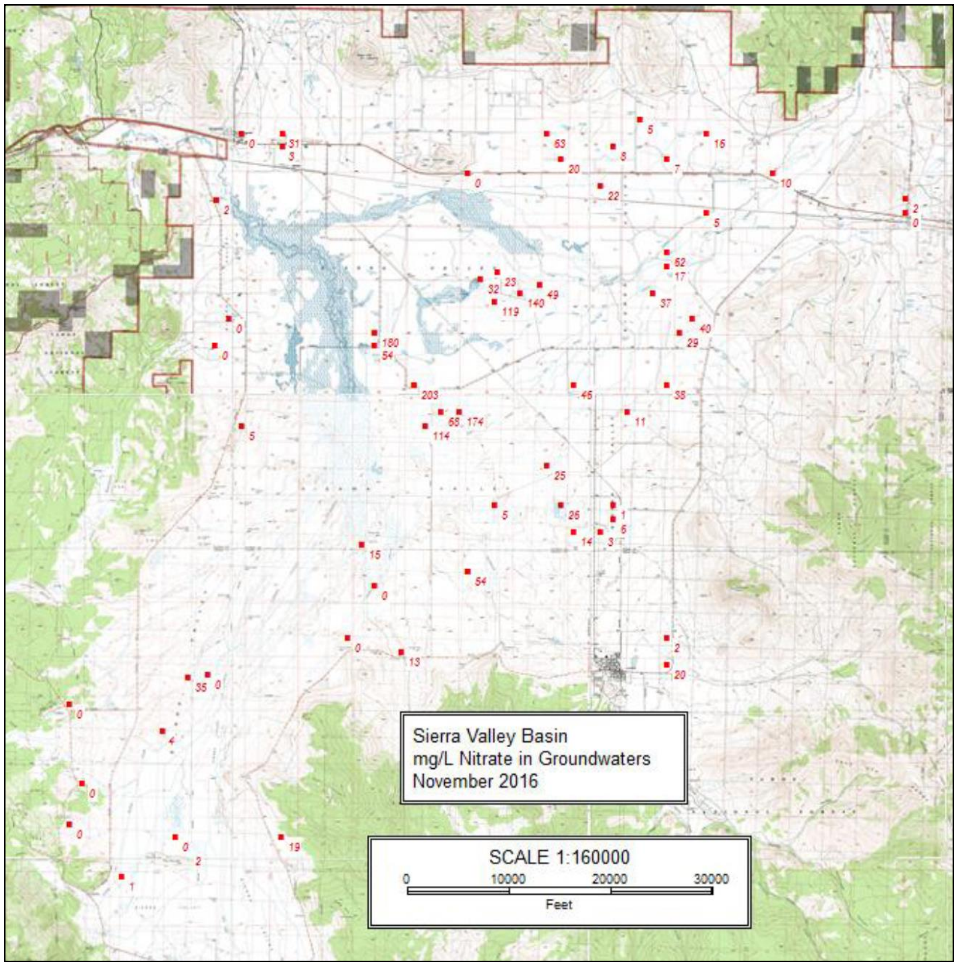


Figure 2.2-24. Nitrate Concentrations in November 2016 Groundwater Samples (Bohm, 2016a).

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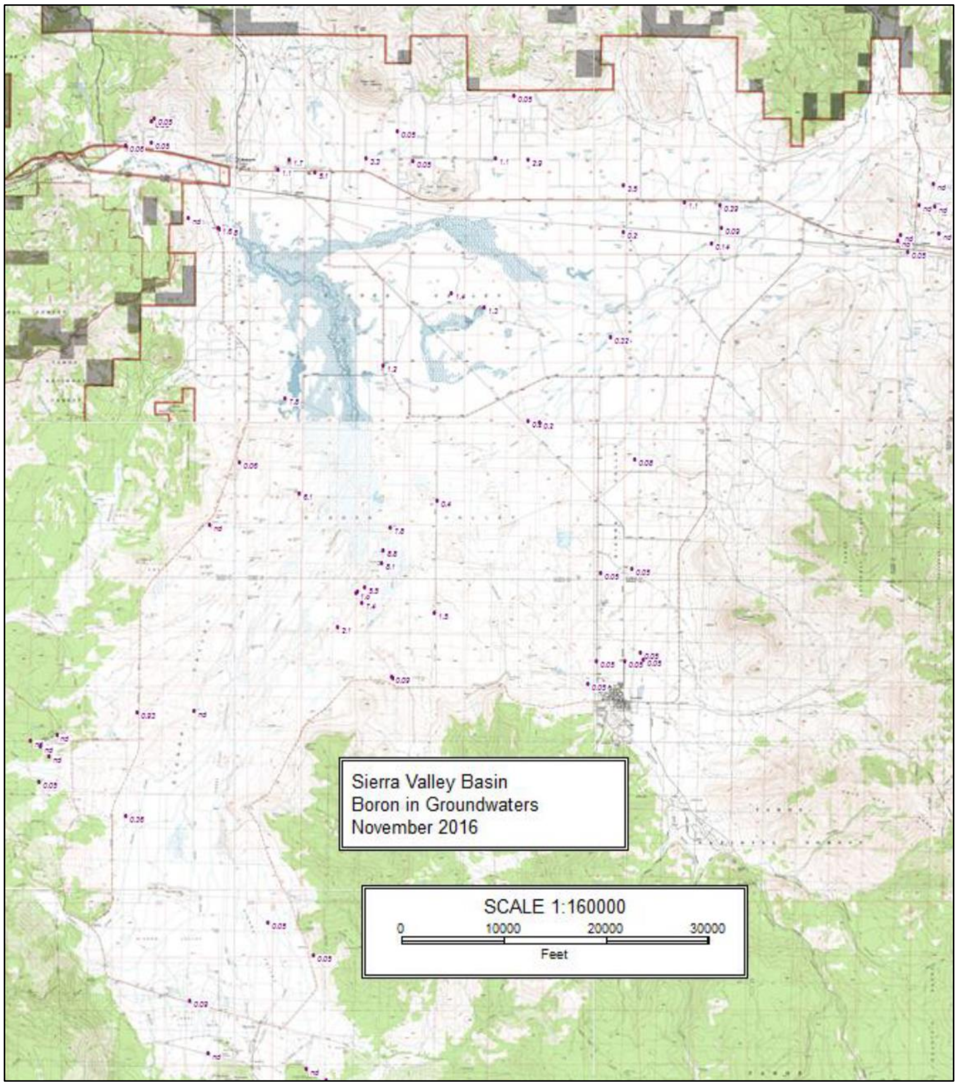


Figure 2.2-25. Boron Concentrations in November 2016 Groundwater Samples (Bohm, 2016a).

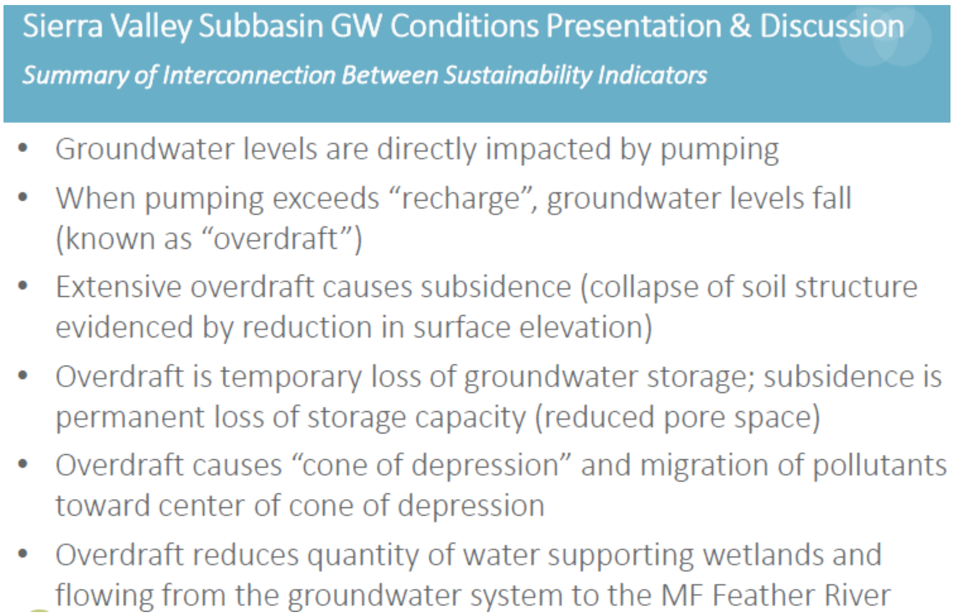
2.2.2 Current and Historical Groundwater Conditions *(Reg. § 354.16)*

Per Reg. § 354.16, this section includes:

Commented [GH22]: This section is not as complete/thorough as I would have hoped. I put this section off for more than a year while awaiting the release of the Bachand study report, because I felt it wouldn't be an efficient use of time to do a thorough job on this section while Backhand's team was simultaneously working on a well-funded analysis of SV Subbasin historical/current groundwater conditions. Delay of the release of the report in combination with my lack of availability after release of the report due to being fully-busy with other work inhibited my ability to complete this section to my satisfaction, but the limited content herein will hopefully be helpful nonetheless.

- Groundwater elevation data
- Estimate of groundwater storage
- Seawater intrusion conditions
- Groundwater quality issues
- Land subsidence conditions
- Identification of interconnected surface water systems
- Identification of groundwater-dependent ecosystems including potentially related factors such as instream flow requirements, threatened and endangered species, and critical habitat.

It may be worth discussing the relationships between sustainability indicators here. Info from Public Presentation delivered in fall 2019:



2.2.2.1 *Groundwater Elevation Data*

Per Reg. § 354.16(a), this section includes groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

- Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin

- Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers

Commented [GH23]: The Bachand report and Schmidt reports have good figures for use here; opportunity for additional analysis and generation of new figures from existing data likely exists as well.

Introduction to Groundwater Elevations

Groundwater elevation (vertical distance from ground surface to the top of the groundwater table) is a primary measure of the sustainability of groundwater management. Simply stated, when too much groundwater is being extracted, groundwater elevations fall, posing risk of land subsidence, associated reduction in aquifer storage capacity and alteration of hydraulic properties of the aquifer system, affecting migration of pollutants in groundwater, and potentially affecting surface water flows and groundwater-dependent ecosystems. Conversely, when groundwater is being sustainably managed, groundwater elevations remain relatively constant with the exception of seasonal fluctuations (increased elevations in the wet season and decreased elevations in the dry season) and perhaps subtle long-term fluctuations associated with changing precipitation patterns/climate. Because of the fundamental importance of groundwater elevations from the perspective of groundwater management sustainability and because of the relationship between groundwater elevations and other sustainability indicators, groundwater elevations are generally considered the most telling indicator of groundwater management sustainability.

Summary of Groundwater Elevations in the Sierra Valley

Based on the comments provided by DWR as part of their basin prioritization (DWR, 2019a), DWR's interpretation of groundwater levels in SV Subbasin can be summarized as follows: the majority of long-term SV Subbasin hydrographs are relatively stable, with a few showing declining groundwater levels. This is essential the same conclusion drawn through inspection of all available groundwater level data for the SV Subbasin, as represented in the below figures. Groundwater elevation data sources include the following:

1. SVGMD Groundwater Elevation Monitoring Data (since 1980)
2. SVGMD Agricultural Pumpage Data (since 1989)
3. DWR's California Statewide Groundwater Elevation Monitoring (CASGEM) Program data (since late 1950s)
4. Data reviews/studies:
    a. DWR's groundwater reports (since 1960s)
    b. SVGMDs groundwater reports by Schmidt (since 1991)
    c. UC Davis Upper Middle Fork study (Dib et al, 2017)
    d. Bachand et al. Study (2020)

Figures 2.2-26 through 2.2-31 show groundwater elevation contour maps prepared in recent years and Figures 2.2-31 through 2.2-36 show some of the most comprehensive long-term hydrographs available for monitoring wells in the SV Subbasin and hydrograph projections into the future based from Dib et al. (2017). It should be noted that the contour maps represent composite ground water levels and may include water from both free (unconfined) and confined aquifers. Bachand et al. (2020) provides additional figures that should be incorporated

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in this Section which distinguish between deep and shallow well data thereby elucidating differences in shallow versus deep groundwater elevation trends.

DWR (1983) provides many other insights resulting from evaluation of groundwater levels over the early years of groundwater development (from 1957 through spring of 1983) in the Sierra Valley, which include the following:

- Ground water levels fluctuate annually in response to pumpage and evapotranspiration and to recharge from infiltration and percolation. Levels are usually highest in spring and lowest in fall.
- Long-term fluctuations occur when recharge exceeds or falls short of discharge.
- Changes in water level elevations from 1960 to 1983 show most of the eastern half of the groundwater basin exhibiting water levels in 1983 10 ft or more lower than in 1960. This decline occurred in wells tapping confined aquifers and is reflected in reduction or loss of artesian flow from wells in the area.
- Changes in water level elevation from 1981 to 1983 show that water level declines of 5 ft or more occurred in most of the eastern half of the ground water basin in those few years, reflecting changes in land use and changes in water supply sources during that period.
- Data from well T23/Rl6E-32Kl, two miles west of Vinton, show a few feet of rise in the water level between summer and winter of October 1981, and peaks developed in response to periods of rainfall and represent temporary ground water storage. These fluctuations are characteristic of wells in shallow un-confined aquifers.
- Data from wells T22N/Rl6E-17Cl and T22N/Rl5E-36J2, 3-1/2 to 4 mi southwest and west of Vinton, respectively, show spring-to-fall water level declines of more than 30 ft. These rapid declines are responses to ground water pumpage nearby and are characteristic of wells completed in confined aquifers from which other wells are also pumping. Temporary reversals or decreases in the rate of water level decline show times when irrigation pumpage was idle or limited. Fall-to-spring water level recovery is continuous until the onset of the next irrigation season.
- Data from well T23/Rl4E-26H2, near Beckwourth, show water level fluctuation of about 10 ft between May and September of 1981. The water level recoveries and declines closely parallel seasonal rainfall patterns and are characteristic of wells in unconfined aquifers.
- Data from well T22/Rl6E-17E2, near the intersection of Highway 49 and Dyson Lane, representative of most artesian wells in the general area west and southwest of Vinton, show spring and fall levels had no significant change until about 1980 when spring-to-fall fluctuations greatly increase and spring water elevations show substantial annual declines. These can be attributed to the development of fourteen center pivot and two lateral ground water irrigation systems in this part of the basin between 1979 and 1981.

- Data from well T22N/Rl5E-22Ql, in the center of the valley near the intersection of Harriet and Dyson Lanes, is typical of deep artesian wells that stopped flowing in the mid-1960s and early 1970s.
- Spring water levels show a gradual lowering between 1965 and 1975, a leveling out for a few years and then a resumption of annual declines. This trend corresponds to land use and irrigation water source changes in the valley and shows that there is hydraulic connection with irrigation wells drilled in the 1960s and '70s, and 1980-81.
- Data from wells T23E/Rl5E-36Jl and T23N/Rl4E-25Kl show water level fluctuations that are typical of wells completed in the unconfined aquifers of the basin. The water levels respond to variations in annual rainfall more than to pumping. The 1976-77 drought shows this quite clearly. These two wells are different in that 36Jl is a deep well with artesian water while 25Kl is shallow with unconfined water. The reason for the similarities in hydrographs is that artesian water in 36Jl is entering the unconfined aquifer via the gravel pack and possibly through leaky casing, so the water levels reflect the elevation of the local unconfined water table.

Bachand et al. (2020) summarizes the SV Subbasin groundwater elevation history as follows:

The groundwater history in Sierra Valley can be broken roughly into four periods of sustainable and non-sustainable conditions, with increased irrigation pumping identified as the major reason for the transition to non-sustainable conditions (DWR, 1983, 2003b, 2019; Schmidt, 2003, 2017; Bohm, 2016a):

- Prior to the 1960s representing sustainable groundwater levels and pre-development conditions;
- The 1960s to 1990 representing steady GWE declines;
- The 1990s representing GWE recovery; and
- Post 2000 with accelerated groundwater pumping and GWE declines.

<u>*Conclusion*</u>

As described above, groundwater elevations in the SV Subbasin have been relatively stable, with the exception of a few monitoring wells showing slightly declining long-term groundwater level trends. However, based on recent studies (Dib et al., 2017; Bachand et al., 2020), changing climate and/or future droughts pose significant risk of greater groundwater level declines in the future. As such, maximizing recharge to the extent practicable is a primary focus of the GSAs and policies for limiting pumping in the event that chronic lowering of groundwater levels is observed in the future have been established, as described in Chapter 4 of this Plan Concept Document.

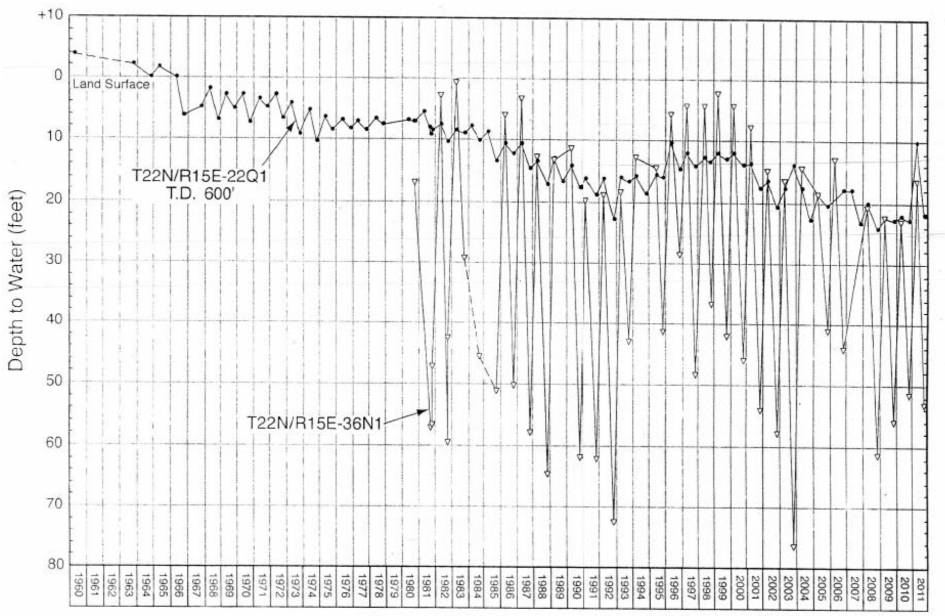


Figure 2.2-26. Water Level Hydrographs for Loyalton Area (Schmidt, 2017).

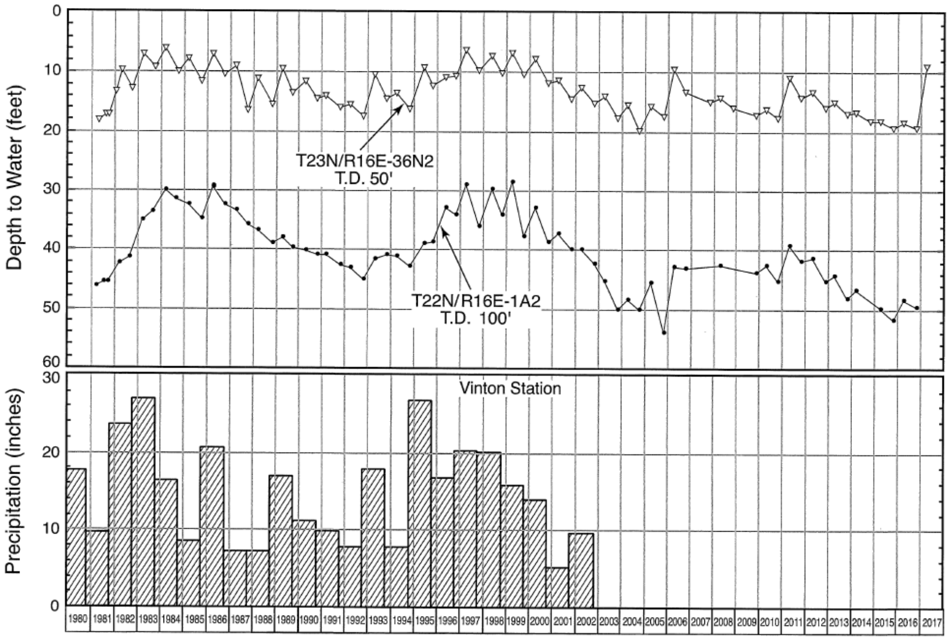


Figure 2.2-27. Water Level Hydrographs and Precipitation for Chilcoot Subbasin (Schmidt, 2017).

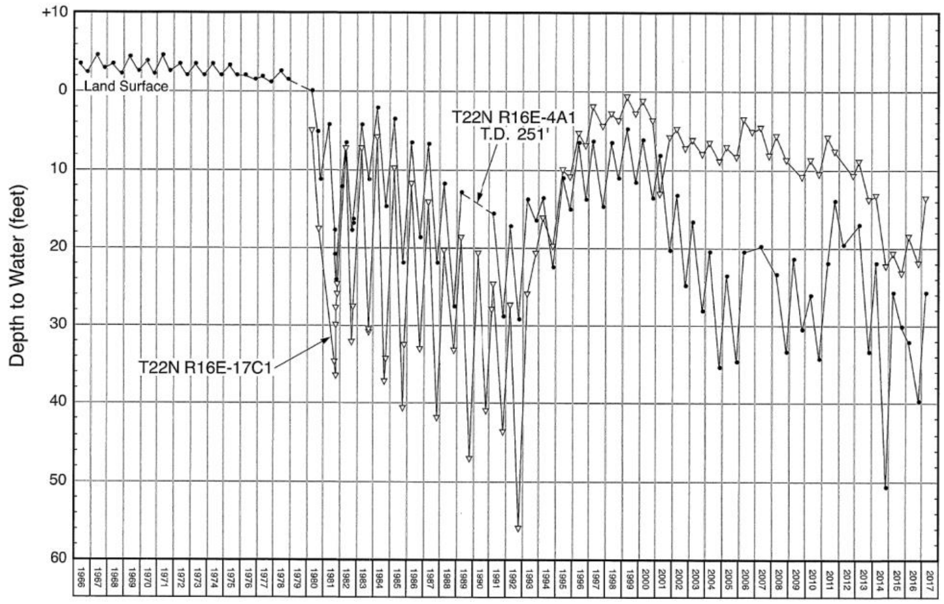


Figure 2.2-28. Water Level Hydrographs for Vinton Area (Schmidt, 2017).

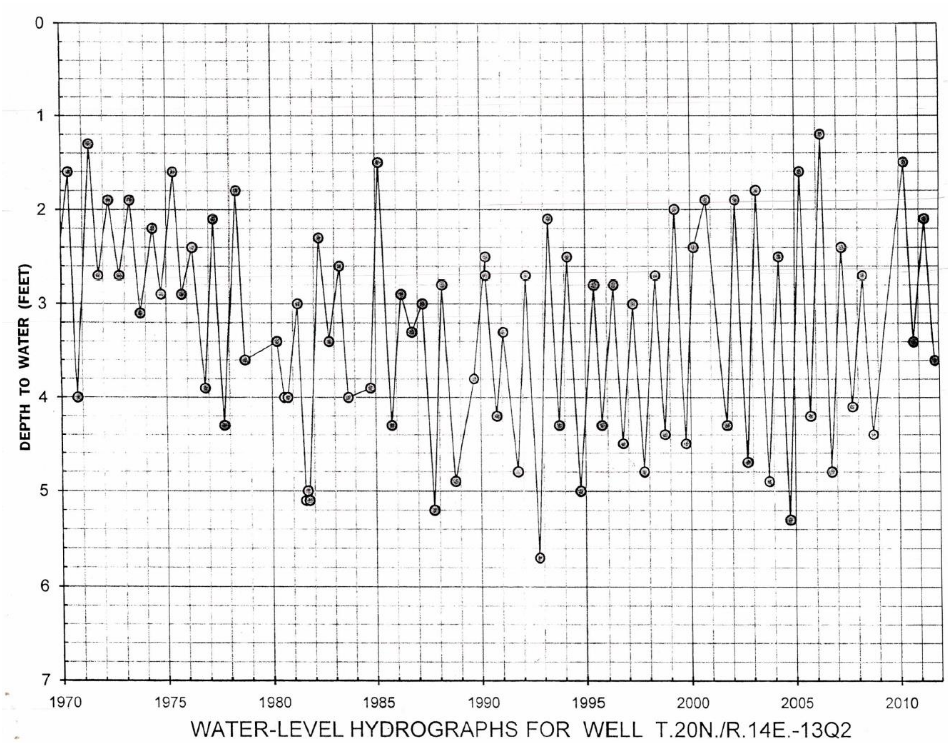


Figure 2.2-29. Water Level Hydrograph for monitoring well near Sierraville (Schmidt, 2017).

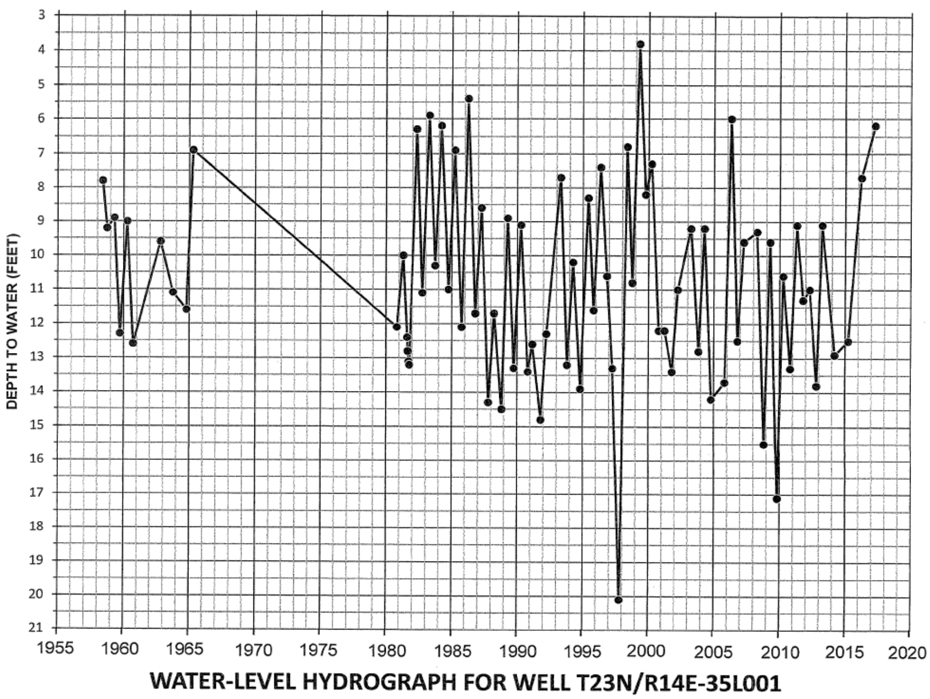


Figure 2.2-30. Water Level Hydrographs near Beckwourth (Schmidt, 2017).

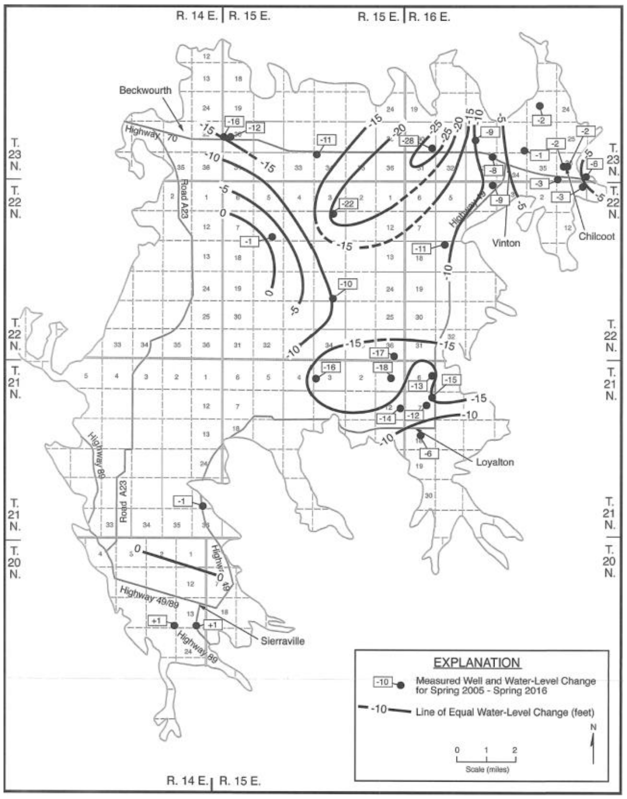


FIGURE 4 - WATER-LEVEL CHANGES FOR SPRING 2005-SPRING 2016

Figure 2.2-30. Groundwater Elevation Changes from Spring 2005 – Spring 2016 (Schmidt, 2017).

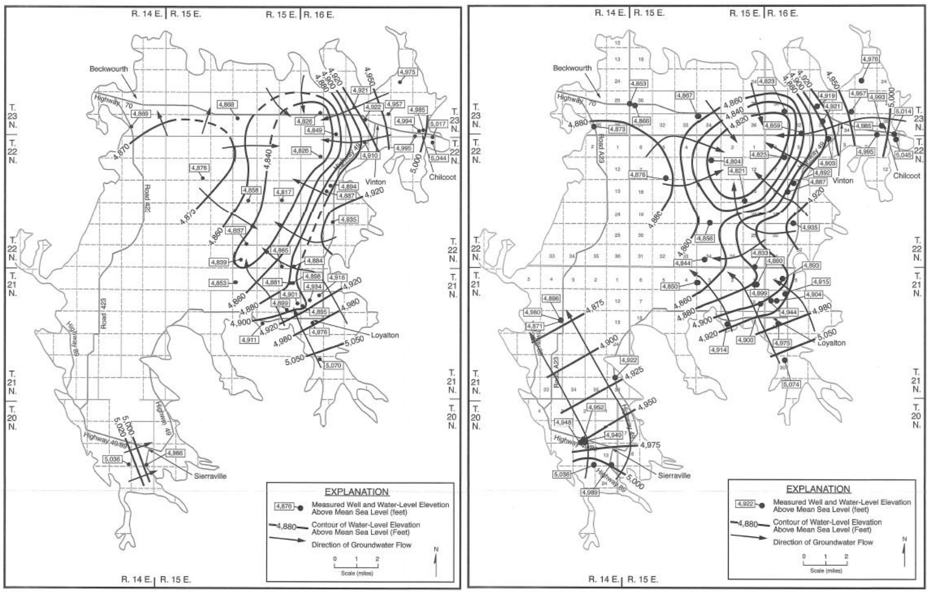


Figure 2.2-31. Groundwater Elevation Contours from Spring 2015 (left) and Spring 2016 (right) showing cone of depression growth leading up to the end of the historic drought of 2011-2017 (Schmidt, 2017).

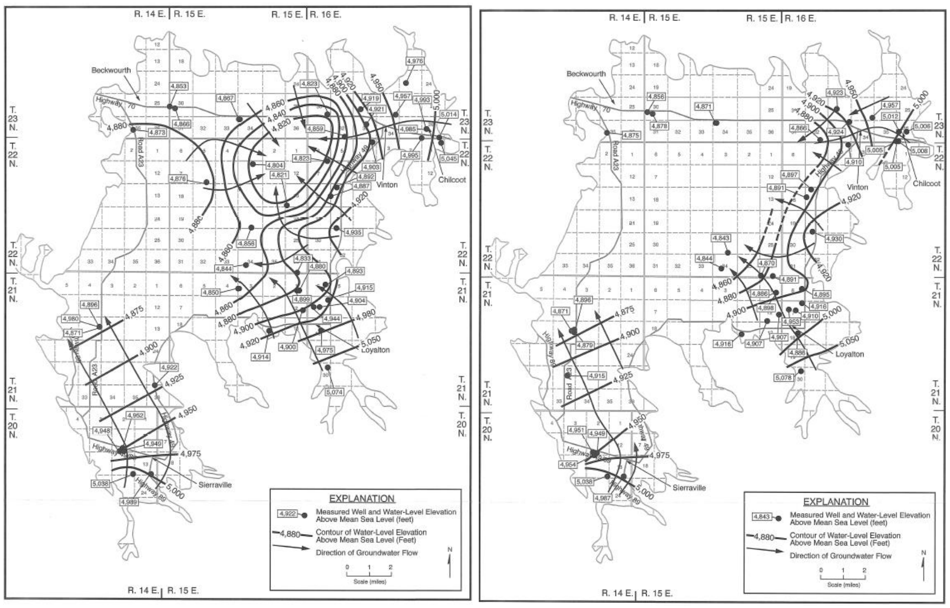


Figure 2.2-32. Groundwater Elevation Contours from Spring 2016 (left) and Spring 2017 (right) showing groundwater level recovery following the historic drought of 2011-2017 (Schmidt, 2017).

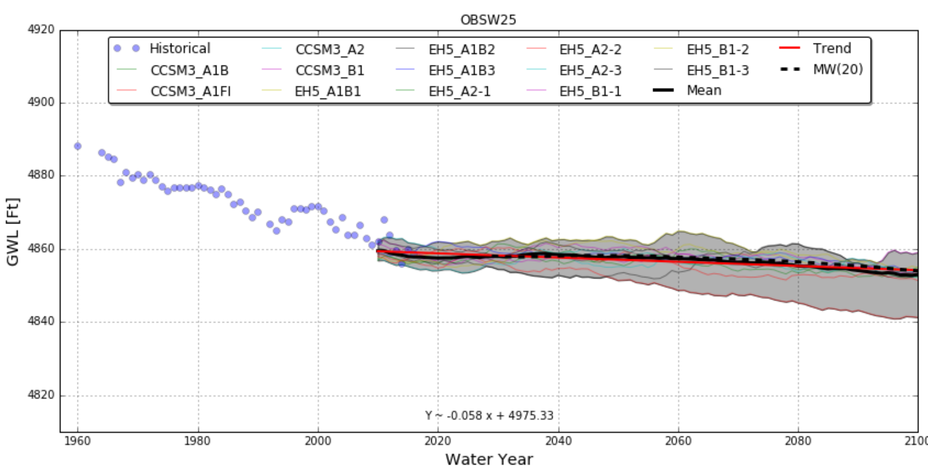


Figure 2.2-33. Long-term Hydrograph Projections for Loyalton Area (Dib et al., 2017).

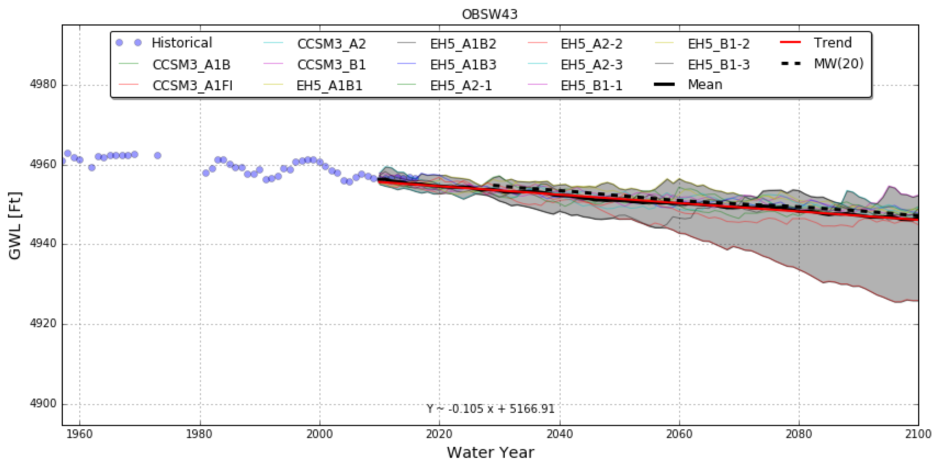


Figure 2.2-33. Long-term Hydrograph Projections for Chilcoot Area (Dib et al., 2017).

2.2.2.2 Estimate of Groundwater Storage

Per Reg. § 354.16(b), this section includes:

- A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.

Introduction to Groundwater Storage

According to DWR (1983), groundwater in storage is the volume of water that would be released from storage from each depth zone of an aquifer or the amount required to resaturate the zone. Total storage would be the sum of the storage of all individual depth zones.

Summary of Groundwater Storage in the SV Subbasin

Groundwater storage in the SV Subbasin was estimated by DWR (1983), assuming unconfined conditions, as follows: storage capacity was estimated by determining average specific yields for each 100-ft interval and multiplying this by the volume of basin sediments estimated to occur in each zone; specific yields range from 3 percent for clay to 25 percent for sand and gravel and were obtained from sediment descriptions contained in well drillers' reports (see Tables 1 and 2 of DWR, 1983). Storage calculated from the average depth to water to 600 ft was estimated to be 5,370,000 ac-ft. It is known that there is a lot of water below 600 ft, but it was not considered in these DWR calculations. Other DWR storage estimates include DWR (1963), which noted that the quantity of water that is useable is unknown, but estimated groundwater storage in the basin to be 7,500,000 acre-feet to a depth of 1000 feet, and DWR (1973), which estimated storage capacity to be between 1,000,000 to 1,800,000 acre-feet for the top 200 feet of sediments based on an estimated specific yield ranging from 5 to 8 percent.

2.2.2.3 *Seawater Intrusion Conditions*

There has never been any documented evidence of seawater intrusion into the SV Subbasin nor is there reason to believe that there ever will be. The geographic location and elevation of the SV Subbasin relative to the ocean and other salt-water bodies make seawater intrusion an irrelevant sustainability indicator for the SV Subbasin. The requirements of Reg. § 354.16(c) are therefore not applicable to the SV GSP.

2.2.2.4 *Groundwater Quality Issues*

Per Reg. § 354.16(d), this section includes:

- Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.

Commented [GH25]: A map or maps may need to be created exhibiting the best available data.

Introduction to Groundwater Quality Issues

The largest uses of ground water in Sierra Valley are irrigation, stock water, and domestic needs. As described by DWR (1983), since suitability of water quality for irrigation is dependent on crop, soil, climate, method of irrigation, etc., no specific groundwater criteria suit all cases. Guidelines have been established, however, and criteria for domestic uses well documented (EPA primary and secondary standards). In cases when groundwater quality does not meet the criteria established for its intended use, the groundwater must be treated or other water supply must be provided. Such a circumstance would be considered a groundwater quality issue. Other examples of groundwater quality issues include migration of unwanted chemical constituents in groundwater, observed increases of concentrations nearly defined limits, and introduction/spread of pollutants which may be dangerous to human and/or environmental health. Per the DWR BMPs, some things to consider when assessing groundwater quality issues include:

- What are the historical and spatial water quality trends in the basin?
- What is the number of impacted supply wells?
- What aquifers are primarily used for providing water supply?
- What is the estimated volume of contaminated water in the basin?
- What are the spatial and vertical extents of major contaminant plumes in the basin, and how could plume migration be affected by regional pumping patterns?
- What are the applicable local, State, and federal water quality standards?
- What are the major sources of point and nonpoint source pollution in the basin, and what are their chemical constituents?

- What regulatory projects and actions are currently established to address water quality degradation in the basin (e.g., an existing groundwater pump and treat system), and how could they be impacted by future groundwater management actions?

Summary of Groundwater Quality Issues in the SV Subbasin

This summary was extracted from DWR (1983). Precipitation and surface runoff that are the major sources of groundwater recharge in Sierra Valley are of excellent mineral quality. They are bicarbonate in character and usually have an electrical conductivity of less than 200 microsiemans per centimeter (uS/cm).

Groundwater found in the recharge areas that rim the valley is bicarbonate in character and reflects the excellent mineral quality of the recharge sources. This water is considered to have no quality problems and to be suitable for existing uses. As the water moves from the recharge areas through the alluvial deposits into the central portion of the basin, it becomes more mineralized, with sodium being the predominant cation.

Sodium chloride waters are found in the hot springs, thermal artesian wells, and in a few low-temperature wells. The thermal waters probably come from superheated mineralized water of magmatic source that has moved along several of the numerous fault zones crossing the valley and commingled with the ground water in the valley fill. The resulting waters are generally sodium chloride in character and contain varying amounts of other dissolved magmatic constituents, such as boron and fluoride. These waters are usually poor in quality and unsuitable for most uses. The location of these poorer quality waters is shown in Plate 10 of DWR (1983).

Boron in drinking water is generally not a hazard to human beings; however, boron in irrigation water can be very important. It is an essential element in the nutrition of plants, yet if present in concentrations as low as 0.5 to 1.0 milligrams per liter (mg/L) in irrigation water, it can be harmful to certain crops. Alfalfa, a major crop irrigated by ground water within the study area, can tolerate boron concentrations as high as 2 to 4 mg/L. Boron concentrations in Sierra Valley groundwater show a similar pattern to the EC pattern, with very high levels associated with the thermal waters in the west central portion of the basin but much lower levels in the basin fringes and recharge areas. Boron concentrations in the thermal waters have exceeded 8 mg/L, while in the basin fringes they are usually less than 0.3 mg/L. An area in the northeastern portion of the basin between the Buttes and Vinton is underlain by groundwater with boron concentrations exceeding 2 mg/L.

There is considerable information indicating that 2 to 3 mg/L of fluoride in drinking water can cause mottling on the teeth of growing children. There is also abundant literature that shows that levels of 0.8 to 1.5. mg/L of fluoride in drinking water help prevent tooth decay. Current drinking water standards are related to the annual average of maximum daily temperatures, based on reasoning that people in warm climates will drink more and receive more fluoride. The annual average of maximum daily temperatures in Sierra Valley is in the 58 to 64° F range.

Therefore, the optimum fluoride concentrations in domestic supplies should be 1.0 mg/L with the average concentration during any month not exceeding 2.0 mg/L. Only in an area along the Hot Springs Fault are the fluoride levels found at concentrations exceeding the 2.0 mg/L. These higher levels were found in the thermal waters that do not meet other drinking water standards. Over the period of monitoring in the basin, fluoride concentrations have remained about the same in these well waters. At several other locations in the basin, monitoring data indicate that some reductions in fluoride concentrations have occurred.

The adjusted sodium absorption ratio (adj. SAR) has been developed for evaluation of sodium hazard to permeability and has been used in this DWR (1983) study. SAR values were calculated for the groundwaters of Sierra Valley and show a great diversity of values. Thermal waters in the west-central portion have SAR values that range from 17 to 23, posing possible severe problems. Most of the central portion of the basin is underlain by waters with SAR values of 3 to 9, indicating increasing potential for problems. Only in the fringe areas of the groundwater basin and in major recharge areas are groundwaters found free of sodium hazard. Over the period of monitoring, the SAR values have increased in only a few well waters from the central portion of the basin, elsewhere they have remained unchanged.

Only a couple of wells in the valley have been found to yield water containing nitrate in excess of drinking water standards. Ammonia has also been detected in several well waters at excessive levels, indicating that anaerobic environments must exist locally in the groundwater basin. Hydrogen sulfide had also been detected in some wells, also indicating an anaerobic environment. Some well waters are discolored with dissolved organics, and a few wells in the central portion of the basin and in the area between the Buttes and Vinton produce waters with iron in excess of recommended levels.

Conclusion

There are certain locations in which groundwater quality data is such that beneficial uses could be impacted (both irrigation and domestic use), including potential issues with boron, fluoride, SAR, nitrate, and iron. The primary problematic areas are areas of geothermal waters (i.e. near Marble Hot Springs road in the northwestern portion of the valley) and an area between the Buttes and Vinton (northern/northeastern portion of the valley). Data is too limited to conclusively determine whether these issues have gotten better or worse, are getting better or worse, or how/to what extent they may be impacted by current groundwater management practices.

2.2.2.5 Land Subsidence Conditions

Per Reg. § 354.16(e), this section includes:

- The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the DWR, or the best available information.

Commented [GH26]: This subsection was originally developed as a stand-alone subsection for the sake of informing the community about subsidence in Sierra Valley using best available data. The purpose of this was to prevent (or reduce) the spread of misinformation that seemed to be occurring about this controversial topic. This subsection went through a couple iterations of review by the GSP Project Team during early 2019, which is why there are so many comments and track-changes edits.

Commented [GH27]: A map or maps may need to be created exhibiting the best available data.

Introduction to Land Subsidence

Land subsidence is defined as a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials (USGS, 2017). Subsidence is a global problem. In the United States, more than 17,000 square miles in 45 States have been directly affected by subsidence (USGS, 2017). Land subsidence primarily occurs as a result of groundwater overdraft and associated aquifer system consolidation, but can also result from collapse of underground cavities, tectonic activity, natural consolidation of sediment, oxidation and compaction of organic deposits, hydrocompaction of moisture-deficient soil and sediments, thawing permafrost, development of geothermal energy, extraction of hydrocarbons and other underground mining (Borchers and Carpenter, 2014; USGS, 2017). Land subsidence in agricultural areas affects irrigation canal gradients and irrigation efficiency, resulting in lower production rates and in some cases requiring major earthwork to reestablish canal gradients and relevel agricultural land. Land subsidence also reduces groundwater storage and hydraulic conductivity in the underlying aquifer system, which translates to reduced sustainable yield (maximum quantity of water that can be pumped annually from the aquifer system without causing an undesirable result). Other common problems caused by land subsidence include damage to buildings, roadways, pipelines, aqueducts, levees, sewerages, and well casings, reduced stormwater infiltration/aquifer recharge, increased flood risk/severity, and impacts associated with the development of earth fissures (i.e. hydrologic disturbance). More than 80 percent of the identified subsidence in the Nation is a consequence of groundwater exploitation (USGS, 2017). Increasing development of land and water resources threatens to exacerbate existing land-subsidence problems and initiate new ones (USGS, 2017).

Commented [GH28]: Changed terminology to consolidation (instead of compaction) throughout section. Consolidation is the more appropriate term for describing subsidence, as pointed out by Sandra and Phil.

Commented [GH29]: Added these sentences because they highlight impacts which hit "closer to home" for Sierra Valley residents and are less obvious (to help increase awareness that impacts may exist, even if they're not the big obvious impacts such as a cracked foundation).

Extraction of groundwater by pumping wells causes a complex three-dimensional deformation of an aquifer system (Galloway and Burbey, 2011). However, for simplicity, land subsidence is typically described as one-dimensional vertical consolidation. The basic physical process of land subsidence caused by groundwater overdrafting can be described as follows (Borchers and Carpenter, 2014): the weight of materials overlying an aquifer (the rocks and sediments, water, soil, vegetation, and structures on the land surface) is borne within an aquifer system by both the water in the pore spaces (pore pressure) and by the clay, silt, sand, and gravel that form the granular mineral skeleton of the aquifer; when pumping lowers groundwater levels thereby reducing pore pressure, the weight of overlying materials must be increasingly supported by the mineral skeleton of the aquifer (increasing effective stress); increased effective stress causes some elastic compression of the aquifer system skeleton (elastic subsidence) and, if the stresses are large enough, some rearrangement of mineral grains and permanent consolidation of the aquifer system (inelastic subsidence).

The following are generally accepted principles about land subsidence:

- Inelastic land subsidence generally occurs when groundwater levels decline past historical low levels (Galloway and Burbey, 2011).
- Different soil types exhibit different elastic and inelastic subsidence characteristics. For example, sands and gravels are much less prone to subsidence than clays and silts.

- Primary water bearing formations ("aquifers") within a groundwater system are generally composed of soils which are less susceptible to subsidence and the confining layers ("aquitards") are generally composed of soils which are more susceptible to subsidence. Accordingly, primary water bearing formations are often less prone to consolidation than the confining layers in a groundwater system (Borchers and Carpenter, 2014).
- Land subsidence can continue long after groundwater levels have recovered from overdraft. The thicker the confining layer and the lower the hydraulic conductivity (permeability) of the layer, the slower the system equilibrates. Pore pressures may take decades or centuries to equilibrate in some systems. As a result, initial subsidence is often less than would be expected, and residual consolidation often occurs over an extended period thereafter (Borchers and Carpenter, 2014).
- As inelastic subsidence occurs, the density of soil grains increases and pore space decreases. The associated permanent reduction in groundwater storage capacity and hydraulic conductivity within the formations in which the consolidation occurred results in greater groundwater level declines in the aquifer system for a given quantity of extraction because less groundwater is available from those formations and it takes longer for the available groundwater to transmit to the formations where extraction is occurring (Borchers and Carpenter, 2014).
- Reduced vertical hydraulic conductivity (due to subsidence) reduces rate and quantity of recharge and increases stormwater runoff and flooding.

Summary of Land Subsidence in the Sierra Valley

Available data shows that land subsidence has occurred in Sierra Valley in locations generally coinciding with locations of observed groundwater level declines (as depicted in Section 2.2.2.1). The magnitude, extents, and duration of subsidence that has occurred is inconclusive. Review of available resources and inquiry with relevant agencies uncovered the following subsidence data sources. Relevant figures extracted from these data sources are included at the end of this subsection.

1. 1983 SVGMD Technical Report by DWR (DWR, 1983)
2. 1983 Plumas County Road Department Surveys
3. 2015-2016 NASA Jet Propulsion Laboratory Study (Farr et al., 2017)
4. 2016 CalTrans Survey (data available upon request)
5. Anecdotal data

According to DWR (1983), based on in-person observations, land had subsided by as much as 1.5 feet in the eastern half of the groundwater basin from the 1950s to 1983. The study cited a number of concrete well pads that were either hanging from well casings with a visible gap above the previously flush land surface or cracked or collapsed from lack of ground support. The study surmised that subsidence had occurred in the general area bounded by Highway 70 on the north, Highway 49 on the east, Highway 89 on the south, and Herriot Lane on the west

Commented [GH30]: These sentences added per Phil and Kristi's revisions – I agree it's better to have this summary of findings introduced right out of the gate, then elaborated upon through the section. Note, I changed "suggests" to "shows", per Phil's recommendation. This is a significant revision which I figured I should check in with the team about. I do agree with Phil that "shows" is a more accurate/precise descriptor than "suggests" in this case, but added the second sentence, because yes the data shows subsidence has occurred, but magnitude/extents/duration are inconclusive – lack of data.

Commented [GH31]: Some attention should be given to the concept that the valley was formed by fault activity, with the valley sinking (per Burkhard's reports), which may still be occurring hence causing subsidence, which may be more or less significant between certain faults. Perhaps this could help explain the substantial quantity/duration of standing water near Harriet Ln at present compared to what was observed in the past.

(DWR, 1983), the same area where groundwater level declines of a few feet to over 20 feet had been documented since 1960 (as described in Section 2.2.2.1 above). Poland and Davis (1969) reported the land subsidence to groundwater level decline ratio is approximately 0.01 to 0.2 foot of subsidence per foot of groundwater level decline. Preliminary data from the study showed subsidence of approximately 2.2 feet at well T22N/Rl6E-17El where a 12-foot groundwater level decline had been recorded since 1968, a subsidence to groundwater level decline ratio of 0.183, within the expected range (DWR, 1983).

During the winter of 1983, the Plumas County Road Department surveyed elevations from the U.S. Geodetic Survey benchmarks on the eastern edge of the basin to 32 wells in the eastern half of the valley (DWR, 1983). It was planned to compare these elevations to 1958 DWR levels of these wells to document the spatial extent and magnitude of ground subsidence (DWR, 1983). However, it was later learned that the 1958 DWR survey notes had been destroyed (DWR, 1983). Regardless, DWR (1983) reported of the 32 wells surveyed, reference points on 7 showed gains of 0.l to 0.7 feet, 14 showed losses of 0.1 to 2.2 feet, 3 remained unchanged, and 8 had been altered or destroyed so that no comparisons could be made. Although these elevation comparisons could not be confirmed, DWR (1983) concluded that 1 to 2 feet of subsidence occurred in Sections 17, 18, 19, 30, and 31 of T22N/Rl6E, MDBM, and in Section 36 of T22N/Rl5E, MDBM. The Plumas County Road Department later established baseline data for future subsidence surveys in support of DWR's recommendation to establish extensometers or resurvey the points on a regular basis, but the follow-up monitoring was not conducted. The data was examined by Plumas County in 2018 and deemed no longer useful due to the obsolete surveying methods used.

The 2015-2016 NASA Jet Propulsion Lab study (Farr et al., 2017) utilized interferometric synthetic aperture radar (InSAR) from satellites and aircraft (from the European Space Agency's satellite-borne Sentinel-1A from the period March 2015 – September 2016 and the NASA airborne UAVSAR for the period March 2015 – June 2016) to produce maps of subsidence covering the majority of California, including Sierra Valley. The study results showed about an inch of swelling (increase in ground surface elevation) from March to about May of 2015 followed by subsidence for the remainder of the study reaching as much as 6 inches by June 2016. The study showed the most significant subsidence occurring in the northeastern portion of the valley (Farr et al, 2017). This area approximately coincided with concurrently observed groundwater table drawdown as described in Section 2.2.2.1 above.

2016 CalTrans survey data collected October 25 and 26 of 2016 and compared to CalTrans data collected on June 27, 2012 showed that two of their monuments in the eastern Sierra Valley ("D143", which is shown as being on the north side of Highway 70 adjacent to the intersection of Highway 70 and Harrison Ranch Road, and "Correco", which is shown as being on the east side of Highway 49 just south of the intersection of Highway 49 and County Route A24/Dyson Lane) had subsided by 1.9 feet and 0.3 feet, respectively. Again, this data is from within the same general area of observed groundwater table drawdown leading up to October 2016, the peak of California's most recent drought.

Commented [GH32]: Is this correct? Should we reference a personal communication here?

Commented [GH33]: Sandra asked if we have any information about these monuments? Are they on a structure of some kind that is sunk into the ground?

Commented [GH34]: Phil added the following below this paragraph (which I don't believe is necessary – redundant, especially if we keep the new "additional data analysis" section below - and therefore deleted, but wanted to give the group a chance to provide input):

"The data taken together suggests widespread subsidence in Sierra Valley:

1. The spatial and temporal land subsidence correspond with the of groundwater level declines (DWR 1983; Farr et al, 2017; Caltranss 2016);

2. The determined subsidence ratios (between measured subsidence and coinciding groundwater level declines; DWR 1983) are consistent with the expected ratios (Poland and Davis, 1969); and

3. The expected effects of groundwater storage reduction based on the area geology are both elastic and inelastic land subsidence (Galloway and Burbey, 2011; Borchers and Capenter, 2014) "

Anecdotal data from local residents corroborate the conclusion that some degree of subsidence has occurred in the Sierra Valley, with accounts of damage to private wells similar to those earlier reported (DWR 1983) and of increased ponding, drainage, and flooding issues in certain areas. Additionally, a dip in the road on County Route A24/Dyson Lane has reportedly emerged over recent years. No major damage to driveways, foundations, or major infrastructure (e.g., highways, railway) has been attributed to subsidence and the general feeling among locals is that inelastic subsidence is not currently a major problem in Sierra Valley. Elastic subsidence, however, has long been considered the cause of certain infrastructure challenges in the valley. Sierra Valley is a high-maintenance area for Plumas County Public Works, with routine swelling of asphalt underlain by clays and variable subsidence of up to 4 inches underlain by other valley soils (source). This problem was first recognized in 1968 on County Road A-23, on the west side of the valley where few agricultural wells exist and observed groundwater level declines have been relatively minimal. 0.5 to 2 feet of "built concrete" cement treated base was placed underneath the asphalt paving layer in order to stabilize shrink and swell on the roadway. The cement base buckled and failed in this area due to extreme movement of underlying soils. Today, County Road A-23 continues to require regular maintenance for this problem.

Additional Data Analysis

Using the subsidence to groundwater level decline ratios of 0.01 to 0.2 reported by Poland and Davis (1969), estimates of the magnitude of subsidence can be calculated for the area of Sierra Valley in which groundwater level decline has been observed. As described in Section 2.2.2.1 above, groundwater declines have been observed in the area of Sierra Valley where groundwater extraction is the greatest (northern and eastern portion) and are generally in the 20 to 40-foot range since groundwater level monitoring began (Bachand et al 2019). The resulting estimated range of cumulative subsidence that is likely to have occurred over the roughly 50-year monitoring period in the area is 0.2 to 8 feet. The associated range of annualized subsidence of 0.05 – 2 inches per year is consistent with the annualized rates calculated from DWR (1983) data (up to 2.2 feet over 30-years corresponds to up to 0.8 inches per year) and the InSAR data (Farr et al 2017) reporting net subsidence of up to 5 inches from January 2015 through June 2016 -.

Conclusion

The limited data available regarding land subsidence in the Sierra Valley shows that some degree of land subsidence has occurred in recent decades, a portion of which has apparently been inelastic subsidence of at least one to two feet which has occurred as a result of groundwater pumping and associated groundwater level declines in the eastern portion of the valley where groundwater pumping and observed groundwater level declines have been the greatest. However, the general lack of historic ground surface elevation data, uncertainty pertaining to inelastic versus elastic subsidence, and the duration and severity of the drought during and leading up to 2016 when the two most recent sets of data demonstrating subsidence were collected, it is impossible to determine the extent to which land subsidence has occurred

Commented [GH35]: This is according to Dean Cook on Harriet Lane. Is anyone aware of this dip? I tried to identify it while driving out there, but was unsure, being that there are several dip-like features. I'm curious if the location coincides with known fault location and would like to find out.

Commented [GH36]: I added this. Would you all agree this is an accurate statement? I think it's important to reflect that although this data shows some subsidence has occurred, it doesn't seem to be a current concern, or even on anybody's radar, at least until all of the GSP discussion on the topic.

Commented [GH37]: Seems we should have a source for this. Personal communication with Leah okay? Or with someone in the roads dept? Or do we have a document to reference?

Commented [GH38]: Phil mentioned that 1968 was after groundwater level decline had already been observed and suggested the county issues were due to inelastic subsidence. I added this content (location of the road and associated groundwater use/data observations) so that a reader won't incorrectly draw that same connection. I also removed the content in parentheses which stated that 1968 was before major ...

Commented [GH39]: Sandra stated "This is totally unrelated to general subsidence"; I think it's relevant because it shows that inelastic subsidence is significant in the valley; it provides a more comprehensive overview of subsidence conditions in the valley, both ...

Commented [GH40]: Is this section necessary? Came from Phil and I revised it. I don't know if it's needed. Or maybe it should go in the paragraph that already discusses the ratio, in which case I'd do away with these added subsection headings.

Commented [GH41]: Likely didn't occur every year – likely occurred mostly during periods of most significant drawdown and less so during periods of near-baseline groundwater levels… Also note, the high end of the ratio range reported by Poland and Davis ...

Commented [GH42]: Actually was 6-7 inches of subsidence observed in one year, May 2015 – June 2016, which is well outside of the 0.05-2 in/year expected, but this was during the most dramatic declines observed, as it was at the end of the severe ...

Commented [GH43]: Phil suggested we replace this paragraph with: "The data and observations show widespread subsidence in Sierra Valley with uncertainty regarding the exact spatial extent of subsidence or its magnitude. There have been ...

and/or is occurring in the Sierra Valley as an undesirable result of groundwater pumping. Accordingly, as described in Section 3.5 below, a formal subsidence monitoring network and protocol is planned for implementation (currently being designed) to allow SVGMD to conclusively determine the extent and magnitude of subsidence occurring, if any, such that appropriate management actions can be taken as necessary to prevent significant and unreasonable impacts to surface land uses and other undesirable results.

Commented [GH44]: I added this based on Kristi's comment so that any reader in the interim is aware that the network/protocol are still in the works. It is highlighted because it will be removed by the time we submit the plan to DWR (the design will be complete well before then).

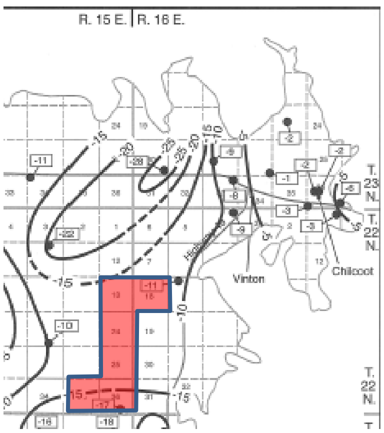


Figure 2.2-34. Map showing Sections in which land subsidence was identified by DWR (1983) over groundwater level contours (Schmidt, 2017).

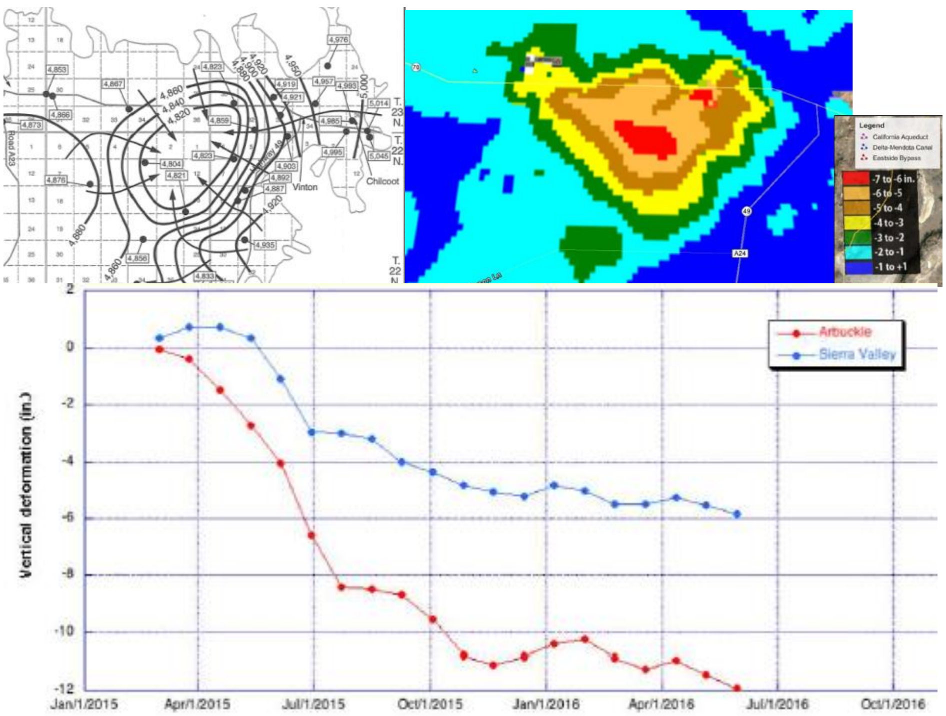


Figure 2.2-35. Maps and Graph showing InSAR land subsidence data (Farr et al., 2017) with location/extents consistent with groundwater level contours for the same time period (Schmidt, 2017).

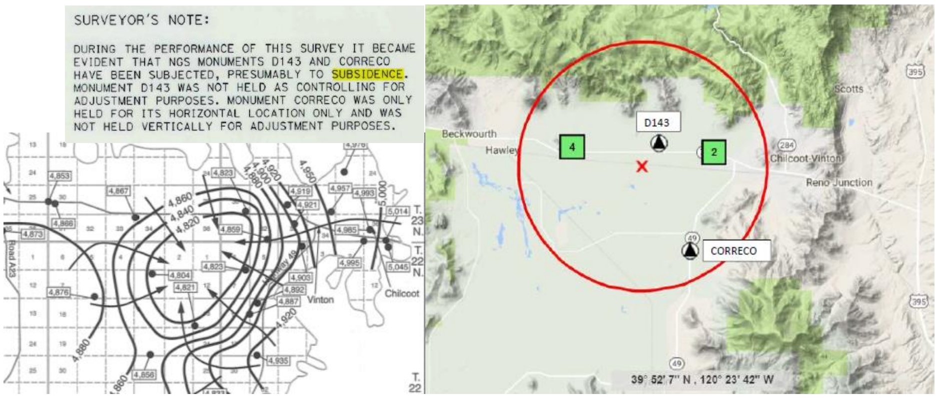


Figure 2.2-36. Map showing locations of CalTrans benchmarks that were noted to have dropped in elevation (documentation available upon request), associated surveyor's note, and groundwater level contours in the same general area during the same general time period (Schmidt, 2017).

2.2.2.6 Identification of Interconnected Surface Water Systems

Per Reg. § 354.16(f), this section includes:

- Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from DWR, or the best available information.

Per the DWR BMPs, some things to consider when identifying and assessing interconnected surface water systems include:

- What are the historical rates of stream depletion for different water year types?
- What is the uncertainty in streamflow depletion estimates from analytical and numerical tools?
- What is the proximity of pumping to streams?
- Where are groundwater dependent ecosystems in the basin?
- What are the agricultural and municipal surface water needs in the basin?
- What are the applicable State or federally mandated flow requirements?

Introduction to Interconnected Surface Water Systems

Surface waters that may be interconnect with the SV Subbasin aquifer system include springs and seeps, streams/channels flowing through the valley, and the MF Feather River flowing out of the valley. This is a complex topic with many unknowns and data gaps (see Section 2.2.1.6). Potential impacts to such interconnected surface water systems include the following: (1) Overdraft could lead to reduced surface water flows within and leaving the valley which could affect in-stream habitat and downstream water users, and (2) overdraft could lead to reduced water supporting wetland/marshes, thereby affecting the sensitive habitat.

Summary of Interconnected Surface Water Systems in the Sierra Valley

Available data relevant to interconnected surface water systems includes:

- MF Feather River Streamgage data at Rocky Point: 1969-80, 2006-present
- Monitoring well data showing gradually declining groundwater level trends indicates that interconnected surface water may be impacted
- Nature Conservancy's "GDE Pulse" primarily shows little/no long-term changes in GDEs; some reduction during drought period then rebound
- Nature Conservancy's database of vegetation and wildlife identified in the Sierra Valley – can be used to track ecosystem health over time

Surface waters that may be interconnect with the SV Subbasin aquifer system include springs and seeps, streams/channels flowing through the valley, and the MF Feather River flowing out of the valley. Monitoring well data showing gradually declining groundwater level trends indicates that interconnected surface water may be impacted, especially the MF Feather River, which is a Wild and Scenic designated river and significant tributary to the California State Water Project. This is a complex topic with many unknowns and data gaps (see Section 2.2.1.6).

Conclusion

Though no dedicated interconnected surface water monitoring network exists in the SV Subbasin and data availability is therefore relatively limited, several datasets exists which can be useful in evaluating interconnectedness of surface water and potential impacts resulting from groundwater overdraft. For example, combined evaluation of precipitation data, MF Feather River streamgage data, Lake Davis Dam flow data, groundwater pumping and groundwater level data, along with other climate and surface water data (from Frenchman Lake, from water rights diversions, etc.) may help elucidate the interconnectedness and dynamics of relationships between deep and shallow aquifers and surface water systems and the effects of changing groundwater conditions. Additionally, anecdotal data and reports of changes to artesian well flows/pressures and prevalence in various areas of the valley compared with groundwater level trends over time shed light on impacts of aquifer development in the SV Subbasin on deep aquifer pressurization and associated spring flows/seeps which feed/have historically fed surface waters. Such analyses have been touched on in existing documents (i.e. Dib et al., 2017; Bachand at al., 2020), but additional thorough, and perhaps creative, analyses are needed to improve the understanding of the relationship between groundwater management and this sustainability indicator and to enable appropriate and effective associated groundwater management actions.

2.2.2.7 *Identification of Groundwater-Dependent Ecosystems*

Per Reg. § 354.16(g), this section includes:

- Identification of groundwater dependent ecosystems within the basin, utilizing data available from the DWR, or the best available information.

Introduction to Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are ecosystems that depend on groundwater, cannot persist without sufficient groundwater supporting them, and therefore recede/disappear when groundwater overdraft reduces/eliminates groundwater supply to them. GDEs may include springs and seeps, caves and karst systems, and deep-rooted plant communities (phreatophytes). In many cases, rivers, wetlands, and lakes are also groundwater-dependent ecosystems. GDEs often support unique and sensitive species of plants and wildlife and are critical components of balanced groundwater basin systems.

Summary of Groundwater Dependent Ecosystems in the Sierra Valley

Sierra Valley has many wetland and march areas that are to some extent dependent on groundwater. The degree to which such GDEs are dependent on deep aquifers and hence impacted by groundwater extraction from deep aquifers is unclear. Data availability on the topic is very limited, but the Nature Conservancy's' GDE "Pulse" provide a good idea of the locations and spatial extents of GDEs in the Sierra Valley and changes to them over the past several decades, as depicted in Figures 2.2-37 – 2.2-39 at the end of this subsection. The figures show mainly moderate increases in GDEs in the wettest portion of the valley from 1985 to 2018, some moderate and large increases and decreases from 2009 to 2018, and mostly large increases with some moderate increases and moderate and large decreases from 2014 to 2018. The location of the large increases may be consistent with the observed changes in standing water near the intersection of Dyson Ln and Harriet Ln where impacts of higher spring water surface levels and longer durations of inundation have been documented. These changes/impacts could be associated with land subsidence and/or the filling in of natural and manmade channels in the vicinity of the "Sierra Valley Channels" in this area with vegetation, sediment, etc. It is worth noting that such changes, though leading to large increases of unique habitat have negative impacts on ranching and residing in this area in the form of a shorter ranching season and damages to private structures from flooding/inundation, and probably a prolonged and intensified mosquito/insect breeding season.

Bachand et al. (2020) offer the following relevant information on the topic:

Groundwater Dependent Ecosystems. Shallow groundwater data in the western and southwestern valley will be needed to address the surface water to groundwater interaction sustainability indicator. Shallow GWE monitoring will be needed to ensure stress on these systems is not occurring from agricultural pumping. Piezometers selectively installed with paired surface water elevation monitoring can be used to understand valley groundwater and surface water interactions. Comparing groundwater and surface water temperatures in such paired stations can also provide information on groundwater-surface water interactions (USGS, 2003; Constanz, 1998).

Conclusion:

Similar to the data circumstances described above for interconnected surface waters, the lack of a formal locally driven groundwater dependent ecosystems monitoring network/program translates to limited data availability for assessment of current and historical groundwater dependent ecosystem conditions in the Sierra Valley. Analyses of available data, however, can elucidate conditions, changes resulting from groundwater extraction, and appropriate direction moving forward with monitoring network/protocol development and associated management actions. According to the Nature Conservancy's GDE Pulse, it does not appear that GDEs in the Sierra Valley have significantly changes over from 1985 to 2018, but temporary changes during periods of drought have been somewhat significant. Changes prior to 1985 may have been significant as well, though no directly applicable data is known to exist dating back that far. A document recently developed which should be utilized in this endeavor is the Nature Conservancy's "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" document.

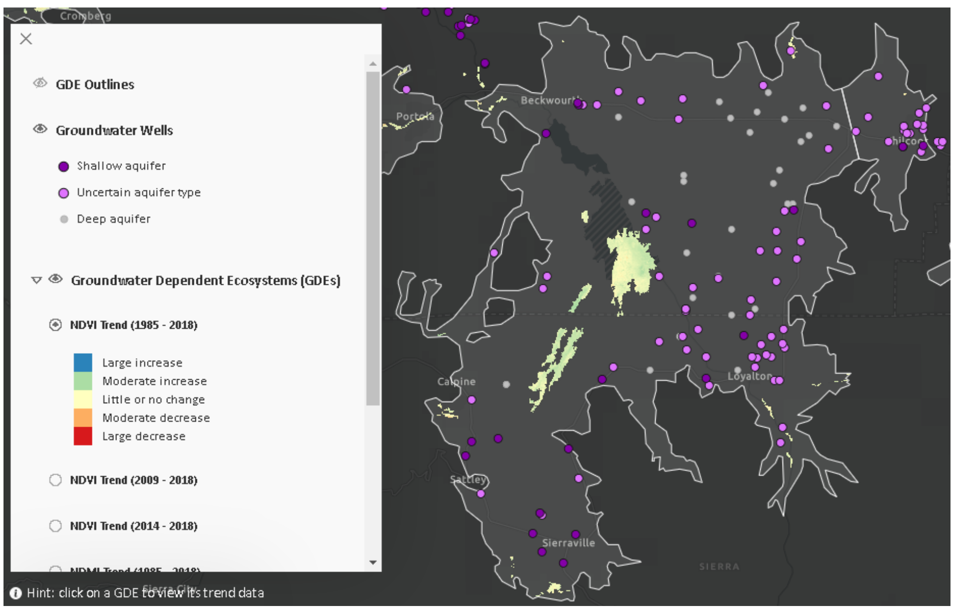


Figure 2.2-37. Nature Conservancy's GDE Pulse Map, Changes in GDEs from 1985-2018.

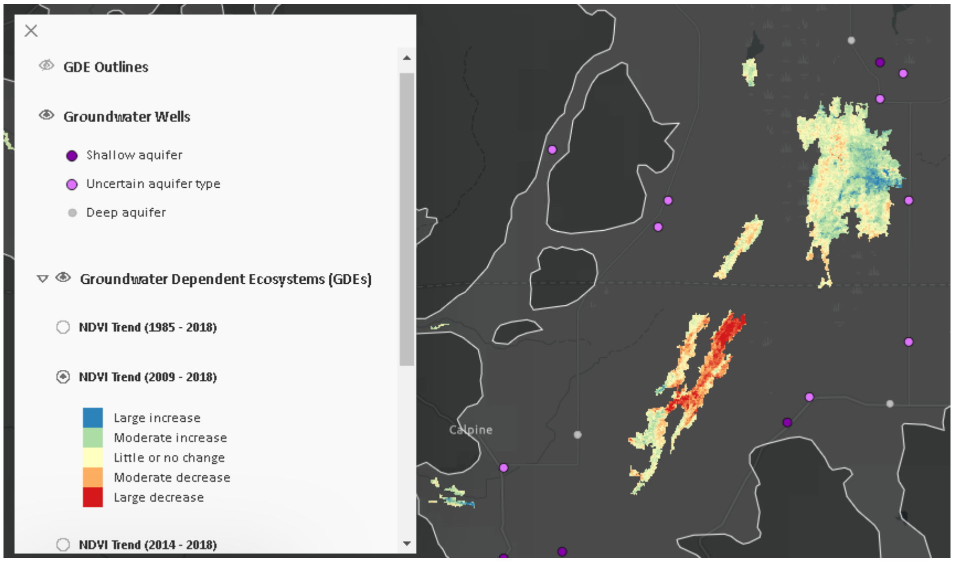


Figure 2.2-38. Nature Conservancy's GDE Pulse Map, Changes in GDEs from 2009-2018.

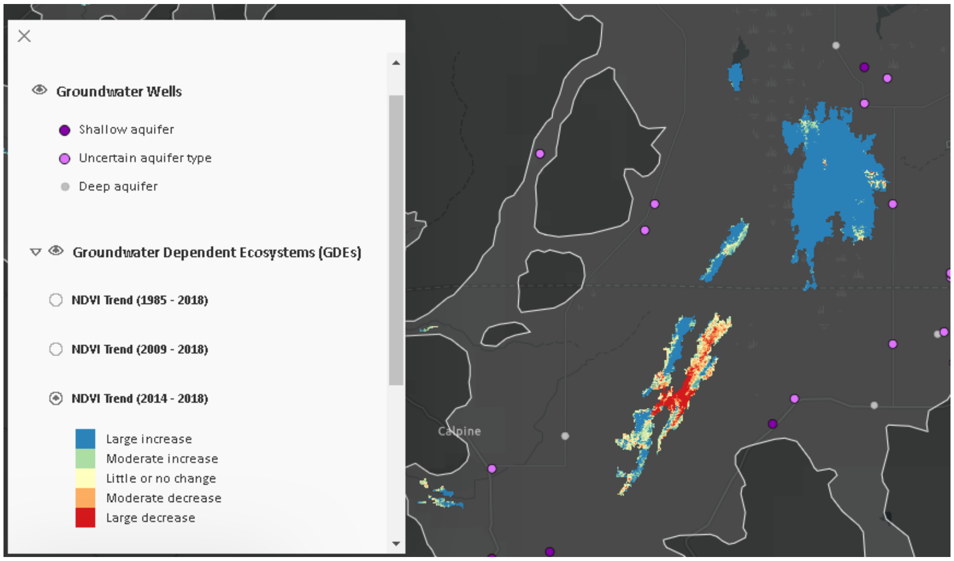


Figure 2.2-39. Nature Conservancy's GDE Pulse Map, Changes in GDEs from 2014-2018.

2.2.3 Water Budget Information *(Reg. § 354.18)*

Commented [GH45]: Not much effort was put into this section, as it is anticipated that a significant effort including model development will be performed by/stamped by a qualified expert as a part of the actual SV GSP development. As such, this section is expected to be carefully developed by said qualified expert and use of time/funds to thoroughly develop this section at this time was deemed to not be worthwhile.

In accordance with Reg. § 354.18 of the California Code of Regulations, this section includes:

- Description of inflows, outflows, and change in storage
- Quantification of overdraft (as applicable)
- Estimate of sustainable yield
- Quantification of current, historical, and projected water budget
- Description of surface water supply used or available for use for groundwater recharge or in-lieu use

The primary water-bearing formations in SV Subbasin are Holocene sedimentary deposits, Pleistocene lake deposits, and Pleistocene lava flows (DWR, 1963; DWR, 1983). DWR (1963) notes that the quantity of water that is useable is unknown, but estimated groundwater storage in the basin to be 7,500,000 acre-feet to a depth of 1000 feet. DWR (1973) estimated storage capacity to be between 1,000,000 to 1,800,000 acre-feet for the top 200 feet of sediments based on an estimated specific yield ranging from 5 to 8 percent.

Groundwater in the SV Subbasin is pumped mainly for irrigation purposes. Metered pumpage records indicate that the sustainable yield is about 6,000 acre-feet per year in the part of the valley tapped by large-capacity supply wells (Schmidt, 2012). In a survey by DWR in 1997, the estimated annual agricultural and municipal/industrial uses were given as 3,400 and 100 acre-feet respectively (DWR, 2004). However, in the recent hydrogeologic studies (Schmidt, 2003, 2005, 2012, 2015) the average annual pumping was reported as 7,000 acre-feet and pumping between 1989 and 2011 and about 12,200 acre-feet per year during 2013 and 2014 when surface water availability was significantly less than average. Although an increase in groundwater levels were observed in low pumpage years, the overall trend shows decreasing water levels, especially in the northeastern portion of the valley where the most pumping and the least recharge occurs (Schmidt, 2003, 2005, 2012, 2015).

These data are used as references in validating the water budget model.

2.2.4 Management Areas (as Applicable) *(Reg. § 354.20)*

Per Reg. § 354.20, this section includes:

- Reason for creation of each management area
- Level of monitoring and analysis
- Description of management areas
- Explanation of how management of management areas will not cause undesirable results outside the management area

A number of distinct "management areas" arise from the somewhat complex fashion in which GSA jurisdictional boundaries and hydrologic boundaries overlap. Although these "management areas" may not have explicitly unique management approaches or actions, it is important to define these areas for purposes of communication and clarity. These areas are as follows:

Commented [GH46]: Other areas, per Bachand et al., 2020, should probably be added to this section – perhaps an area defined as the areas east of the east grizzly fault, per Bachand et al., 2020

"Plan Area"	The entire SV Subbasin as defined in DWR (1980) and digitally represented by DWR (viewable on the SGMA Basin Prioritization Dashboard tool available here: https://gis.water.ca.gov/app/bp-dashboard/final/)
"SVGMD Area"	The area within the SVGMD jurisdictional boundary; encompasses > 99.9% of the SV Subbasin (a.k.a. the "Plan Area") and the majority of the Sierra Valley Watershed;
"Plumas County Area"	The area within the SV Subbasin which is outside of the SVGMD jurisdictional boundary (around 100 acres, < 0.1% of the SV Subbasin);
"Sierra Valley"	The entire Sierra Valley, the outer boundary of which is defined as the interface of the valley floor and surrounding mountains and approximately coincides with the outer boundaries of the SV Subbasin and Chilcoot Subbasin; encompasses the entire Plan Area; is approximately equivalent to the area encompasses by the SV Subbasin and the Chilcoot Subbasin;
"Sierra Valley Watershed"	The entire Sierra Valley Watershed; encompasses all above management areas; includes areas beyond the SVGMD jurisdictional boundary for which SVGMD does not have direct management authority, but which are still relevant to this Plan Concept Document due to their hydrologic connection with the Plan Area.

In addition to the above "management areas", certain specific areas may be identified as areas subject to different management and/or monitoring actions based on land uses, observed monitoring data, etc. Only one such area currently existing in the Plan Area (described below). In the event that any additional management areas be established in the future, additional associated descriptions will be added here.

"Restricted Area"	The area within the SV Subbasin defined in SVGMD Ordinance 18-01 Exhibit A (see Figure 2.2-40) in which new high-capacity well drilling/activation of existing inactive high-capacity wells is restricted due to observed historic overdraft.

Management, monitoring, and analysis are essentially the same for all management areas encompassed within the Plan Area, with one major exception: new high-capacity well drilling/activation of existing inactive high-capacity wells is restricted within the Restricted Area. Management outside of the Plan Area but within the SVGMD Area is limited to management allowable under the SVGMD enabling legislation (e.g. the legal authorities of a GSA as defined in SGMA do not apply), but is generally not expected to be significantly different. Defining additional management areas could be useful, such as the area east of the east Grizzly Fault, an area defined in Bachand et al. (2020).

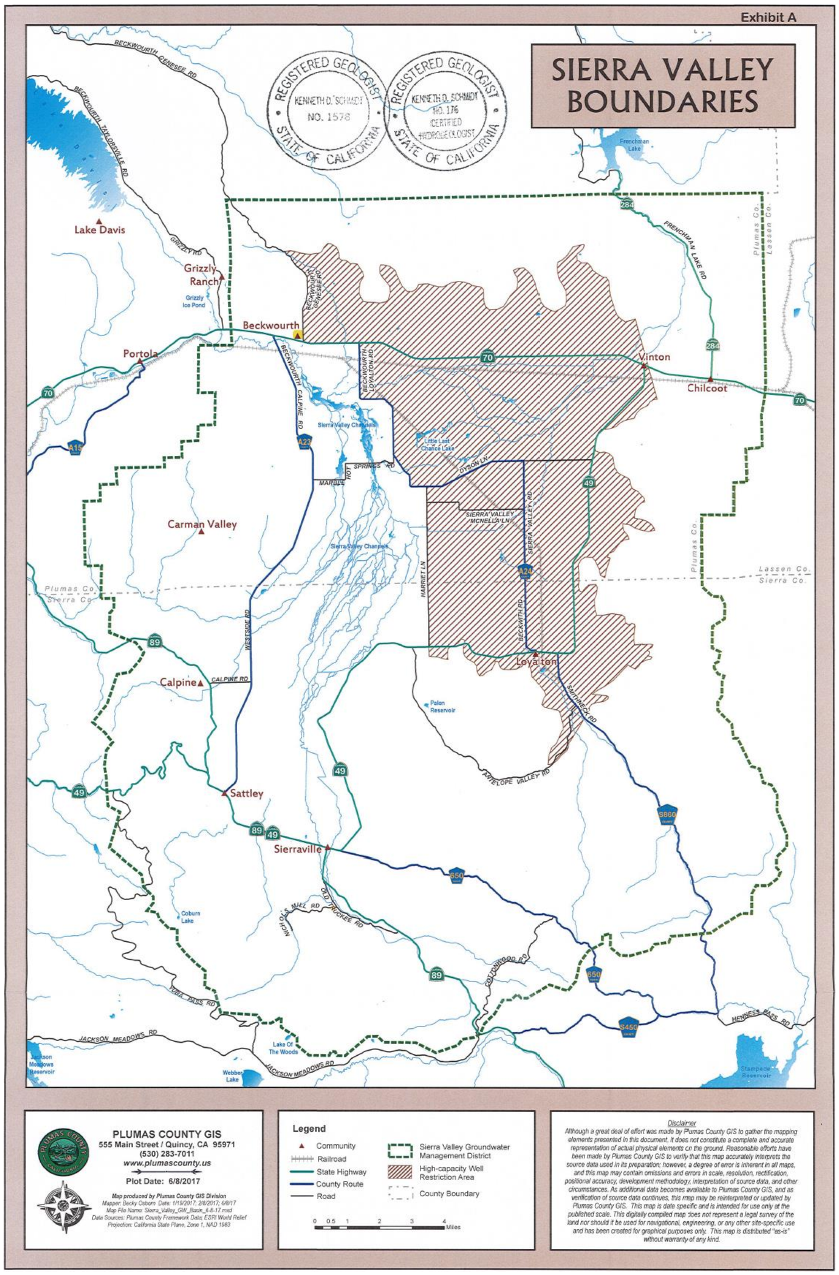


Exhibit A
SIERRA VALLEY BOUNDARIES
REGISTERED GEOLOGIST
KENNETH D. SCHMIDT
NO. 1578
STATE OF CALIFORNIA
REGISTERED GEOLOGIST
KENNETH D. SCHMIDT
NO. 176
CERTIFIED HYDROGEOLOGIST
STATE OF CALIFORNIA
Lake Davis
Grizzly Ranch
Beckwourth
Portola
Vinton
Chilcoot
Carman Valley
Calpine
Sattley
Sierraville
Loyalton
Frenchman Lake
Plumas Co.
Lassen Co.
Sierra Co.
BECKWOURTH GENESEE RD
FRENCHMAN LAKE RD
CALPINE RD
ANTELOPE VALLEY RD
HENNESS PASS RD
JACKSON MEADOWS RD
Lake Of The Woods
Jackson Meadows Reservoir
Webber Lake
Stampede Reservoir
Palen Reservoir
Sierra Valley Channels
70
89
49
284
PLUMAS COUNTY GIS
555 Main Street / Quincy, CA 95971
(530) 283-7011
www.plumascounty.us
Plot Date: 6/8/2017
Map produced by Plumas County GIS Division
Mapper: Becky Osborn Date: 1/19/2017; 2/8/2017; 6/8/17
Map File Name: Sierra_Valley_GW_Basin_6-8-17.mxd
Data Sources: Plumas County Framework Data; ESRI World Relief
Projection: California State Plane, Zone 1, NAD 1983
Legend
Community
Railroad
State Highway
County Route
Road
Sierra Valley Groundwater Management District
High-capacity Well Restriction Area
County Boundary
0 0.5 1 2 3 4 Miles
Disclaimer
Although a great deal of effort was made by Plumas County GIS to gather the mapping elements presented in this document, it does not constitute a complete and accurate representation of actual physical elements on the ground. Reasonable efforts have been made by Plumas County GIS to verify that this map accurately interprets the source data used in its preparation; however, a degree of error is inherent in all maps, and this map may contain omissions and errors in scale, resolution, rectification, positional accuracy, development methodology, interpretation of source data, and other circumstances. As additional data becomes available to Plumas County GIS, and as verification of source data continues, this map may be reinterpreted or updated by Plumas County GIS. This map is date specific and is intended for use only at the published scale. This digitally compiled map does not represent a legal survey of the land nor should it be used for navigational, engineering, or any other site-specific use and has been created for graphical purposes only. This map is distributed "as-is" without warranty of any kind.

Figure 2.2-40. SV Subbasin Restricted Area, as Defined by SVGMD Ordinance 18-01 Exhibit A.

3.0 Sustainable Management Criteria

Commented [GH47]: All content in the chapter is suggestive/hypothetical and very incomplete. – it is merely an attempt to provide a starting point reflective of the sentiments of the SVGMD directors and others as I have interpreted them.

3.1 Sustainability Goal *(Reg. § 354.24)*

Per Reg. § 354.24, this section includes:

- Description of sustainability goal, including:
  - Information from the basin setting used to establish the sustainability goal
  - Discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield
  - Explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

SGMA defines "Sustainability Goal" as the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield. The development and implementation of this GSP thus constitutes the Sustainability Goal for the SV Subbasin.

Additionally, per Reg. § 354.24 of the California Code of Regulations, the GSP must establish a sustainability goal, including a description of the goal, information from the basin setting used to establish the goal, discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

As described in Chapter 1 of this Plan Concept Document, the essence of the Sustainability Goal is as follows:

Sustainability Goal *(PLACEHOLDER – CONCEPT):* groundwater management within the SV Subbasin by SVGMD which by 2042 eliminates any and all impacts associated with groundwater level declines, groundwater storage reductions, water quality degradation, land subsidence, and/or surface water depletions which result from groundwater extraction and are locally considered to be significant and unreasonable (*as will be described in the SV GSP*) and to prevent any such impacts from occurring thereafter at least until 2072.

An essential step toward achieving the sustainability goal is the development and implementation of a long-term strategy for management of the groundwater. Some of the basic components of the Districts long-term strategy, as described in the District's 2006 Draft Management Plan, are:

1. Making maximum beneficial use of the groundwater and all other reasonable sources of water to augment the water supply in the District,
2. Development and implementation of plan components and adoption of appropriate rules which;
    a. Require conservation and responsible management of water used,
    b. Regulate existing and new groundwater withdrawals to reduce, and eventually eliminate, damage from groundwater level changes, groundwater quality changes, land subsidence, and any other undesirable results.
3. Identification and completion of projects that foster groundwater recharge or reuse of water in the District, and
4. Identification and elimination of unreasonable institutional barriers to the sound management of water resources.

The most pressing challenge that must be overcome in the endeavor to achieve sustainable groundwater management in the SV Subbasin is to prevent further groundwater level declines while minimizing economic impacts to locals. Agriculture is a primary economic driver in Sierra Valley, providing jobs/livelihood for a large portion of the local population. Agriculture is also responsible for the vast majority of groundwater extraction from the SV Subbasin and the associated decline in groundwater levels (described in greater detail in subsequent sections). While groundwater overdraft and associated impacts (i.e. reduced groundwater in storage, land subsidence, etc.) are relatively minimal in Sierra Valley, impacts have been documented in recent decades.

To prevent future impacts, groundwater demand must be balanced with groundwater supply (i.e. pumping must be kept within the limits of the basin's sustainable yield). To accomplish this, the long-term SV Subbasin management strategy focuses on the following two key elements: (1) maximize groundwater recharge, and (2) minimize agricultural pumping demand.

To maximize groundwater recharge, a recharge study has been conducted (Bachand et al., 2020) and opportunities for enhancing recharge have been identified. Additional proposed studies, pilot projects, and other efforts are outlined in Chapter 4 of this Plan Concept Document. Through these efforts, groundwater recharge to the SV Subbasin is expected to be maximized to the greatest degree practicable over the next decade or two.

To minimize agricultural pumping demand, the following three core strategies have been developed:

4. Prevent construction of new agricultural (a.k.a. "high capacity") wells in the portion of the SV Subbasin in which groundwater level declines have been observed through the passage and enforcement of a local ordinance (SVGMD Ordinance 18-01, passed April 9, 2018 to accomplish this).
5. Optimize the sustainable use of surface water for agricultural irrigation thereby reducing agricultural groundwater demand (e.g. optimize conjunctive use); this strategy includes efforts to work with DWR/area water master to review water rights allocations and identify any opportunities for improved water rights use, water rights "banking"/sharing , surface water storage during wet season for irrigation use in the dry season, etc., and also includes efforts to work with DWR/State Water Project to review the Frenchman Dam Operating Policy and identify opportunities to better utilize surface waters stored in Frenchman Reservoir through revising the Policy.
6. Optimize irrigation efficiency through use of improved irrigation technologies/systems such as low-elevation sprinkler application (LESA) and low-elevation precision application (LEPA).

An additional strategy being explored by some of the agricultural residents of the Valley is the possibility of changing agricultural business frameworks to reduce water demand, i.e. by switching to production of crops with lower water demand, etc.

In addition to implementing these strategies, SVGMD will utilize monitoring data to inform adaptive groundwater management. Specifically, groundwater level data and agricultural pumping data will be assessed annually to evaluate the accuracy of the estimated sustainable yield of the SV Subbasin and the SV Subbasin Groundwater Model will be fine-tuned as needed utilizing this data in combination with other relevant data (i.e. weather/climate data) such that the estimated sustainable yield (and associated pumping restrictions, i.e. restriction implementation threshold and pumping allocation quantities) can be adapted accordingly over time. This will enable the fine-tuning of groundwater management over time and adaptation of groundwater management policies to parallel changes in climate and/or other factors that may affect groundwater availability.

3.2 Measurable Objectives *(Reg. § 354.30)*

Per Reg. § 354.30, this section includes:

- Description of each measurable objective and how the measurable objectives were established for each relevant sustainability indicator
- Description of how a reasonable margin of safety was established for each measurable objective

- Description of a reasonable path to achieve and maintain the sustainability goal including a description of interim milestones for each relevant sustainability indicator
    - Measurable Objective for Sustainability Indicator 1
        - Interim Milestone at 5 years
        - Interim Milestone at 10 years
        - Interim milestone at 15 years
        - Milestone at 20 years
    - Measurable Objective for Sustainability Indicator 2
        - Interim Milestone at 5 years
        - Interim Milestone at 10 years
        - Interim milestone at 15 years
        - Milestone at 20 years
    - Measurable Objective for Sustainability Indicator X
- If management areas are used, a description of *(Reg. § 354.20 b)*:
    - The measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.
    - An explanation of how the management area can operate under different measurable objectives without causing undesirable results outside the management area, if applicable.

SUGGESTION FOR DISCUSSION FOR ESTABLISHING MEASUREABLE OBJECTIVES: The measurable objectives for the five applicable sustainability indicators for the SV Subbasin are the numeric values recorded during the spring of 2011 prior to the historic drought of 2011 – 2017, as displayed in Table 3.2-1 below. The groundwater conditions observed at the end of the historic drought, which lasted from December 2011 to March 2017 and was reportedly one of the most intense droughts in California history, with the period of late 2011 through 2014 being the driest in California history, were the worst on record in the SV Subbasin. However, no resulting impacts exceeded the standards of acceptability of impacts (i.e. what would be considered "significant and unreasonable") for the five applicable sustainability indicators described in Section 3.4, which if exceeded would constitute undesirable results, hence a failure to meet the Sustainability Goal for the SV Subbasin. It can thus be concluded that the conditions prior to this drought, e.g. those observed in the spring of 2011, provided a sufficient "margin of operation flexibility" (as referred to in SGMA) to enable continuation of typical agricultural activities and other groundwater dependent activities through a historic drought without causing impacts in excess of the standards of acceptability established for the SV Subbasin during the GSP development process, a.k.a. without causing undesirable results. As such, it was agreed upon during the GSP development process setting the measurable objectives values equal to the values observed during the spring of 2011 is a reasonable and safe means of ensuring that undesirable results within the SV Subbasin will be prevented.

Note, if a drought of equal magnitude were to again occur in the future while groundwater demand in Sierra Valley remains unchanged, no special groundwater management actions, i.e. restricting agricultural pumping, would be expected to be needed to avoid exceeding the minimum thresholds described below, based on available data. However, it is possible that a worse drought could occur and/or a similar drought could occur in combination with increased groundwater demand in the Sierra Valley. In such instances, special management actions such as implementing agricultural pumping restrictions would likely be required to present undesirable results, per the definitions provided in the subsequent sections of this document. Monitoring and management action implementation protocols have been developed accordingly, as outlined in subsequent sections of this document.

To accomplish these measurable -objective 20-year milestones, interim milestones have been established in 5-year intervals, which were set simply by interpolating between current numeric values from most recent data and the measurable objective 20-year milestone numeric values.

Table 3.2-1. Measurable Objectives (20-Yr Milestones) – Spring 2011 Pre-Drought Conditions

(PLACEHOLDER)

3.3 Minimum Thresholds *(Reg. § 354.28)*

Per Reg. § 354.28, this section includes:

- Description of each minimum threshold and how they were established for each relevant sustainability indicator
- Relationship for each sustainability indicator
- Description of how minimum thresholds have been selected to avoid causing undesirable results
- Description of how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.
- Standards related to sustainability indicators
- How each minimum threshold will be quantitatively measured for each relevant sustainability indicator
- If management areas are used, a description of *(Reg. § 354.20 b)*:

- o The minimum thresholds established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.
- o An explanation of how the management area can operate under different minimum thresholds without causing undesirable results outside the management area, if applicable.

SUGGESTION FOR DISCUSSION FOR ESTABLISHING MINIMUM THRESHOLDS: The minimum thresholds set for the five applicable sustainability indicators for the SV Subbasin are the numeric values recorded in the spring of 2016, as displayed in Table 3.3-1 below. At this time, the region was near the end of a historic drought and as such, groundwater conditions in the SV Subbasin were at or near the worst ever recorded. However, no resulting impacts exceeded the standards of acceptability of impacts for the five applicable sustainability indicators described in Section 3.4, which if exceeded would constitute undesirable results, hence a failure to meet the Sustainability Goal for the SV Subbasin. Because observed conditions in the SV Subbasin have never been worse than observed during the spring of 2016, it cannot be known how much worse conditions would have to become to exceed the standards of acceptability for impacts agreed upon by engaged stakeholders during the GSP development process. As such, it was agreed upon during the GSP development process that setting the minimum thresholds equal to the values observed during the spring of 2016 is a reasonable and safe means of ensuring that undesirable results within the SV Subbasin will be prevented, provided the minimum thresholds are not exceeded.

Table 3.3-1. Minimum Thresholds – Spring 2016 Worst Recorded Conditions

(PLACEHOLDER)

3.4 Undesirable Results *(Reg. § 354.26)*

Per Reg. § 354.26, this section includes:

- Description of undesirable results for any of the sustainability indicators
- Cause of groundwater conditions that would lead to undesirable results
- Criteria used to define undesirable results based on minimum thresholds
- Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results

As described in Section 1.1, definitions of undesirable results hinge upon descriptions of what would be considered “significant and unreasonable” impacts resulting from groundwater conditions throughout the SV Subbasin associated with each of the five applicable sustainability indicators, which per SGMA were required to be developed through the stakeholder engagement and decision making processes described in this document. The descriptions that resulted from this process are described in detail in this Section. Additional information elucidating the description development process is included in Appendix F – Comments and Responses.

Groundwater Levels: Groundwater level declines which result in increases in pumping costs and/or decreases in well production rates that prevent safe and economically feasible continuation of existing groundwater dependent activities within the SV Subbasin and/or declines which result in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Groundwater Levels sustainability indicator.

Groundwater Storage: Reduction in groundwater storage which results in increases in pumping costs and/or decreases in well production rates that prevent safe and economically feasible continuation of existing groundwater dependent activities within the SV Subbasin and/or reduction which results in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Groundwater Storage sustainability indicator.

Water Quality: Changes in water quality which prevent safe and economically feasible continuation of existing groundwater dependent activities within the SV Subbasin and/or which result in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Water Quality sustainability indicator.

Land Subsidence: Land subsidence which demonstrably results from groundwater level declines and demonstrably causes major damages to existing infrastructure and/or dwellings within the SV Subbasin and/or prevents the safe and economically feasible continuation of existing surface land uses within the SV Subbasin, and/or which results in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Land Subsidence sustainability indicator.

Interconnected Surface Water: Depletion of interconnected surface water which demonstrably results from groundwater level declines and demonstrably shrinks groundwater dependent ecosystems and/or prevents the safe and economically feasible continuation of existing beneficial uses of surface water within the SV Subbasin, and/or which results in any of the significant and unreasonable impacts described herein for other applicable sustainability indicators would be considered significant and unreasonable impacts associated with the Interconnected Surface Water sustainability indicator.

3.5 Monitoring Network

This section describes and assesses the existing monitoring network and monitoring protocol used to monitor groundwater conditions and related surface water conditions in the Sierra Valley and describes planned improvements.

3.5.1 Description of Monitoring Network *(Reg. § 354.34)*

Per Reg. § 354.34, this section includes:

- Description of how the monitoring network is capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation
- Description of monitoring network objectives including explanation of how the network will be developed and implemented to monitor:
  - Groundwater and related surface conditions
  - Interconnection of surface water and groundwater
- Description of how implementation of the monitoring network objectives demonstrate progress toward achieving the measurable objectives, monitor impacts to beneficial uses or users of groundwater, monitor changes in groundwater conditions, and quantify annual changes in water budget components
- Description of how the monitoring network is designed to accomplish the following for each sustainability indicator:
  - Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features
  - Reduction of Groundwater Storage. Estimate the change in annual groundwater in storage
  - Seawater Intrusion. Monitor seawater intrusion
  - Degraded Water Quality. Determine groundwater quality trends
  - Land Subsidence. Identify the rate and extent of land subsidence
  - Depletions of Interconnected Surface Water. Calculate depletions of surface water caused by groundwater extractions
- Description of how the monitoring plan provides adequate coverage of the sustainability indicators
- Density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends
- Scientific rational (or reason) for site selection

- Consistency with data and reporting standards
- Corresponding sustainability indicator, minimum threshold, measurable objective, and interim milestone
- Location and type of each site on a map
- If management areas are used, a description of the level of monitoring and analysis appropriate for each management area. *(Reg. § 354.20 b)*

3.5.1.1 Groundwater Elevation Monitoring Network

This section provides a summary of the existing groundwater elevation monitoring network in the SV Subbasin.

SVGMD maintains six sets of groundwater level monitor wells around the valley. Monitoring data was collected from these wells by SVGMD twice annually until late 2019, when monitoring frequency was increased to monthly throughout the agricultural season (from early spring to late fall). DWR monitors several other wells, also typically collecting data twice annually. Monitoring data dates back to the 1980s for most wells. Data for select wells extends back to the 1950s. Certain wells have significant data gaps, but monitoring data is generally sufficient to illuminate long-term groundwater level trends and spatial variances around the valley. SVGMD recently completed a multi-completion monitoring well through DWR's technical support services program and is in the process of planning another to expand their monitoring network. SVGMD also monitors agricultural groundwater pumping and has been doing so since 1989. Figures 3.5-1 and 3.5-2 below show the locations of groundwater elevation monitoring wells and metered groundwater pumpage by section.

From Bachand et al., 2020:

Groundwater well network. The current District well network provides insufficient deep groundwater data density and accuracy. The CASGEM online system provides a cost-effective opportunity to expand the well network, and well construction reports are available that provide well metadata. Metadata includes well depth, screened interval, location and elevation (DWR, 2018c). Enrolled private wells currently have groundwater elevation accuracy of +/- 5 ft, greater than the 0.5 ft error deemed acceptable for a GSP monitoring network (DWR, 2016b), meaning the metadata of wells will need to be improved. Review and screening of available CASGEM wells to provide good spatial distribution and density likely offers a cost-effective approach to expand the GWE monitoring network.

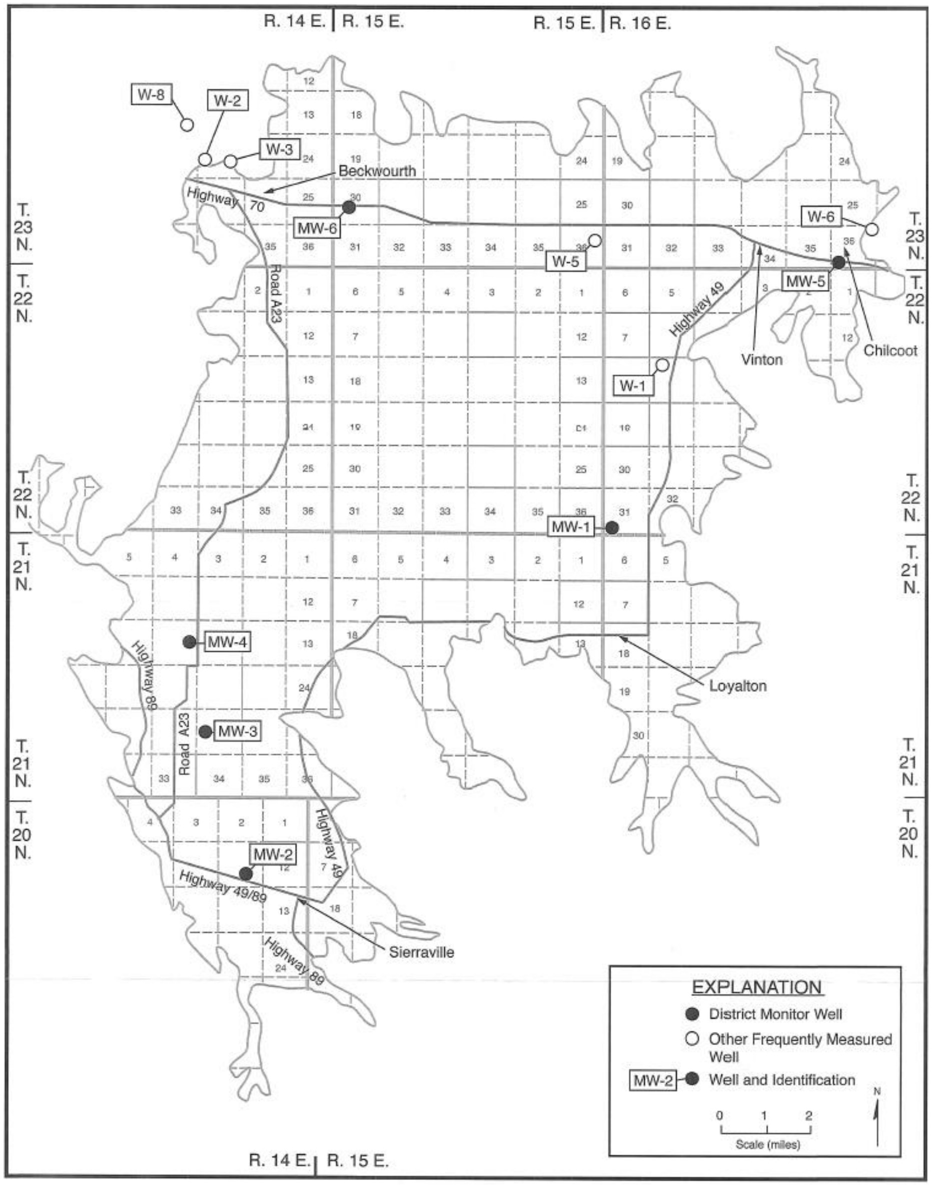


Figure 3.5-1. SV Subbasin Frequently Measured Monitoring Wells (Schmidt, 2017)

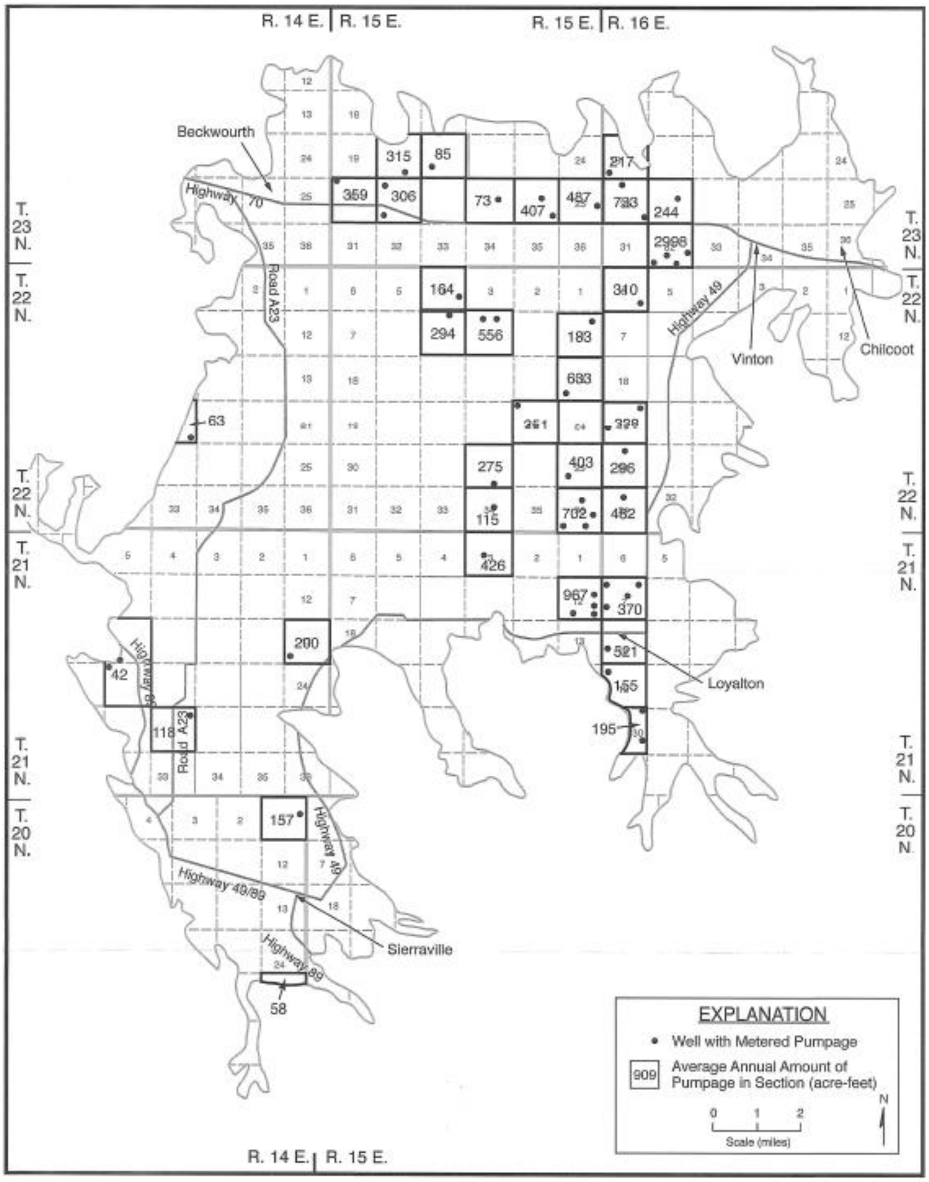


Figure 3.5-2. Metered Groundwater Pumpage Totals from 2015 – showing groundwater pumping monitoring by section (Schmidt, 2017).

3.5.1.2 Groundwater Storage Monitoring Network

There is no formal groundwater storage monitoring network in the SV Subbasin. The SV Subbasin GSAs will monitor groundwater storage through monitoring groundwater levels, modeling, and storage computations.

3.5.1.3 Seawater Intrusion Monitoring Network

There is no formal groundwater storage monitoring network in the SV Subbasin, because Seawater Intrusion is not applicable to the SV Subbasin as previously described.

3.5.1.4 Groundwater Quality Monitoring Network

This section provides a summary of the existing groundwater quality monitoring network in the SV Subbasin. Figure 3.5-X shows the existing groundwater quality monitoring wells in the SV Subbasin. Table 3.5-X provides a summary of groundwater quality sampling events for the various monitoring wells. This network is expected to be expanded as needed and sampled regularly by DWR and SVGMD.

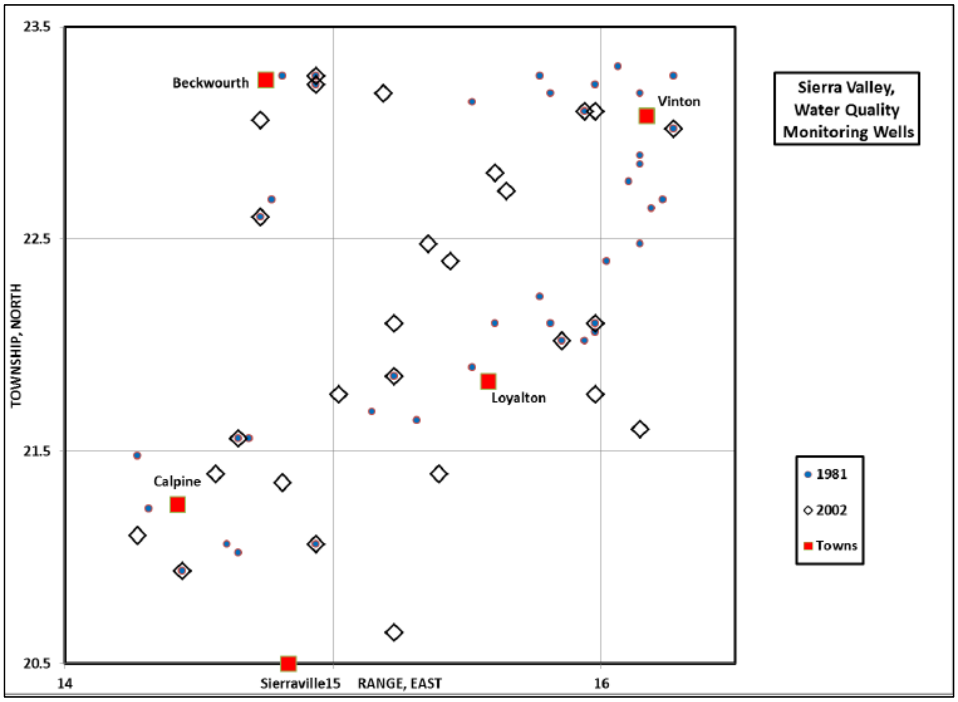


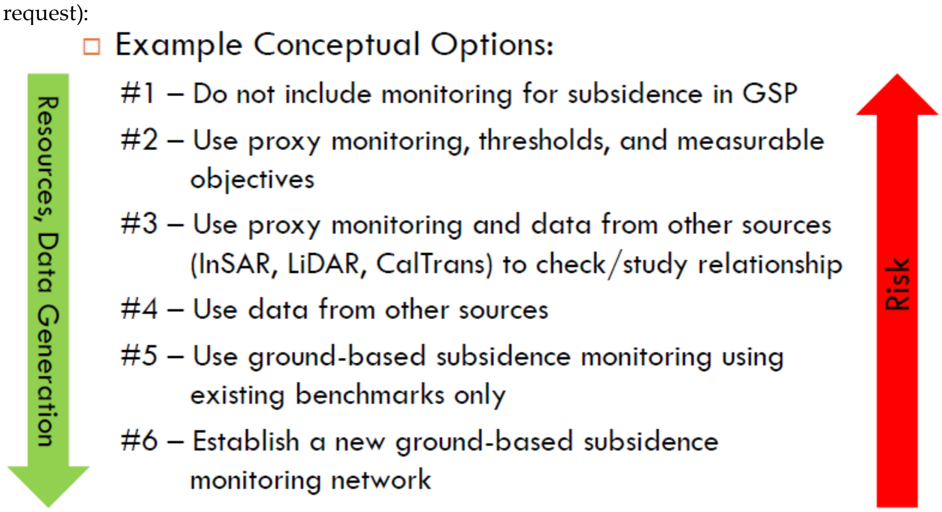
Figure 3.5-X. Groundwater Quality Monitoring Wells in the Sierra Valley (Bohm, 2016a).

Table 3.5-X. Summary of Groundwater Quality Monitoring Sampling Events (Bohm, 2016a).

Sierra Valley Monitoring Wells - Water Quality:																			
Monitoring events - time & location						total # of historic samples:			204										
						# of Wells sampled:			40	10	3	5	7	22	27	23	25	15	27
	priority wells:	38	2						Year sampled:										
WQ-Well #	State Well Number	priority	sampled	Easting	Northing	Name	DMS-#	Date first sampled	1981	1982	1983	1984	1985	1986	1987	1989	1993	1995	2002
WQ-62	23N/16E-36P07							3/10/1989								1	1	1	
WQ-64	23N/16E-36L 04							4/5/1989								1	1	1	
WQ-61	23N/16E-33A02							3/10/1989								1	1	1	
WQ-32	23N/16E-32Q01	2		738871	4409060	D&S NW 10 E38	DMS 14	7/9/1981	1										1
WQ-31	23N/16E-30R01	1						7/9/1981	1										
WQ-30	23N/16E-30C01	1		736711	4411894	Green Gulch NW 6	DMS 11	7/9/1981	1						1				
WQ-29	23N/16E-29G01	1	1	738698	4411155	Green Gulch NW 5	DMS 13	7/9/1981	1										
WQ-71	23N/15E-36H02							9/17/2002											1
WQ-28	23N/15E-36G01	2		735499	4409495	D&S NW 7	DMS 09	7/9/1981	1										1
WQ-40	23N/15E-34D01							7/10/1981	1										
WQ-70	23N/15E-29N02	2		728246	4410341	Goodwin South New	DMS 52	9/16/2002											1
WQ-27	23N/15E-26R01	1		734699	4410262	Green Gulch NW 2	DMS 07	7/9/1981	1						1				
WQ-26	23N/15E-26G01	1		733905	4411403	Green Gulch NW 1	DMS 08	7/9/1981	1										
WQ-25	23N/15E-25J 01	1		736264	4410709	Green Gulch NW3	DMS 10	7/9/1981	1						1				
WQ-67	23N/14E-35L04							4/18/1989								1			
WQ-57	23N/14E-35L02							5/2/1985					1			1	1	1	1
WQ-09	23N/14E-26H02	1						7/8/1981	1					1					
WQ-24	23N/14E-25K02	2						7/9/1981	1	1							1		
WQ-56	23N/14E-25K01	2						5/2/1985					1	1	1	1			1
WQ-08	23N/14E-25G02	2						7/8/1981	1					1		1	1	1	1
WQ-23	22N/16E-19M01	1	1	736694	4402730	Bar One OW2	DMS 218	7/9/1981	1					1	1				
WQ-22	22N/16E-19A01	1		737486	4403795	Bar One NW 14	DMS 42	7/9/1981	1										
WQ-21	22N/16E-17D01	1		738318	4405523	D&S NW 9b	DMS 41	7/9/1981	1					1	1				
WQ-20	22N/16E-08P01	1		738427	4405658	D&S NW 9a	DMS 18	7/9/1981	1			1		1	1				
WQ-19	22N/16E-07G01	1		737388	4406549	D&S NW 12	DMS 17	7/9/1981	1										
WQ-18	22N/16E-06R02	1		737686	4407369	D&S NW 11	DMS 16	7/9/1981	1										
WQ-17	22N/16E-06J 04							7/9/1981	1	1				1	1	1	1	1	
WQ-16	22N/15E-36Q01	1		736186	4398984	Bar One OW 5	DMS 28	7/9/1981	1					1					
WQ-15	22N/15E-36N01	1		735114	4398966	Bar One OW 6	DMS 27	7/9/1981	1										1
WQ-14	22N/15E-36H01	2		736167	4399785	Bar One OW 3	DMS 26	7/9/1981	1					1	1		1		1
WQ-13	22N/15E-36 J01	2						7/9/1981	1										
WQ-12	22N/15E-35H01	2						7/9/1981	1	1				1	1		1		
WQ-11	22N/15E-34G01	2		732802	4399725	Bar One OW 8	DMS 25	7/9/1981	1						1		1		
WQ-78	22N/15E-32F01							10/8/2002											1
WQ-10	22N/15E-26K03	1						7/9/1981	1					1	1		1		
WQ-60	22N/15E-24D01							3/10/1989								1	1		
WQ-77	22N/15E-21L04							10/8/2002											1
WQ-44	22N/15E-21L01/04							7/14/1982		1									
WQ-43	22N/15E-21K01							7/14/1982		1						1			1
WQ-42	22N/15E-21J 01							7/14/1982		1	1						1		
WQ-53	22N/15E-21D02							4/16/1985					1		1	1	1	1	1
WQ-48	22N/15E-21D01							8/25/1983			1								
WQ-65	22N/15E-17F03							4/6/1989								1	1		
WQ-41	22N/15E-17C03	1						7/14/1982		1									
WQ-59	22N/15E-17C01	1						7/9/1987							1	1	1	1	
WQ-47	22N/15E-11F01							7/15/1982		1				1	1				
WQ-52	22N/15E-11E01							7/12/1984				1	1	1	1				
WQ-76	22N/15E-10J01							9/30/2002											1
WQ-58	22N/15E-10H02							5/3/1985					1						
WQ-46	22N/15E-10C01	2		731972	4406546	Roberti Big	DMS 01	7/15/1982		1					1				
WQ-51	22N/15E-10B01	2		732136	4406948	Roberti New	DMS 02	7/12/1984				1			1				1
WQ-66	22N/14E-23R01							4/18/1989								1	1	1	
WQ-02	22N/14E-14F02							7/7/1981	1										1
WQ-01	22N/14E-11Q01	1						7/7/1981	1					1					
WQ-50	21N/16E-18H01							7/11/1984				1		1	1	1	1		1
WQ-63	21N/16E-07R01							4/5/1989								1			
WQ-39	21N/15E-17A01	1						7/10/1981	1										
WQ-69	21N/15E-12H01	1		736446	4396582	Cassida West	DMS 31	9/16/2002											1
WQ-38	21N/15E-07R01	1						7/10/1981	1										
WQ-68	21N/15E-07E01							9/16/2002											1
WQ-37	21N/15E-05P01	1						7/10/1981	1										1
WQ-54	21N/15E-05D01							5/1/1985					1	1	1	1	1	1	
WQ-49	21N/15E-03M03	2		732220	4397631	Macey West	DMS 37	8/26/1983			1								
WQ-07	21N/15E-03M02							7/8/1981	1			1		1	1	1	1	1	
WQ-06	21N/14E-36K01							7/8/1981	1					1	1	1	1	1	1
WQ-36	21N/14E-34R01							7/10/1981	1										
WQ-35	21N/14E-34K01							7/10/1981	1										
WQ-45	21N/14E-32G01							7/15/1982		1				1	1	1	1	1	1
WQ-05	21N/14E-29J 01							7/8/1981	1					1	1	1			
WQ-75	21N/14E-23R01							9/30/2002											1
WQ-55	21N/14E-22L01							5/2/1985					1		1		1		1
WQ-34	21N/14E-20B02	1						7/10/1981	1										
WQ-04	21N/14E-15J01							7/8/1981	1					1	1	1	1	1	1
WQ-33	21N/14E-14M01							7/10/1981	1										
WQ-72	20N/15E-17C04							9/30/2002											1
WQ-03	20N/14E-04G02	2						7/8/1981	1					1	1	1	1	1	1

3.5.1.5 Land Subsidence Monitoring Network

This section provides a summary of the existing land subsidence monitoring network in the SV Subbasin. Although no formal land subsidence monitoring network exists, data sources are available as described in Section 2.2.2.5 and additional data is expected to become available in the future including InSAR, LiDAR, and future survey data from other entities such as Caltrans. A concerned local resident who lives off of Harriet Lane in an area of the Sierra Valley that is regularly inundated during the spring runoff months has been collecting RTK survey data annually since 2017 at a benchmark set near their home, which provides another data source. SVGMD may consider requesting approval to incorporate said benchmark into their subsidence monitoring network as it is being designed and implemented. Much discussion took place in 2019 regarding subsidence monitoring needs and it was concluded that some formal monitoring network is likely needed to supplement representative/proxy groundwater elevation monitoring to some extent. An example of conceptual options that were presented to the SVGMD Directors is pasted below (from presentation prepared by Greg Hinds, available upon request):



Establishing and monitoring dedicated land subsidence benchmarks with a reasonable spatial density using RTK GPS surveying appears to be a promising option.

3.5.1.6 Interconnected Surface Water Systems Monitoring Network

This section provides a summary of the existing interconnected surface water monitoring network in the SV Subbasin. Though no formal network exists, useful data does exist as described elsewhere in this document. For example, combined evaluation of precipitation data, MF Feather River streamgage data, Lake Davis Dam flow data, groundwater pumping and groundwater level data, along with other climate and surface water data (from Frenchman Lake, from water rights diversions, etc.) may help elucidate the interconnectedness and dynamics of relationships between deep and shallow aquifers and surface water systems and the effects of changing groundwater conditions. It is expected that some fashion of formal interconnected surface water monitoring – network and protocol – will be developed during the development of the actual SV GSP to help fill interconnected surface water data gaps. Bachand et al. (2020) offers the following relevant info on the topic:

Stream network monitoring. Limited steam monitoring currently exists in Sierra Valley with only the MFFR monitored (CDEC, 2018). A stream monitoring effort for a comprehensive water budget is impossible given the resources available in Sierra Valley and the high degree of uncertainty and complexity. Long-term selected stream monitoring could help document climate change effects and be incorporated into other research efforts (e.g., model validation/calibration, groundtruthing).

3.5.1.7 Groundwater-Dependent Ecosystems Monitoring Network

This section provides a summary of the existing groundwater dependent ecosystem monitoring network in the SV Subbasin. The SV Subbasin GSAs do not yet have a formal monitoring network established for groundwater dependent ecosystems. Some existing data is available, however, which sheds light on the topic and could potentially be used moving forward in a formally designed groundwater dependent ecosystem monitoring program. Perhaps the most useful of such data is the data collected and presented by the Nature Conservancy, as outlined in Section 2.2.2.7. It is expected that some fashion of formal groundwater dependent ecosystem monitoring – network and protocol – will be developed during the development of the actual SV GSP to help fill associated data gaps. Bachand et al. (2020) offers the following relevant info on the topic:

Groundwater Dependent Ecosystems. Shallow groundwater data in the western and southwestern valley will be needed to address the surface water to groundwater interaction sustainability indicator. Shallow GWE monitoring will be needed to ensure stress on these systems is not occurring from agricultural pumping. Piezometers selectively installed with paired surface water elevation monitoring can be used to understand valley groundwater and surface water interactions. Comparing groundwater and surface water temperatures in such paired stations can also provide information on groundwater-surface water interactions (USGS, 2003; Constanz, 1998).

3.5.2 Monitoring Protocols for Data Collection and Monitoring (*Reg. § 352.2*)

Per Reg. § 352.2, this section includes:

- Description of technical standards, data collection methods, and other procedures or protocols to ensure comparable data and methodologies.

Protocols for monitoring, data collection, and data analyses are expected to be developed by qualified experts during the development of the actual SV GSP based on common practice and president set in other groundwater basins/GSPs taking into account the limited local capacity to collect, organize, and assess data. The resulting protocols should aim to fill data gaps, simplify/streamline data analysis, be proportional to the scale of groundwater issues in the SV Subbasin, and be representative of engaged stakeholders in the SV Subbasin.

3.5.3 Representative Monitoring *(Reg. § 354.36)*

Per Reg. § 354.36, this section includes:

- Description of representative sites if designated
- Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators
- Adequate evidence demonstrating site reflects general conditions in the area

It is anticipated that certain sites will be selected as representative monitoring sites for each applicable sustainability indicator.

3.5.4 Assessment and Improvement of Monitoring Network (*Reg. § 354.38*)

Per Reg. § 354.38, this section includes:

- Review and evaluation of the monitoring network
- Identification and description of data gaps
- Description of steps to fill data gaps
- Description of monitoring frequency and density of sites

It is anticipated that all existing monitoring networks/protocols will need to be improved to ensure compliance with SGMA and satisfaction of DWR. Some improvements have been made in recent years, as described in Section 4.1, and additional studies (tracer studies, etc.) have been proposed by local geohydrologist, Burkhard Bohm. Some discussion on the topic of improving networks is included in Section 3.5.1. Some information on efforts to set up weather stations is also expected to be included in this section. Bachand et al. (2020) offered relevant info on improving monitoring networks, as pasted in Section 3.5.1 and 2.2.2.

4.0 Projects and Management Actions to Achieve Sustainability Goal (*Reg. § 354.44*)

Per Reg. § 354.44, this Chapter includes descriptions of the projects and management actions the SV Subbasin GSAs have determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin and projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent, with each description included the following, as applicable:

- Description of the measurable objective that is expected to benefit from the project or management action.
- Description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of

projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.

- The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.
- A summary of the permitting and regulatory process required for each project and management action.
- The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.
- An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.
- An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.
- A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.
- A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.
- A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.

Per Reg. § 354.44, the projects and management actions included herein are supported by best available information and best available science and the SV Subbasin GSAs took into account the level of uncertainty associated with the basin setting when developing these projects or management actions. Because overdraft has been documented in the SV Subbasin, this Chapter includes a management action to develop a policy for limiting pumping including quantification of demand reduction or other methods, for the mitigation of overdraft, per Reg. § 354.44.

This chapter also describes actions taken to protect groundwater resources in the Sierra Valley prior to the development of this Plan Concept Document, which are also relevant to the overall effort to achieve sustainable groundwater management in the SV Subbasin.

4.1 Management Action Made Prior to GSP Development

Consistent with observations pertaining to the sustainability of groundwater use and management in the Sierra Valley prior to and during the development of this Plan Concept Document as described in Chapter 4, the SVGMD has developed and passed a number of ordinances. These ordinances are listed below and can be accessed from: http://www.sierravalleygmd.org/ordinances-resolutions.

Ordinance 82-01 - Requiring a permit to export groundwater & banning exports of groundwater during overdraft (9/30/82)

Ordinance 82-03 - Requiring metering of certain extraction facilities (9/30/82)

Ordinance 83-01 - Regarding development projects and sufficient groundwater available (3/2/83)

Ordinance 83-03 - Amending Ordinance No. 82-03, Section 2 (11/7/83)

Ordinance 84-02 - Adopting requirements pertaining to development project groundwater supply evaluations and imposing a fee on project developers related thereto (3/2/84)

Ordinance 00-02 - Adopting new groundwater supply evaluation requirements for development projects & new fee for development projects (4/10/2000)

Ordinance 17-01 - Enacting a management charge for fiscal year 2017-2018 (3/13/17)

Ordinance 17-03 - Enacting a large-capacity well management charge for fiscal year 2017-2018 (9/11/17)

Ordinance 18-01 - Establishing requirements pertaining to new water well permits (4/9/2018)

Ordinance 18-02 - Enacting a management charge for fiscal year 2018-2019 (5/14/2018)

The ordinances have successfully limited exploitation of groundwater resources in the SV Subbasin (Ordinance 82-01), achieved basin-wide monitoring of extraction from high capacity wells (Ordinance 82-03), limited new development where such development would likely impact groundwater resources (Ordinance 83-01, 84-02, and 00-02), generated revenue for groundwater management (Ordinance 17-01, 17-03, and 18-02), and limited construction of new high capacity wells where such construction would likely impact groundwater resources (Ordinance 18-01).

Additional management action taken by the SVGMD to aid in achieving sustainable groundwater management in the SV Subbasin include:

- coordination of groundwater recharge study conducted by Bachand & Associates (Bachand et al., 2020) with funding from the Feather River Land Trust (FRLT), the results of which informed project/management action/policy development and land management strategies to be implemented by the FRLT on their conservation properties.
- development and submittal of groundwater-related projects through the Upper Feather River Integrated Regional Water Management Plan (IRWM) Prop 1 grant funding process and additional projects (implementation subject to acquisition of funding) – see project descriptions below;
- coordination of meetings and facilitation for generating public discussion and stakeholder input pertaining to development of groundwater projects and management actions and policies;

- development of corrective action policies for incorporation in this Plan Concept Document to respond to (correct) and observed undesirable results (as defined in Section 3.4) including policy for limiting groundwater extraction from existing wells in the event that undesirable (chronic) lower of groundwater levels is observed.

4.2 Management Action #1 – Establishment of Emergency Pumping Reduction Policy

SB 1391, the SVGMD's enabling legislation, outlined standards for limiting pumping in the event of chronically lowering groundwater levels or significant water quality impairment, as follows:

Sec. 709.5. In the event that the District limits or suspends extractions by district users in order to eliminate existing or threatened conditions of overdraft, rights to the use of the available supply of ground water shall be allocated primarily on the basis of the number of acres overlying the basin or subbasin that a user owns or leases in proportion to the total number of acres overlying the basin or subbasin. The District may adjust any figure so arrived at up or down for any of the following factors:

(1) the number of acres actually irrigated compared to the number of acres owned or leased

(2) crop type

(3) wasteful or inefficient use

(4) reasonable need

(5) any other factor that the District reasonably feels it should consider in order to reach an equitable distribution within the entire District.

A benefit of this plan may be to encourage free-market trading of water by making clearer who owns what and how much. With lively trading, market forces may be sufficient to promote wise allocation of the ground water resource without the need for the District to exercise its full authority.

It is expected that SVGMD will refine and formally establish a policy for limiting agricultural pumping in the event that undesirable results occur in the SV Subbasin based on the above and/or other common strategies for limiting pumping such as use of a groundwater banking system.

4.3 Project #1 Description

PLACEHOLDER

5.0 Plan Implementation

5.1 Estimate of GSP Implementation Costs *(Reg. § 354.6)*

Per Reg. § 354.6, the GSP must include a substantiated estimate of GSP implementation costs. To develop such a cost estimate…. *PLACEHOLDER*

5.2 Schedule for Implementation

Timely implementation of the elements of the SV GSP is critical to ensuring SGMA compliance and accomplishment of the SV GSP Sustainability Goal. Accordingly, the following schedule for implementation has been developed. The schedule may change slightly as the GSAs work through early-implementation adaptive management, but the following schedule provides an accurate framework of the anticipated implementation sequence. *PLACEHOLDER.*

5.3 Annual Reporting

Per Reg. § 356.2, SVGMD, with the assistance of Plumas County as needed, will prepare and submit an annual report to DWR by April 1 of each year following the adoption of the SV GSP. Each annual report will include the following components for the preceding water year:

- General information, including an executive summary and a location map depicting the basin covered by the report.
- A detailed description and graphical representation of the following conditions of the basin managed in the Plan:
    - Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:
        - Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.
        - Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.
    - Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector, and identifies the method of measurement (direct or estimate) and accuracy of measurements, and

a map that illustrates the general location and volume of groundwater extractions.

- Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.
- Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.
- Change in groundwater in storage shall include the following:
  - Change in groundwater in storage maps for each principal aquifer in the basin.
  - A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.
  - A description of progress towards implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report.

Per Reg. § 352.6, a spreadsheet-based data management system has been established for the SV Subbasin in which all data generated from the previously described monitoring networks via the previously described monitoring protocols will be stored. Per Reg. § 354.40, a copy of the data management system spreadsheet file will be included in the Annual Report and submitted electronically on forms provided by DWR.

5.4 Periodic Evaluations

Per Reg. § 356.4, SVGMD, with the assistance of Plumas County as needed, will evaluate the SV GSP at least every five years and whenever the Plan is amended, and provide a written assessment to DWR. The assessment will describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:

- A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.

- A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.
- Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.
- An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.
- A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:
    - An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.
    - If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.
    - The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.
- A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.
- A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.
- Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin. A description of completed or proposed Plan amendments.
- Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.
- Other information the Agency deems appropriate, along with any information required by DWR to conduct a periodic review as required by Water Code Section 10733.

6.0 References and Technical Studies *(Reg. § 354.4)*

Commented [GH48]: Citation formatting is consistent throughout this section, but may not be consistent with required/expected reference formatting.

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Appendices

- Appendix A - Interbasin and Coordination Agreements (as applicable) *(Reg. § 357)*
- Appendix B - Contact Information for Plan Manager and GSA Mailing Address *(Reg. § 354.6)*
- Appendix C - List of Public Meetings *(Reg. § 354.10)*
- Appendix D - Technical Appendices
- Appendix E - Groundwater Model Documentation
- Appendix F - Comments and Responses *(Reg. § 354.10)*
- Appendix G - Stakeholder Communications and Engagement Plan

Appendix A

Interbasin and Coordination Agreements (as applicable) *(Reg. § 357)*

Appendix B

Contact Information for Plan Manager and GSA Mailing Address *(Reg. § 354.6)*

Appendix C

List of Public Meetings *(Reg. § 354.10)*

Appendix D

Technical Appendices

Appendix E

Groundwater Model Documentation

Appendix F

Comments and Responses *(Reg. § 354.10)*

Appendix G

Stakeholder Communication and Engagement Plan

Attachments

- Attachment 1 - GSA Submittal (Water Code Section 10723.8)
- Attachment 2 - SVGMD Policies and Procedures Manual
- Attachment 3 - Preparation Checklist for GSP Submittal

Attachment 1

GSA Submittal (Water Code Section 10723.8)

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Attachment 2

SVGMD Policies and Procedures Manual

Attachment 3

Preparation Checklist for GSP Submittal