2 Plan Area and Basin Setting

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

The Plan Area is the area within the Sierra Valley (SV) Subbasin (DWR Groundwater Basin Number 5-012.01) as most recently defined in the Bulletin 118 February 2019 Update (following 2019 SV Subbasin Boundary Modification) and viewable on the SGMA Basin Prioritization Dashboard tool[1]. The SV Subbasin is located within Sierra Valley.

Sierra Valley is an irregularly shaped, complexly faulted valley with seismic influences located in southeastern Plumas County and northeastern Sierra County in northeastern California. Sierra Valley has a long history of agriculture, is renowned for its beauty and is a nationally designated Important Bird Area. It is home to the largest wetland[2] in the Sierra Nevada Mountains[3] and is considered one of the most biodiverse landscapes in the United States[2]. It is also commonly regarded as the largest high-alpine valley in the United States (Vestra, 2005).

The outer boundaries of the SV Subbasin and adjacent 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.

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 Chilcoot Subbasin is known to be significant, with some level of surface water hydrology and groundwater interaction but it is not well understood. The subbasins are to some extent discontinuous at depth due to a bedrock sill (DWR, 2004b).

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

The Sierra Valley Watershed boundary is spread across three counties including: Plumas, Sierra, and a small portion in Lassen. The Sierra Valley Watershed area is located in California Assembly District 1, California Congressional District 1, Plumas County Supervisorial District 1, with a small portion in Plumas County Supervisorial District 5, and portions of Sierra County Supervisorial Districts 3, 4, and 5.

The SV Subbasin is shown in Figure 2.1.1-1 and the Plan Area is shown in Figure 2.1.1-2.

A relatively small portion (approximately 115 acres) of the northwest area of the SV Subbasin boundary is located outside of the SVGMD jurisdictional boundary. This area is owned by the U.S. Forest Service and is the responsibility of Plumas County exclusively as an Agency, defined in Reg § 351, or GSA. SVGMD is the GSA for the remainder of the SV Subbasin boundary or 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 2.1.1-2), and

[1] https://gis.water.ca.gov/app/bp-dashboard/final/
[2] Wetlands are areas where water is at or near the surface for at least part of the year
[3] https://www.nature.org/en-us/get-involved/how-to-help/places-we-protect/sierra-valley/

2. Plumas County's SGMA jurisdictional area, which is the portion of the Plan Area which is not within the SVGMD boundary (see Figure 2.1.1-2).

The SV Subbasin, adjacent Chilcoot Subbasin, and other surrounding groundwater basins are shown in Figure 2.1.1-3.

Jurisdictional boundaries of federal, state, or local lands, state highways, and locations of the communities within the Plan Area, and other land ownership are displayed within the Sierra Valley Watershed boundary in Figure 2.1.1-4.

Land ownership by area and percent of watershed are listed in Table 2.1.1-1.

Water management agencies are presented in Figure 2.1.1-5.

The only community in the Plan Area that is an incorporated city is Loyalton, with city limits generally corresponding to the City of Loyalton Water District's boundary. All of the communities within the Plan Area are to some extent groundwater-dependent.

There are no Tribal Trust Land Tracts (U.S. Department of Interior, Bureau of Indian Affairs) within the SV Subbasin based on information and data published by DWR.[4] Should any new information change this determination in the future, a figure showing Tribal Trust Land Tracts will be added to this Section. However, there are tribal cultural influences throughout the Sierra Valley watershed as described further below.

The Northern Sierra Nevada Mountains contain the physical evidence of a rich and complex Native American history reaching back thousands of years. These landscapes are rooted deeply in tribal memory. The mountain valleys were central places from which long-used trails radiated out following the ridgetops and the many water courses. The benches and terraces above the valleys were places where large encampments were established and maintained season after season. Sierra Valley presented an expansive base for settlement and held an array of valuable resources. The low-elevation pass at the northeast end was a gateway for Great Basin populations to enter the mountains while the northwest arm of Sierra Valley and the outlet of the Middle Fork of the Feather River (Middle Fork) provided a natural pathway east from Northern Sierra Nevada (Elliott 2021).

Archaeological sites in this same vicinity show evidence of human occupation from as early as 5,500 years ago. As climate and ecosystems fluctuated from warmer and wetter to colder and drier conditions, Sierra Valley was continuously used for seasonal forays and settlement. Artifacts and cooking features present at multiple ancient campsites documented in the area suggests a strong emphasis on the processing and export of bulbs, roots, and seeds. Hunting of the abundant waterfowl within the marsh-like lowlands, and rabbits and deer on the drier valley bottom and surrounding hills was also very important (Elliott 2021).

The Washoe to the east and the Mountain Maidu (or Northeastern Maidu) to the north and west met within Sierra Valley for uncounted generations. These tribes had different cultural backgrounds and very different languages. The pre-contact Washoe were a Great Basin tribe. Sierra Valley was at the northeastern edge of a large traditional territory that encompassed much of today's Western Nevada. They gathered a variety of roots, bulbs, and grasses from the valley but there was reportedly a particularly prized grass found here that they called *múćim* which was also the name they applied to the valley itself. The Washoe obtained resources through trade or access into Mountain Maidu territory (e.g., acorns and salmon) (Elliott 2021).

[4] https://gis.water.ca.gov/app/boundaries/ and DWR Guidance Document for the Sustainable Management of Groundwater, Engagement with Tribal Governments (January 2018)

The pre-contact Mountain Maidu were adept at life in the Northern Sierra Nevada Mountains. Central to them was the upper reaches of the Middle Fork and the North Fork of the Feather River including the fall salmon runs. A strong Mountain Maidu presence in Northwestern Sierra Valley is evident in the archaeological resources recorded in this vicinity. The Mountain Maidu also benefited in trade coming from the east, obtaining resources not readily available in their traditional territory (e.g., obsidian) (Elliott 2021).

All of this was massively disrupted in the middle of the nineteenth century with Euro-American contact. While there are no known accounts confirming entry into Sierra Valley, early trappers were reportedly working along the Truckee River in the early 1830s (Elliott 2021). The pioneer ranches that began to be developed in the mid-1850s spelled the end of traditional lifeways of the Mountain Maidu and the Washoe within Sierra Valley. By the 1860s, large portions of the valley bottom were being drained and put under cultivation. Yet at least some of the mountain camps were still used by surviving families and groups. As late as November 1867, the *Mountain Messenger* noted that the tribes had once again engaged in their annual practice of fall burning in the hills surrounding Sierra Valley. Burning was routinely undertaken season after season but this period certainly marked the end of the annual cycle. The remaining Native American population could no longer gain access to manage the ecosystem at a landscape level (Elliott 2021).

Figure 2.1.1-1: Sierra Valley Groundwater Subbasin

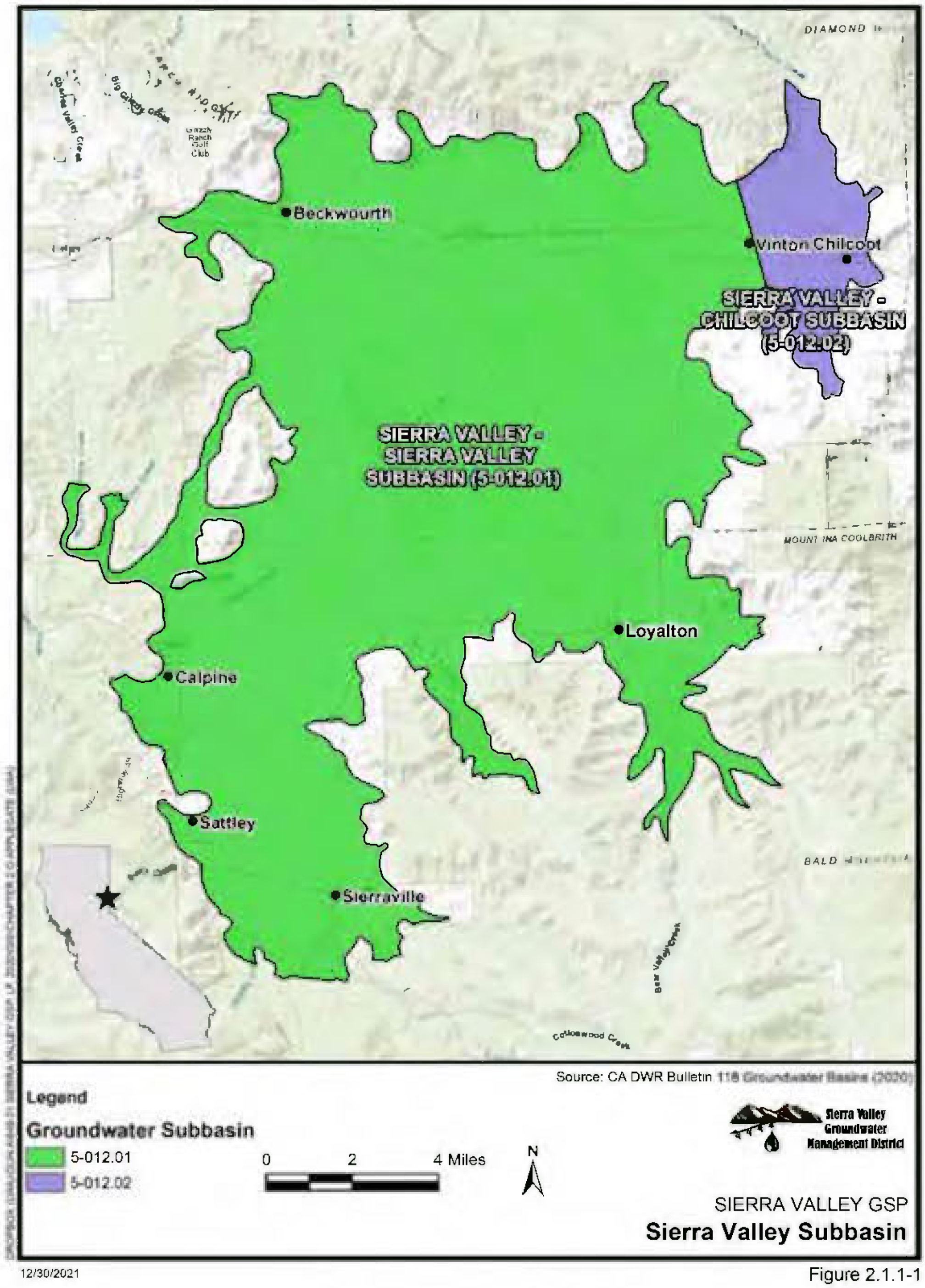
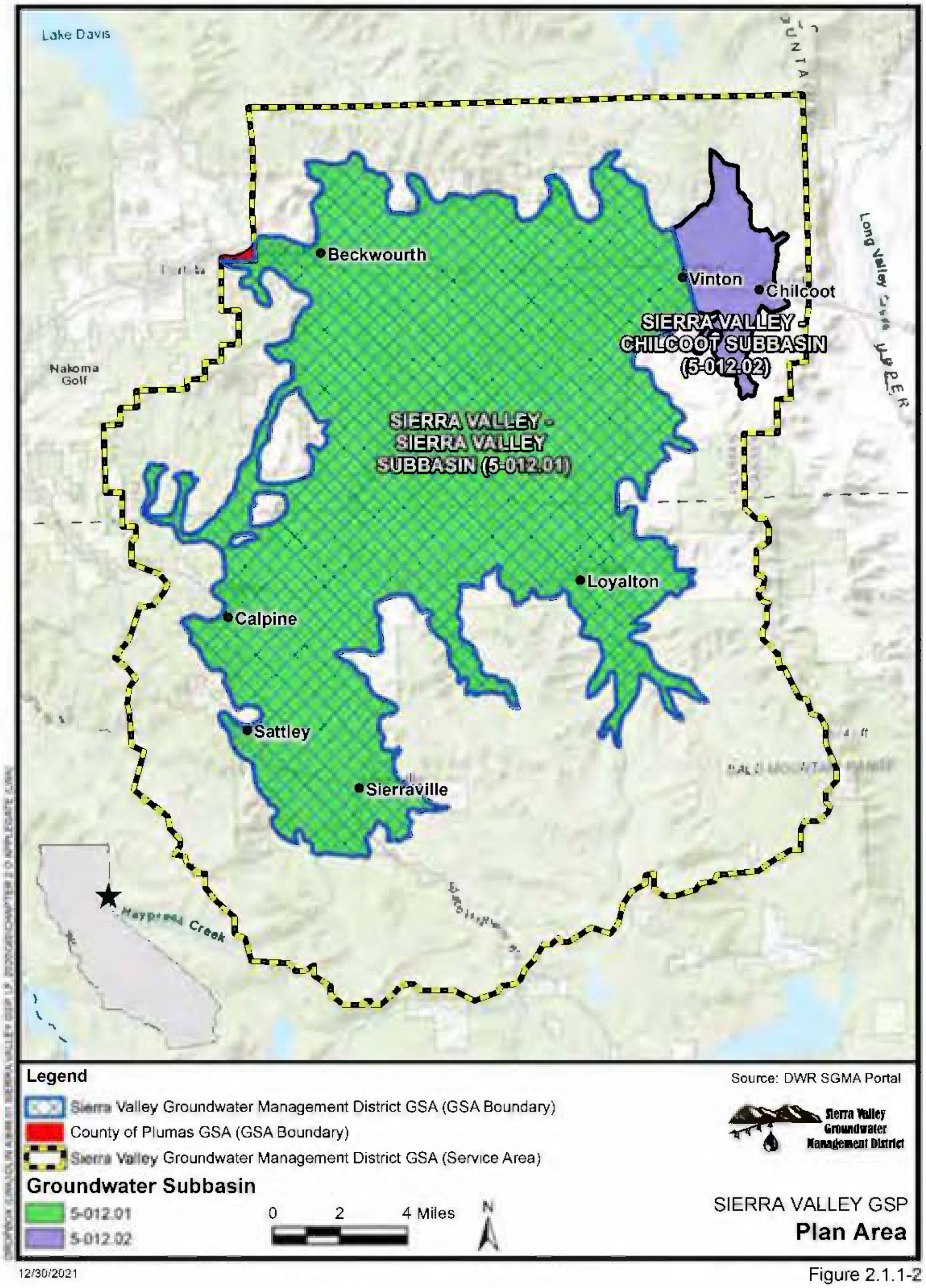


Figure 2.1.1-2: Sierra Valley Groundwater Sustainability Plan Area



Areas covered by relevant general plans are:

1. portion of the Plan Area within Plumas County (Plumas County General Plan),
2. portion of the Plan Area within Sierra County (Sierra County General Plan),
3. area within the City of Loyalton (City of Loyalton General Plan).

As listed in Table 2.1.1-1, the SV Subbasin contains federally owned lands of the U.S. Department of Agriculture, Bureau of Land Management, Forest Service within the Plumas National Forest and Tahoe National Forest. Associated Land and Resource Management Plans for Plumas (1988)[5] and Tahoe (1990)[6] are also relevant.

Existing land use designations in the Plan Area are shown in Figure 2.1.1-6.

The approximate number of domestic and municipal wells per square mile, agricultural wells per square mile, and unknown (i.e., water use type not provided/available) wells per square mile, according to DWR, are shown in Figure 2.1.1-7, Figure 2.1.1-8, and Figure 2.1.1-9, respectively (source: DWR Well Completion Report Map[7]). The numbers of wells per type are listed in Table 2.1.1-2. It is important to note that there may be significant numbers of wells for which no information exists in the DWR database. This is a data gap that will be addressed during the first two years of GSP implementation.

[5] https://www.fs.usda.gov/main/plumas/landmanagement/planning
[6] https://www.fs.usda.gov/main/tahoe/landmanagement/planning
[7] Available from: https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

Figure 2.1.1-3: Sierra Valley Groundwater Basin (SV Subbasin) and Adjacent Groundwater Basins

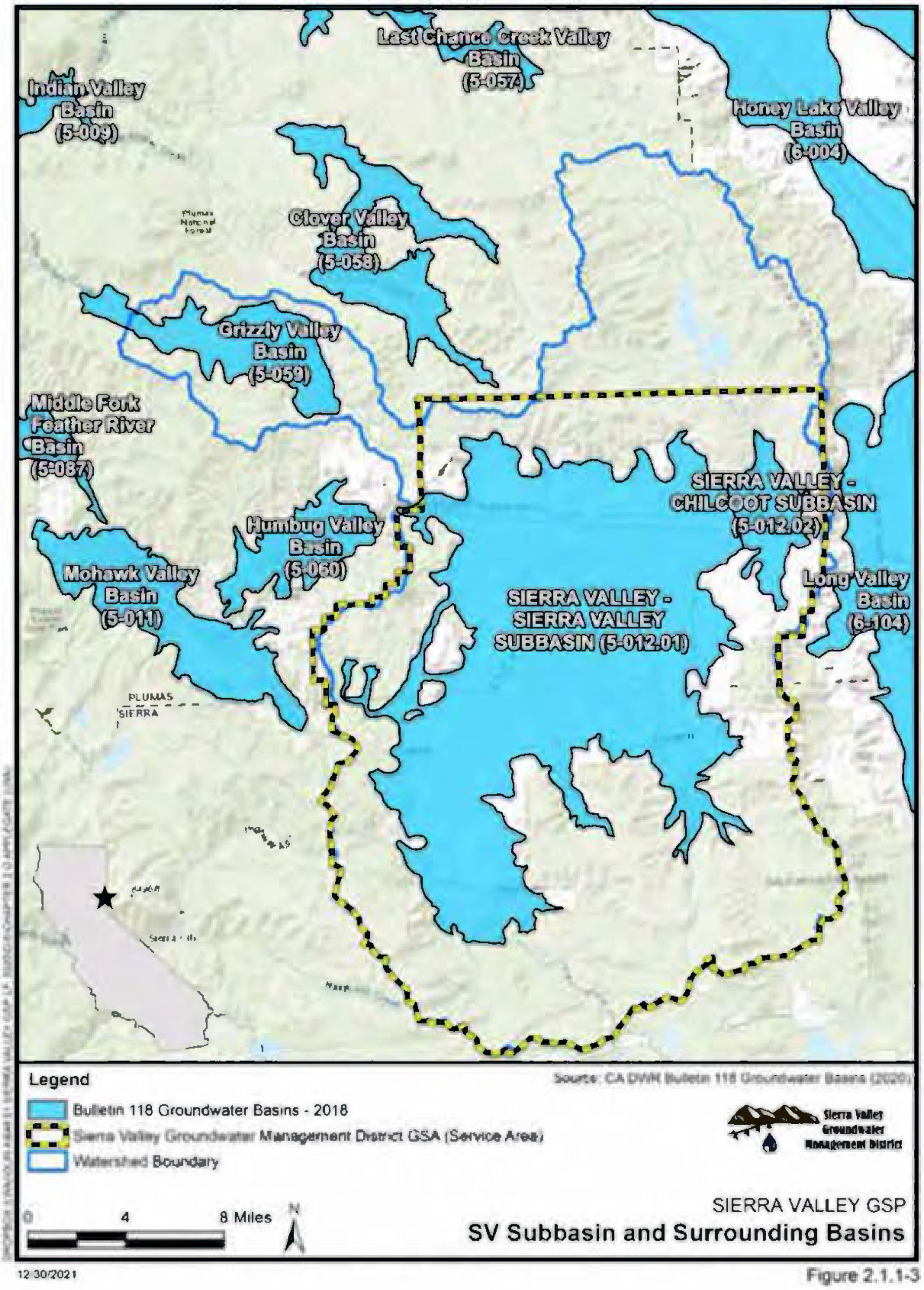


Figure 2.1.1-4: Sierra Valley Watershed Boundary, State Highways, Locations of the Communities within the Plan Area, and Land Ownership

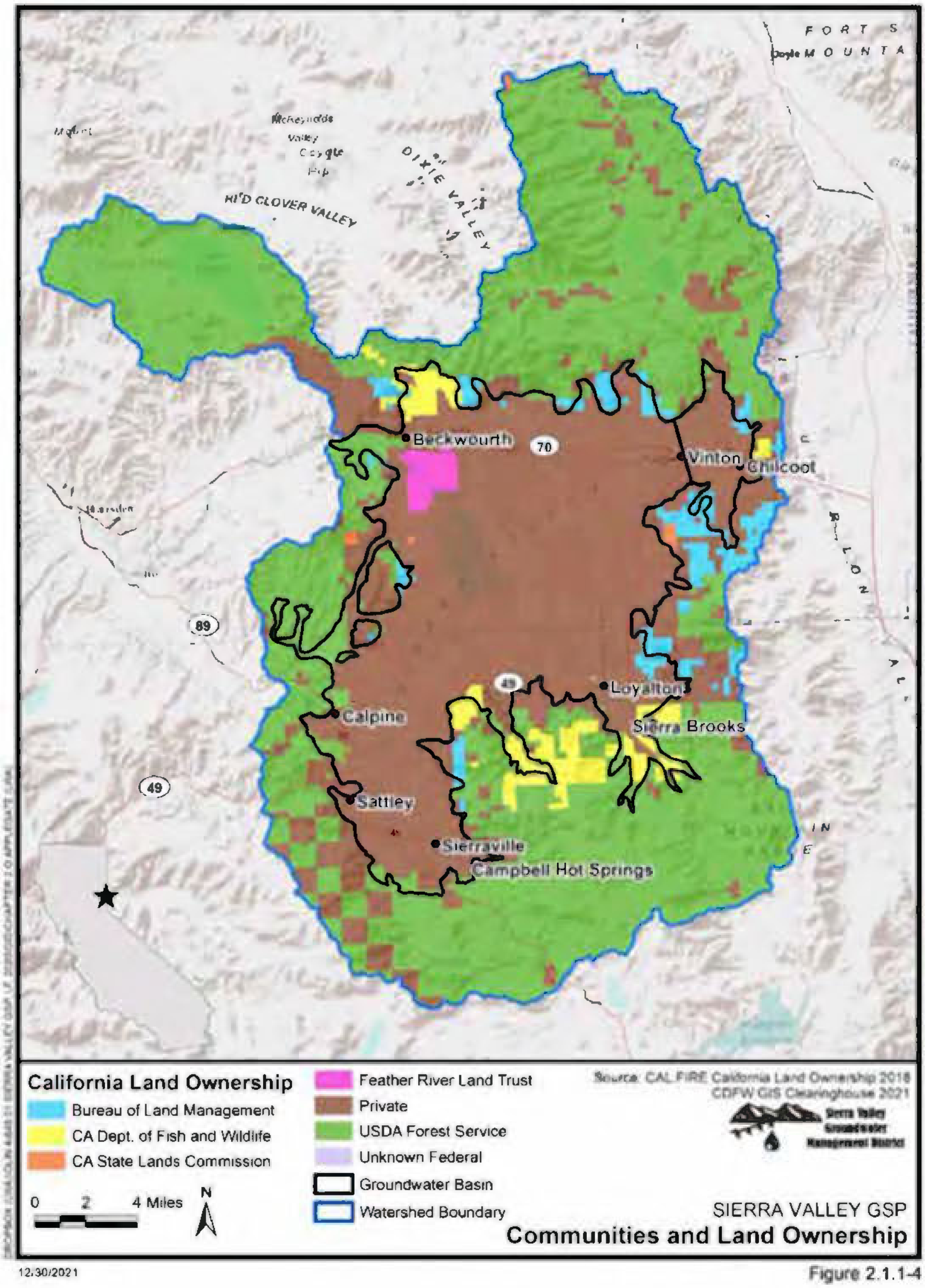


Table 2.1.1-1: Sierra Valley Watershed Land Ownership

Owner	Total Acres	Percent of Watershed
Bureau of Land Management	11,590	3.1%
California Department of Fish and Wildlife	11,087	3.0%
California State Lands Commission	639	0.2%
Feather River Land Trust	2,540	0.7%
City of Loyalton	8	0.0%
Private	149,804	40.1%
County of Sierra	3	0.0%
Unknown Federal/Other Federal	2	0.0%
United States Forest Service	197,954	53.0%
Total	**373,627**	**100%**

Source: CAL FIRE, land ownership, last updated October 2018 (https://frap.fire.ca.gov/mapping/gis-data/) and California Department of Fish and Wildlife, GIS Clearinghouse (https://wildlife.ca.gov/Data/GIS/Clearinghouse)

Figure 2.1.1-5: Plan Area Agencies with Water Management Responsibilities shown atop Groundwater Basin Boundaries

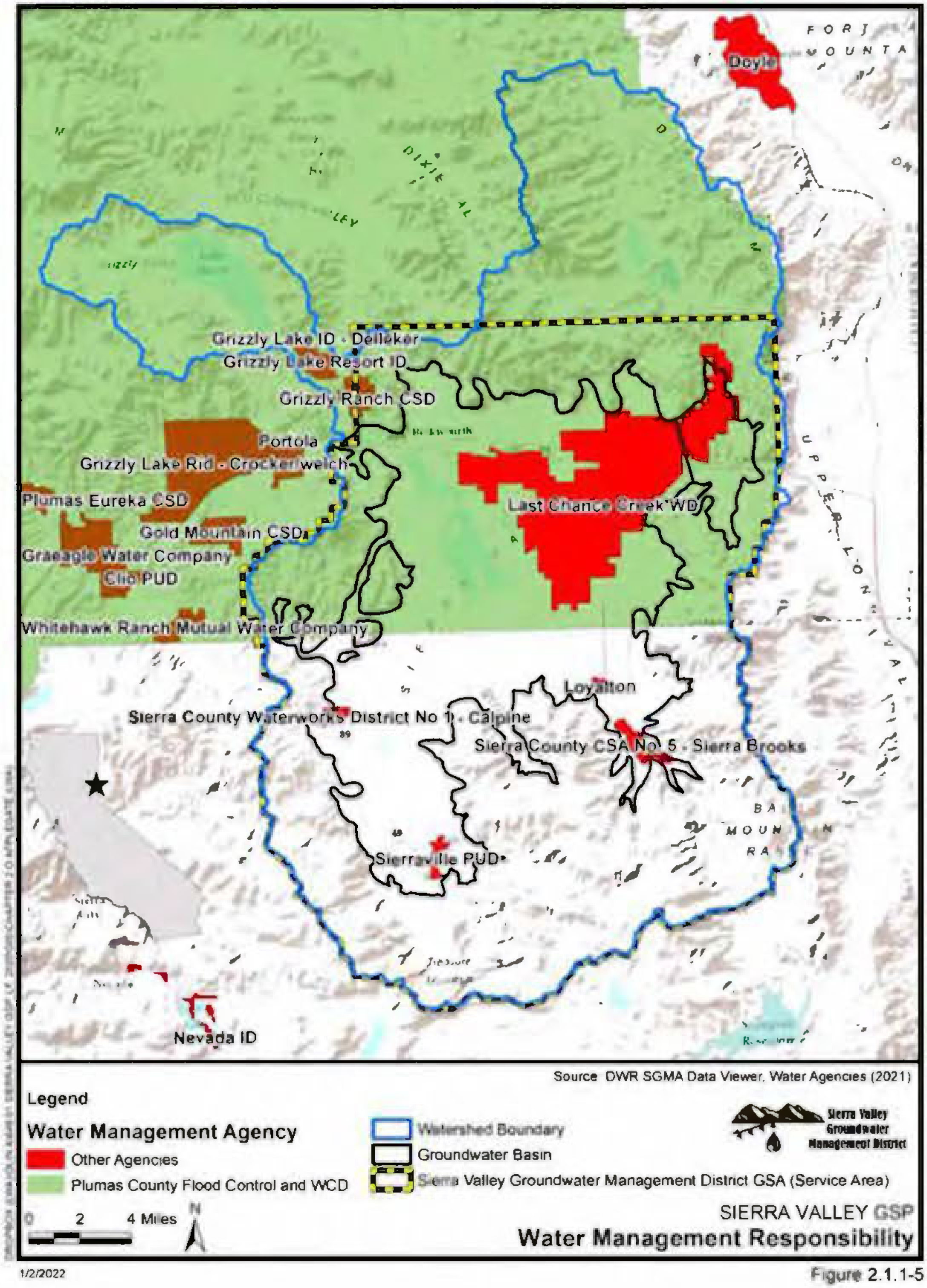


Figure 2.1.1-6: Existing Land Use Designations in the Plan Area

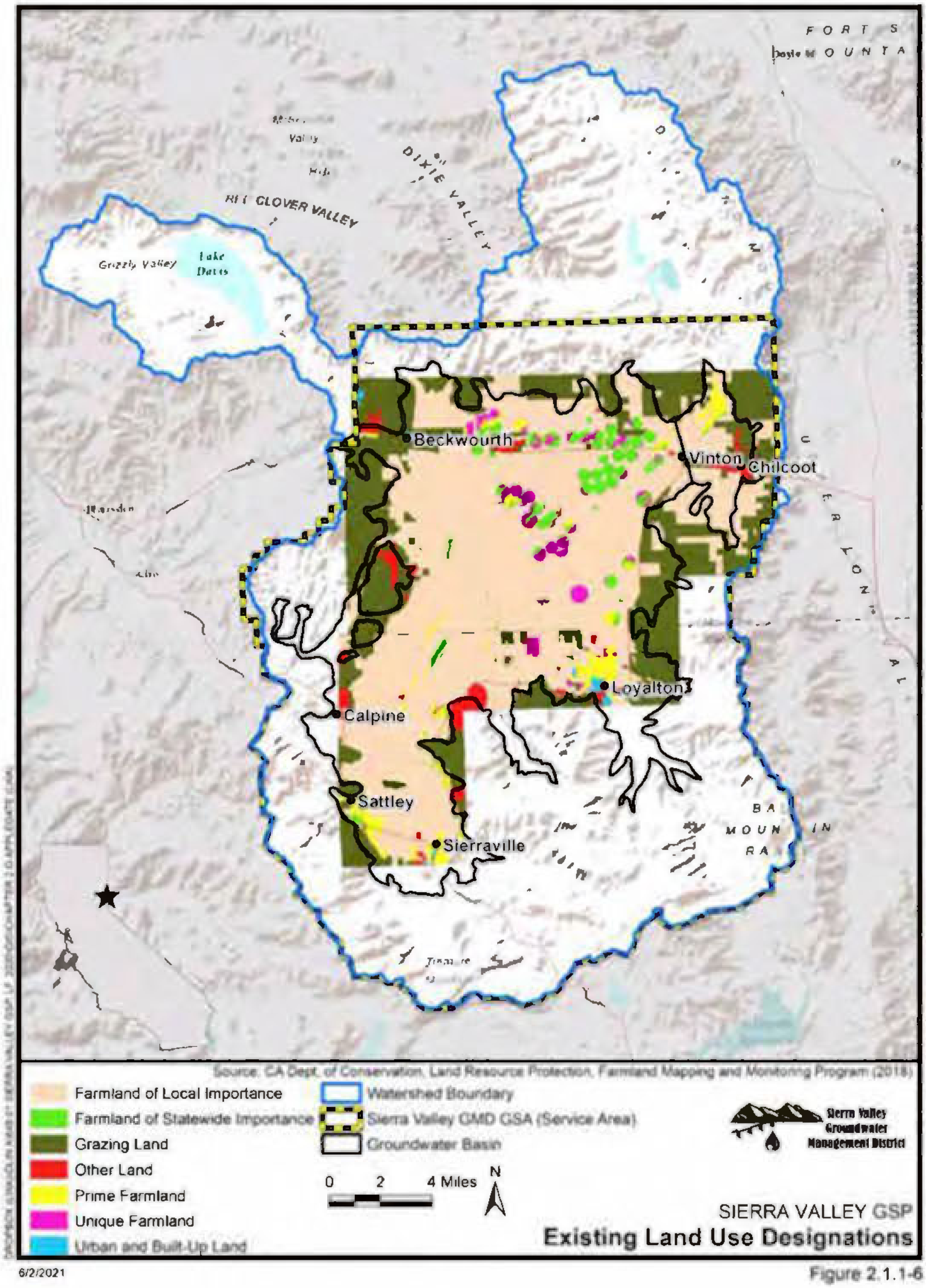
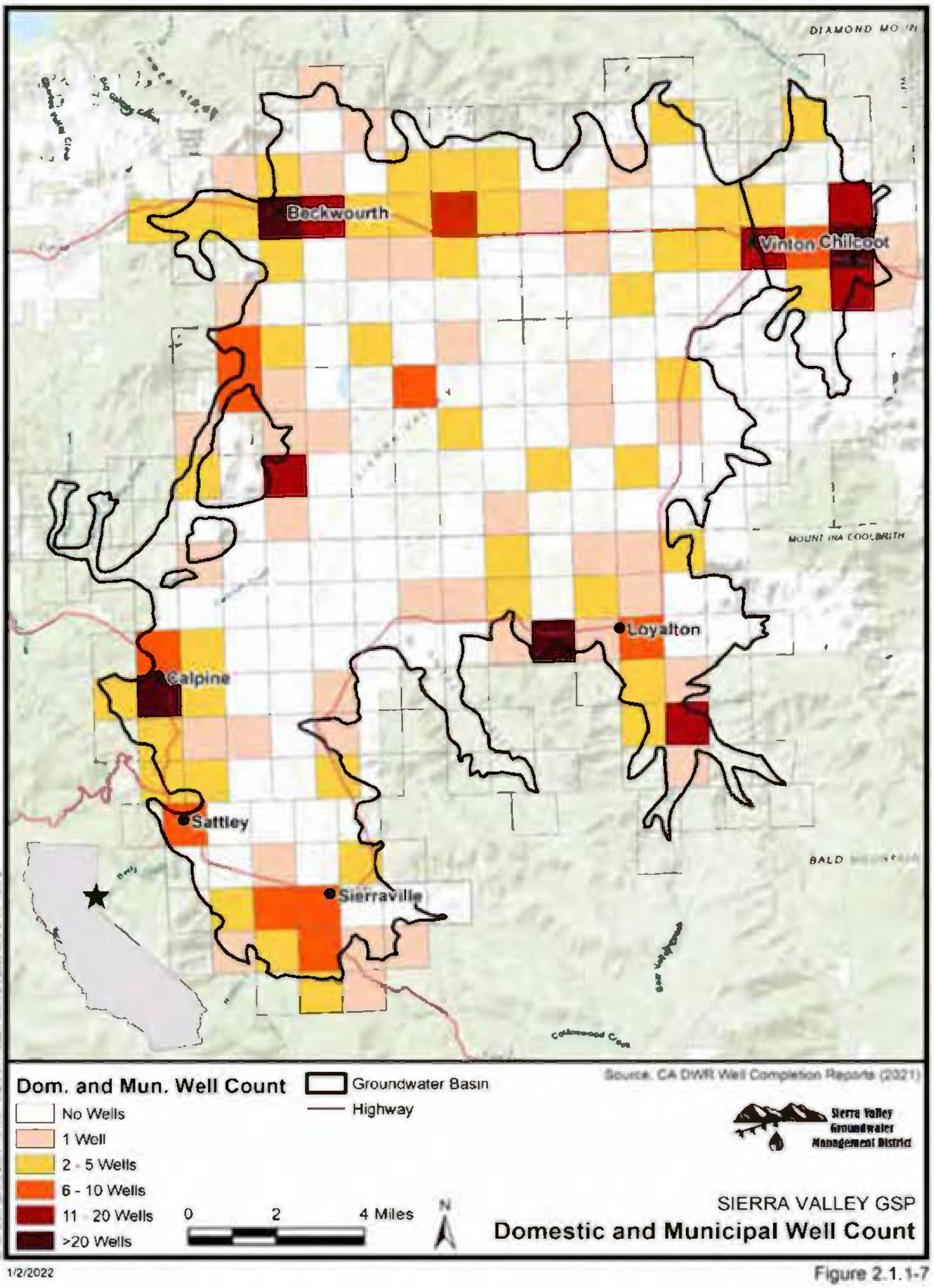
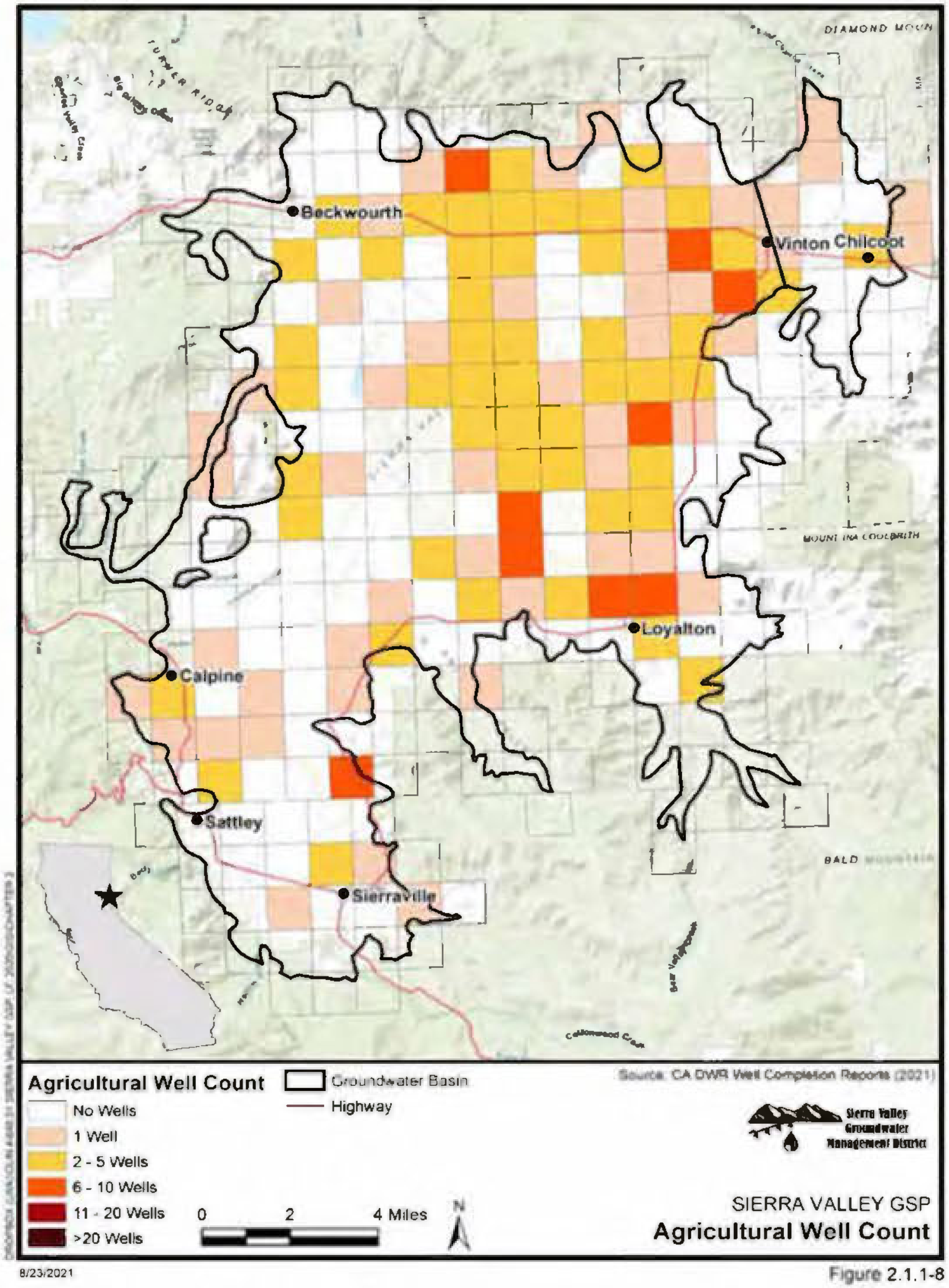


Figure 2.1.1-7: Approximate Number of Domestic Wells and Municipal Wells per Square Mile within the Plan Area



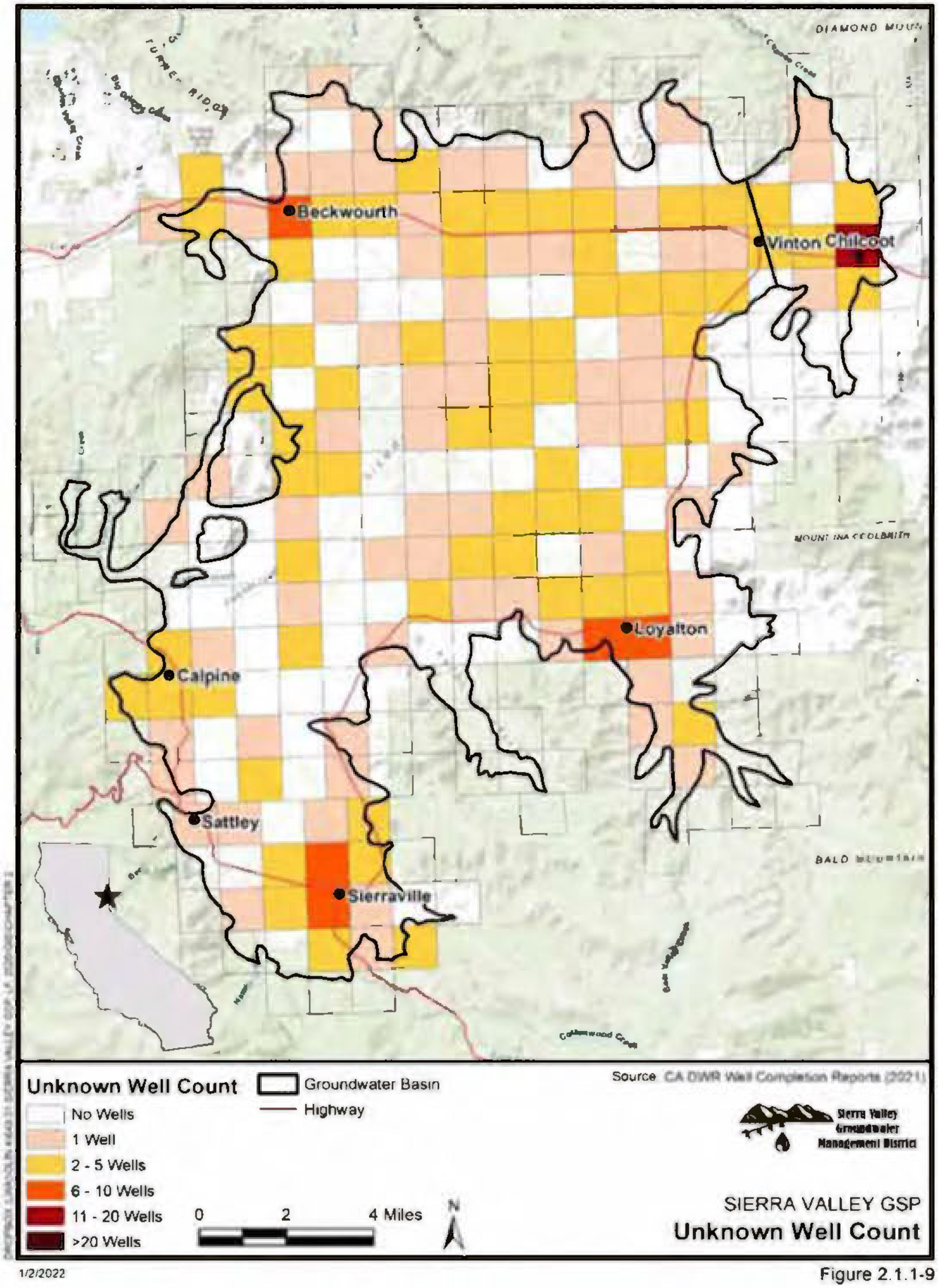
Source: DWR Well Completion Report Map Application

Figure 2.1.1-8: Approximate Number of Agricultural Wells per Square Mile within the Plan Area



Source: DWR Well Completion Report Map Application

Figure 2.1.1-9: Approximate Unknown Wells per Square Mile within the Plan Area



Source: DWR Well Completion Report Map Application

Table 2.1.1-2: Well Count in Sierra Valley by Type[1]

Well Type	Well Status				
	Active	Inactive	Destroyed	Unknown	Abandoned
Municipal	32	1	2	19	1
Agricultural	59	60	14	54	
Domestic	32	2	3	438	
Monitoring	77		12	47	
Spring/Seep	7				
Stockwater	24	2	3	22	
Unknown	101		7	186	
Exploratory Boring		5		6	
Heat Exchange				1	
Industrial				8	
Production				5	
Total	**332**	**70**	**41**	**786**	**1**

1. Well information obtained from DWR's Online System for Well Completion Reports, State Water Resources Control Board (SWRCB) and United States Geological Survey (USGS) Groundwater Ambient Monitoring Assessment (GAMA) GeoTracker, and SVGMD. Methods detailed in the Data Management System (DMS) Technical Memorandum, Appendix 2-1.

2.1.1.1 Plan Area, Exclusive Agencies, and Adjacent Basins

The SV Subbasin was characterized as a medium priority basin in DWR Bulletin 118; therefore, it is the primary focus of this Plan in compliance with SGMA (DWR, 2018a). 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 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.

All groundwater basins adjacent to the SV Subbasin are very low priority basins, including the Chilcoot Subbasin (DWR, 2018b). Adjacent groundwater basins, as shown in Figure 2.1.1-3, 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 Valley Groundwater Basin.

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

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 description and figure identifying such areas will be added to Section 2.1. 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 exclusively the Groundwater Sustainability Agency (GSA) is identified in Figure 2.1.1-2. 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 2.1.1-4);
2. The portion of the Plan Area within Plumas County (Plumas County jurisdictional area), the portion of the Plan Area within Sierra County (Sierra County jurisdictional area), and the area within the City of Loyalton (City of Loyalton jurisdictional area), see Figure 2.1.1-2 and Figure 2.1.1-3; and
3. The portion of the Plan Area within the jurisdictional areas for 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, Sierra County Waterworks District No. 1 Calpine, and Sierra Valley Mutual Water Company, see Figure 2.1.1-5.

2.1.1.4 Land Use and Water Sources History

In 1850 James P. “Jim” Beckwourth entered Sierra Valley and recognized the advantage of the low elevation pass at the northeast end. He blazed a trail beginning at what istoday Sparks, Nevada crossing the pass then continuing along the north end of Sierra Valley then through Grizzly Valley and American Valley to finally reach the settlement of Bidwell’s Bar; now below the waters of Oroville Reservoir. Between 1851 and 1854 some 1,200 emigrants used the trail leading 12,000 head of cattle, 700 sheep, and 500 horses into Northern California. While most emigrants continued on, being eager to realize the promise of gold, a hardy few remained behind to establish the first ranches and homesteads in Sierra Valley (Elliott 2021).

Beckwourth established a trading post, or what he named the War Horse Ranch, at the northwestern end of Sierra Valley where his cabin would be the first constructed house emigrants would see since the Utah territory. (Elliott 2021).

While early emigrants came in search of gold, silver, and copper, soon logging and sawmills followed, along with railroad development to move those products, as well as dairies, farms, and ranches to supply the miners and others.

Considerable Italian-Swiss immigration into Sierra Valley had been well underway by the 1880s. Many of the old pioneer ranches ultimately passed to Italian-Swiss families who made a name for themselves in the region and particularly in the dairy industry (Elliott 2021).

Agricultural operations changed the natural flow of streams into and through Sierra Valley, draining water from some areas and bringing irrigation to others through extensive development of irrigation ditches.

For more information on the settlement and history of Sierra Valley, including historic photographs, see Appendix 2-2 (A Brief History of the Ramelli Ranch Vicinity, Sierra Valley, CA – Elliot 2021).

Present day land use is generally characterized by different 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 are 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. The Sierra Valley watershed boundary, shown in Figure 2.1.1-5, fully encompasses the Plan Area and extends slightly into Lassen County to the northeast. State highways and county lines are also shown on the Figure. 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 and 414 in 2019. Both Vinton and Chilcoot are unincorporated communities in Plumas County located near the northeast corner of the valley. They are both included in the CDP of Vinton-Chilcoot. The population of the Chilcoot-Vinton CDP from the 2010 census was 454 and 422 in 2019/2020. 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 and 292 in 2019/20. 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 and 1093 in 2019. Campbell Hot Springs, also known as Sierra Hot Springs, is a small resort community located near the southern boundary of valley approximately 6 miles southeast of Sierraville, just southeast of the Sierraville Dearwater Airport. 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. 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 and 85 in 2019. 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 and 86 in 2019. 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 and 182 in 2019.

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.

As listed in Table 2.1.1-1, the U.S. Forest Service (USFS), Bureau of Land Management (BLM), California Department of Fish and Wildlife (CDFW), and State Lands Commission hold approximately 59 percent of land in the watershed. Of the 59 percent of the land held by federal agencies, the USFS is the biggest landholder with approximately 53 percent. There are three national forests in the Sierra Valley Watershed. Roughly half of national forest land in the watershed is either Tahoe National Forest, or Plumas National Forest. A small amount is comprised of Humboldt-Toiyabe National Forest.

The primary existing land use designation is agriculture/cropland and grazing. As shown on Figure 2.1.1-6, 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).

Crops are grown throughout Sierra Valley including alfalfa, improved pasture, meadow pasture, grain, and specialty crops. The majority of crops are pasture or production of hay. The top five crops in Plumas and Sierra County for 2021 listed by value were stockers and feeders, timber products, alfalfa hay, irrigated pasture, and forage products (CFBF, 2021).

Others land uses include various forms of recreation. Large areas of open space that are publicly and privately owned accompany relatively low-density areas of human settlement in the Sierra Valley Watershed. Some 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, agritourism, birding, and nature study. 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, 2019 states that groundwater makes up 36% of the total water supply in the SV Subbasin. See Section 2.2.1.6 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 an important component of water supply management in Sierra Valley. Conjunctive use programs and practices are described in Section 2.1.2.3 of this Plan. For surface waters in Sierra Valley, there are adjudicated water rights (established in 1940[8]) along Last Chance Creek, Smithneck Creek, West Side Canal, Fletcher Creek, Little Truckee River (imported water), and Middle Fork Feather River. These water rights place some restrictions on water use and water diversions.

2.1.1.5 Groundwater Well Density and Groundwater Dependent Communities

All of the communities within the Plan Area are to a large extent groundwater-dependent. The density of wells per square mile, showing the general distribution of agricultural, domestic, municipal, and unknown water supply wells in the basin, including de minimis extractors, utilizing data provided by DWR, as specified in Reg. § 353.2, are shown in Figure 2.1.1-7, Figure 2.1.1-8,

[8] Judgement and Decree State of California, Division of Water Resources to F. E. Humphrey, Jr., et al" dated January 19, 1940 Superior Court of California, County of Plumas, Case No. 3095

and Figure 2.1.1-9.The density of domestic wells and municipal wells, agricultural wells, and unknown wells in the Plan Area range from 0 to 80, 0 to 10, and 0 to 17 per square mile, respectively, with the majority of domestic and municipal wells located around the communities of Sierra Valley, the majority of the agricultural wells located in the central and eastern portions of the valley, and unknown wells primarily located within/around the communities of Beckwourth, Chilcoot, Loyalton and Sierraville. Sierraville obtains its municipal water supply from springs. A review of DWR well data, which included locating wells based on well log information, was performed during the development of the hydrogeologic conceptual model for this Plan. Agricultural wells make up the majority of pumping, as subsequently described (see Section 2.1.2.1.3). Industrial wells are limited to the former Loyalton Mill/Co-gen Plant Supply Well near Loyalton and a number of smaller wells providing water to industrial facilities near Beckwourth and in other areas of Sierra Valley.

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

Documentation of water resources monitoring preceding the 1960s is relatively limited. Water Resources monitoring programs conducted since then and associated studies and findings are summarized below.

2.1.2.1.1 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 have changed over time. The SV Subbasin has been included in several geology and hydrogeology studies and several focused studies and monitoring projects. The first comprehensive study was by DWR (1983) and included review of all previous studies (e.g., DWR [1963, 1973]) of the area geology, hydrogeology, and natural resources. Since 1983, DWR Northern District prepared eight annual updates on groundwater conditions in the Sierra Valley Subbasin 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, 2012-2014 (Schmidt, 1999); Schmidt, 2003; Schmidt, 2005; Schmidt, 2012; Schmidt, 2015; and 2017). A comprehensive review of groundwater data was later prepared by Bachand and Associates (2020) 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. Studies and monitoring by SVGMD and DWR are ongoing. Studies will be conducted and associated reports will be prepared throughout the implementation horizon of this Plan, as described in Sections 5.3 and 5.4.

2.1.2.1.2 Groundwater Level Monitoring

SVGMD has been monitoring groundwater levels in Sierra Valley since 1980. Currently, nineteen 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 including the wells being monitored by SVGMD. 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. A detailed description of the groundwater level monitoring network and protocol and proposed improvements is provided in Section 3.4.

2.1.2.1.3 Agricultural Groundwater Extraction Monitoring

Per SVGMD Ordinance 82-03, continued monitoring of agricultural extraction wells is required in the SV Subbasin. SVGMD has been monitoring agricultural groundwater extraction using flowmeters since 1989. As of 2015, pumping from 50 active agricultural wells was metered to measure the volume of groundwater extracted. Current and historic agricultural groundwater extraction data and trends are depicted and discussed in Section 2.2.3 (Water Budget). Agricultural groundwater extraction monitoring is critical for water budget refinement and sustainable management of groundwater resources, as groundwater extraction for agriculture exceeds groundwater extraction for municipal, industrial, commercial, and de minimis uses combined. As detailed in Section 2.2.3, having complete data records from 1989 through September 2020 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.

2.1.2.1.4 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[9] from 1968 to 1980 and DWR has monitored and maintained the gauge[10] since 2006. Available data includes 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. Inflows from Big Grizzly Creek are offset by outflows from MFFR via flow-routing in the model.

Water Master data dating back to 2011 was obtained by SVGMD in 2018 and additional data through 2020 was obtained in 2021 for analysis to supplement water budget

[9] https://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11392100

[10] https://water.weather.gov/ahps2/hydrograph.php?wfo=rev&gage=mftc1

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 3.4.

2.1.2.1.5 Water Quality Monitoring

Sierra Valley groundwater chemistry data have been collected by DWR since the late 1950s 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 with 48 surface water quality samples evaluated between 1970 and 1980 at USGS Streamgage 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. A detailed description of the groundwater quality monitoring network and protocol and proposed improvements is provided in Section 3.4.

2.1.2.2 Existing Water Resources Management Programs

Several water resources management programs exist in 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, and groundwater management by SVGMD. This includes a large-capacity well inventory, metering and tracking program, monitoring of new well applications and subdivisions proposals, and a large-capacity well moratorium in the overdrafted portion of the subbasin as described further in Section 2.1.3.4. The Upper Feather River Integrated Regional Water Management Plan addresses planning issues and priorities for the larger watershed encompassing SV Subbasin. In addition, the Natural Resources Conservation Service has worked with many private landowners in the SVGWMD to install projects and management tools to improve water resource management.

2.1.2.3 Indirect Groundwater Recharge

Indirect recharge (or conjunctive use) involves supplying a water demand with an alternative water source that would otherwise be met by groundwater extraction or surface water diversion. In California, conjunctive use is defined as "the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives."[11]

[11] DWR (2016), Conjunctive Management and Groundwater Storage – A Resource Management Strategy of the California Water Plan. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/RMS/2016/08_ConjMgt_GW_Storage_July2016.pdf

In the SV Subbasin, conjunctive use plays a role in optimizing management/use of water resources to maximize surface water use for irrigation as water rights allow and switch to supplement with groundwater irrigation only as needed[12]. 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, surface water is more abundantly and reliably available in the southern/western portions of the valley, where precipitation totals are higher and the number of tributaries flowing down from the surrounding hills are greater in number relative to the northern/eastern portions of the valleys. For ranching and other activities, there is a variety of irrigation types and water sources that facilitate conjunctive use in 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.

Existing 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. 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 present in the valley and along the valley periphery.

An example of a potential recharge opportunity would be to work with US Forest Service to improve upland recharge through improved forest management. Approaches and benefits of upland forest management is described further in Chapter 4 (Projects and Management Actions).

Another promising conjunctive use opportunity in the SV Subbasin would be to further optimize water from Frenchman Lake (reservoir), for example during the wet season and years of above-average precipitation, and through strategic use of surface irrigation and recharge in the SV Subbasin during the dry season, especially during years of below average precipitation. This is also described further in Chapter 4.

Over the course of the implementation of this Plan, the GSAs will strive to optimize conjunctive use strategies to maximize groundwater recharge and minimize agricultural demand for groundwater. A comprehensive approach to conjunctive water management will require the use of improved monitoring, ongoing evaluation of monitoring data, and use of monitoring data to inform management actions.

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

The existing monitoring programs and networks provide data to characterize current conditions in the Sierra Valley as described in Section 2.2.2. The existing monitoring programs and networks will be expanded as described in Section 3.4 to ensure groundwater and related 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 GSP through an integrated effort between local districts, agencies, relevant state entities, etc. No conflicts are expected to arise between monitoring and/or management programs as a result of the implementation of the GSP.

[12](groundwater irrigation demand = total irrigation demand – surface water irrigation supply

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 or 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

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 involves extensive public review and environmental review under the California Environmental Quality Act (CEQA).

The Plumas County 2035 General Plan Vision & Planning Goals statement is to promote a healthy physical and aesthetic environment, a vital economy, and a supportive social climate that can accommodate the expected growth and change over the next 20 years. Specifically, seven vision goals are incorporated into the General Plan, as follows:

1. To preserve and promote a rich environment of arts, culture, and heritage in Plumas County into the 21st century.
2. To create and retain jobs, and reinvest wealth through our economy, community, and natural resources.
3. To increase the communications and technology capability of Plumas County to function successfully in the 21st century.
4. To promote a future for Plumas County citizens in which land use decisions balance social, economic, and natural resource health.
5. To improve the health and well-being of all Plumas County residents.

6. To provide a range of facilities, programs and activities for the health and enjoyment of residents and visitors.
7. To recognize the well-being of local youth as fundamental to the health of the community as a whole.

Additionally, the 2035 General Plan planning goals include, but are not limited to, support of the environment, economy, agriculture and forestry, and the community to:

- meet and sustain the basic needs of clean and available water;
- promote the economics of pure water resources (quality and quantity) development;
- protect and sustain agricultural and forest lands and encourages best management practices;
- define agricultural and forest lands with the intent of meeting the needs of the ranching and farming families;
- preserve and protect cultural, historical, and archaeological resources;
- protect natural habitats;
- promote economic development in harmony with surroundings;
- maintain Plumas County's status as a premier recreation area; and
- protect and sustain existing communities and supporting sustainable development.

Further, 2035 General Plan Goals and Policies speak to groundwater resources and management, such as:

- Protect areas identified as significantly contributing to groundwater recharge from uses that would reduce the ability to recharge or would threaten the quality of the underlying aquifers.
- Manage groundwater as a valuable and limited resource and ensure its sustainability as a reliable water supply sufficient to meet the existing and future needs of Plumas County.
- Encourage the use of alternate sources of water supply as appropriate and to the maximum extent feasible in an effort to reduce demand on key groundwater resources.

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 include:

- City of Loyalton General Plan (2008)
- Plumas National Forest Land and Resource Management Plan (1988)
- Tahoe National Forest Land and Resource Management Plan (1990)

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 the GSP in this section 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 the GSP in this section 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 2.1.4). SVGMD approves applications where 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 large-capacity 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 landowners of Sierra Valley shortly after passage of the ordinance in 2018 addressed existing inactive large-capacity wells in the valley. The ordinance/letter required residents to respond to the letter registering (i.e., providing the number of and information on) any existing large-capacity 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 large-capacity 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 GSP 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 are 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 clarified 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 and possibly influenced by irrigation pumping in the northeast part of the Subbasin. 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 accomplished by efforts to improve recharge through various projects and measures, including 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 GSP discuss replenishment efforts that exist or could be implemented in Sierra Valley in greater detail.

2.1.4.6 Conjunctive Use Programs and Groundwater Storage

Conjunctive use programs in Sierra Valley are described in Section 2.1.2.3. Based on best available data, it is expected that the majority of groundwater storage in the SV Subbasin is for domestic/fire purposes at private residences for which public water access is not available.

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

Groundwater cleanup activities in Sierra Valley are described in Section 2.2.2.4.6. Industry, fuel storage, and other activities that are likely to cause groundwater contamination requiring cleanup are relatively sparse in Sierra Valley.

Initial exploration of the feasibility of recharge projects was undertaken by Bachand (Bachand, et.al., 2019) to explore opportunities for improving recharge, including potential for pilot studies, possibility of groundwater injection, and more.

Diversion to storage in 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 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 help prevent conversion to land uses that may have increased water demands. Water conservation efforts include research on and support for efforts switching traditional irrigation systems to higher efficiency irrigation technologies (i.e., LESA/LEPA technologies). Other efforts for water conservation include agricultural producers 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 as described in Section 2.1.2.3 of this Plan.

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.

No groundwater extraction projects, other than typical residential/agricultural/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

As discussed in Section 2.1.1.4, the USFS, BLM, CDFW, and State Lands Commission hold approximately 59 percent of land in the watershed. In addition, The U.S. Environmental Protection Agency (USEPA) Region 9, the State Board, Central Valley Regional Board, DWR, and CDFW are major regulatory agencies involved within Sierra Valley Basin.

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, 2019), several monitoring wells adjacent to wetlands and streams are showing significant declines that could be impacting the largest freshwater 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, 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 GSP. More detailed studies on this topic are needed, as described in Sections 2.2.1.6 and 3.4.

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 (C&E Plan) included as Appendix 2-3. The central objective of the C&E Plan is to provide a framework and identify options for stakeholder engagement in current and future SGMA activities in the SV Subbasin. A list of comments regarding the Plan received by the GSA and responses provided by the GSA is included as Appendix 2-4. Beneficial uses and users of groundwater in the SV Subbasin, a description of the GSAs decision-making process, and additional information on outreach and engagement is provided below.

2.1.5.1 Beneficial Uses and Users

Per California Code of Regulations (CCR) § 354.10(a), a description of the beneficial uses and users of groundwater in the basin is provided here, including the land uses and 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.

Table 2.1.5-1 incorporates the following elements:

- beneficial uses of groundwater required, at a minimum, by the Central Valley Regional Water Quality Control Board's Basin Plan; and
- interests representing groundwater uses and uses, to be considered by GSAs as identified in California Water Code (CWC) § 10723.2 as "including but not limited to."

Stakeholder communication and engagement may be impacted by the economic status of the community. The Sierra Valley is generally considered a Disadvantaged Community (DACs) based on DWR criteria (https://gis.water.ca.gov/app/dacs/) in that the City of Loyalton and Chilcoot-Vinton and the City of Portola (nearby in Plumas County) are all classified by DWR as DACs.

Table 2.1.5-1: Beneficial Groundwater Uses, Users, and Interests

Groundwater Uses	Groundwater Users	Representative Interests	How Involved
Domestic water supply[1]	Domestic well owners[2]	Disadvantaged communities[2] Broader community	TAC composition Interested parties email list Public workshops SVGMD monthly public meetings
Municipal water supply[1]	Municipal well operators[2] Public water systems[2]	• Town of Loyalton • Sierra Brooks Water System • Sierraville Public Utilities District	TAC composition
Agricultural supply[1]	Agricultural users[2]	• Ag Commissioner for Plumas and Sierra counties • Sierra Valley RCD • UC Cooperative Extension	TAC composition Interested parties email list Working sessions Direct communication to Agricultural large-capacity well owner/operator e/mailing lists
Industrial service supply[1]	Industrial operations	(no active industrial uses in Sierra Valley)	Interested parties email list
Industrial process supply[1]	Industrial operation	(no active industrial uses in Sierra Valley)	Interested parties email list
Environmental supply	Environmental users of groundwater[2]; groundwater dependent ecosystems	• CA Dept. of Fish & Wildlife • US Forest Service • Feather River Land Trust • Plumas Audubon • Trout Unlimited	TAC composition Interested parties email list Public workshops
Interconnected surface water (ISW) supplies	ISW users	Surface water users if there is a hydrologic connection between surface and groundwater bodies[2]	TAC composition Interested parties email list Public workshops

Groundwater Uses	Groundwater Users	Representative Interests	How Involved
Other	California Native American Tribes[2]	• Estom Yumeka Maidu Tribe of the Enterprise Rancheria • Greenville Rancheria of Maidu Indians • Honey Lake Maidu • KonKow Valley Band of Maidu • Mechoopda Indian Tribe of Chico Rancheria • Mooretown Rancheria of Maidu Indians • Pyramid Lake Paiute Tribe • Reno-Sparks Indian Colony • Susanville Indian Rancheria • Tsi Akim Maidu • United Auburn Indian Community of the Auburn Rancheria • Washoe Tribe of NV and CA	Targeted Tribal outreach TAC emails
Other	Land use managers: water managers; watershed systems	GSA – Sierra Valley Groundwater Mgmt. District GSA – Plumas County Sierra County Environmental Health Department Local land use planning agencies[2] Plumas County City of Loyalton Federal government[2] Plumas Nation Forest Tahoe National Forest Integrated Regional Water Mgmt. (IRWM) – Upper Feather River Watershed Grp Hinds Engineering Integrated Environmental Restoration Services Per CWC §10927, entities monitoring and reporting groundwater elevations…[2]	Planning Committee TAC composition Outreach from technical team and GSAs

[1] – as identified in Centra Valley Regional Water Quality Control Board Basin Plan
[2] – as identified in CWC § 10723.2

2.1.5.2 Decision-Making Processes

Decision-making authority and responsibility rests with the GSAs: Plumas County and Sierra Valley Groundwater Management District (SVGMD). The GSAs entered into a Memorandum of Understanding (MOU) in January 2019 "…to facilitate a cooperative and ongoing working relationship to develop a single Sierra Valley GSP that will allow compliance with SGMA and state law…" Additionally, the MOU states that "… all actions taken and/or contemplated under the GSP will be based on sound groundwater science and local expertise…"

The approach for developing and implementing the GSP is informed by a collaborative planning approach as described in the following section.

2.1.5.3 Collaborative Planning and Public Engagement Process

As part of the technical planning approach for developing the GSP, the GSAs established a collaborative planning approach. As described in the Communication and Engagement Plan, Appendix 2-3, opportunities for public involvement featured:

- convening of a Technical Advisory Committee, consisting of an array of stakeholder interests that met on a monthly basis;
- periodic Public Workshops, which provided information on planning efforts and received feedback and input from local participants;
- presentations and updates at monthly SVGMD Board meetings; and
- regular email communication and updates to interested parties.

Planning Committee

An internal Planning Committee was established to track project management and ensure compliance with SGMA requirements. Members included representatives from each GSA, the technical team and the DWR SGMA liaison.

The Planning Committee provided planning guidance and review of materials for TAC meetings, public workshops, informational emails to interested parties, and updates to the SVGMD Board.

Technical Advisory Committee (TAC)

The Technical Advisory Committee was comprised of individuals representing the following organizations or interests:

- Agricultural Commissioner for Plumas and Sierra Counties
- City of Loyalton
- Feather River Land Trust
- Feather River Trout Unlimited
- Hinds Engineering
- Integrated Environmental Restoration Services
- Plumas Audubon
- Plumas County Planning Department
- Plumas County Environmental Health
- Sierra Brooks Water System
- Sierra County Environmental Health
- Sierra Valley Groundwater Management District
- Sierra Valley Resource Conservation District

- Sierraville Public Utility District
- UC Cooperative Extension
- Upper Feather River Watershed Group (IRWM)
- USFS – Plumas National Forest
- USFS – Tahoe National Forest

In developing the GSP, the TAC met 17 times to address specific GSP elements as reflected in Table 2.1.5-2. Meetings were generally conducted in person, with an option for remote participation. Due to COVID-19, some meetings were virtual only. A link to a visual recording and all meeting summaries and related materials were posted for each TAC meeting on the GSP webpage at: https://www.sierravalleygmd.org/gsp-meetings.

Table 2.1.5-2: List of Sierra Valley TAC Meetings through December 31, 2021

Date	Location	Agenda Items
11/2/2020	Beckwourth, CA	Overview: SGMA, GSPs, Community Involvement; Sustainable Management Criteria (SMCs); Subsidence
12/7/2020	Virtual only	Overview: Website; Assessing Sustainability; Groundwater Quality
1/11/2021	Virtual only	Pre-meeting Orientation: Data Portal Modeling Approach Data Management
2/8/2021	Beckwourth, CA	SMCs: Subsidence, Water Quality Groundwater Dependent Ecosystems
3/8/2021	Virtual only	Groundwater Levels and Unreasonable Conditions
4/12/2021	Virtual only	Preliminary Sierra Valley Water Budget Groundwater Levels and SMCs
5/10/2021	Beckwourth, CA	Groundwater Levels; Brainstorming of Projects / Mgmt. Actions; GDEs, Interconnected Surface Water
6/21/2021	Beckwourth, CA	Sierra Valley Water Budget Interconnected Surface Water
7/19/2021	Beckwourth, CA	Sierra Valley Water Budget Projects & Management Actions (PMAs)
8/16/2021	Beckwourth, CA	Funding for GSP Implementation Sierra Valley Water Budget
9/8/2021 Working Session	Beckwourth, CA	Dedicated brainstorming of PMAs
9/13/2021	Virtual only	Discussion of PMAs: Ag Efficiency Improvements; Water Conservation and Demand Management; Watershed Mgmt. and Restoration; Voluntary Managed Land Repurposing
9/20/2021	Virtual only	Sustainability Goal; SMCs, PMAs, SMC Implementation
10/18/2021	Beckwourth, CA	Discussion of PMAs, Model update
11/29/2021	Beckwourth, CA	Monitoring Networks, Water Budget, Public Comments & Responses

Date	Location	Agenda Items
12/6/2021	Virtual only	Public Comments, Sustainable Management Criteria and Monitoring strategy
12/13/2021 Workgroup Session	Virtual only	GDE Public Comments and responses, Groundwater elevation SMCs

Additionally, two ad hoc TAC work teams were created to refine the discussion on Groundwater Dependent Ecosystems and a proposal for a Watershed Restoration PMA.

Public Workshops

Public workshops have been held to share information, invite participation and receive feedback on GSP content. These workshops were designed to maximize opportunities for public input in advance of and during key points in the GSP process. The following table recaps the workshops held in 2016, 2017, 2018, 2019 and 2021. All workshops were noticed through traditional media, posting of fliers, and the Interested Parties email list; some were also announced via social media sites. In May 2021, the workshop was conducted twice to maximize opportunities to participate.

Table 2.1.5-3: List of Sierra Valley GSP Public Workshops

Workshop Number	Workshop Dates	Agenda Topics
1	4/4/2016	• SGMA – What it means to people in the Sierra Valley groundwater basin • Groundwater Banking • Nitrate and Community Vulnerability Study • Other regulatory changes (reporting, Irrigated Lands, Watermaster)

2	2/24/2017	• SGMA overview
		• Results of recent studies on Sierra Valley:
		  ○ Groundwater recharge,
		  ○ Water quality, and
		  ○ Sierra Valley well inventory

3	3/31/2017	• Introduction of the UC Davis Sierra Valley Groundwater Model • Model Simulations of Climate Change Projections for Sierra Valley • SGMA and how the model can help
4	10/25/2018	• SGMA overview and milestones; implementation activities to date, • GSP planning process timeline/work plan overview • Identification of opportunities for stakeholders to participate in GSP planning
5	12/3/2019	• Update the community on the planning grant, work plan, and schedule • Basin conditions and other elements related to description of preliminary basin setting • Solicit community input on preliminary basin setting results

Workshop Number	Workshop Dates	Agenda Topics
6	5/8/2021 5/10/2021	• Description of conditions relating to Sustainability Indicators • Input on groundwater conditions and undesirable results • Initial ideas about projects and management actions
7	10/17/2021	• Presentation on Public Draft GSP and Reviewers; Guide • Initial input on GSP

In addition, a Special Meeting of the SVGMD board was held on February 29, 2016, featuring a talk with the district's geohydrologist about GSA formation and the basin's safe yield, and discussions with DWR's Bill Ehorn about basin prioritization, the GSP and GSA formation.

Public input and responses have been used to guide the development of the Sierra Valley GSP, including sustainable management criteria and potential projects and management actions. Public input will continue to be used to shape adaptive management and refinement of this Plan throughout the implementation horizon.

2.1.5.4 Outreach Activities

To encourage active involvement of diverse social, cultural, and economic elements of the population within the basin, SVGMD uses a variety of traditional and web-based communication tools to keep stakeholders informed and engaged, including:

- Print and on-line media/newspaper announcements: Mountain Messenger; Plumas News; Sierra Booster and www.sierraville.org
- Outreach partners' newsletters, websites, and social media accounts
- GSA websites, with posting of TAC meeting minutes, materials, and recordings on the SVGMD website
- Interested parties email lists
- Posting of public workshop flyers at local establishments
- Distributing surveys using multiple formats: hard copies at workshops, posted as PDFs, and links to online versions

Dedicated Tribal Outreach

SGMA requires GSAs to consider the interests relating to the uses and users of groundwater. These interested parties comprise a wide range of entities including California Native American tribes (federally recognized and non-federally recognized) (WC Section 10723.2).

While there are no Tribal Trust Land Tracts (U.S. Department of Interior, Bureau of Indian Affairs) within SV Subbasin boundary based on information and data published by DWR, [13] the SV Subbasin and immediate watershed is located within California Native American traditional lands, including the Maidu, Paiute, and Washoe Tribes.

A small portion of the SV Subbasin is located outside of the SVGMD boundary, but within Plumas County. This area is the responsibility of the Plumas County GSA, is known to have significant Tribal cultural connections, is entirely comprised of federal lands owned by Plumas National Forest and is a hydrologically important area located along the federally designated

[13] https://gis.water.ca.gov/app/boundaries/

Wild and Scenic River corridor of the Middle Fork Feather River. Accordingly, Plumas County served as the lead entity for SGMA Tribal outreach.

Plumas County utilized the DWR Engagement with Tribal Governments[14] document, which is intended to provide general guidance to GSAs regarding how and when to engage with Tribal governments. As part of DWR's guidance document, the recommended communication and engagement procedures for Tribes starts with contacting the Native American Heritage Commission (NAHC) to identify the appropriate Tribal entities for notification and engagement outreach. Additionally, Plumas County worked with a local Native American contact and the Plumas National Forest.

The NAHC was contacted by Plumas County and a list of Tribes with traditional lands or cultural places located within the SVGMD boundary, SV Subbasin boundary, and watershed boundary was provided. Those Tribes include:

- Estom Yumeka Maidu Tribe of the Enterprise Rancheria
- Greenville Rancheria of Maidu Indians
- Mooretown Rancheria of Maidu Indians
- Susanville Indian Rancheria
- Tsi Akim Maidu
- United Auburn Indian Community of the Auburn Rancheria
- Washoe Tribe of Nevada and California

In addition, the following Tribes were also contacted, as they may have traditional lands or cultural places or knowledge of cultural Tribal resources within the boundaries of the SVGMD, SV Subbasin, and watershed:

- Pyramid Lake Paiute Tribe
- Reno-Sparks Indian Colony
- Mechoopda Indian Tribe
- KonKow Valley Band of Maidu
- Honey Lake Maidu

Communications by email, phone, and/or mail were made to these twelve Tribes to notify them of the SGMA SV Subbasin GSP planning process, to invite them to participate, and to confirm that Tribal engagement is directed by individual Tribes, with interested Tribes communicating their preferred methods of contact and pathways of engagement. For example, engagement could solely be in the form of informational updates as an interested party or could be more involved with direct participation on a committee or during meetings or while attending public workshops. Follow up with individual Tribes was conducted and tailored to the specific Tribal responses received.

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 SVGMD board meetings and public workshops as

[14] DWR Guidance Document for the Sustainable Management of Groundwater, Engagement with Tribal Governments (January 2018)

documented in the CE Plan and through information and documents posted on the District's website. To keep the public informed on GSP implementation progress, information will continue to be posted on the website and updates will be provided at Board meetings. In addition, the status of projects and management actions will be included in the annual evaluation and reporting to be facilitated by SVGMD. Updates and an assessment of GSP progress will be presented annually in the fall or winter subsequent to completion of the annual reports, as described in the C&E 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 C&E Plan.

The Sierra Valley TAC seeks to ensure timely implementation of an expanded monitoring network and GSP projects and management actions. To support this objective, continued engagement of TAC members and Interested Parties should be maintained throughout GSP implementation. This could be achieved through a variety of means: a standing agenda item on District Board meetings to report on GSP implementation on a recurring basis (e.g., every third month), email updates using a newsletter format, ad hoc working groups to advance specific PMAs, and/or periodic GSP implementation reviews (e.g., every six months) as part of Board meetings.

2.2 Basin Setting

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

A hydrogeologic conceptual model (HCM) is a framework for understanding how water moves into, within, and out of a groundwater basin and underlying aquifer system. According to the California Department of Water Resources (DWR), the HCM fundamentally provides [DWR, 2016]:

- *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*
- *Context to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks*
- *A tool for stakeholder outreach and communication*

All groundwater sustainability plans (GSPs) are required to include an HCM (23 CCR §354.14) that contains the following information:

- *Regional geologic and structural setting*
- *Basin boundaries*
- *Principal aquifers and aquitards*
- *Primary use or uses and general water quality for each principal aquifer*
- *At least two (2) scaled geologic cross sections*
- *Physical characteristics (e.g., topography, geology, soils, etc.)*

Development of a basin HCM is an iterative process as data gaps (see Monitoring Network and Data Gaps Analysis technical memo, Appendix 2-5) are addressed and new information becomes available.

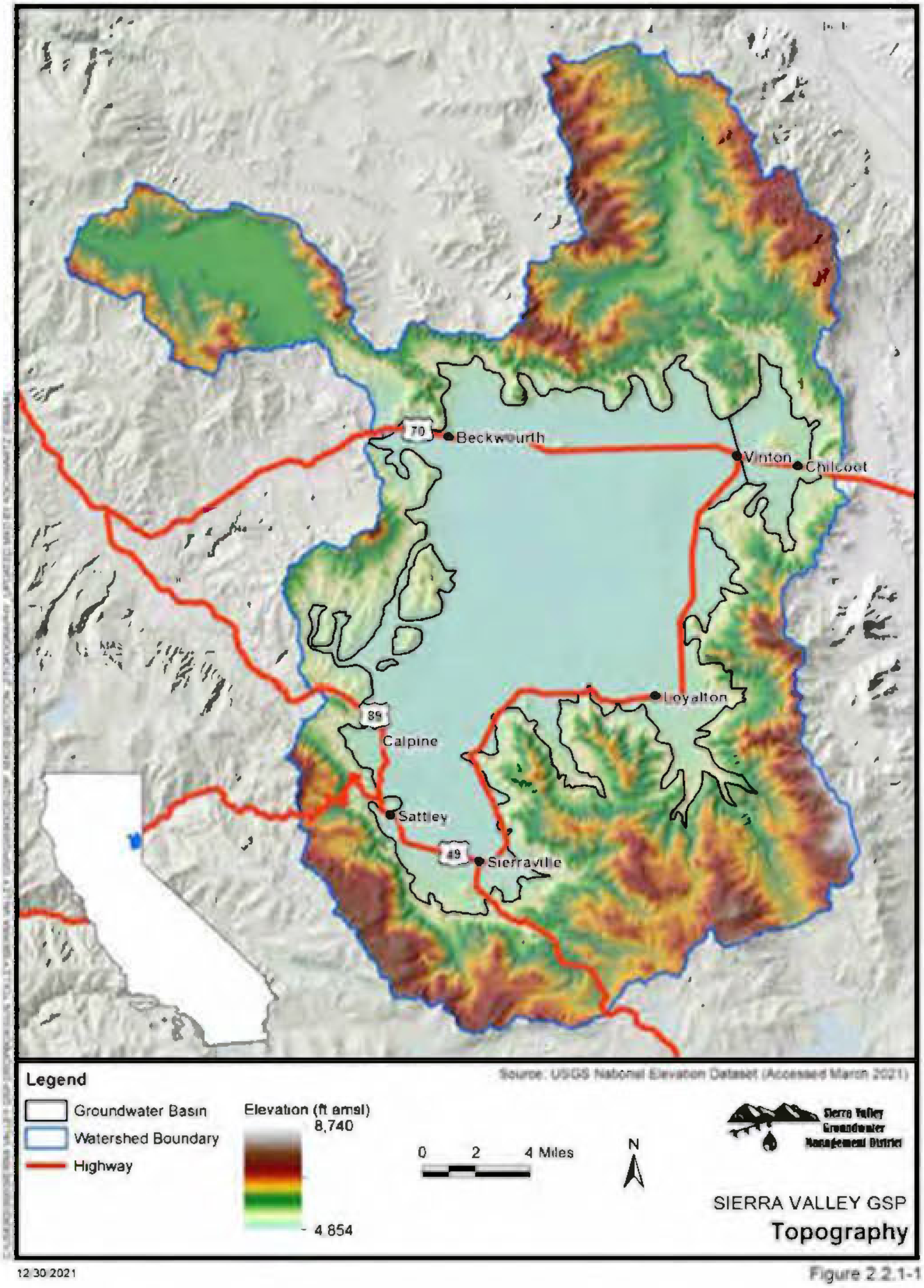
Several geologic and water resource studies have been conducted in Sierra Valley since the 1960s. A detailed review of all previous work is beyond the scope of this report, but all relevant information was reviewed during development of the Sierra Valley HCM. The sections below summarize information pertinent to HCM development.

2.2.1.1 Physiography

Sierra Valley is a large sub-alpine valley located in the eastern Sierra Nevada Mountains in the northern portion of the Sierra Nevada geomorphic province of California and drains nearly 374,000 acres. The groundwater basin is about 125,900 acres and comprised of the Sierra Valley (5-012.01) and Chilcoot (5-012.02) subbasins. Although the Chilcoot subbasin is currently designated as very low priority by DWR and therefore not required to have a GSP, it has been included in this Plan.

The valley is surrounded by steep mountains and alluvial fans with various slope gradients. Elevations in the watershed range between 4,854 feet above mean sea level (ft amsl) in the valley floor to 8,740 feet amsl at Babbit Peak in the southeastern mountains (Figure 2.2.1-1). The valley floor is a relatively flat Pleistocene lakebed, with a zero to five percent slope gradient. Volcanic outcrops disrupt the flat topography in various locations throughout the valley.

Figure 2.2.1-1: Sierra Valley Subbasin Topography



Stream channels cutting through the steep slopes of the surrounding mountains drain precipitation and snowpack into the Sierra Valley form the headwaters of the Middle Fork Feather River (MFFR) (Figure 2.2.1-2).

2.2.1.2 Climate

Climate in Sierra Valley watershed is strongly correlated with elevation. The higher elevations receive the greatest amount of precipitation (Figure 2.2.1-3) and are cooler (Figure 2.2.1-4).

The watershed experiences more precipitation in the west due to the "rain shadow effect" caused by the Sierra Nevada Mountains. Moist air masses moving eastward off the Pacific Ocean rise as they encounter the Sierra Nevada slopes: the rising air cools, and water vapor condenses and falls as rain or snow. As air masses descend the eastern slope, the descending air warms, clouds evaporate, and precipitation declines east of the Sierra Nevada. The combination of topography and the "rain shadow effect" results in highly variable precipitation in the watershed. Sierra Valley also becomes drier northward.

Long-term total mean annual precipitation (1981-2010) in the watershed ranges from 62.4 inches in the southwest mountain slopes to 13.6 inches in the eastern part of the Chilcoot Sub-Basin (PRISM Climate Group, n.d.). 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% of the annual total received between November and March and less than 5% accounted for during summer months.

Long-term averages of total mean annual temperatures (1981-2010) range from 40.4°F in the mountain slopes in the southwest portion of the watershed to 48.5°F in the eastern part of the basin. Monthly averages are lowest from December through February and highest in July and August (PRISM Climate Group, n.d.). In addition to high elevations, cold continental air masses moving west from the Great Basin create cold winter temperatures and a short growing season in Sierra Valley. Data collected at the Sierraville Ranger Station (elevation 4,975 feet above amsl), show freezing temperatures typically occur from September until May, while some surrounding higher elevations experience freezing temperatures throughout the year. Growing season of the valley floor is approximately 60 to 90 days and shortens considerably in the mountainous regions to the west and south of the valley.

In this high-elevation valley, snowfall is common. Sierraville Ranger Station shows January has the highest monthly average snowfall at approximately 17.9 inches, and average annual snowfall of approximately 71.8 inches. The average snow depth measured in Sierraville is 5 to 6 inches in January and consistently greater than two inches from December through April.

2.2.1.3 Vegetation and Land Use

The majority of the Sierra Valley subbasin is private land, while the surrounding watershed is primarily National Forest. Approximately 1,200 plant species representing 18% of California's flora are found in Sierra Valley (NRCS, 2016). Vegetation overlying the watershed is a mix of desert and semi-arid desert, agricultural, forest and woodland, and shrub and herb classification types (Figure 2.2.1-5).

On the valley floor, pasture land and alfalfa grown for hay are the dominant irrigated crops. Braided streams and agricultural irrigation support wetland and riparian communities. The western valley supports approximately a 20,000-acre wetlands complex and 30,000-acre meadow complex, both the largest in the Sierra Nevada (NRCS, 2016). Bulrushes grow in anaerobic soil conditions in the larger wetlands, whereas sedges and rushes thrive in the fringes and smaller wetlands. Willows and other riparian vegetation grow along the streams and canals in the Sierra Valley (Vestra, 2005). The western portion of Sierra Valley contains vernal pools, which are seasonally flooded depressions with limited drainage due to an underlying hardpan soil layer (CDFG, 2003). Vernal pools typically support a specialized set of species (e.g., Santa Lucia dwarf rush and Modoc County knotweed) due to their seasonal cycle of filling in the winter, flourishing in spring, and drying out in summer. The pools are surrounded by rush dominated meadows. Grasslands and sagebrush scrub cover areas that have not been cultivated. Native grasses of the basin include Sandberg Bluegrass, Idaho fescue, various needlegrasses, and wildrye. Although colder temperatures of the Sierra Valley have helped prevent most invasive grass species from spreading, Cheatgrass is an invasive European grass found on the valley floor that poses a fire risk and out competes native species. Sagebrush scrub is more concentrated along the perimeter and in the eastern portion of the basin and includes big sagebrush, antelope bitterbrush, curlleaf mountain mahogany, and rubber rabbitbrush (Vestra, 2005).

Sagebrush scrub makes up the majority of the vegetation in Sierra Valley and is found along the valley floor and the slopes along the north and east sides of the valley (Harnach 2016). Ponderosa Pine Alliance and Eastside Pine Alliance (comprised of a mix of ponderosa and Jeffrey pines, Douglas fir, and white fir) occur along the edge of the southern portion of the valley, particularly in hillslopes with northern aspects (USDA 2014, Harnach 2016). Oak woodlands also occur in the northern portion of the valley and into the uplands. Red fir forests occur in the highest elevations above the valley (6,000 to 9,000 feet) along the southwest watershed's border, with white fir below (5,000 to 6,000 feet), and 41reenleaf manzanita and snow brush in open, undisturbed areas. The Sierran Mixed Conifer forest in the watershed includes white fir, ponderosa pine, sugar pine, incense cedar, and Douglas fir. The upland areas of the watershed also contain wet meadows, montane riparian aspen, and other hardwood vegetation types including Black Oak woodland. Wildfires have historically burned 44,000 acres of upland vegetation within the watershed since 1994 (Vestra, 2005), and more recently, burned over 150,000 acres in the Loyalton Fire and Beckwourth complex.

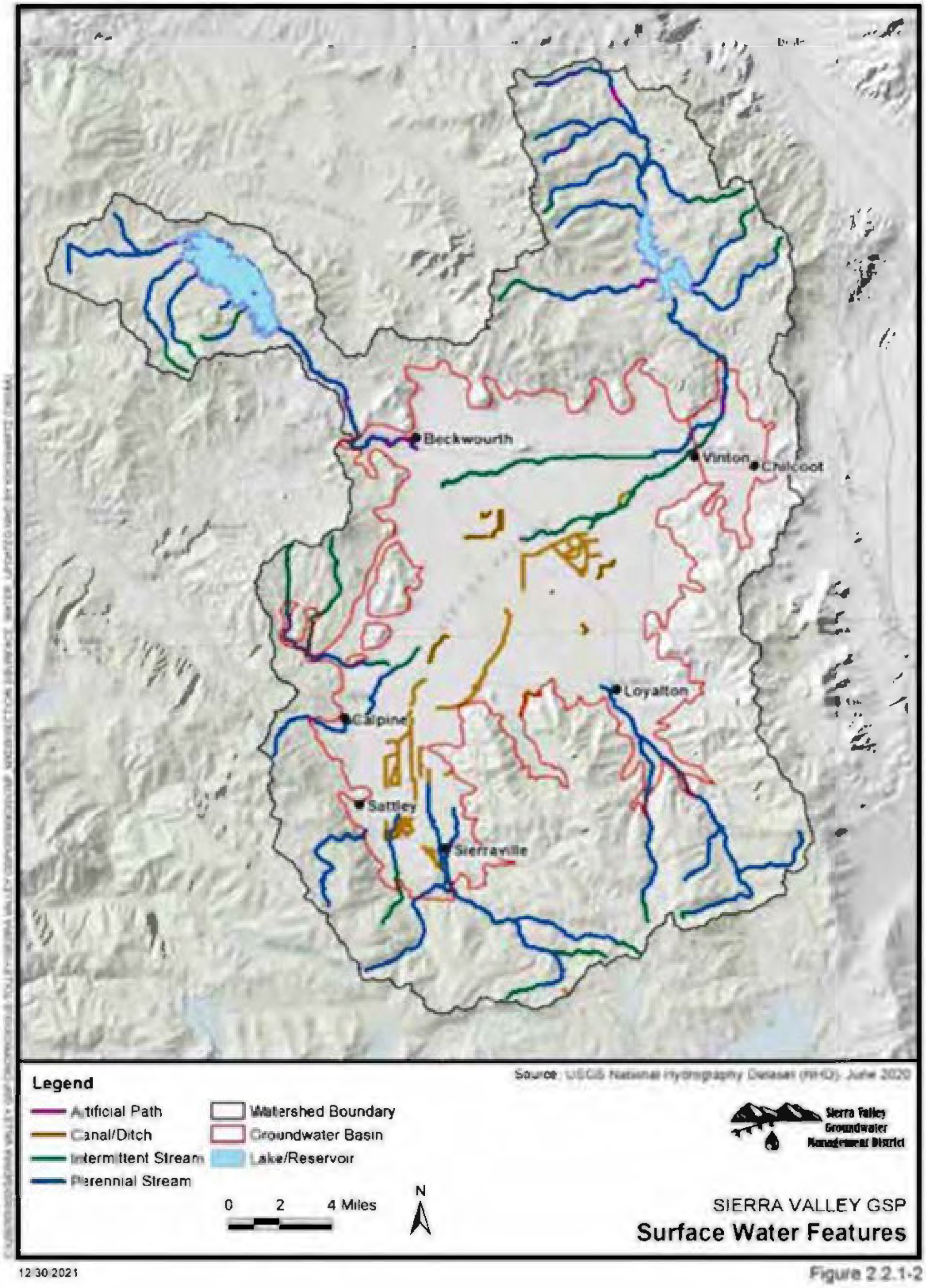
Climate, fire, invasive species, timber management, agricultural production and water management systems have changed the composition of the Sierra Valley watershed vegetation (Vestra, 2005). The impact of wildfires and drought in 2021 will also have a significant but yet to be evaluated effect on the watershed.

2.2.1.4 Soils

Surficial soil data were obtained from the Natural Resources Conservation Service (NRCS) soil survey geographic (SSURGO) database. Areas of similar soils are grouped into map units, which have similar physical, hydrologic, and chemical properties. Map unit properties are assigned a range of values based on the soils contained within them.

Soils within the Sierra Valley Watershed vary considerably in productivity, depth, and use based on parent material, topography, and precipitation. A total of 2,499 unique soil map units were identified within the Sierra Valley watershed with 1,071 units overlying the groundwater basin. Figure 2.2.1-6 shows a general summary of these map units classified by soil type defined by the Unified Soil Classification System (USCS), with approximately 90% of the groundwater basin defined. Surface soil types within the groundwater basin are dominated by sands, clays, and silts (Table 2.2.1-1). Silty sands make up the largest fraction of surficial soils in the groundwater basin, accounting for about 41% of the surface area. Finer grained soil textures, such as silts and clays, make up approximately 37% of the surface area and are generally located adjacent to stream channels and wetland regions. The rest of the basin has either not been classified or is composed of relatively small fractions of mixed soils.

Figure 2.2.1-2: Surface Water Features



Note: The USGS NHD dataset for surface water features is an industry standard used in hydrological reports, yet commonly has potential for improvement that can be addressed by submitting recommended changes to the USGS on their NHD webpage.

Figure 2.2.1-3: Mean Annual Precipitation

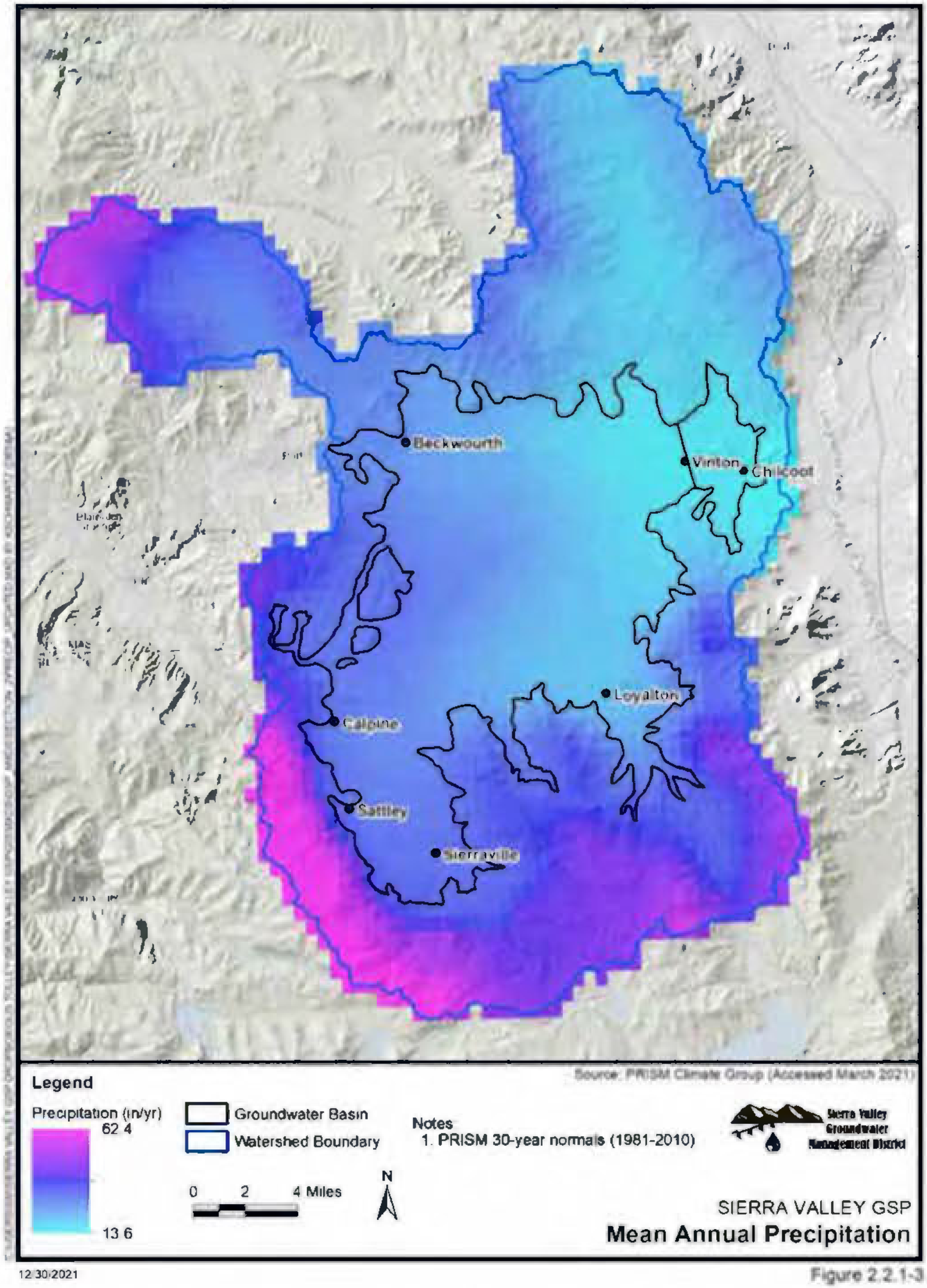


Figure 2.2.1-4: Mean Annual Temperature

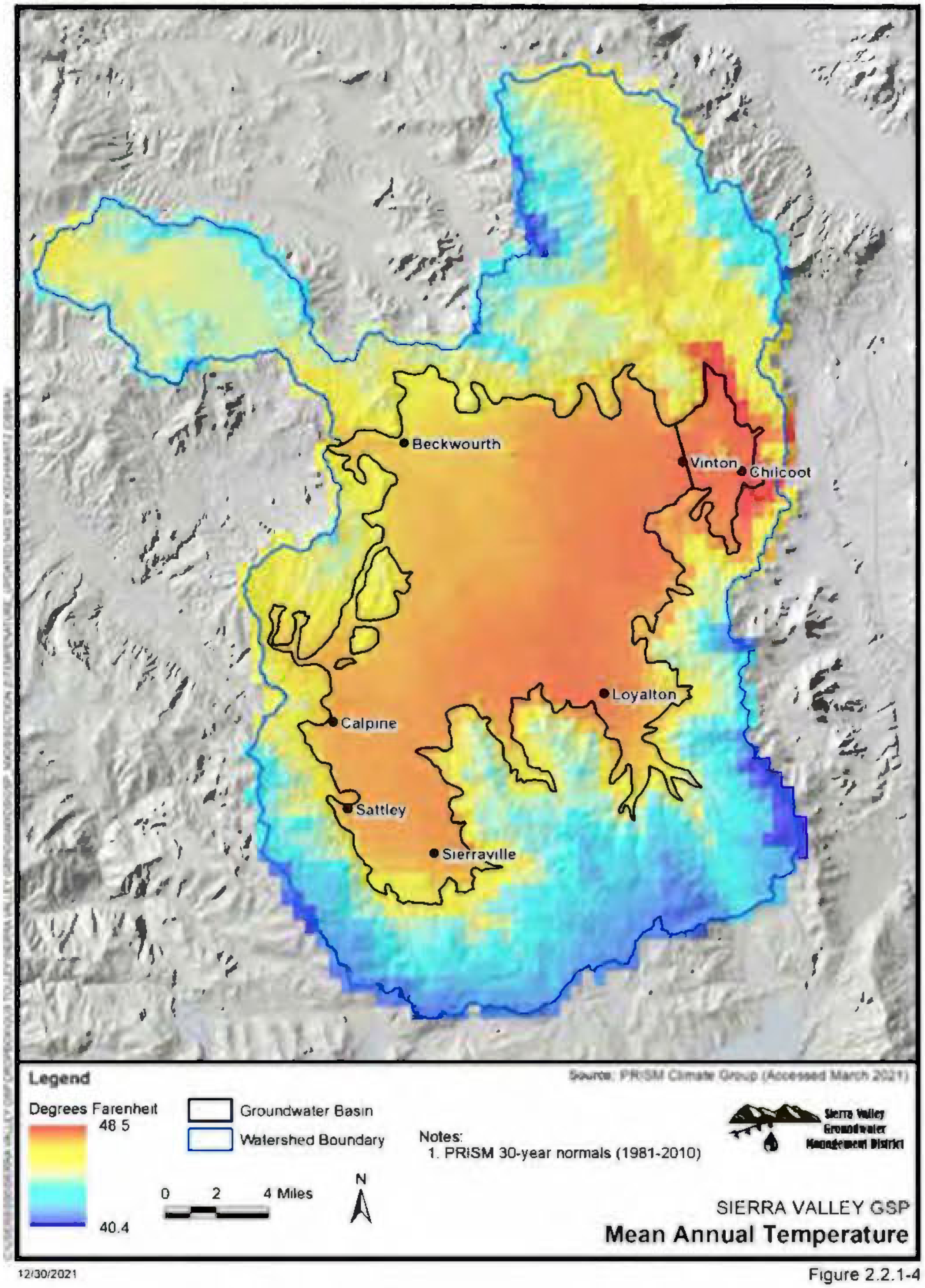


Figure 2.2.1-5: Vegetation and Land Use

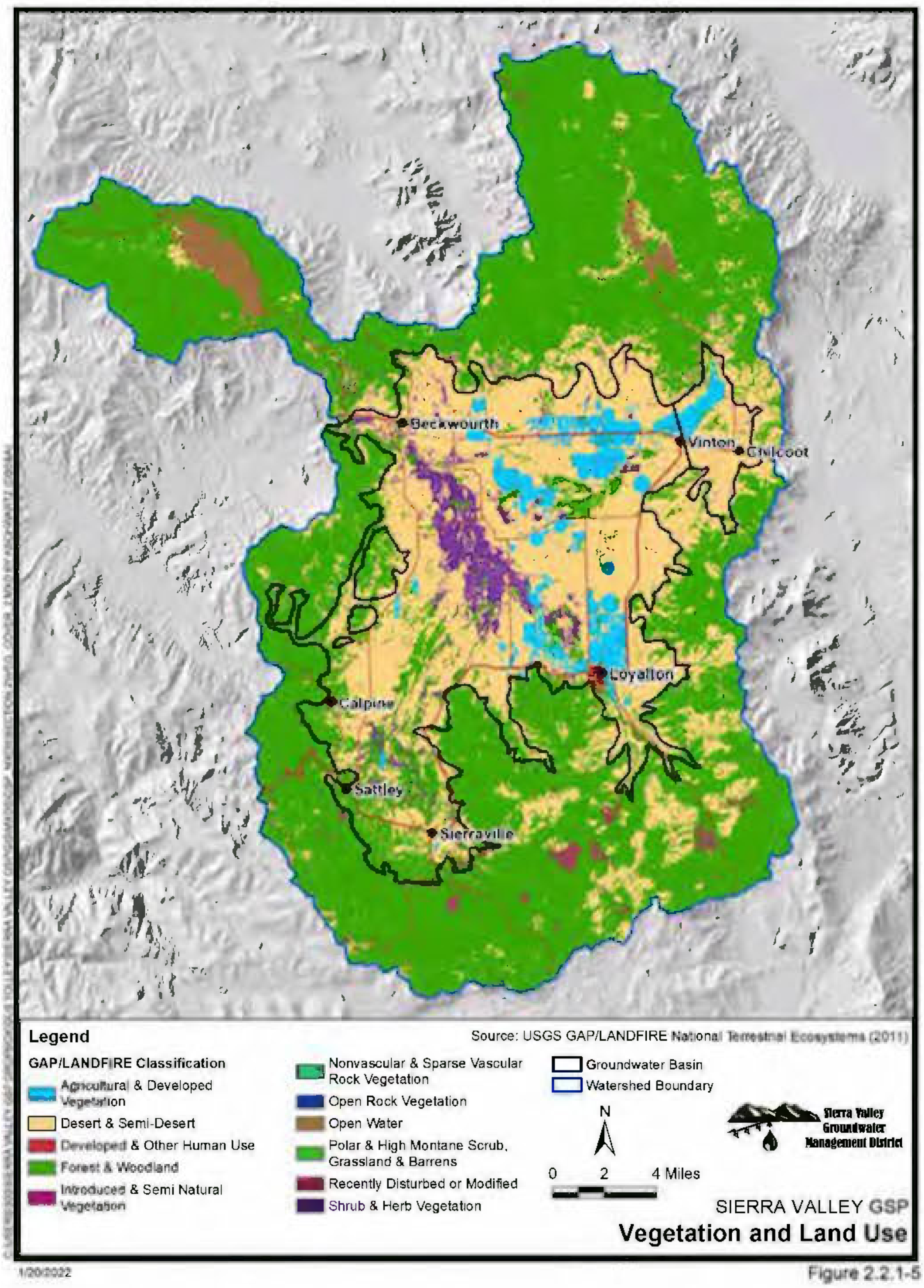


Figure 2.2.1-6: Soil Types

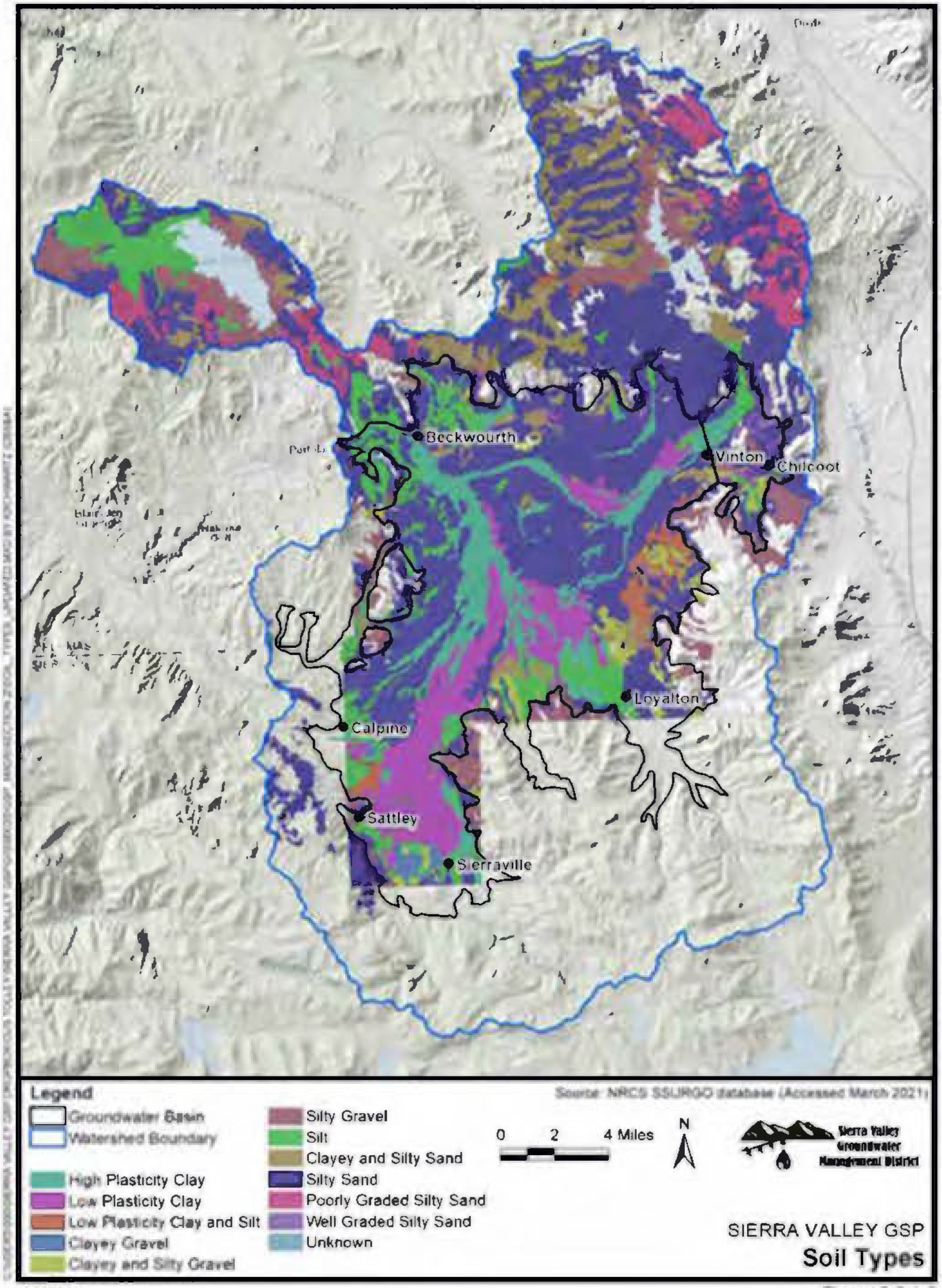


Table 2.2.1-1: Summary of Groundwater Basin Soil Texture Composition

Soil Type	Area (Acres)	Area (%)
Silty Sand	51,333.5	41.10
Low Plasticity Clay	17,549.4	14.05
High Plasticity Clay	15,751.2	12.61
Silt	13,276.0	10.63
Unknown	12,446.9	9.97
Clayey and Silty Sand	4,047.6	3.24
Clayey and Silty Gravel	4,012.0	3.21
Low Plasticity Clay and Silt	2,703.3	2.16
Silty Gravel	2,323.3	1.86
Clayey Gravel	1,058.6	0.85
Well Graded Silty Sand	400.4	0.32

Figure 2.2.1-7 shows the drainage class for soils in the watershed. Poorly drained soils are found primarily in areas of fine-grained sediments adjacent to stream channels and wetlands, where finer textured soils and shallow groundwater depths are found. Well-drained very stony soils, underlain by hardpan approximately 10 to 20 inches below ground surface, are found on terrace deposits around the western and southern rims of the valley. In general, soils located along the rim of the valley, where various alluvium soil types and lake terrace deposits exist, are excessively to moderately drained due to a combination of coarse soil textures and lack of a shallow water table. Soils found in the surrounding mountains are generally moderately to excessively drained soils that were derived from the various volcanic flows, tuffs, granitic rocks, and some metamorphic rocks found in the mountains.

Saturated soil hydraulic conductivity of surface soils in the groundwater basin ranges over four orders of magnitude from 0 to 40 ft/day (Figure 2.2.1-8). The lowest conductivity soils are generally located adjacent to stream channels and wetlands. The distribution of hydraulic conductivity values is similar to the distribution of soil textures in the groundwater basin, which is expected as coarser soil textures tend to have greater hydraulic conductivities. Saturated hydraulic conductivity within the groundwater basin generally exceeds 1 ft/day.

Soil salinity in the watershed ranges from non-saline to strongly saline (Figure 2.2.1-9). In general, the high elevation areas of the watershed and the western portion of the groundwater basin have non-saline to very slightly saline soils due to the greater amount of precipitation received. Moderately to strongly saline soils are primarily found in the central basin and adjacent to the creeks and wetlands where the water table is shallowest.

Figure 2.2.1-7: Soil Drainage Class

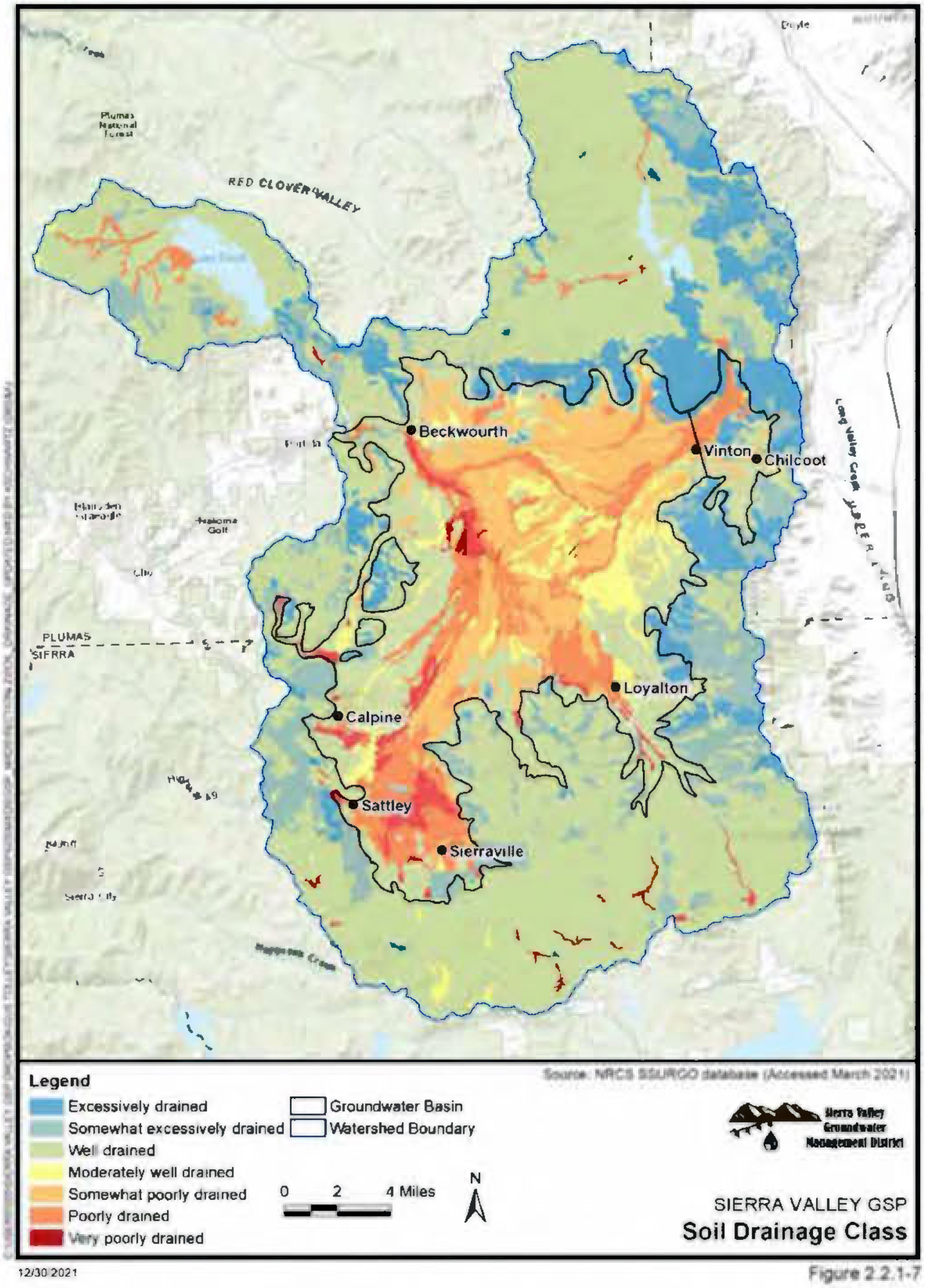


Figure 2.2.1-8: Soil Saturated Hydraulic Conductivity

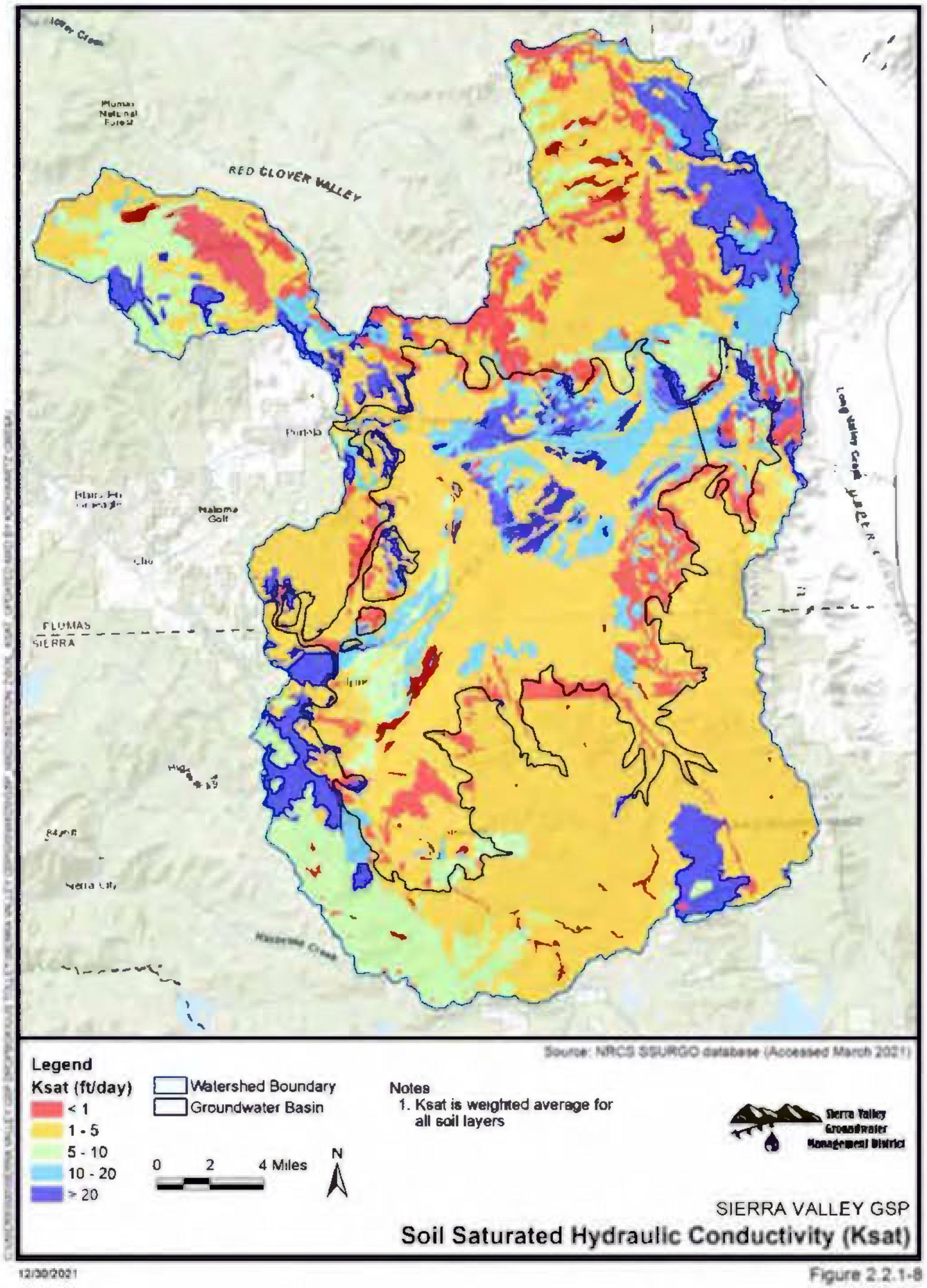
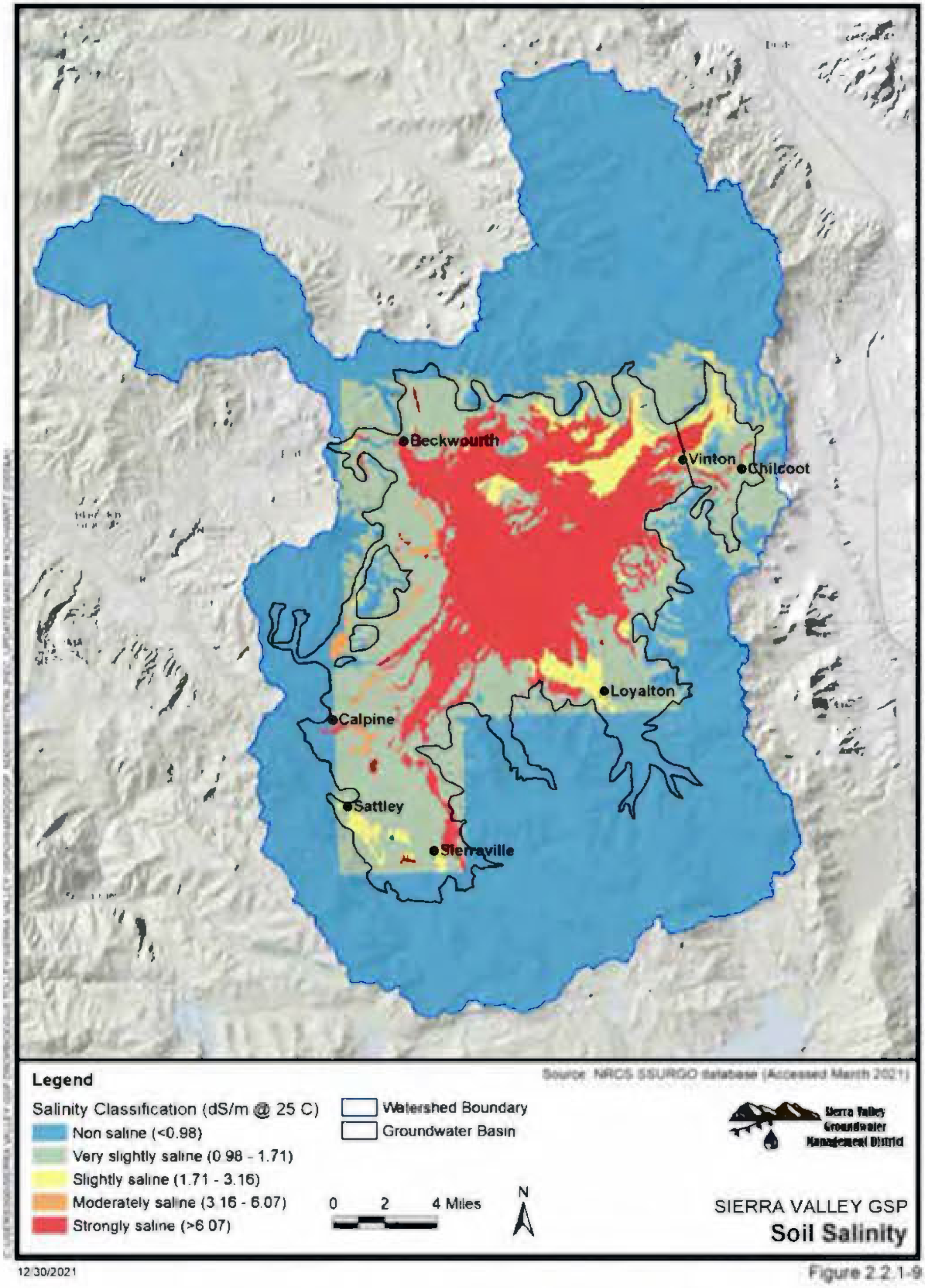


Figure 2.2.1-9: Soil Salinity



2.2.1.5 Geology

Sierra Valley lies at the eastern edge of the Sierra Nevada Province, along the western edge of the Great Basin Province. The 400-mile-long Sierra Nevada mountain range trends north-northwesterly and is a west-dipping block of granitic and remnant metamorphic rocks. The geologic history of Sierra Valley is a complex mixture of orogenies, volcanism, rifting, faulting, and deposition. Figure 2.2.1-10 provides a spatial overview of Sierra Valley geology, and Figure 2.2.1-11 provides a stratigraphic overview interpreted by DWR (1963). Figure 2.2.1-12 depict generalized cross-sections of the Sierra Valley prepared by DWR (1963). Schmidt and Associates created several additional subsurface geologic cross-sections (Figure 2.2.1-13) showing more detail using electrical logs (Schmidt, 2003; Schmidt, 2005).

Sierra Valley subbasin is part of a down dropped fault block, or graben, surrounded by uplifted mountains, or horsts. The valley floor consists of an irregular surface of basement rock, formed by steeply dipping northwest and northeast-trending vertical, normal, and strike-slip faults. Throughout its geologic history, the fault trough floor gradually subsided, while being occupied by one or several lakes. Lacustrine (lake), fluvial, and alluvial deposits were formed as sediments eroded from the surrounding uplands and volcanic tuffs (ash deposits) and filled the space created by the fault trough floor as it continued to subside.

Sierra Valley geologic units can be divided into three groups: 1) basement complex metamorphic and granitic rocks, 2) Tertiary volcanics, and 3) Quaternary sedimentary deposits of clay, silt, sand, and gravel. The following descriptions are summarized from DWR (1983).

The basement complex contains metamorphic rocks that represent volcanic rocks and sediments deposited and altered as a result of regional overthrusting and volcanism during a series of orogenic events between the Farallon plate and the North American plate. The basement complex consists of quartzite, slate, marble, and metavolcanics of Paleozoic to Mesozoic age. Although most of these rocks have since eroded away, they are still present in some locations such as the belt exposed on the east side of the valley. It is presumed that these rocks underlie some of the region now covered by Tertiary and Quaternary units. Subsequent subduction of the Farallon plate beneath the North American plate resulted in emplacement of Mesozoic Sierran granitic pluton intrusions into the basement metamorphic complex (country rock). Exposures of these granitic rocks occur along the northern and western edges of the valley, predominantly in the higher elevations, as part of the Sierran batholith of the Jurassic to Cretaceous age and underlie the majority of the basin. An exploratory drill hole in the middle of the valley encountered granitic rocks at a depth of 2,165 feet (DWR, 1983). These generally massive, crystalline, fractured rocks range in composition from quartz diorite to granite and are observed as rounded outcrops and some granitic pegmatite dikes.

A variety of Tertiary volcanic rocks erupted as subduction continued, consisting of rhyolite, andesite, basalt, and pyroclastic flows. These rocks outcrop mainly in the upland areas surrounding the valley or as isolated buttes and low hills in the valley but are also present at depths within the valley according to drill logs. The basin is bounded to the north by Miocene pyroclastic rocks of Reconnaissance Peak, to the west by Miocene andesite, to the south and east by Tertiary andesite, and to the east by Mesozoic granitic rocks (DWR, 2004; Saucedo, 1992).

In the Late-Pliocene time, faulting and erosion began to change the landscape toward its present shape (Berry, 1979). Lakes filled depressions and received sediment from the surrounding highlands. Plio-Pleistocene Lake Beckwourth filled Sierra Valley to a probable elevation of 5,120 feet 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 lake.

Figure 2.2.1-10: Geology

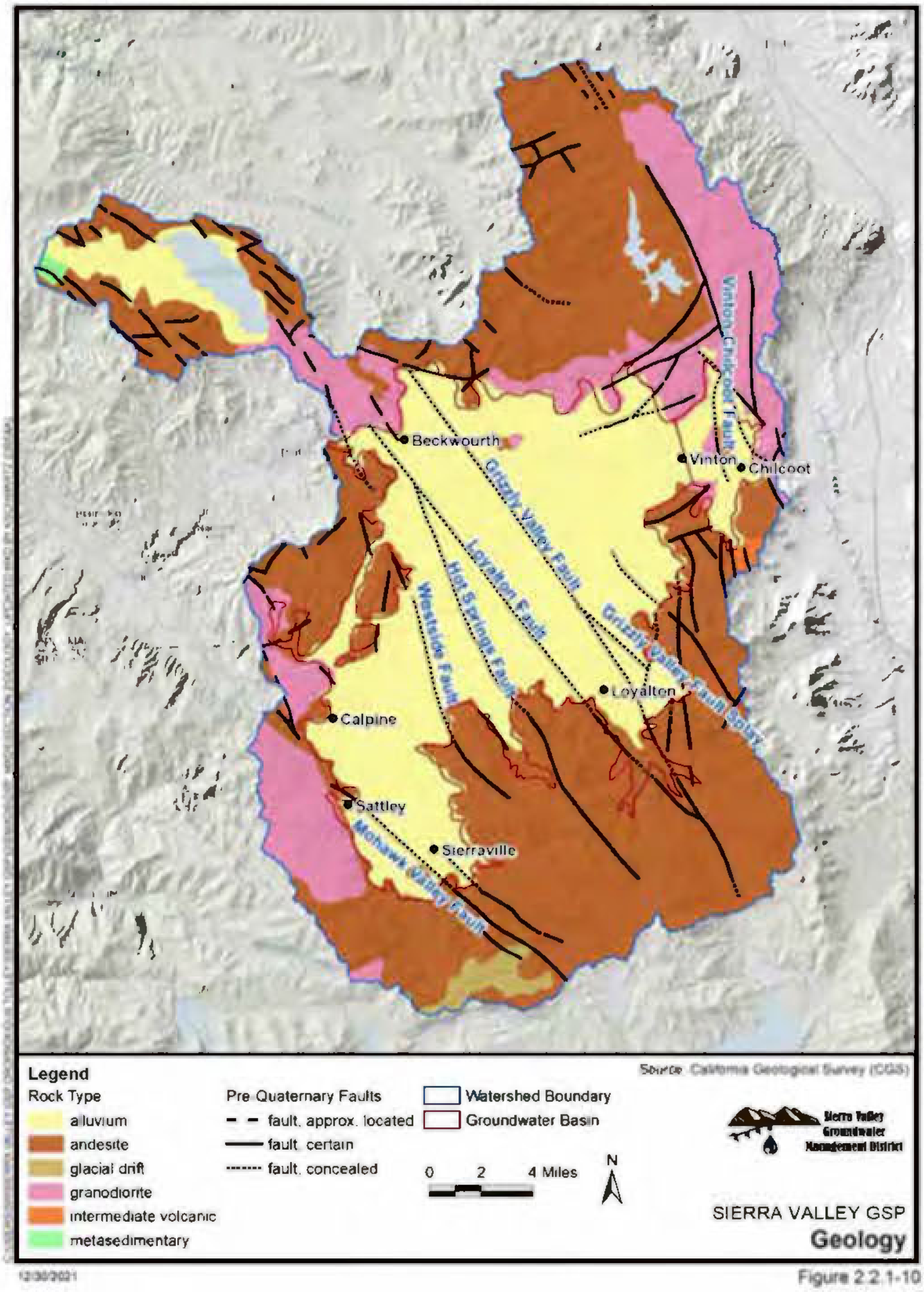
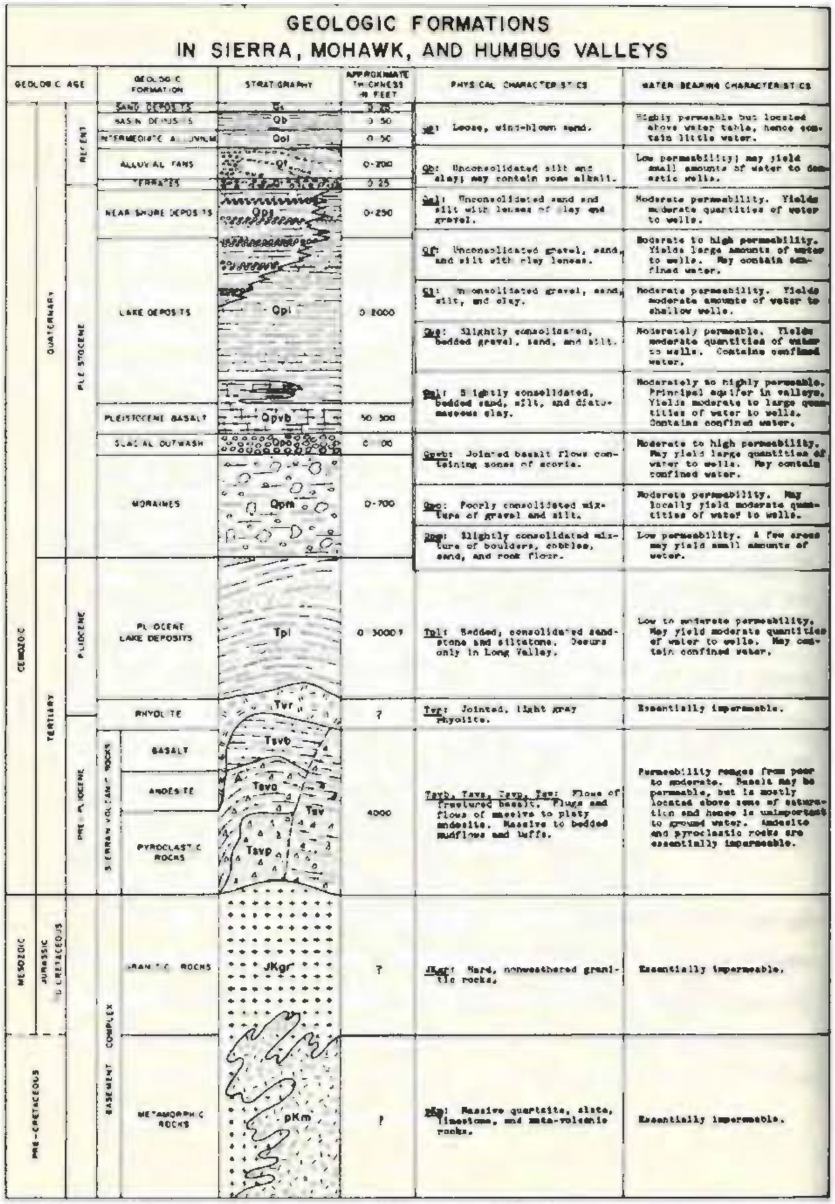


Figure 2.2.1-11: Stratigraphic Column of Sierra Valley



Notes:
1. Table 13 in DWR (1963)

Sierra Valley Groundwater Management District

SIERRA VALLEY GSP

Stratigraphic Column of Sierra Valley

12/30/2021

Figure 2.2.1-11

Figure 2.2.1-12: Generalized Cross Sections

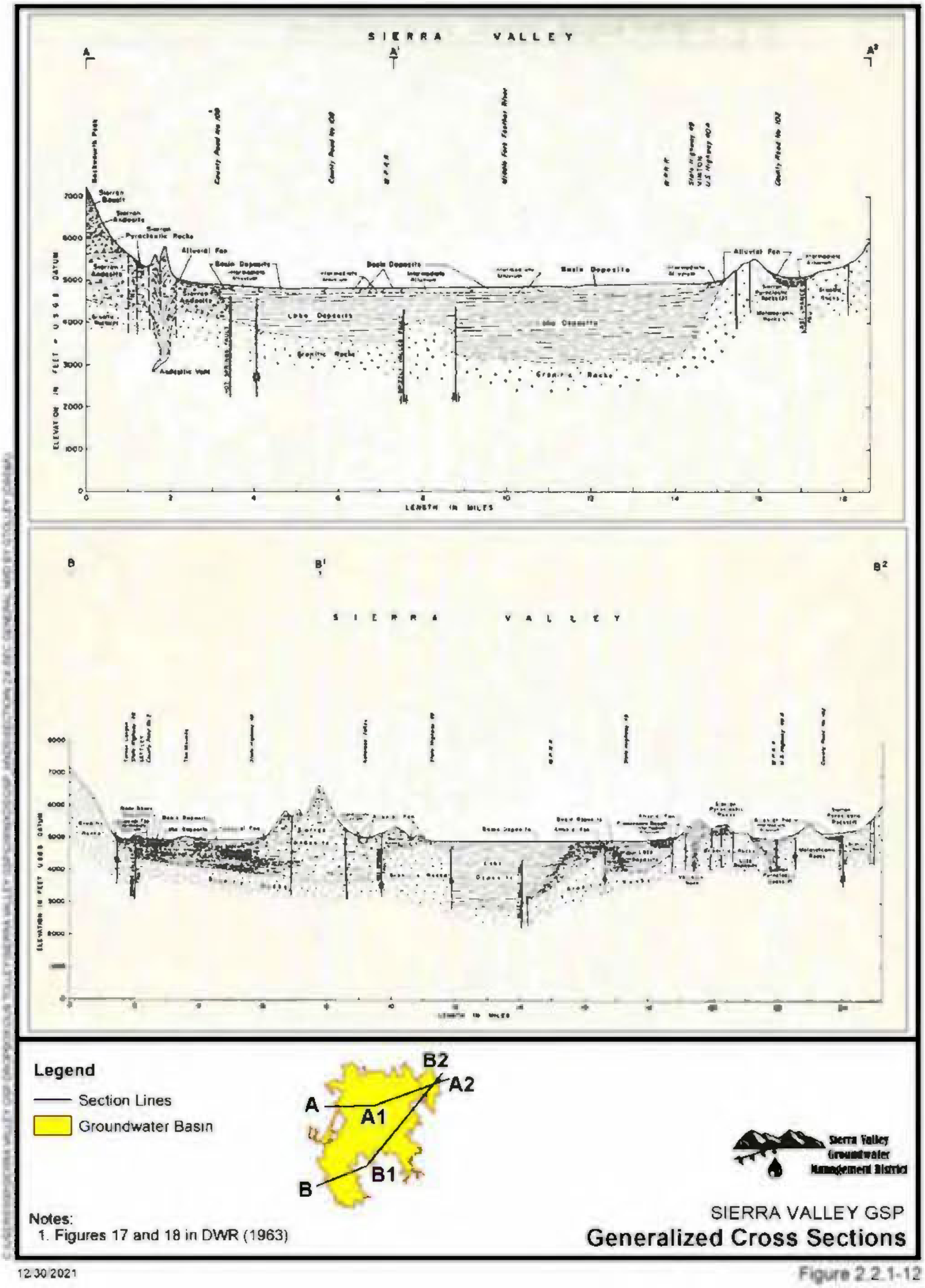
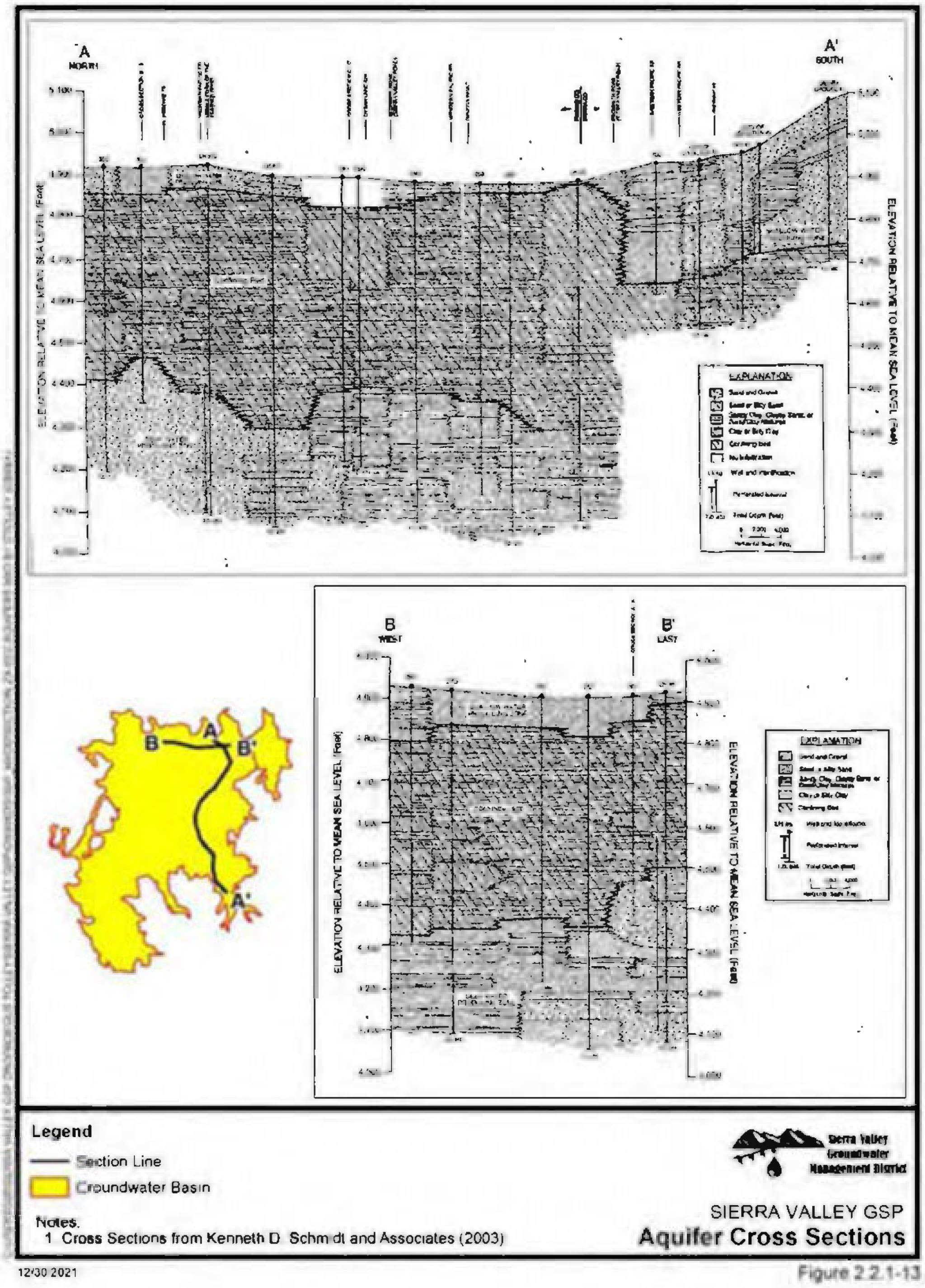


Figure 2.2.1-13: Aquifer Cross Sections



Approximately 10,000 years ago outflow from the lake eroded a gap to the west and slowly emptied, forming the present-day headwaters of the MFFR.

Sedimentary deposits found in Sierra Valley vary in origination, weathering methods, and particle size distribution that range in age from Pleistocene to Recent. Pleistocene lake deposits underlie a thin layer of recent sediments throughout the valley floor and outcrop around the basin perimeter. The lake deposits vary in thickness (up to 2,000 feet) and grade from generally coarse-grained around the basin perimeter to finer in the central valley. Probable reasons for this variability include diversity in upland rock lithology, local tributary sediment input, slow filling of the lake, lake level fluctuations corresponding to seasonal and longer-term climatic variations, and topographic changes caused by erosion and seismic activity (DWR,1983). A few small Pleistocene glacial moraines exist around Sierraville. Recent alluvial fan deposits occur around the margins of the valley adjacent to highland areas, predominantly where streams enter the valley floor. Up to 200 feet thick, the alluvial fan deposits consist of stratified, poorly sorted sand, gravel, and silt layers, with occasional clay lenses. Recent alluvium up to 50 feet thick is found along stream channels and slightly elevated areas in the center valley and 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. Extensive recent basin deposits consisting of clay and silt are found throughout Sierra Valley that are up to 35 ft thick and overlie the Pleistocene lake deposits. In the northeastern corner of the valley there are unconsolidated, fine-grained recent sand deposits representing an area of once active sand dunes that have stabilized and are now vegetated.

Sierra Valley lies among one of the most faulted regions in California with regional strike-slip and normal faulting. The area is dominated by northwest and northeast striking faults. Boundary faults define the basin periphery and act as permeable barriers. It is suspected many normal faults propagate into the underlying basement rocks, resulting in substantial variations in the thickness of valley sediments with estimates ranging from 800 feet below ground surface (bgs) to 2,000 feet bgs (DWR, 1963). The primary faults and fault zones that are suspected to dissect the basin are identified differently by various individual sources. For the purpose of this document, we will use the identifications shown in Figure 2.2.1-10 and described below.

The Grizzly Valley Fault Zone consists of a left lateral high angle normal fault striking northwest. It divides the basin into a southwestern one-third section and northeastern two-thirds section and acts as a potential barrier to groundwater flow. The fault zone is approximately 10 miles long and 1 to 2 miles wide and is traced from Mapes Canyon (north of Beckwourth), along Smithneck Creek and into Sardine Valley. The eastern lineament of the fault zone is identified as Grizzly Valley Fault. The western lineaments are identified as Hot Springs Fault and Loyalton Fault. Hot Springs Fault parallels Grizzly Valley Fault approximately 3 miles to the southwest. A number of springs occur along this and other faults in the area that act as barriers to flow across the fault plane. Loyalton Fault is located between Grizzly Valley Fault and Hot Springs Fault and is traced from Smithneck Creek Canyon to a point west of Beckwourth, where it apparently merges with Hot Springs Fault. These two faults are mostly strike-slip faults and with a significant dip-slip component (Bohm, 2016). An additional fault southwest of Hot Springs Fault has been identified as Westside fault and assumed as part of the fault zone.

Mohawk Valley Fault Zone defines much of the topography of the uplands west of Sierraville and Sattley (Bohm, 2016). The northwest striking 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).

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 (Berry, 1979). The most recent was a magnitude 4.7 that occurred on May 6th, 2021, about 20 miles south of the basin.

2.2.1.6 Hydrogeologic Framework

Sierra Valley and the surrounding uplands support the MFFR headwaters and provide water to Lake Oroville as part of the California State Water Project (SWP). Many named and unnamed streams enter the Sierra Valley subbasin (Figure 2.2.1-2) creating a large braided stream and irrigation canal network on the valley floor. These stream flows are fed seasonally by rainfall, snowmelt, and groundwater discharge. The western portion of the valley receives greater precipitation and has more surface water than the eastern valley. Appropriative and riparian water rights holders divert most of eastern stream flow during summer, such that the downstream stretches usually dry out completely before confluence with the western channels (Vestra, 2005, Bohm 2016). Releases from Frenchman Lake and water from the Little Truckee River Diversion support valley irrigation during the growing season (DWR, 1983). Many of these tributaries drain the valley as they connect to the headwaters of MFFR through a water gap in the northwestern corner of the Sierra Valley watershed.

Table 2.2.1-2: Historical Streamflow Summary for Tributaries to MFFR

Stream Name	Average Flow (CFS)	Average Discharge (AF/Year)	Percent of MFFR Discharge (Measured near Portola)	Record Period	Monitoring Agency
Smithneck Creek	11.1	8,076	4.5%	1937 - 1966	DWR
Bonta Creek[1]	39.0	28,224	16%	1940 - 1959	DWR
Berry Creek	11.3	7,838	4.4%	1940 -1967, 1971 - 1983	DWR, USGS
Little Truckee Diversion[2]	19.4	7,039	4.0%	1937 - 1966	DWR
Little Last Chance Creek	26.8	19,400	11%	1959 - 1979	USGS
Little Last Chance Creek	20.4	14,770		2000 - 2020	DWR
Big Grizzly Creek	34.7	25,100	14%	1926 - 1931, 1951 - 1952, 1955 - 1979	USGS
Big Grizzly Creek	10.7	7,737		2000 - 2020	DWR
Middle Fork Feather River (MFFR)	246	177,800	100%	1969 - 1979, 2007 - Present[3]	USGS

1. Gauge location unclear, may include Cold Stream
2. Diversion is open no longer than 6 month irrigation season, often less, and feeds into Cold Stream
3. Recent MFFR data not included in average calculation

The only active flow monitoring station in Sierra Valley is the MFFR station near Portola. Table 2.2.1-2 provides a summary of historical stream flow for tributaries to the MFFR and respective percentages of gauged MFFR discharge. This table was modified from Bachand and Carlton (2020) to include flows measured since 2000 by DWR at Frenchman reservoir to Little Last Chance Creek and at Davis reservoir to Big Grizzly Creek. The sum of historically gauged discharge in the valley only accounts for about 45% of gaged MFFR discharge, likely due to inflows from ungaged streams in the western valley where greater precipitation occurs and groundwater-surface water connections occur (Bohm, 2016) as well as mountain front recharge that enters the groundwater basin from fractures in the surrounding bedrock (Bachand and Associates, 2020). Total average annual MFFR discharge of 177,800 AF was measured at the Portola station downgradient of the Sierra Valley groundwater basin. Total MFFR discharge from Sierra Valley Subbasin equals 157,700 AF since 25,100 AF of the total gauged discharge at Portola is attributed to Big Grizzly Creek. Big Grizzly Creek, supplied by Lake Davis, enters the groundwater basin less than a mile from the outlet and, therefore, does not have a significant impact on groundwater conditions in Sierra Valley.

Little Last Chance Creek, supplied by Frenchman Lake, and Smithneck Creek are the main perennial creeks that spread across the eastern basin and feed the many braided channels to the west. Little Last Chance Creek and Smithneck Creek annually contribute approximately 19,400 AF and 8,076 AF, respectively, to the valley surface water in the eastern portion as regulated discharge from Frenchman Lake (55,477 AF capacity).

Several creeks enter the valley from the west and southern uplands, where rain is more significant, and are the primary source of MFFR outflows from the basin. Webber Lake supplies the Little Truckee River, which diverts imported water into the Sierra Valley via the Little Truckee Diversion Canal. Bonta Creek (may include Cold Stream flow), Berry Creek, and Little Truckee Diversion Canal contribute a total of about 42,000 AF annually as surface water flow into Sierra Valley.

There are at least 5,000 acres of seasonal and perennial flooded wetlands on the valley floor, the largest being a 3,000-acre fresh emergent wetland (Vestra, 2005). For example, the area of the valley surrounding Island Ranch (north of the channel through which Smithneck Creek flows through the southeastern portion of the valley) is commonly inundated with water well into summer.

Inflows to the Sierra Valley groundwater system are primarily sourced from infiltration of surface-water in the alluvial fans at the periphery of the valley from adjacent uplands and flow from the fractured bedrock in contact with the shallow and deep aquifers (Bohm, 2016). A small amount of recharge is likely derived from direct precipitation on fan surfaces, deep percolation from irrigated agricultural fields, seepage from losing reaches of tributaries, and irrigation ditches in the valley. Recharge areas tend to be high elevation areas with underlying soils and geologic formations containing sufficient hydraulic conductivity and the right combination of climate. The eastern part of basin is drier and pumped significantly more, creating substantial changes in storage and room for recharge. The western portion experiences more precipitation and minor changes in storage, producing more runoff. Groundwater elevation data show that the Chilcoot sub-basin, south valley, and Smithneck Creek drainage are main groundwater supply sources (Bohm, 2016). Upland recharge centers may provide significant recharge into limited portions of the Sierra Valley Subbasin aquifers by distinct zones of high permeability fractured rock. Bohm (2016) identified nine recharge centers supplying Sierra Valley using groundwater quality and isotopic data and general (Figure 2.2.1-14). Little Truckee Summit, Yuba Pass, and Dixie Mountain (connection via Frenchman sub-basin) were identified as likely the three most significant recharge areas for the Sierra Valley (Bohm, 2016).

Most natural groundwater discharge occurs on the valley floor in the form of evapotranspiration (ET), direct surface evaporation, outflowing reaches of streams, natural springs, seeps, and wetlands. Approximately 70 to 80% of the watershed's total water budget is lost to evapotranspiration (Vestra, 2005). Springs and wetlands are found around the edges of the valley floor and are generally more abundant in the southwestern portions of the valley, where the uplands receive significantly more precipitation. Some exist along the northern valley perimeter, likely fed by the relatively large upland recharge areas that exist north of the valley (Bohm, 2016). 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. 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 DWR (1983).

The Sierra Valley subbasin is a fault-trough basin that has been filled with various lacustrine and fluvial sediment, which comprise the primary aquifers of the basin and are the source of most of the areas pumped groundwater. The trough floor is characterized by several subsiding fractured volcanic and granitic bedrock blocks. The basin boundaries are generally delineated by the contact between the basin fill and adjacent bedrock units created by deposition or faulting. These two hydrostratigraphic units will be referred to as the "basin fill unit" and "bedrock unit" for the purpose of this report. Well drilling records and gravity surveys conducted by DWR in 1960 indicate depth to bedrock up is to 1,500 feet in the central basin, with sediment thickness along the periphery of the basin being no more than a few hundred feet. Some deeper sediments near centrally located geothermal areas have been lithified by low grade hydrothermal alteration, resulting in a shallower aquifer system in these areas.

The basin fill unit contains the primary water-bearing formations in Sierra Valley and includes Holocene sedimentary deposits, Pleistocene lake deposits, and Pleistocene lava flows. Fine grained sediments generally dominate the central portion of the groundwater basin, whereas coarse grained sediments are found along the margins of the valley and represent the former lake shoreline (Bohm, 2016). As the faulted basin has continued to subside the older layers have become increasingly curved with depth, whereas recent (shallow) deposits are relatively flat lying. Alternating non-contiguous layers of clay, sand and silt are in lenticular form, and do not necessarily cover the entire basin. Low-permeability fine-grained layers separating aquifers are thinner to non-existent near the valley periphery. (Bohm, 2016). Although "shallow" and "deep" aquifer terms have been historically adopted by DWR, analysis of data from drilling records, water level response, groundwater chemistry and groundwater temperature studies do not necessarily indicate two distinctive aquifers throughout the groundwater basin. Parts of a deep aquifer zone may be pressurized by confining low-permeability layers (Bohm, 2016), although extent and isolation between shallow and deep aquifer zones likely vary throughout the Sierra Valley subbasin (Schmidt, 2005 and Bohm, 2016). Very few pumping test data are available for the basin fill unit. As shown in Table 2.2.1-3 from Bohm (2016), reported hydraulic conductivities range from 36 to 69 gpd/ft^2, with an anomalous 375 gpd/ft^2 for the basin fill.

Table 2.2.1-3: Summary of Basin-Fill Aquifer Parameters

Aquifer parameters in valley fill formations														
Pumpingtest results, Sierra Valley														
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)

The bedrock units underlying the basin fill units are characterized by secondary (fracture) permeability and porosity. Except for the highly permeable fault zones, the bedrock unit is deemed impermeable for all practical purposes (Bohm, 2016). A number of pumping tests in the bedrock have been conducted in the basin periphery. Aquifer parameters determined are highly variable dependent on the number of fractures intersected and rock's material ability to hold open fractures and joints with seismic activity. The estimated bedrock hydraulic conductivity is about three orders of magnitude smaller than the sedimentary basin fill in Sierra Valley. Bedrock aquifer parameters are included in Table 2.2.1-4 from Bohm (2016).

The principle geologic structures affecting groundwater flow are the basin's bedrock boundaries and faults in the valley-fill material. The bedrock underlying the basin is generally impermeable relative to the valley fill sediments, with the exception of zones where faulting has significantly increased the secondary permeability. Generally, the northwest striking faults can act as partial barriers to groundwater flow, while northeast striking normal faults can possibly act as conduits for groundwater flow (Bohm, 2016). Evidence of faults acting as groundwater flow barriers includes emergence of springs along fault traces and changes in water level elevations across faults. Well level data suggests the northwest trending Grizzly Valley Fault Zone impedes horizontal flow along the eastern gradient, although the impediment may not be contiguous along the entire length of the lineaments (Bachand and Associates, 2020). Northwest striking Mohawk Fault Zone acts as a barrier between the Sierra Valley groundwater basin and Mohawk Valley groundwater basin, with about a 500 foot groundwater level difference between the basins (Bohm, 2016).

Table 2.2.1-4: Summary of Bedrock Aquifer Parameters

Bedrock aquifer parameters Sierra Valley bedrock aquifers from selected well tests									
			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 Est:	FLRE 1	granite	265	1162	T measured	4.4	0.179	2.1E-06	Juncal & Bohm, 1986)
Frenchman Lake Road Est:	FLRE 2	granite	254	27	T measured	0.1	0.004	5.1E-08	Juncal & Bohm, 1986)
Frenchman Lake Road Est:	FLRE-3	granite	96.74	13	T measured	0.1	0.005	6.3E-08	Juncal & Bohm, 1986)
Frenchman Lake Road Est:	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	

Water supply sources include groundwater and surface water. Groundwater accounts for 36% of the total (DWR, 2019). Irrigated agriculture is the primary groundwater use in the Sierra Valley. Since 1989, agricultural groundwater extraction rates have been metered by SVGMD. An average annual pumping volume of 9,150 acre-feet for irrigation use occurred between 2008 and 2019 based on data from SVGMD. Agricultural pumping ranges are substantially influenced by precipitation and snowpack. Only approximately 6% of the total number of wells in Sierra Valley are irrigation wells, however they have a high pumping capacity. Total municipal annual pumping for residential water supply in Sierra Brooks, Calpine, and Loyalton averages 670 acre-feet based on data spanning 2008 through 2019 from SVGMD. Most domestic pumping in the Sierra Valley occurs along the margin of the valley with many wells completed in bedrock outside of the groundwater basin boundary.

Surface Water Diversions are managed by the area Watermaster and 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

2.2.1.6.1 Summary of available surface water data

Surface water monitoring is limited within the Sierra Valley watershed and the groundwater basin. The following are locations where surface water data is being actively collected. See Figure 2.2.1-14 and Figure 2.2.1-15 for locations maps of surface water monitoring stations.

- Frenchman Reservoir daily outflow data
- Davis Reservoir daily outflow data
- Little Truckee Diversion daily flow data during the irrigation season
- Middle Fork Feather 15-minute flow data
- Various streams and springs with periodic measurements during the irrigation season (see Table 2.2.1-5 for a better summary of this data)
    - Cold Stream
    - Webber
    - Lemmon
    - Spring East
    - Spring West
    - Fletcher
    - Turner
    - Berry (Miller)
    - Hamlin
    - Parshall 180
    - Smithneck
    - Staverville

Surface water monitoring is presently focused near and outside of the groundwater basin margin. There are no continuous stream flow monitoring locations within the central portion of the Valley. The data being collected by the DWR Watermaster for the Sierra Valley is only done in preparation for and during the irrigation season on up to 12 different tributaries that flow into the Valley. It is important to differentiate these periodic instantaneous measurements during the irrigation season from year-round continuous stream flow gaging, such as that which takes place on the Middle Fork Feather River presented earlier in Table 2.2.1-2. The periodic flow measurements are made solely for the purpose of determining surface water deliveries based on allocations defined by established water rights, and measurements are taken manually with a flow meter or by observing stage in an installed weir. Because of the discontinuous nature (only during the irrigation season) and infrequency of measurements (weekly at best), the data collected by the Watermaster can not be used for more in-depth analysis such as volume calculations or flood-frequency analysis. Table 2.2.1-5 summarizes the data collected by the Sierra Valley Watermaster since 2007.

Figure 2.2.1-14: Streams Monitored by the Sierra Valley Watermaster during the Irrigation Season

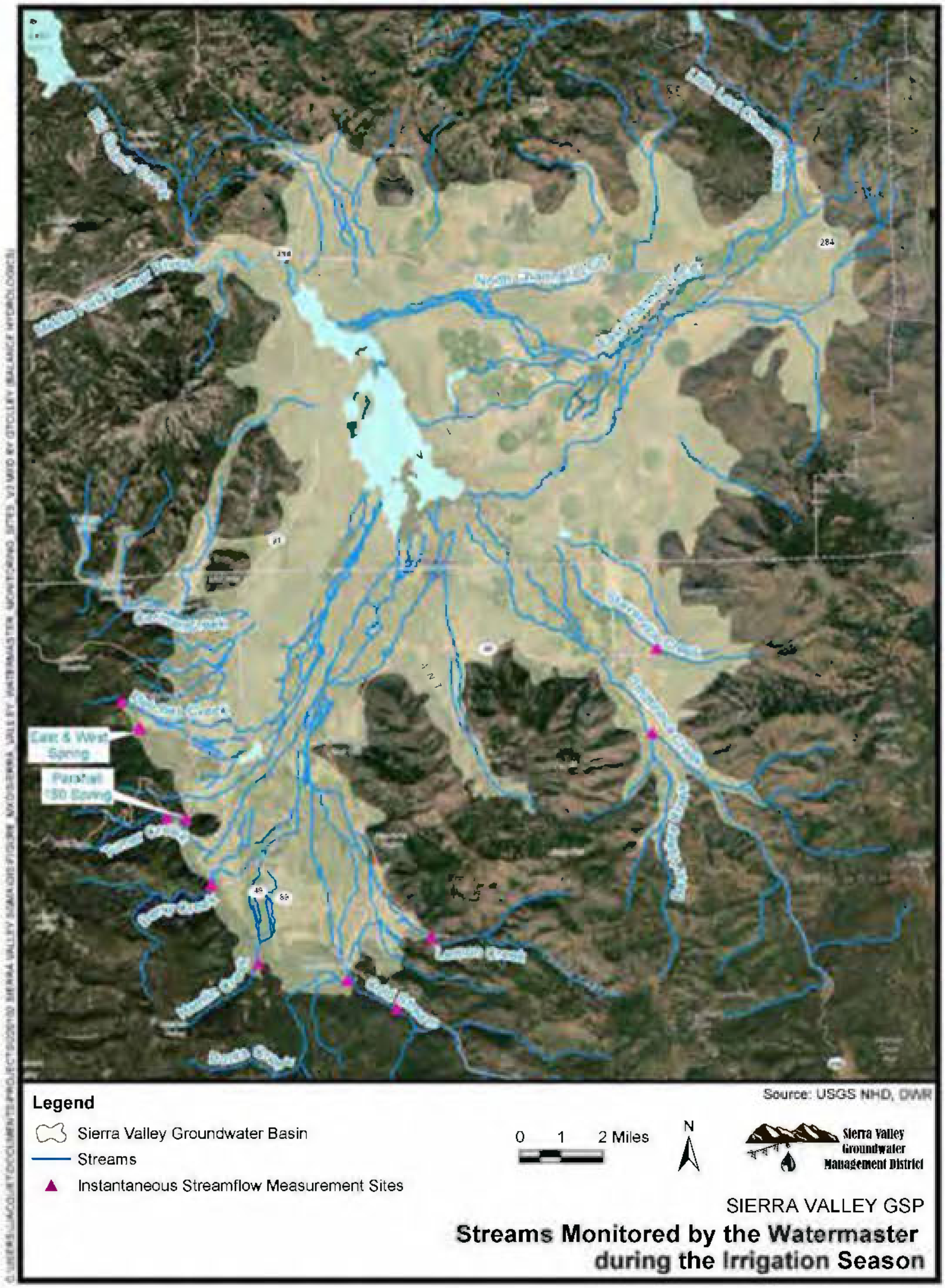


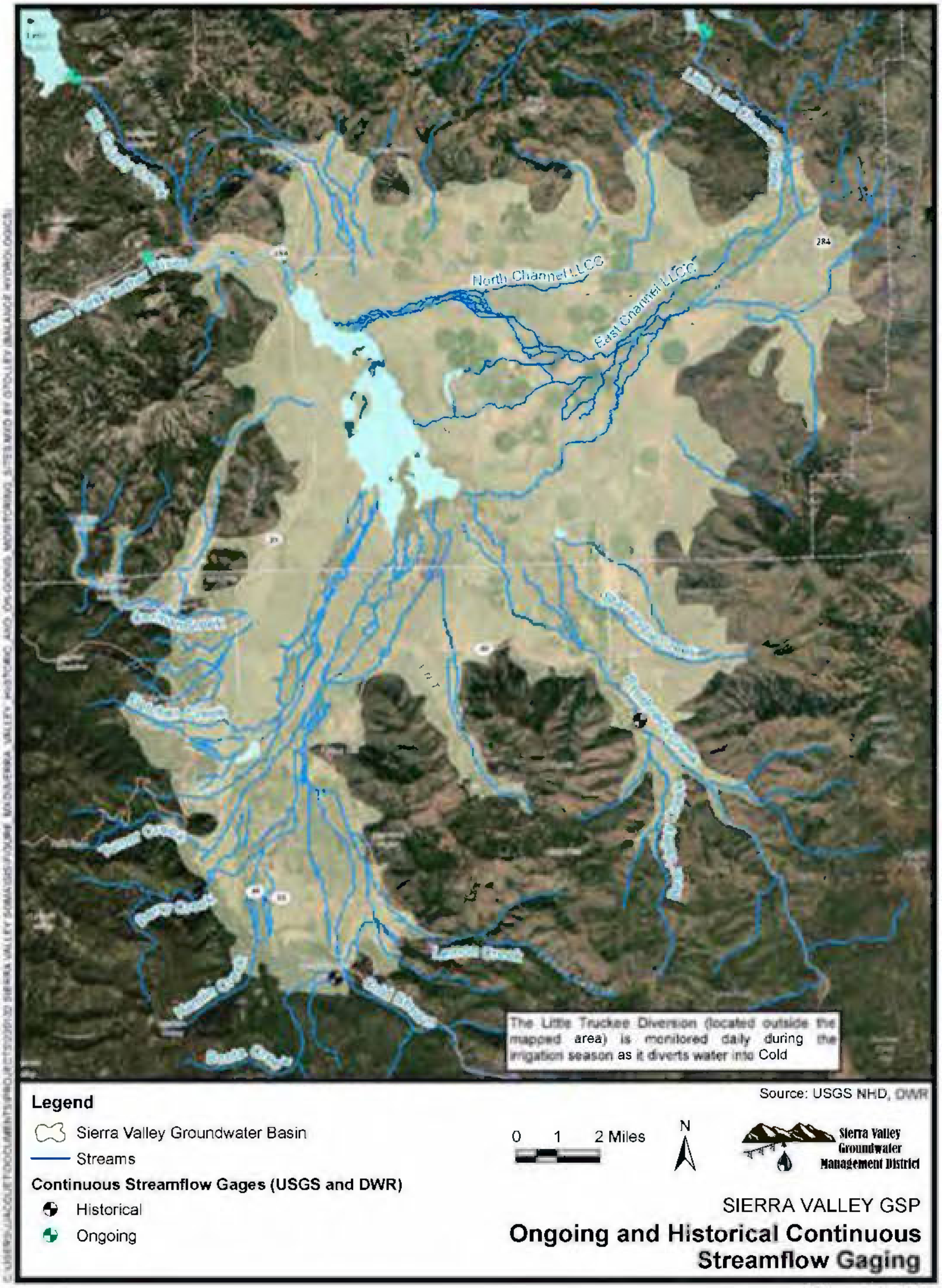
Table 2.2.1-5: Streamflow Measurements

Stream Name	Total No. of Observations	Stage Readings	Flow Measurements	Period of Record	Average Flow of All Observations (cfs)
Cold Stream	124	4	120	4/2007-9/2020	36.1
Webber	114	14	100	7/2007-9/2020	17.8
Lemmon	21	0	21	5/2009-9/2020	7.3
Spring East	22	11	11	6/2018-9/2020	0.9
Spring West	22	10	12	6/2018-9/2020	0.9
Fletcher	49	15	34	7/2011-9/2020	4.2
Turner	81	16	65	5/2009-9/2020	5.6
Berry (Miller)	89	0	89	4/2007-9/2020	14.6
Hamlin	74	0	74	4/2007-9/2020	13.0
Parshall 180	48	0	48	3/2015-9/2020	0.8
Smithneck	54	0	54	7/2008-9/2020	13.4
Staverville	7	0	7	3/2019-9/2020	3.9

Based on the available flow measurements, Cold Stream is the most significant water delivery to the Valley as that measurement also includes flow from the Little Truckee Diversion. Webber, Berry, Hamlin, and Smithneck also appear to be significant sources of surface water to the Valley; however, the discontinuous and periodic measurements during the irrigation season and do not represent the full range of hydrologic conditions in the streams.

Historically, a greater number of area streams were monitored continuously by the USGS or DWR. In the past stream flow data has been collected on Smithneck Creek near Loyalton, Bonta Creek near Sierraville, Berry (Miller) Creek near Sattley, and Little Last Chance Creek near Chilcoot (Vestra, 2005; Bachand and Associates, 2019).

Figure 2.2.1-15: Ongoing and Historical Continuous Streamflow Gaging or Reservoir Outflow for the Sierra Valley



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

Per Reg. § 354.16, this section includes:

- Groundwater elevation data
- Estimate of groundwater storage
- Seawater intrusion conditions
- Groundwater quality
- 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.

2.2.2.1 Groundwater elevation data

2.2.2.1.1 Introduction to Groundwater Elevations

Groundwater elevation (measured as the vertical distance above mean sea level) is the primary measure for tracking the sustainability of groundwater management. Simply stated, when more groundwater is extracted than recharged over a long-term period, groundwater elevations decrease. Depending on the magnitude and duration, groundwater elevation declines can pose risks such as land subsidence, drying of shallow wells, migration of pollutants in groundwater, and decreased extent, duration, and/or quality of groundwater dependent ecosystems. Conversely, when groundwater is sustainably managed, groundwater elevations will show seasonal or interannual fluctuations indicative of wet and dry years, but long-term averages groundwater elevations will remain stable. Because of the fundamental importance of groundwater elevations from the perspective of groundwater management sustainability, the relationship between groundwater elevations and other sustainability indicators, and the relative ease of data collection, groundwater elevations are generally considered the most telling indicator of groundwater management sustainability.

2.2.2.1.2 Summary of Groundwater Elevations in the Sierra Valley

Based on the comments provided by DWR as part of their basin prioritization (DWR, 2019), DWR's interpretation of groundwater levels in SV Subbasin can be summarized as follows: the majority of long-term SV Subbasin hydrographs along the periphery of the basin are relatively stable, with wells in the central basin showing declining groundwater levels. Groundwater level trends for select monitoring wells are displayed in Figure 2.2.2-1. The trend of groundwater level change ranges from deep red for high rates of declining to deep blue for high rates of increasing levels. The well levels are generally slightly increasing to slightly decreasing, with wells in the central portion of the basin showing the greatest decline. Trends for six of the wells are displayed on the right side of the figure. Wells with greatest declines generally have high seasonal variability corresponding to seasonal irrigation use. Groundwater level trends are shown for shallow and deep wells in Figure 2.2.2-2. As noted in the figure, the trends for the majority of wells are between +1 and -1 ft/yr.

Average spring measurements of groundwater levels for 2013-2016 are presented in Figure 2.2.2-3. These levels represent recent conditions during dry and critically dry years reflective of minimal wet-season recharge. More recent dry conditions can be compared to these levels as the data becomes available. Figure 2.2.2-4 is a depiction of the water levels averaged over 2013-2016 fall measurements. Comparing the two figures provides a basis for evaluating the effect of groundwater use during dry periods and the ability of the basin to recharge under dry water years. The eastern, and especially the north-eastern, portion of the basin experiences the greatest depression of groundwater levels over the irrigation season, and the western portion of the basin remains relatively stable.

Figure 2.2.2-1: Sierra Valley Groundwater Level Trends

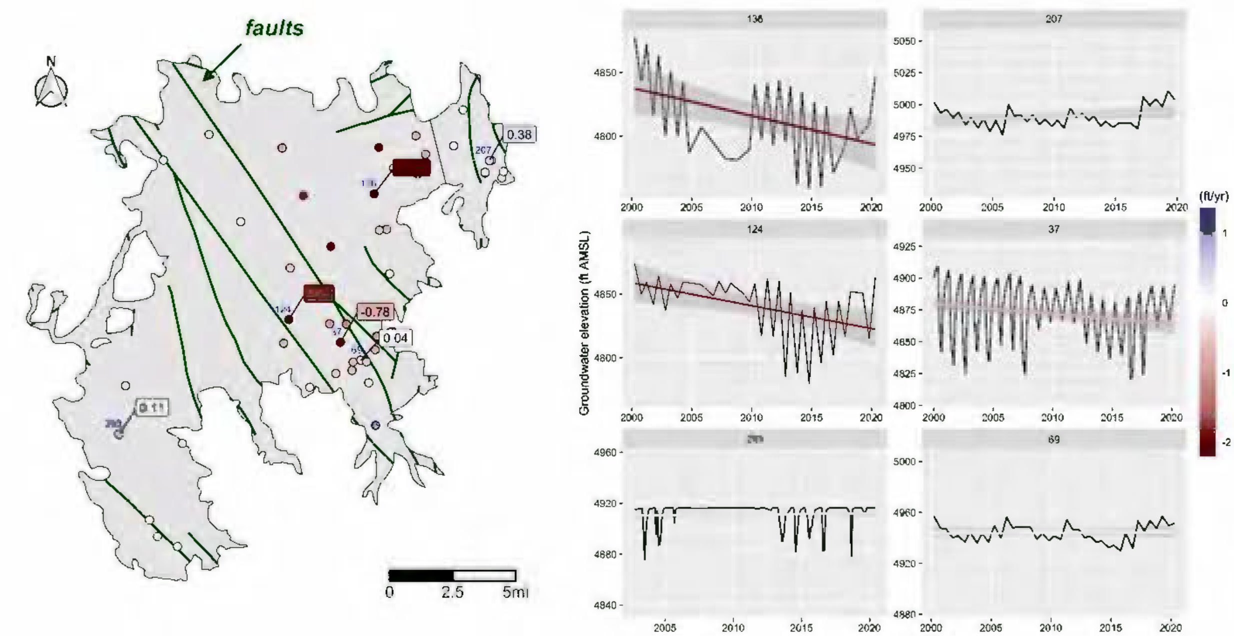


Figure 2.2.2-2: Sierra Valley Groundwater Level Trends for Deep and Shallow Wells

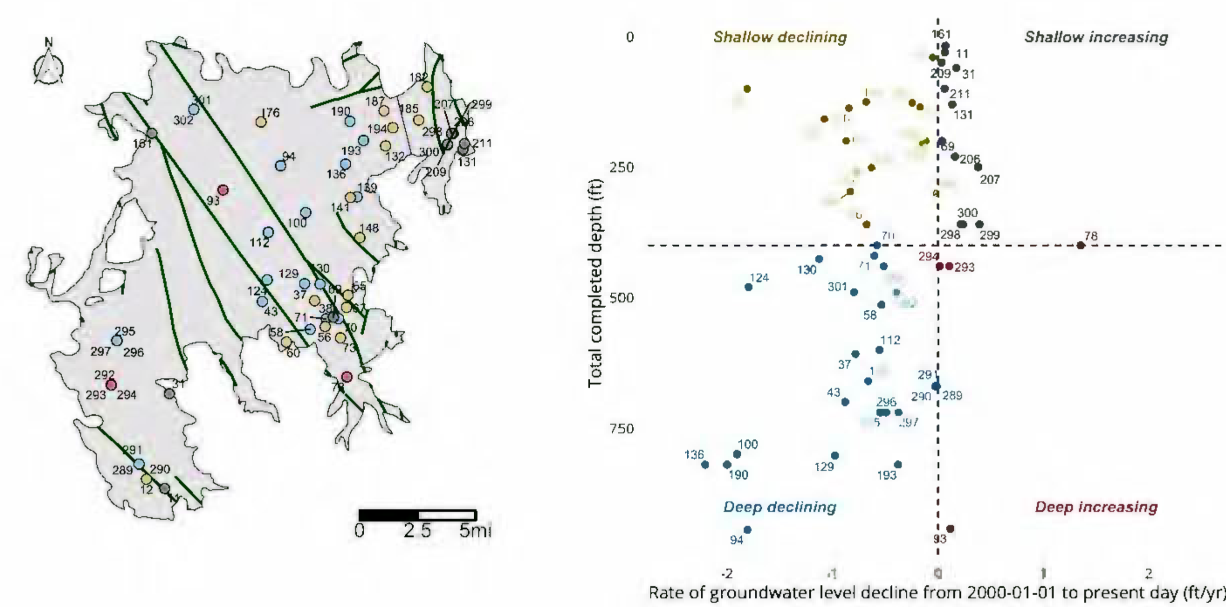


Figure 2.2.2-3: 2013-2016 Spring Average Sierra Valley Groundwater Levels

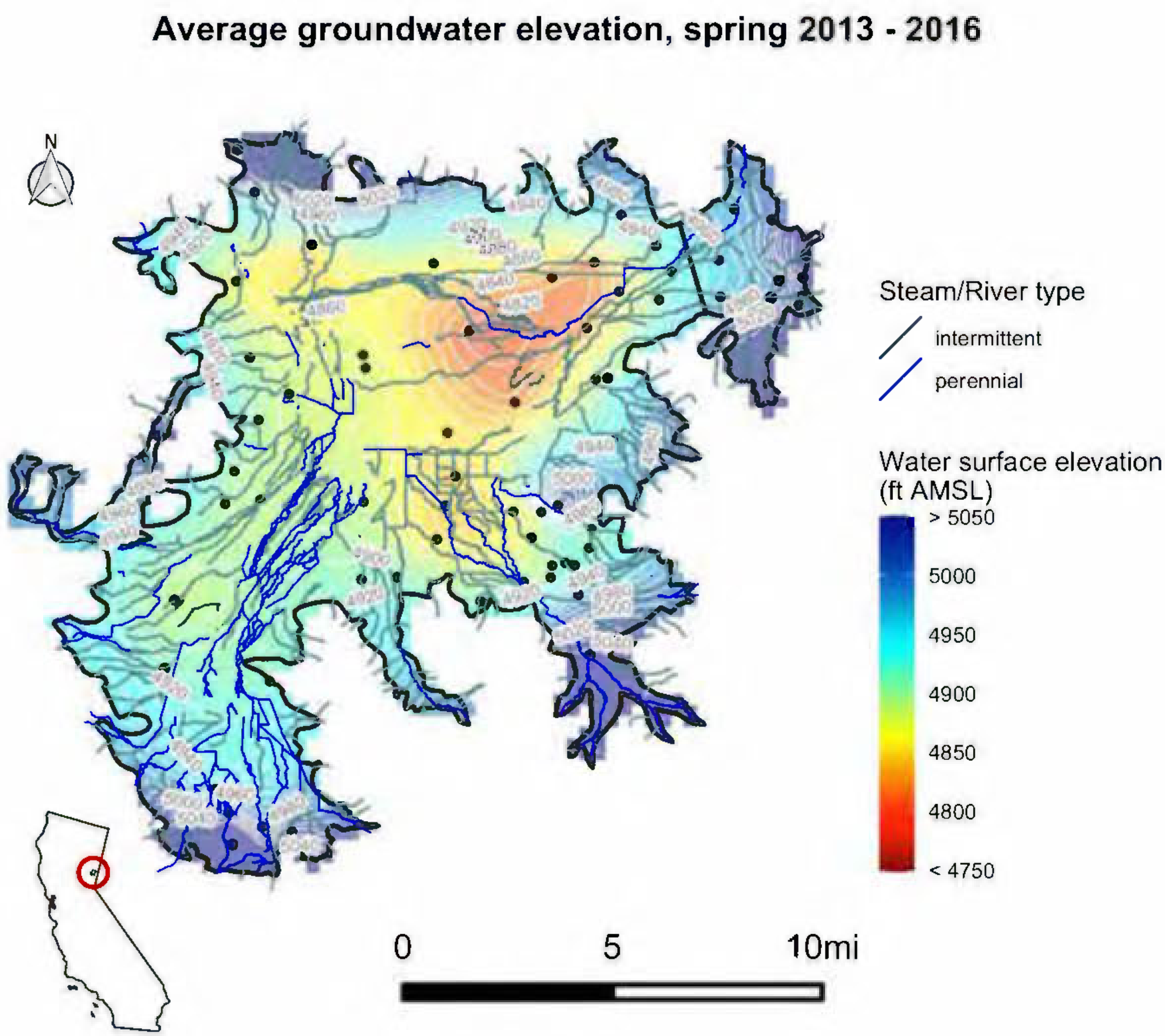
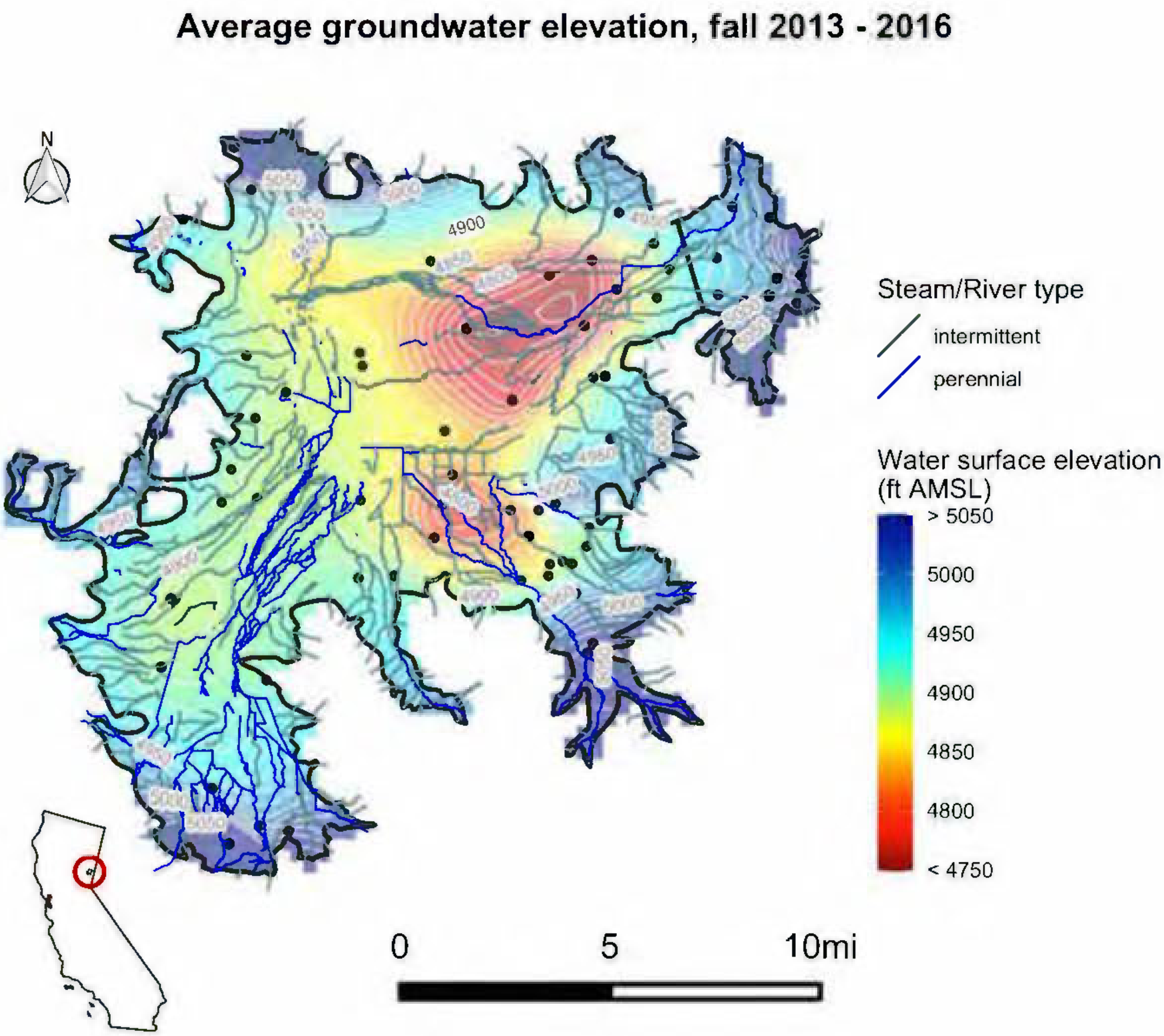


Figure 2.2.2-4: 2013-2016 Fall Average Sierra Valley Groundwater Levels



2.2.2.2 Estimate of groundwater storage

The 3D geologic model developed for the Sierra Valley currently estimates total sediment volume in the groundwater basin to be 21.1 mi^3 (88.1 km^3), with a total groundwater storage capacity of approximately 22,000 TAF (Table 2.2.2-1). Accessible groundwater in storage is estimated to be 3,100 TAF, calculated from SVHSM using simulated specific yield.

Table 2.2.2-1: Summary of Sierra Valley Storage Volume

Lithology	Volume (m^3)	Volume (mi^3)	Volume (km^3)	Percentage (%)	Typical Porosity (-)	Storage Volume (TAF)
Sand and Gravel	5.80E+09	1.4	5.8	7%	0.25	1,175
Silty Clayey Sand and Gravel	3.69E+09	0.9	3.7	4%	0.2	599
Sandy Gravelly Silt and Clay	1.78E+10	4.3	17.8	20%	0.3	4,335
Silt and Clay	3.06E+10	7.3	30.6	35%	0.5	12,396
Tuff	1.76E+08	0.0	0.2	0%	0	0
Unknown	3.01E+10	7.2	30.1	34%	0.15	3,658
Total	*8.81E+10*	*21.1*	*88.1*			*22,162*

1. *Unknown lithology represents areas of model where lithology cannot be determined due to limited data*
2. *Typical porosity used for determination of total volume of water in storage. This differs from the effective porosity, which is typically lower, that was used in SVHSM.*

2.2.2.3 Seawater intrusion conditions

The SV Subbasin is not located in a coastal area, therefore, seawater intrusion conditions are not applicable to this GSP.

2.2.2.4 Groundwater quality

SGMA regulations require that the following be presented in the GSP, per §354.16 (d): 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.

2.2.2.4.1 Basin Groundwater Quality Overview

Water quality includes the physical, biological, chemical, and radiological quality of water. An example of a biological water quality constituent is E. coli bacteria, commonly used as an indicator species for fecal waste contamination. Radiological water quality parameters measure the radioactivity of water. Chemical water quality refers to the concentration of thousands of natural and inorganic and organic chemicals. All groundwater naturally contains some microbial matter, chemicals, and usually has a low level of radioactivity. Inorganic chemicals that make up more than 90% of the total dissolved solids (TDS) in groundwater include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}) and sulfate (SO_4^{2-}) ions.

When levels of one or more constituents become a concern for either ecosystem health, human consumption, industrial or commercial uses, or for agricultural uses, the water quality constituent of concern becomes a “pollutant” or “contaminant”. Groundwater quality is influenced by many factors – polluted or not – including elevation, climate, soil types, hydrogeology, and human activities. Water quality constituents are therefore often categorized as “naturally occurring”, “point source”, or “non-point source” pollutants, depending on whether water quality is the result of natural processes, of contamination from anthropogenic point sources, or originates from diffuse (non-point) sources that are the result of human activity.

Groundwater in the Subbasin is generally of good quality and meets local needs for municipal, domestic, and agricultural uses. The high-quality water is derived from the large amount of snowmelt runoff from the surrounding mountains that recharges the groundwater aquifer and the limited amount of industry in the Subbasin. A wide range of water types exist in the Subbasin, a pattern that is symptomatic of groundwater chemistry evolution in silicate rocks and sediments under various elevated groundwater temperatures (up to 174ºF was reported by GeothermEx, 1986). The Subbasin ranges from comparatively low percentages of chloride, sulfate, sodium, and potassium plotting in the southwest to high percentages of the same constituents in the northeast. As described in more detail below and in Appendix 2-6 (Water Quality), TDS ranges between about 100 and 865 mg/L. Chloride and sulfate concentrations range between 1 to 230 mg/L and 1 to 360 mg/L, respectively. Nitrate as nitrogen concentrations are generally low, with no concentrations exceeding 5 mg/L since 1990.

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 (DWR, 1983). 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 (Bohm, 2016a). Boron concentrations in thermal waters have been measured in excess of 8 mg/L, and usually less than 0.3 mg/L at the Subbasin margin (DWR, 1983). Several wells in this area also have high arsenic and manganese concentrations. There is also a sodium hazard associated with thermal waters and some potential for problems in the central portion of the basin (DWR, 1983).

A recent groundwater quality assessment that analyzed 10 domestic wells and 5 agricultural irrigation wells for nitrate, boron, arsenic, and TDS was conducted in April of 2021 (UCCE, 2021). The assessment, which sampled each well once, found water to generally be of good quality. All nitrate samples were below the regulatory standard of 10 mg/L; 1 domestic well produced a boron result just above the California Notification Level; and 2 domestic wells resulted in TDS concentrations above the recommended secondary maximum contaminant level (SMCL) of 500 mg/L. Of the 15 wells, one domestic well produced elevated levels of arsenic above the primary MCL. This high concentration was attributed to the volcanic geology of the northern portion of the Subbasin in which it is located. Explanation of regulatory standards for water quality is provided in Section 2.2.2.4.4.

Ongoing monitoring programs show that some constituents, including TDS, boron, arsenic, and manganese exceed water quality standards in parts of the Subbasin. Exceedances may be caused by localized conditions and may not be reflective of regional water quality. Two points of concern raised by stakeholders within the Subbasin include: 1) higher levels of naturally occurring arsenic and manganese near Calpine; and, 2) possible water quality impacts from septic systems.

A summary of information and methods used to assess current groundwater quality in the Subbasin as well as the results of the assessment, are presented below. A detailed description of information, methods, and all findings of the assessment can be found in Appendix 2-6 – Water Quality Assessment.

2.2.2.4.2 *Existing Water Quality Monitoring Networks*

Most wells in the Subbasin are not regularly monitored for water quality, and it is uncommon for a well to be tested consistently between 1990 - 2020 for multiple constituents. Monitoring is most often driven by regulatory programs, and wells that are monitored on a regular basis (e.g., annually) are often municipal supply wells or monitoring wells. These wells are often located near the populated areas of Loyalton, Beckwourth, and Sierraville. As described in the following subsection, data collected through multiple agencies is used for analysis of water quality in the Subbasin.

2.2.2.4.3 *Data Sources for Characterizing Water Quality*

The assessment of groundwater quality for the Subbasin was prepared using available information obtained from the California Groundwater Ambient Monitoring and Assessment (GAMA) Program Database, which for the Sierra Valley Subbasin includes water quality information collected by the following agencies:

- Department of Water Resources (DWR)
- State Water Board, Division of Drinking Water public supply well water quality (DDW)
- State and Regional Water Board Regulatory Programs (Electronic Deliverable Format (EDF) and Irrigated Agricultural Land Waiver (AGLAND))
- U.S. Geological Survey (USGS)

Groundwater quality data, as reported by GAMA, has been collected in the Subbasin since 1955. Within the Subbasin, a total of 200 wells were identified and used to characterize existing water quality based on a data screening and evaluation process that identified constituents of interest important to sustainable groundwater management. Figures in Appendix 2-6 show the Subbasin boundary, as well as the locations and density of all wells with available water quality data for the GSP constituents of interest collected in the past 30 years (1990-2020). In addition to utilizing GAMA for basin-wide water quality assessment, GeoTracker, the State Water Board's internet accessible database system to track discharges to land and groundwater, was searched individually to identify data associated with groundwater contaminant plumes.

2.2.2.4.4 *Classification of Water Quality*

To determine what groundwater quality constituents in the Subbasin may be of current or near-future concern, a reference standard was defined to which groundwater quality data were compared. Numeric thresholds are set by state and federal agencies to protect water users (environment, humans, industrial and agricultural users). The numeric standards selected for the current analysis represent all relevant state and federal drinking water standards, and state water quality objectives, for the constituents evaluated and are consistent with state and Regional Water Board assessment of beneficial use protection in groundwater. The standards are compared against groundwater quality data to determine if a constituent's concentration exists above or below the threshold and is currently impairing or may have the potential to impair beneficial uses designated for groundwater.

Although groundwater is utilized for a variety of purposes, the use for human consumption requires that supplies meet strict water quality regulations. The federal Safe Drinking Water Act (SDWA) protects surface water and groundwater drinking water supplies. The SDWA requires the United States Environmental Protection Agency (USEPA) to develop enforceable water quality standards for public water systems. The regulatory standards are named maximum contaminant levels (MCLs) and they dictate the maximum concentration at which a specific constituent may be present in potable water sources. There are two categories of MCLs:

Primary MCLs (1° MCL), which are established based on human health effects from contaminants and are enforceable standards for public water supply wells and state small water supply wells; and Secondary MCLs (2° MCL; or SMCL), which are unenforceable standards established for contaminants that may negatively affect the aesthetics of drinking water quality, such as taste, odor, or appearance.

The State of California has developed drinking water standards that, for some constituents, are stricter than those set at the federal level. The Basin is regulated under the Central Valley Regional Water Quality Control Board (Regional Water Board) and relevant water quality objectives (WQOs), and beneficial uses are contained in the Water Quality Control Plan for the Central Valley Region (Basin Plan). For waters designated as having a Municipal and Domestic Supply (MUN) beneficial use, the Basin Plan specifies that chemical constituents are not to exceed the Primary and Secondary MCLs established in Title 22 of the California Code of Regulations (CCR) (hereafter, Title 22). The MUN beneficial use applies to all groundwater in the Sierra Valley subbasin.

Constituents may have one or more applicable drinking water standard or WQOs. For this GSP, a prioritization system was used to select the appropriate numeric threshold. This GSP used the strictest value among the state and federal drinking water standards and state WQOs specified in the Basin Plan for comparison against available groundwater data. Constituents that do not have an established drinking water standard or WQO were not assessed. The complete list of constituents, numeric thresholds, and associated regulatory sources used in the water quality assessment can be found in Appendix 2-6. Basin groundwater quality data obtained for each well selected for evaluation were compared to a relevant numeric threshold.

Groundwater quality data were further categorized by magnitude of detection as 1) not detected, 2) detected below half of the relevant numeric threshold, 3) detected below the relevant numeric threshold, and 4) detected above the relevant numeric threshold. Maps were generated for each constituent of interest showing well locations, the maximum value measured at each well, and the number of measurements for each category of detection (Appendix 2-6 Figures A-9, A-11, A-13, A-15, A-17, A-19, A-21, A-23). These maps indicate wells designated as municipal in the GAMA dataset.

To analyze groundwater quality that is representative of current conditions in the Subbasin, several additional filters were applied to the dataset. Though groundwater quality data are available dating back to 1955 for some constituents, the data evaluated were limited to those collected from 1990 to 2020. Restricting the time span to data collected in the past 30 years increases confidence in data quality and focuses the evaluation on information that is considered reflective of current groundwater quality conditions. A separate series of maps contained in Appendix 2-6 was generated for each constituent of interest showing the location of wells with two or more measurements collected during the past 30 years (1990-2020; Appendix 2-6 Figures A-10, A-12, A-14, A-16, A-18, A-20, A-22, A-24). This series of maps also indicates the maximum value measured at each well.

Finally, for each constituent, an effort was undertaken to examine changes in groundwater quality over the period 1990-2020. Constituent concentrations were plotted as “box and whisker” plots, where the box represents the concentration range for the middle 50 percent of the data (first quartile to third quartile, or interquartile range), the mean is represented as an ‘x’, and the median is shown as the line in the center of the box. The top whisker extends to the highest concentration that is less than or equal to the sum of the third quartile and 1.5 times the interquartile range; and the bottom whisker extends to the lowest concentration that is greater than or equal to the difference of the first quartile and 1.5 times the interquartile range. Regulatory limits are displayed as a dashed red line, and the concentration is displayed on the left side of each plot. Maps and box and whisker plots for each constituent of interest are referenced in the following subsections and are provided in Appendix 2-6.

The approach described above was used to consider all constituents of interest and characterize groundwater quality in the Subbasin. Appendix 2-6 contains additional detailed information on the methodology used to assess groundwater quality in the Subbasin.

2.2.2.4.5 Subbasin Groundwater Quality

All groundwater quality constituents monitored in the Subbasin that have a numeric threshold were initially considered. The evaluation process described above showed the following parameters to be important to sustainable groundwater management in the Subbasin: nitrate, TDS, arsenic, boron, pH, iron, manganese, MTBE. The following subsections present information on these water quality parameters in comparison to their relevant regulatory thresholds and how the constituent may potentially impact designated beneficial uses in different regions of the Subbasin. Table 2.2.2-2 contains the list of constituents of interest identified for the Subbasin and their associated regulatory threshold.

Table 2.2.2-2: Regulatory Water Quality Thresholds for Constituents of Interest in the Sierra Valley Subbasin

Constituent	Water Quality Threshold	Regulatory Basis
Arsenic (μg/L)	10	Primary MCL – Title 22[1]
Boron (mg/L)	1.0	Cal. Notification Level[2]
Iron (μg/L)	300	Secondary MCL – Title 22[1]
Manganese (μg/L)	50	Secondary MCL – Title 22[1]
MTBE (μg/L)	13 5	Primary MCL – Title 22[1] Secondary MCL – Title 22[1]
Nitrate (mg/L as N)	10	Primary MCL – Title 22[1]
pH	6.5 – 8.5	Basin Plan[3]
Total Dissolved Solids (mg/L)	500 (Recommended) 1000 (Upper)	Secondary MCL – Title 22[1]

1. Reference for Primary, and Secondary MCL – Title 22: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/dw_regulations_2019_04_16.pdf
2. Reference for Cal. Notification level: https://www.waterboards.ca.gov/water_issues/programs/gama/docs/coc_boron.pdf
3. Central Valley Basin Plan, surface water objective

Nitrate

Nitrate is one of the most common groundwater contaminants and is generally the water quality constituent of greatest concern. Natural concentrations of nitrate in groundwater are generally low. In agricultural areas, application of fertilizers or animal waste containing nitrogen can lead to elevated nitrate levels in groundwater. Other anthropogenic sources, including septic tanks, wastewater discharges, and agricultural wastewater ponds may also lead to elevated nitrate levels. Nitrate poses a human health risk, particularly for infants under the age of 6 months who are susceptible to methemoglobinemia, a condition that affects the ability of red blood cells to carry and distribute oxygen to the body. The Primary MCL (Title 22) for nitrate is 10 mg/L as N.

Recent nitrate data collected in the Subbasin (1990-2020) show that only 1 sample of 366 resulted in a concentration between 5-10 mg/L. No samples were above the MCL of 10 mg/L.

The highest concentration during the period was 5.2 mg/L, and the average concentration during the last ten years (2011-2020) was 1.5 mg/L. Samples are primarily collected near Loyalton and Beckwourth. Box and whisker plots for seven periods show that nitrate concentrations have been relatively stable during the period of analysis, with increasing concentrations from 2011-2020 (Appendix 2-6) but still well below the MCL of 10 mg/L. As stated, average and median concentration remain relatively low during these years.

Total Dissolved Solids (TDS)

The TDS concentration in water is the sum of all the substances, organic and inorganic, dissolved in water. The dissolved ions calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and nitrate typically make up most of the TDS in water. Natural and anthropogenic sources contribute to variations TDS in groundwater. Increases of TDS in groundwater can be due to dissolution of rock and organic material and uptake of water by plants, as well as anthropogenic activities including the application of fertilizers, discharges of wastewater and discharges from septic systems or industrial facilities. High TDS can be problematic as it can have adverse effects on plant growth and drinking water quality. The Title 22 SMCL for TDS is 500 mg/L as the recommended level, and the Upper SMCL is 1,000 mg/L. While the recommended SMCL of 500 mg/L is desirable for a higher degree of consumer acceptance, concentrations below the Upper SMCL of 1,000 mg/L are also deemed to be acceptable.

Recent TDS data collected in the Subbasin (1990-2020) show that only 11 of 216 samples resulted in a concentration between 500-1,000 mg/L, while the vast majority (175) resulted in a concentration less than 250 mg/L. No samples were above 1,000 mg/L. The highest concentration during this period was 864 mg/L, and the average concentration during the last ten years (2011-2020) was 200 mg/L. Spatial distribution of TDS samples is good, as samples are collected throughout the Subbasin. Spatial analysis shows that elevated concentrations are collected from wells located in the central and northwestern portion of the Subbasin. Box and whisker plots for seven periods show that average and median TDS concentrations have remained relatively stable since 1986 (Appendix 2-6).

Arsenic

Arsenic is a naturally occurring element in soils and rocks and has been used in wood preservatives and pesticides. Classified as a carcinogen by the USEPA, the International Agency for Research on Cancer and the Department of Health and Human Services, arsenic in water can be problematic for human health. Drinking water with levels of inorganic arsenic from 300 to 30,000 parts per billion (ppb; 1 ppb = 1 µg/L) can have effects including stomach irritation and decreased red and white blood cell production (ATSDR, 2010). Long-term exposure can lead to skin changes and may lead to skin cancer. The Primary MCL (Title 22) for arsenic is 10 µg/L.

Recent arsenic data collected in the Subbasin (1990-2020) show that only 16 of 128 samples resulted in a concentration between 5-10 µg/L, while the vast majority (112) resulted in a concentration less than 5 µg/L. No samples were above the MCL of 10 µg/L. The highest concentration during this period was 10 µg/L, and the average concentration during the last ten years (2011-2020) was 0.5 µg/L. Samples are primarily collected near Loyalton and Beckworth. Box and whisker plots for seven periods show that average concentrations have a decreasing trend (Appendix 2-6). It is noted that there are municipal wells near Calpine with elevated levels of arsenic (great than 20 µg/L); however, these wells are located outside the boundaries of the Subbasin and tap groundwater that is not hydrologically connected to the Sierra Valley Subbasin.

Boron

Boron in groundwater can come from both natural and anthropogenic sources. As a naturally occurring element in rocks and soil, boron can be released into groundwater through natural weathering processes. Boron can be released into the air, water or soil from anthropogenic sources including industrial wastes, sewage, and fertilizers. If ingested at high levels, boron can affect the stomach, liver, kidney, intestines, and brain (Agency for Toxic Substances and Disease Registry (ATSDR), 2010). The California Notification Level provides a threshold for boron of 1.0 mg/L as for groundwater in the Sierra Valley.

Recent boron data collected in the Subbasin (1990-2020) show that 14% of samples (15 of 104) resulted in a concentration greater than the Notification Level of 1.0 mg/L, while 78% of samples (81 of 104) have resulted in a concentration below 0.5 mg/L. The highest concentration during this period was 5.4 mg/L. High reporting limits[15] (typically 0.1 mg/L) are typical during the analytical assessment of boron and make analysis of average concentration imprecise. Spatial distribution of boron samples is good, as samples are collected throughout the Subbasin. Boron concentrations above the Notification Level primarily occur in the central region of the Subbasin and extend to the west. The area east of Loyalton is the only region to detect low concentrations of Boron. Box and whisker plots for seven periods show that average and median boron concentrations have fluctuated since 1986. Since 2011, concentrations have decreased, with median values falling below the MCL (Appendix 2-6).

pH

The pH of groundwater is determined by a number of factors including the composition of rocks and sediments through which water travels in addition to pollution caused by human activities. Variations in pH can affect the solubility and mobility of constituents. Acidic or basic conditions can be more conducive for certain chemical reactions to occur; arsenic is generally more likely to mobilize under a higher pH while iron and manganese are more likely to mobilize under more acidic conditions. High or low pH can have other detrimental effects on pipes and appliances including formation of deposits at a higher pH and corrosion at a lower pH, along with alterations in the taste of the water. The Central Valley Basin Plan specifies a pH range of 6.5-8.5 as a water quality objective for surface water in the Sierra Valley. This range is used as an indicator of potential water quality concerns based on the beneficial use of the groundwater.

Recent pH data collected in the Subbasin (1990-2020) show that 2 of 71 samples resulted in a pH above the range of 6.5-8.5, while 2 samples resulted in a pH below the range. The highest concentration during this period was 8.7, while the lowest was 6.4. Spatial distribution of pH samples is good, as samples are collected throughout the Subbasin.

Iron and Manganese

Iron and manganese in groundwater are primarily from natural sources. As abundant metal elements in rocks and sediments, iron and manganese can be mobilized under favorable geochemical conditions. Iron and manganese occur in the dissolved phase under oxygen-limited conditions. Anthropogenic sources of iron and manganese can include waste from human activities including industrial effluent, mine waste, sewage, and landfills. As essential nutrients for human health, iron and manganese are only toxic at very high concentrations. Concerns with iron and manganese in groundwater are commonly related to the aesthetics of

[15] Defined as the lowest concentration at which an analyte can be detected in a sample and its concentration reported with a reasonable degree of accuracy and precision.

water and the potential to form deposits in pipes and equipment. The Title 22 SMCLs, for iron and manganese are 300 µg/L and 50 µg/L, respectively.

Recent iron data collected in the Subbasin (1990-2020) show that 6 of 125 samples resulted in a concentration above the SMCL of 300 µg/L, while the vast majority (116) resulted in a concentration less than 150 µg/L. The highest concentration during this period was 2,400 µg/L, and the average concentration during the last ten years (2011-2020) was 82 µg/L. Except for the northeast portion of the Subbasin near Vinton, the spatial distribution of iron samples is good. Spatial analysis shows that elevated concentrations are collected from wells located near Loyalton and Beckwourth. Box and whisker plots for seven periods show that average concentrations have remained relatively stable since 1986, with median concentrations decreasing from 2001-2020 (Appendix 2-6).

Recent manganese data collected in the Subbasin (1990-2020) show that 28 of 99 samples resulted in a concentration above the SMCL of 50 µg/L, while 71 of 99 samples resulted in a concentration below 50 µg/L. The highest concentration during this period was 1,200 µg/L, and the average concentration during the last ten years (2011-2020) was 119 µg/L. These elevated concentrations were sampled from monitoring wells less than 100 feet in depth located to the east of Loyalton. If these monitoring wells are removed from the data, the highest concentration during the period 1990-2020 decreases to 439 µg/L, and the average concentration during the last ten years (2011-2020) decreases to 25 µg/L. Except for the northeast portion of the Subbasin near Vinton, the spatial distribution of manganese samples is good. Wells sampled on the southern boundary of the Subbasin appear to contain lower concentrations of manganese compared to wells sampled near Beckwourth or the central portion of the Subbasin. Box and whisker plots for seven periods show that average concentrations were elevated during the periods 2001-2005 and 2006-2010 in comparison to other periods (Appendix 2-6). As stated, these high concentrations are attributed to monitoring wells east of Loyalton.

MTBE

Methyl Tertiary Butyl Ether (MTBE) does not occur naturally in the environment, and is synthesized from methanol, a compound derived from natural gas, and isobutylene or other petroleum refinery products. It is a fuel oxygenate added to gasoline to reduce air pollution and increase octane ratings. MTBE can be released to groundwater by leaking underground storage tanks and piping, spills during transportation, and leaks at refineries. A minor amount can be attributed to atmospheric deposition. Underground storage tank or piping releases comprise the majority of the releases that have impacted groundwater. As of January 1, 2004, California has prohibited the use of MTBE in gasoline. Low levels of MTBE can make drinking water supplies undrinkable due to its offensive taste and odor. Although breathing small amounts of MTBE for short periods may cause nose and throat irritation, there are no data available on the effects in humans of ingesting MTBE. The primary MCL for drinking water is 13 µg/L, and the Title 22 SMCL is 5 µg/L.

Recent MTBE data collected in the Subbasin (1990-2020) show that 109 of 558 samples resulted in a concentration above the primary MCL of 13 µg/L, and 144 samples resulted in a concentration above the SMCL of 5 µg/L. The highest concentration during this period was 44,000 µg/L and average concentration during the last ten years (2011-2020) was 3 µg/L. All samples resulting in a concentration greater than 1,000 µg/L were collected during the period 2001-2005. Samples are primarily collected near Loyalton, Sierraville, and Beckwourth, with primary MCL exceedances occurring near Loyalton and Sierraville. Box and whisker plots for seven periods show that concentrations were elevated during the period 2001-2005 and 2006-2010 (Appendix 2-6). Since 2011, concentrations have generally declined.

2.2.2.4.6 Contaminated Sites

Groundwater monitoring activities also take place in the Subbasin in response to known and potential sources of groundwater contamination, including underground storage tanks. These sites are subject to oversight by regulatory entities, and any monitoring associated with these sites can provide opportunities to improve the regional understanding of groundwater quality. To identify known plumes and contamination within the Subbasin, SWRCB GeoTracker was reviewed for active cleanup sites of all types. Within the Subbasin, the GeoTracker database shows one open land disposal site (Loyalton Sanitary Landfill) and one cleanup program site with potential or inactive groundwater contamination (SPI Loyalton Division). In addition to sites located within the Subbasin boundary, three sites are in close proximity to the Boundary. These include two land disposal sites (Portola Class III Landfill: open – closed/with Monitoring; and Golden Dome Project: open – inactive), and one cleanup program site (Vinton Spill: complete – case closed).

A brief overview of notable information related to open contaminated sites in the Subbasin is provided below; however, an extensive summary for each of the contamination sites is not presented. The location of the contaminated sites is shown in Figure 2.2.2-5.

Loyalton Sanitary Landfill

The case (No. 5A460300001) for this cleanup site was opened in January of 1965. This site is a Title 27 municipal solid waste landfill site. Substances released from the site, and contaminants of concern are not specified by GeoTracker.

SPI Loyalton Division

The leak associated with this case was reported in January of 1965, and the case for this cleanup site was opened in November 2004 and is currently listed as open and inactive. GeoTracker does not provide a case number for this site. Potential contaminants of concern associated with the site include waste oil (motor, hydraulic, lubricating).

While current data is useful to determine local groundwater conditions, additional monitoring is necessary to develop a basin-wide understanding of groundwater quality and greater spatial and temporal coverage would improve evaluation of trends. From a review of all available information, none of the sites listed above have been determined to have an impact on the aquifer, and the potential for groundwater pumping to induce contaminant plume movement towards water supply wells is negligible.

Figure 2.2.2-5: Contaminated Sites

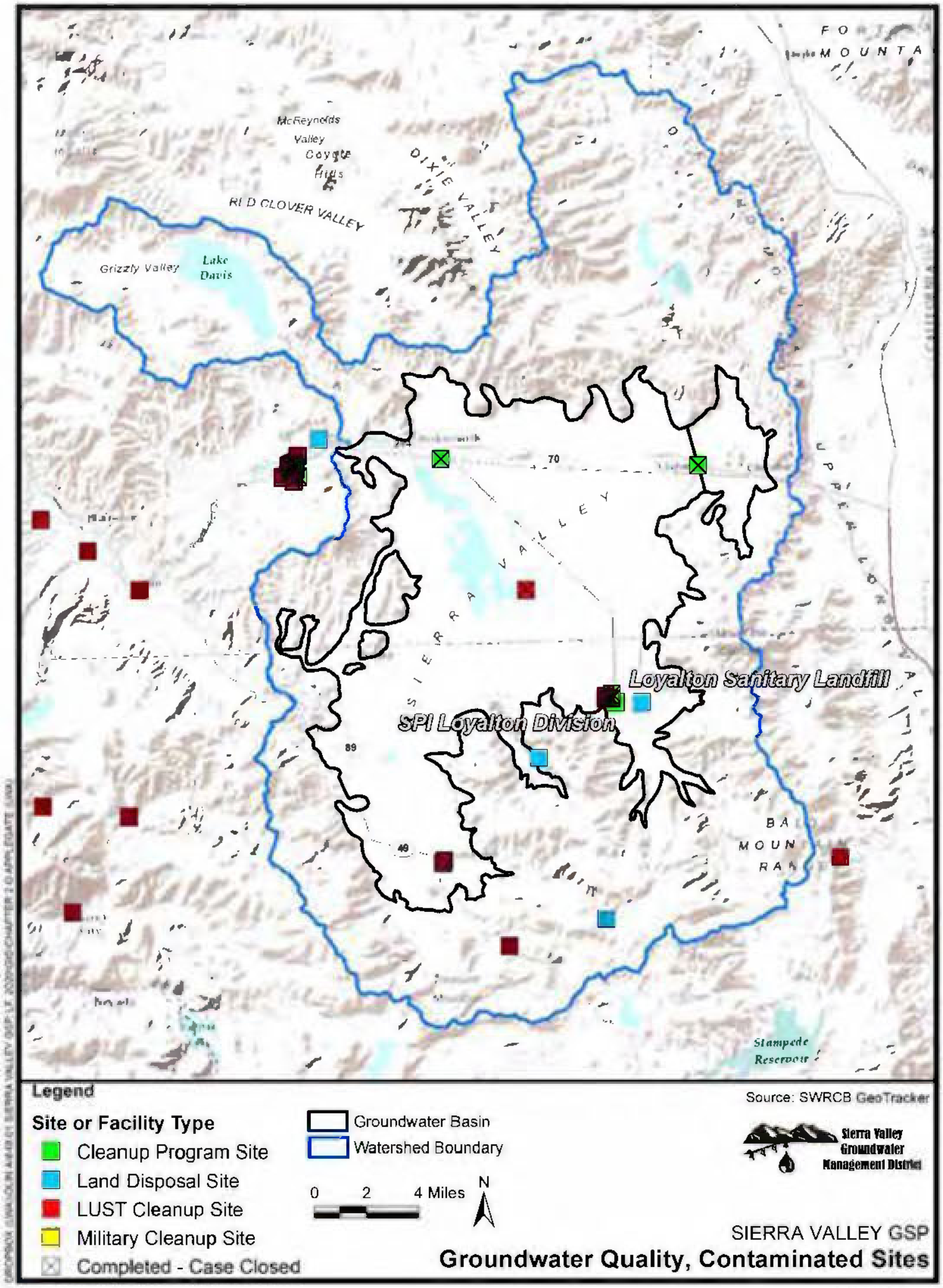


Figure 2.2.2-5

2.2.2.5 Land subsidence conditions

Land subsidence is the lowering of the ground surface elevation. This is often caused by pumping groundwater from within or below thick clay layers. Land subsidence can be elastic or inelastic, meaning that the lithologic structure of the aquifer can compress or expand elastically due to water volume changes in the pore space or is detrimentally collapsed when water is withdrawn (inelastic). Inelastic subsidence is generally irreversible. Elastic subsidence is generally of a smaller magnitude of change, and is reversible, allowing for the lowering and rising of the ground surface and can be cyclical with seasonal changes.

The various data available for Sierra Valley show that inelastic subsidence has occurred in the recent past and likely continues to the present. While the subsidence has occurred in varying areas in Sierra Valley over time, it has overlapped with areas known to have significant groundwater pumping. The geology present in Sierra Valley is dominantly eroded alluvial sediment deposits consisting of clay, silt, sand, and gravel, which is typical of mountain valleys in California. The clay deposits are particularly susceptible to inelastic subsidence when heavy groundwater pumping is present.

2.2.2.5.1 Ground-based measurements of land subsidence

The first account of recorded subsidence in Sierra Valley was by the California Department of Water Resources (DWR, 1983). DWR (1983), along with Plumas County Road Department surveys, reported that inelastic subsidence occurred in the Sierra Valley and was consistent within the expected range considering the amount of groundwater decline observed. About 1-2 feet of total subsidence occurred during the period of 1960-1983. The subsidence during the period of 1983-2012 is unaccounted for as we have not found any reports accounting for subsidence during this period. The California Department of Transportation (CalTrans, 2016) conducted a survey where they collected data that suggested that subsidence of about 0.3 to 1.9 feet occurred in total during the period of 2012 to 2016. The area of this subsidence also coincided with known areas of heavy groundwater pumping.

In April 2021, the California Department of Transportation Office of Geotechnical Design North assessed anomalous roadway cracking in the northern region of the Subbasin on State Route 70, just east of its intersection with State Route 49 (postmiles 85.9, 87.5, and 89.35 in Plumas County). During a field visit, cracks with 1 inch of vertical subsidence, and extension of 1.5 inches were observed. According to CalTrans maintenance crews, the cracks began appearing about five years ago. The location of the cracking is in an area that underwent 0.25 to 0.5 ft of subsidence from June 2015 to September 2019 based on DWR's SGMA data viewer. Based on lack of evidence linking the roadway pavement fractures to tectonic or surficial water processes, it was determined that it is highly probable that the fractures are the result of subsidence resulting from groundwater pumping (CalTrans, 2021).

There are no known Continuous Global Positioning System (CGPS) stations or extensometers installed in Sierra Valley. However, there are survey monuments remaining from previous ground elevation surveys.

2.2.2.5.2 Satellite observations of land subsidence

Satellite-based Interferometric Synthetic Aperture Radar (InSAR) data from a NASA JPL study show up to 0.5 feet of subsidence occurred in the northeast part of Sierra Valley during the period of 2015-2016. The study also shows up to 1.2 feet of subsidence occurred during the period of March 2015 to November 2019 (Farr et al., 2017; T. Farr, personal communications, Oct.-Dec. 2020). These data are shown in Figure 2.2.2-6 for the whole subbasin, and focused on the area with greatest subsidence in Figure 2.2.2-7.Time series of subsidence for six select locations are presented in Figure 2.2.2-8.

To produce the subsidence dataset, NASA JPL obtained and analyzed data from the European Space Agency's (ESA) satellite-borne Sentinel-1A from the period March 2015 – September 2016 and the NASA airborne UAVSAR for the period March 2015 – June 2016 and produced maps of total subsidence from the two data sets. These data add to the earlier data processed from the Japanese PALSAR for 2006 – 2010, Canadian Radarsat-2 for the period May 2014 – January 2015, and UAVSAR for July 2013 - March 2015, for which subsidence measurements were reported previously (Farr et al., 2017). As multiple scenes were acquired during these periods, they also produce time histories of subsidence at selected locations and transects showing how subsidence varies both spatially and temporally. Geographic Information System (GIS) files were furnished to DWR for further analysis of the 4-dimensional subsidence time-series maps.

A similar InSAR study from DWR/TRE Altamira (TRE Altamira, 2021; Towill, 2020) shows subsidence of up to 0.6 +/-0.1 feet over widespread areas of Sierra Valley, potentially higher in smaller areas, during the period of June 2015 to September 2019. They estimated an annual subsidence rates of up to 0.15 +/-0.1 feet/year in this same study. These data are shown in Figure 2.2.2-9.

The TRE Altamira (TRE) InSAR dataset represents measurements of vertical ground surface displacement. Vertical displacement estimates are derived from Interferometric Synthetic Aperture Radar (InSAR) data that are collected by ESA Sentinel-1A satellite and processed by TRE, under contract with DWR as part of its SGMA technical assistance. Sentinel-1A InSAR data coverage began in late 2014 for parts of California, and coverage for the entire study area began on June 13, 2015. Included in this dataset are point data that represent average vertical displacement values for 328 ft by 328 ft areas, as well as GIS rasters that were interpolated from the point data; rasters for total vertical displacement relative to June 13, 2015, and rasters for annual vertical displacement rates with earlier coverage for some areas, both in monthly time steps. Towill, Inc. (Towill), also under contract with DWR as part of DWR's SGMA technical assistance, conducted an independent study comparing the InSAR-based vertical displacement point time series data to data from CGPS stations. The goal of this study was to ground truth the InSAR results to best available independent data.

Both TRE and JPL process the same satellite data using different techniques, resulting in results that can be similar but not the same. InSAR data reports on changes in levels of the ground surface without distinguishing between elastic (temporary) or inelastic (permanent) subsidence. Visual inspection of monthly changes in ground elevations typically suggest that elastic subsidence is largely seasonal and can potentially be factored out of the signal, if necessary. Finally, the DWR/TRE InSAR data are the only InSAR data that can be used for estimating subsidence going forward as they are the only known subsidence-related data provided to and available for this subbasin by DWR for an indefinite period of time during the GSP implementation period.

2.2.2.5.3 DWR/TRE Altamira InSAR subsidence data quality

InSAR results are within approximately 1.2 inches of continuous GPS data (95% confidence level).

Figure 2.2.2-6: InSar-based Land Subsidence (March 2015 to November 2019)

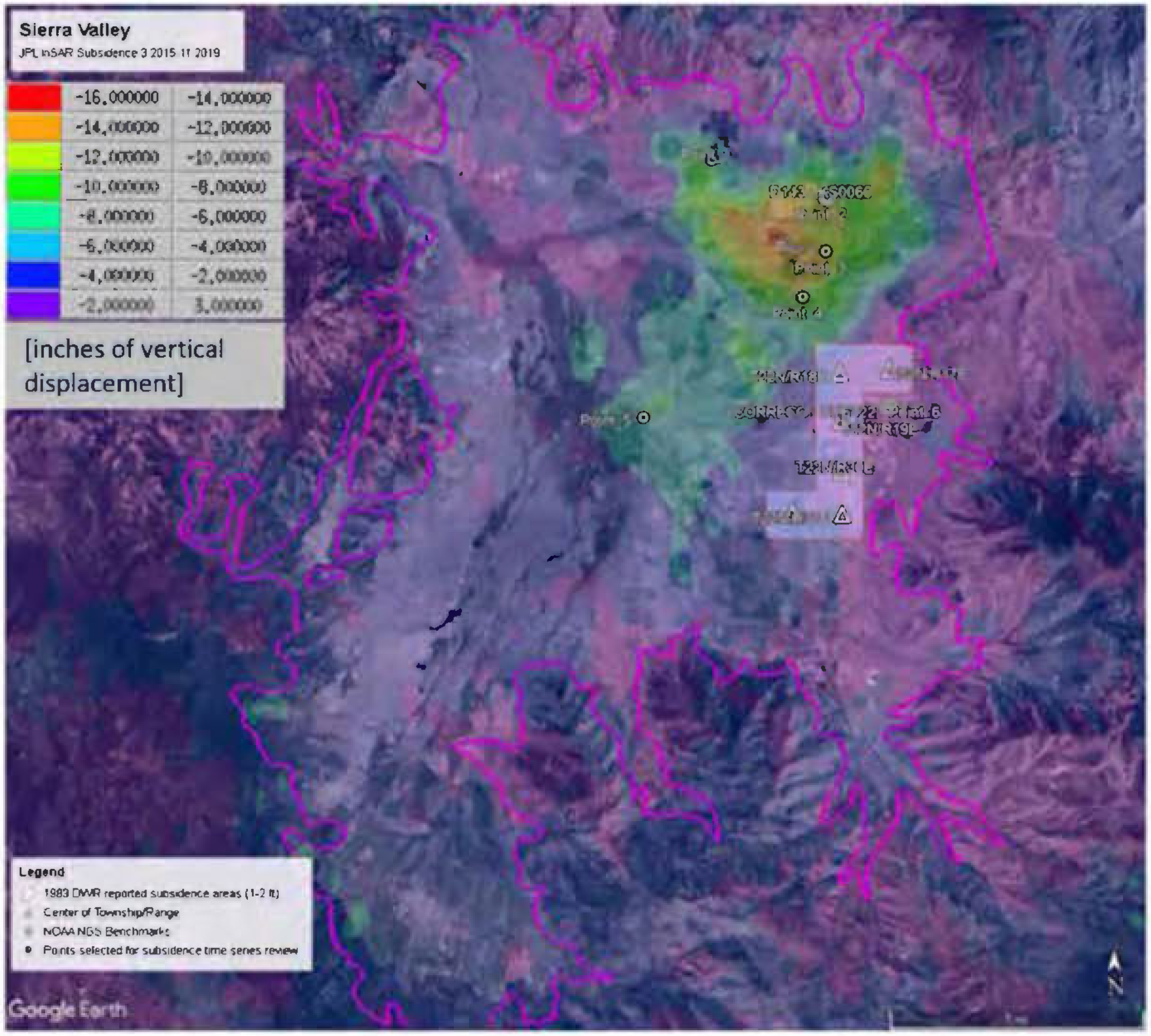


Figure 2.2.2-7: InSar-based Land Subsidence (March 2015 to November 2019) with Focus on Portion of Subbasin with Greatest Measured Subsidence

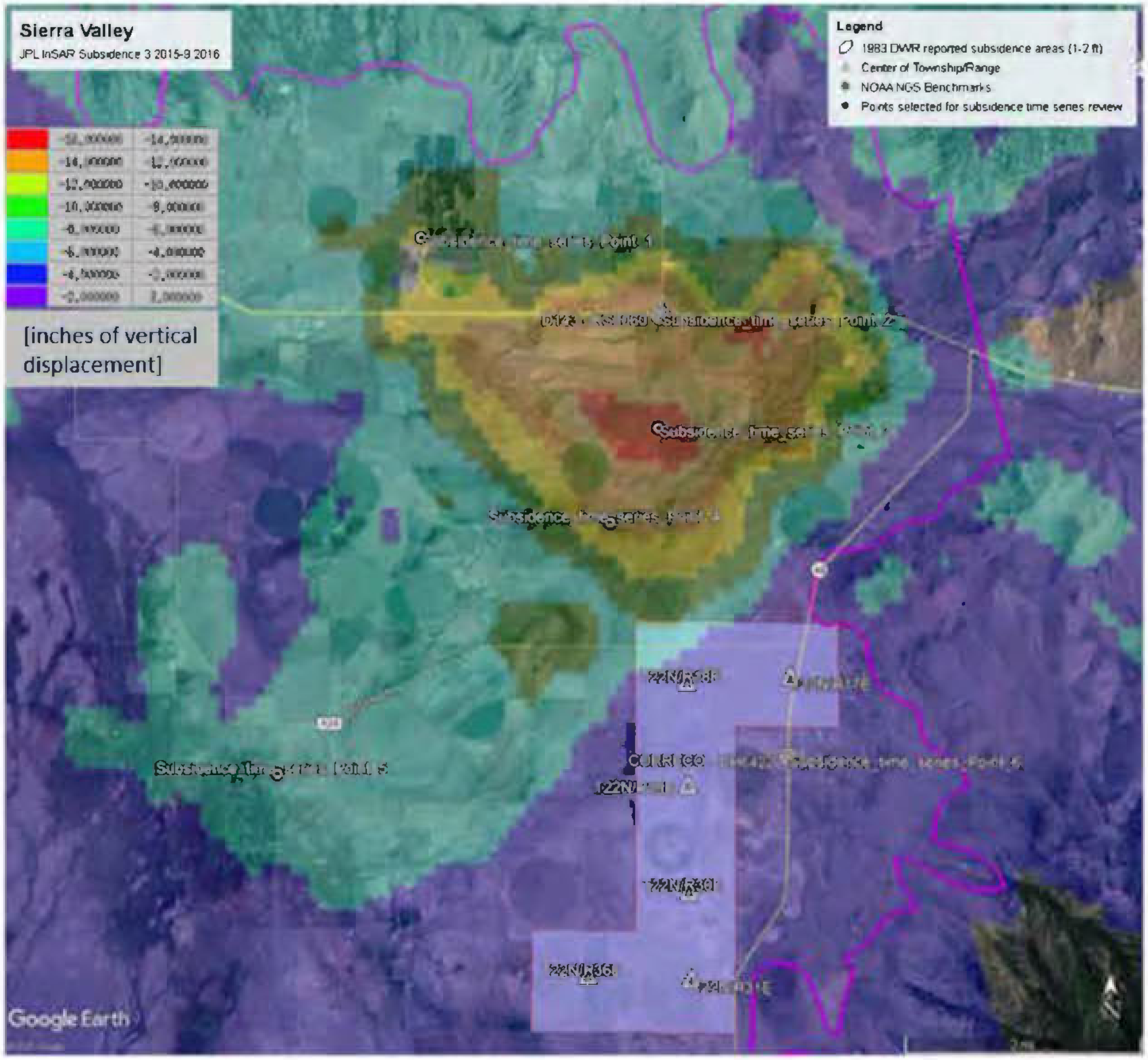


Figure 2.2.2-8: Time Series of JPL InSAR Land Subsidence Data for Locations in Figure 2.2.2-3

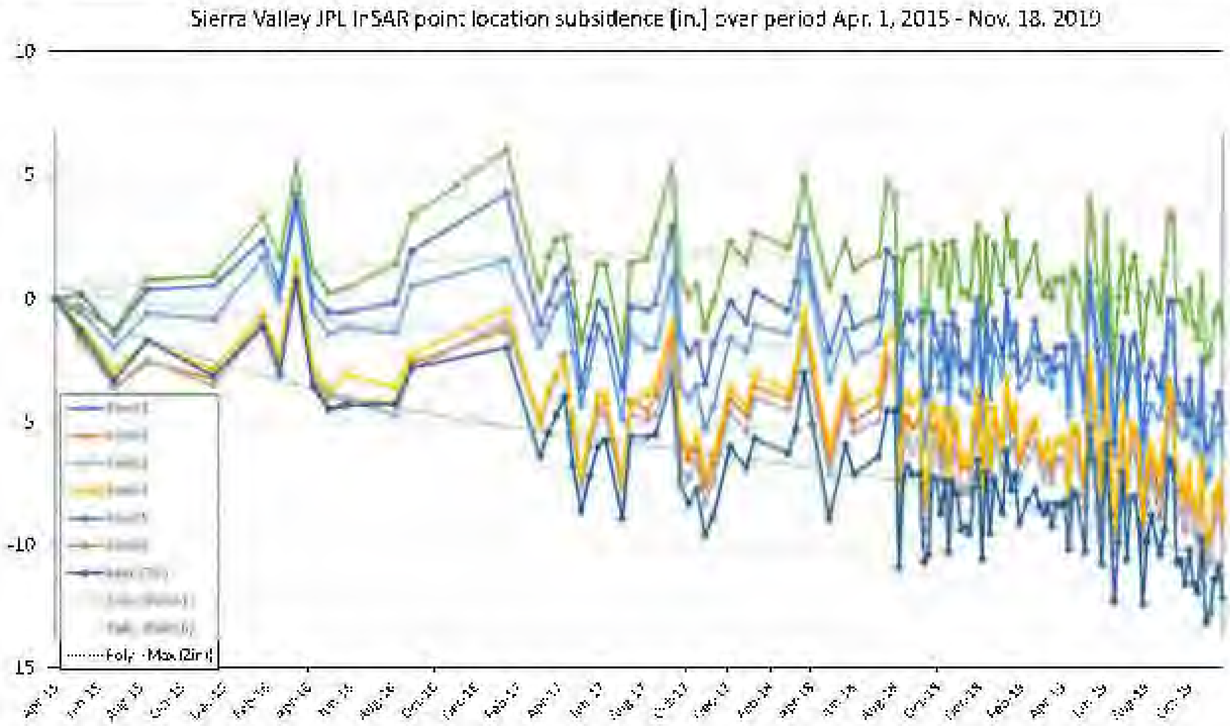
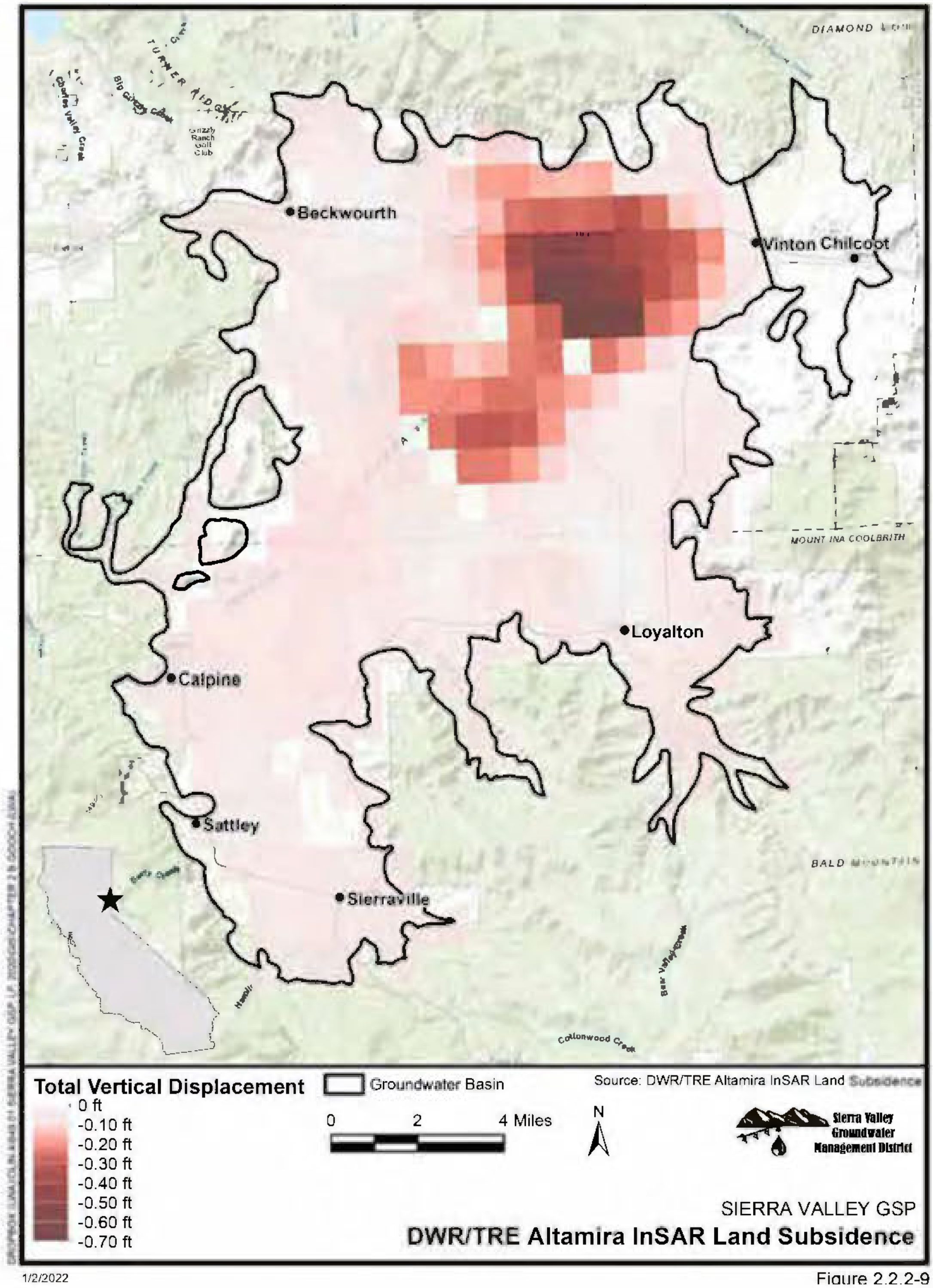


Figure 2.2.2-9: DWR/TRE Altamira InSAR Land Subsidence (June 2015 to September 2019)



2.2.2.6 Identification of interconnected surface water systems

Surface water within the Sierra Valley is composed of a complex network of single and multi-channel streams, irrigation ditches, ponds, seasonal wetlands, and springs. In general, groundwater is located close to the land surface in much of the south and west side of the valley and near the valley margins. The potential exists for interconnected surface water where surface water features and shallow groundwater coincide. Section 351 (o) of the GSP Regulations defines interconnected surface water (ISW) as, “surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.”

The methodology of identifying interconnected surface water was to first identify the surface water features within the valley. We focused on streams and excluded emergent wetlands since those will be in the groundwater dependent ecosystem (GDE) mapping. We next looked at monitoring wells and springs within the valley and used that data over multiple years to generate a composite potentiometric surface of groundwater elevations. The generated groundwater surface elevations were then differenced from the land surface elevations to develop a map of the depth to groundwater. With the exception of portions of the Middle Fork Feather River, channel thalwegs (which are defined by a line connecting the lowest points along a stream) are on the order of 5 feet lower than the adjacent floodplain areas. Therefore, where overlying surface water exists and groundwater was estimated to be less than 5-feet below the land surface, the surface water body is considered to be hydraulically connected and classified as an ISW.

2.2.2.6.1 Identification of Surface Water

Unlike many groundwater basins where tributary streams join to form larger streams or rivers, the majority of streams entering the Sierra Valley are distributary in nature. As discussed above in Section 2.2.1.6, as streams enter the Valley, they flow across alluvial fans in the transition zone from steep mountainous channel to flat valley bottom and bifurcate to become multi-threaded channels. This process of a single threaded channel transitioning to a multi-threaded channel has been further enhanced by decades of straightening, diverting, and otherwise altering flow paths to redistribute water and better irrigate the landscape for cattle grazing. Ultimately, the many streams that enter the valley coalesce in the central wetland complex before moving north as a more defined channel, the Middle Fork Feather River.

Due to the numerous streams and stream networks within the basin, the USGS National Hydrography Dataset Plus High Resolution (NHDPlus HR) was used as a first pass to map surface water. This dataset is created using a geospatial model to map the flow of water across the landscape using a digital elevation model of 10-meter ground spacing or better. The NHD mapping includes 844 miles of streams in the groundwater basin, which was then reduced to identify surface water bodies through a mix of field and aerial imagery verification. The verified surface water mapping for this GSP now includes a total of 365 miles of streams.

Springs in the Basin were also identified using the USGS NHD dataset. While the exact source of the spring data could not be obtained, a study on the natural resources of the Sierra Valley mentions a field inventory of springs and wells that was conducted in 1960 (California DWR, 1973). This is assumed to be the basis of the NHD spring layer.

2.2.2.6.2 Depth to Groundwater

The average depth to groundwater map was estimated using available data from CASGEM, district monitoring wells (DMWs), and mapped springs. The NHD mapping of springs was then verified in the field or by high resolution aerial imagery. Due to the limited temporal resolution of the monitoring well dataset, it was necessary to use a four-year running seasonal mean to develop a potentiometric surface of groundwater elevations. For identification of ISW, the average of monitoring well data from the Spring seasons from 2017 to 2020 was used. This period includes an adequate amount of well data and represents a wetter than average period as a conservative approach to identify where groundwater levels may regularly be near the ground surface. The average standard deviation of the depth to groundwater map across the groundwater basin is approximately 55 feet. Given the level of uncertainty, a conservative approach was taken when excluding any streams from ISW classification. For those streams that were classified as disconnected, a shallow groundwater well no greater than 0.5 miles from the stream was used to verify the groundwater depth.

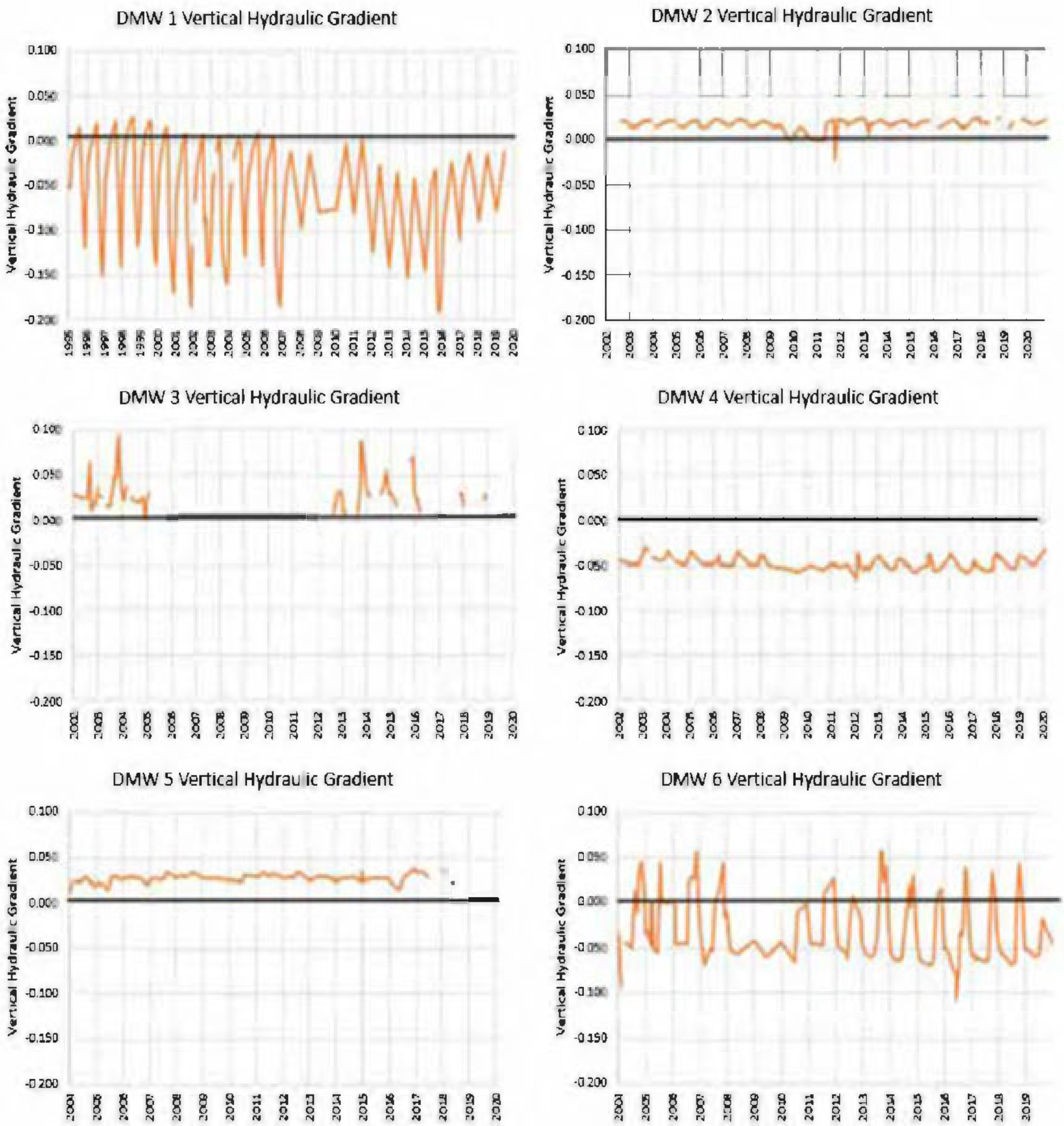
2.2.2.6.3 Identification of Interconnected Surface Water

Together the surface water mapping of streams and the shallow depths to groundwater map were used to identify areas of potential ISWs. Before overlaying these two data sets, we first needed to estimate a buffer to account for the depth of the stream below the surrounding landscape. The channel thalweg represents the lowest point in a stream that could be connected to groundwater. The approximate channel thalweg elevation was estimated by evaluating channel sections cut from a 1-meter DEM prepared from the USGS LPC CA NoCAL Wildfires B1 2018 LiDAR dataset. Streams within the Sierra Valley are generally not deeply incised; the channel thalweg was consistently found to be 5-feet or less below the adjacent floodplain. Only dry channels were evaluated because the type of LiDAR data gathered does not penetrate water; therefore, better estimates of channel depth could be developed by conducting more detailed topographic and bathymetric surveys. Where overlying surface water was present and groundwater was found to be within 5-feet of the land surface, the surface water was classified as ISW.

2.2.2.6.4 Nested Monitoring Wells

Nested monitoring wells were used to confirm ISWs that were identified using the approach outlined above. Nested monitoring wells are District monitoring wells (DMW's) that were installed throughout the valley beginning in the Fall of 1995, with the majority of wells being installed in the early 2000's and the most recent in the Spring of 2020. A total of 7 sets of nested wells have been installed at varying depths throughout the valley. The DMW's are unique compared to other monitoring wells as each location contains two to three nested wells. Nested wells are constructed with two or more wells within the same borehole and screened at different depths. The wells are isolated from each other using an annular seal and were used to measure a difference in hydraulic head for each screened depth. Vertical hydraulic gradient was then calculated by differencing the hydraulic head of the shallow well to the deeper well and dividing by the distance between the midpoints of the screened intervals. A negative value indicates the potential for downward flow and is an indication that surface water or shallow groundwater is recharging the deeper aquifer. A positive value indicates the potential for upward flow where deeper groundwater is moving toward the shallow aquifer or discharging to surface water. Time series plots showing vertical hydraulic gradients in nested wells are presented in Figure 2.2.2-10, and locations of each DMW nested well is included in Figure 2.2.2-11.

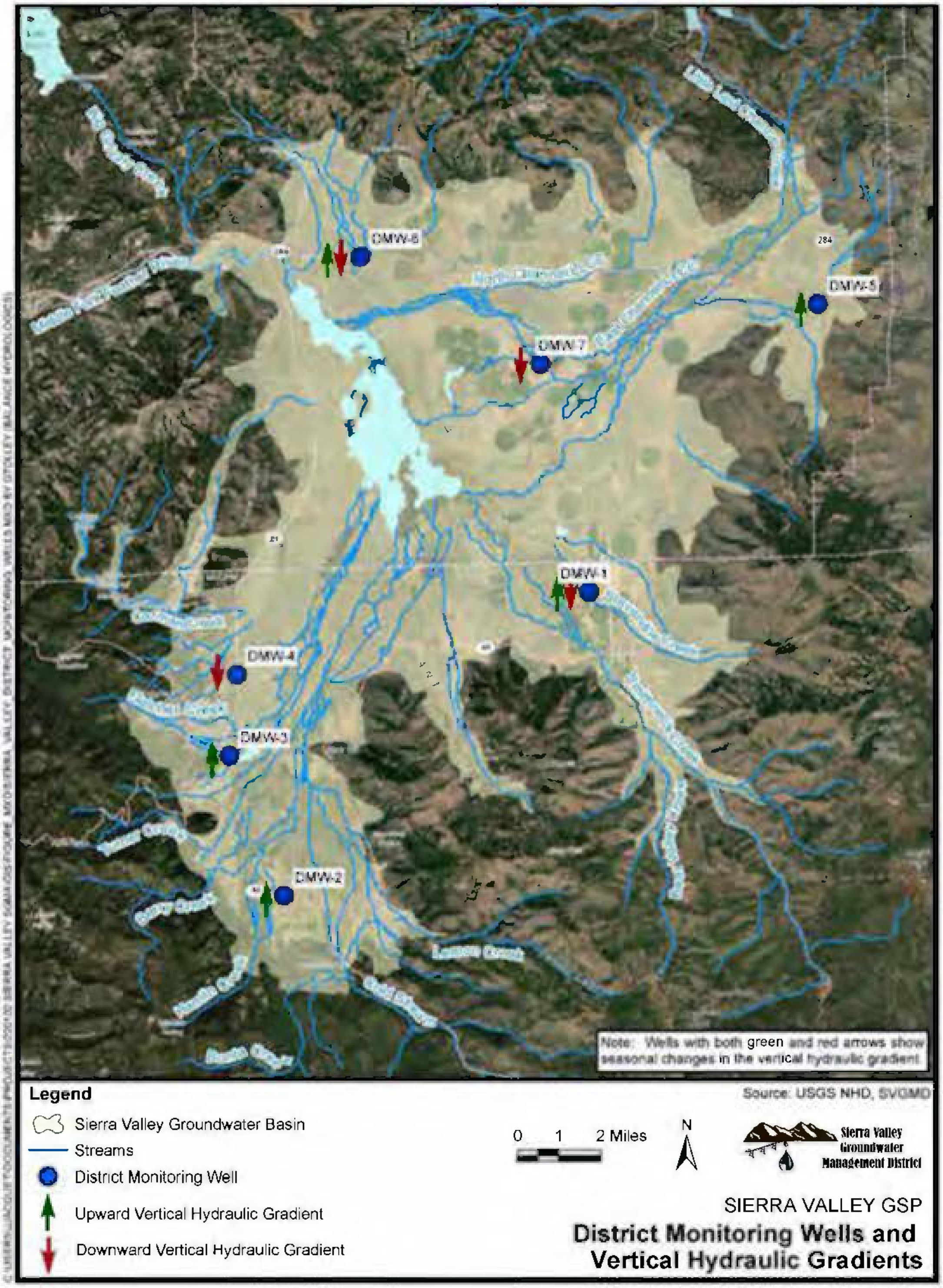
Figure 2.2.2-10: Calculated Vertical Hydraulic Gradients between Deep and Shallow Nested District Monitoring Wells



[16]

[16] Positive values indicate an upward gradient where the deep aquifer has the potential to flow toward shallow groundwater or discharge to surface water. A negative value indicates a downward gradient and the potential for shallow groundwater or surface water to be recharge the deep aquifer.

Figure 2.2.2-11: Locations of District Monitoring Wells in the Sierra Valley



Notes:
- Wells with both green and red arrows show seasonal changes in the vertical hydraulic gradient

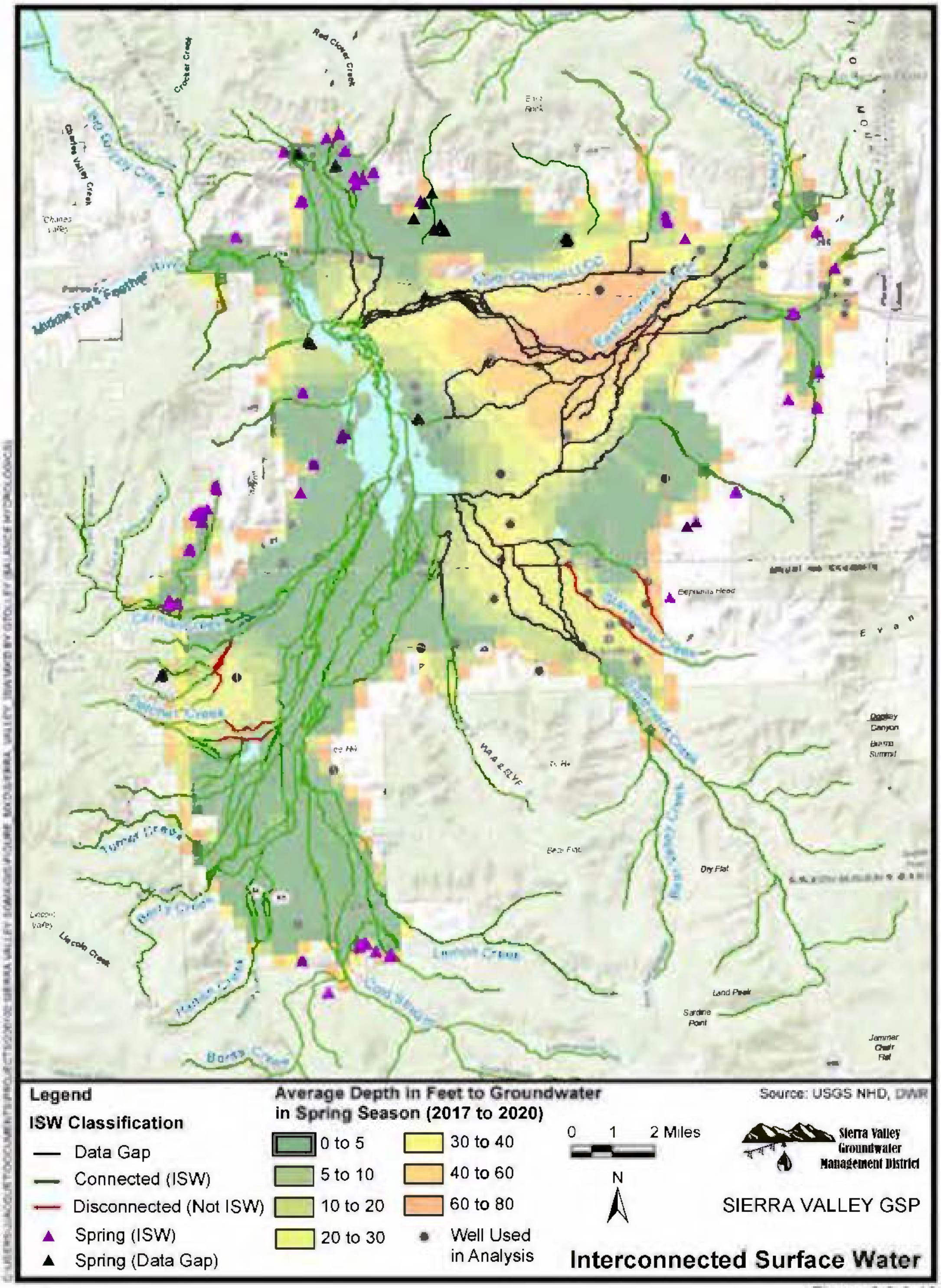
Vertical gradients from DMW-2, DMW-3, and DMW-5 show the potential for upwelling of deep groundwater to shallow groundwater. This indicates that where ISW exists near these wells, the surface water is likely gaining and supported by groundwater. DMW-1, DMW-4, and DMW-7 show a mostly downward vertical gradient. This indicates that where ISW exists in the vicinity of these wells, the streams are likely losing and most at risk from being disconnected from groundwater. DMW-1 and DMW-6 show both upward and downward gradients. Seasonal variation in DMW-1 from an upward vertical gradient in the spring to a downward vertical gradient in the fall results from a decrease in deep groundwater elevations in late summer while shallow groundwater elevations stay relatively steady. Seasonal variation in DMW-6 from a downward gradient in the Spring to upward gradient in the Fall results from a decrease in shallow groundwater elevation below the elevation of the deep groundwater.

Nested wells also help establish whether a surface body is connected to a perched aquifer or the principal aquifer. Perched aquifers represent groundwater that is separated from the regional or principal aquifer by an unsaturated zone. They occur when a relatively impermeable layer (e.g., a clay layer with very low hydraulic conductivity) prevents the downward movement of groundwater creating saturated conditions above the low permeability layer. There is limited data to define the extent of perched aquifers, but preliminary data from DMW-7 (installed in 2020) valley fill stratigraphy, and anecdotal evidence from valley residents indicate the existence of perched aquifers near Little Last Chance Creek and Smithneck Creek. Due to the lack of shallow groundwater monitoring in these areas, streams here have not been classified as disconnected or interconnected surface water, but instead have been classified as a data gap. Section 3.4 presents the proposed monitoring network that can be used to fill this data gap and establish the presence or absence of perched aquifers. For any perched aquifers that are identified, the importance to agricultural and/or environmental users will be evaluated, and a decision will be made on whether it should be included and managed in future GSP updates.

2.2.2.6.5 Interconnected Surface Water Results

Figure 2.2.2-12 presents a map of streams identified as ISW, non-ISW, and streams that do not have enough information to make a distinction on connectedness that are classified as a data gap. Springs are also identified in the map and classified as either an ISW (observed to have water during a field investigation or through recent aerial imagery) or data gap (observed dry during a field investigation or recent aerial imagery but may contain water during wetter seasons or years). In general, streams in the central and eastern portions of the Sierra Valley is classified as a data gap due to the lack of shallow groundwater elevation data. This includes Smithneck Creek downstream of Loyalton and Little Last Chance Creek downstream of Highway 70 to the large central wetland complex. An area of disconnected streams exists on the western side of the Valley including Carman and Fletcher Creeks downstream of the Westside Road. Streams on the south, west, and near the Valley margins are generally connected to groundwater. This includes the streams on the south and west side such as Lemon Creek, Cold Stream, Bonta Creek, Hamlin Creek, Berry Creek, Turner Creek, Fletcher Creek, and Carman Creek. On the east side of the Valley this includes Little Last Chance Creek above Highway 70, Staverville Creek, Smithneck Creek above Loyalton, and Bear Valley Creek.

Figure 2.2.2-12: Map of Interconnected Surface Water (ISW) in the Sierra Valley



12/15/2021
Figure 2.2.2-12

2.2.2.7 Identification of groundwater-dependent ecosystems

SGMA requires GSAs to consider groundwater dependent ecosystems (GDEs) and other beneficial uses of groundwater when developing GSPs. SGMA defines GDEs as "ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (23 CCR § 351(m)). As described in The Nature Conservancy's guidance for GDE analysis (Rohde et al. 2018), a GDE's dependence on groundwater refers to reliance of GDE species and/or ecological communities on groundwater for all or a portion of their water needs. GDEs include ecosystems associated with springs and seeps as well as plant communities that can tap groundwater using their roots. In addition, ISW (see Section 2.2.2.6) can be used by both aquatic and riparian GDEs. Identification of GDEs involves determining which vegetation types can tap groundwater through their root systems and identifying ecosystems that rely on ISW (including rivers, springs, and seeps) by mapping the extent of ISW features (Rohde et al. 2018). Here, potentially groundwater dependent vegetation units were identified from existing vegetation maps within Sierra Valley and compared with measurements of groundwater depth. Streams with interconnected surface water were identified in Section 2.2.2.6. Once the GDEs are mapped, the occurrence of special-status species was used to determine the beneficial users of GDEs and the ecological value of GDEs in the basin.

2.2.2.7.1 Methods

2.2.2.7.1.1 GDE Identification

This section includes brief descriptions of the vegetation community data and other information sources used to identify and aggregate potential GDEs into final GDE units. The Natural Communities Commonly Associated with Groundwater database (CA DWR 2020) was reviewed in a geographic information system (GIS) and used to generate a preliminary map to serve as the primary basis for initial identification of potential GDEs in the Sierra Valley Groundwater Basin. This information was then refined based on local information.

The steps for defining and mapping GDEs outlined in Rohde et al. (2018) were used as a guideline for this process. A decision tree was applied to determine when species or biological communities were considered groundwater dependent based on definitions found in 23 CCR § 351(m) (State Water Resources Control Board 2021) and Rohde et al. (2018). This decision tree, created to systematically and consistently address the range of conditions encountered, is summarized below; the term "unit" refers to an area with consistent vegetation and hydrology:

The unit is a GDE if groundwater is likely:

1. Interconnected with surface water or spring
2. An important hydrologic input to the unit during some time of the year, AND
3. Important to survival and/or natural history of inhabiting species, AND
4. Associated with a principal aquifer used as a regionally important source of groundwater

The unit is not a GDE if its hydrologic regime is primarily controlled by:

1. Surface discharge or drainage from an upslope human-made structure(s) with no connection to a principal aquifer, such as irrigation canal, irrigated fields, reservoir, cattle pond, or water treatment pond/facility.
2. Precipitation inputs directly to the unit surface. This excludes vernal pools from being GDEs where units are hydrologically supplied by direct precipitation and very local shallow subsurface flows from the immediately surrounding area.

Rohde et al. (2018) recommend that maps of potential GDEs be compared with local groundwater elevations to determine where groundwater is within the rooting depth of potential GDE vegetation communities. Given uncertainties in extrapolating well measurements to GDEs and differences in surface elevation of wells and GDEs, Rohde et al. (2018) recommend assigning GDE status to vegetation communities either where groundwater is within 30 ft of the ground surface or where interconnected surface waters are mapped. Because of uncertainties in the source of water used by vegetation and aquatic organisms, coupled with limited shallow groundwater data and relatively old vegetation maps, with little species information ecosystems connection to groundwater is uncertain throughout the SVGB. The GDEs identified below are all potential GDEs.

The following datasets were used to develop a map of potential GDEs in the Sierra Valley Groundwater Basin:

- Classification and Assessment with Landsat of Visible Ecological Groupings (CalVeg) – United States Department of Agriculture - Forest Service (USDA 2014). *North Sierra region: Imagery date: 2000–2009; Minimum mapping unit (MMU): 2.5-acre.*
- National Wetlands Inventory - Version 2.0 (NWI), U.S. Fish and Wildlife Service (USFWS, 2018). *Imagery date: 1984; Minimum mapping unit (MMU): 0.5-acre.*
- Statewide Crop Mapping 2018b, California Department of Water Resources (CA DWR 2018b)
- Interconnected surface water and springs map detailed in Section 2.2.2.6
- Average spring depth to water (2017-2020) in the Sierra Valley Groundwater Basin, Larry Walker Associates (Appendix 3-1)

Both CalVeg and NWI were used to construct the vegetation map, which are included in CA DWR (2020). Where CalVeg and NWI overlapped, NWI was used to denote potential wetland vegetation, based on comparison of the two vegetation maps and aerial photography. Potential GDEs were defined as plant communities that were likely dependent on groundwater or interconnected surface water. Sites classified as agriculture by CA DWR (2018b) were not included as GDEs. Because the position of channels in the interconnected surface water (ISW) map (Section 2.2.2.6) differed from riverine map units in the NWI dataset. NWI riverine polygons that were not within 50 ft of ISW points were classified as unlikely GDEs.

The potential GDE map was then overlain with a depth to groundwater raster derived from average groundwater elevation contours from 2017–2020 were subtracted from a 2018 1-m USGS DEM (OCM Partners, 2021). Potential GDEs that occur where depth to groundwater exceeds 30 ft were removed from the potential GDE map. Average spring depth to water from 2017 to 2020 was used for this assessment. The average value from 2017 to 2020 was used instead of an individual year because using multiple years allowed for a much more robust estimate of groundwater depth than using a single year alone.

Three meadows along Carman Creek were added to the GDE map based on observations of the vegetation and shallow groundwater described in (Rodriguez et al, 2017; Davis et al., 2020).

Interconnected surface water maps described in Section 2.2.2.6 were used in place of NWI riverine polygons. Where the replaced riverine polygons occurred within other GDE polygons, they were not removed to avoid holes in the map. Otherwise, the riverine polygons were removed. In addition, the GDE map includes springs from the NHD (USGS 2021) identified as part of the ISW analysis.

2.2.2.7.1.2 Special-status Species

As part of the ecological inventory, special-status species and sensitive natural communities that are potentially associated with GDEs in the Sierra Valley Groundwater Basin were identified. For the purposes of this document, special-status species are defined as those:

- listed, proposed, or under review as endangered or threatened under the federal Endangered Species Act or the California Endangered Species Act;
- designated by California Department of Fish and Wildlife (CDFW) as a Species of Special Concern;
- designated by CDFW as Fully Protected under the California Fish and Game Code (Sections 3511, 4700, 5050, and 5515);
- designated as Forest Service Sensitive according to the Regional Forester's Sensitive Species Management Guidelines listed per USFS Memorandum 2670 (USFS, 2011);
- designated as Bureau of Land Management (BLM) sensitive;
- designated as rare under the California Native Plant Protection Act; and/or
- included on CDFW's most recent Special Vascular Plants, Bryophytes, and Lichens List (CDFW, 2020a) with a California Rare Plant Rank (CRPR) of 1, 2, 3, or 4.

Sensitive natural communities are defined as vegetation communities identified as critically imperiled (S1), imperiled (S2), or vulnerable (S3) on the most recent California Sensitive Natural Communities List (CDFW, 2020b).

Databases on regional and local occurrences and spatial distributions of special-status species within the Sierra Valley Groundwater Basin were reviewed for available information. Spatial database queries (e.g., CNDDB) included potential GDEs plus a 1-mile buffer. Information on the special-status species that have potential to occur in the groundwater basin was obtained from the following sources:

- California Natural Diversity Database (CNDDB) (CDFW, 2020c);
- California Native Plant Society (CNPS) Manual of California Vegetation (2021);
- eBird (2021);
- TNC freshwater species lists generated from the California Freshwater Species Database (CAFSD) (TNC, 2021);
- USFWS's Information for Planning and Consultation (IPaC) portal (USFWS, 2021); and
- Feather River Land Trust Sierra Valley Birder's Guidebook (Feather River Land Trust n.d.).

Botanists and wildlife biologists reviewed the database query results and identified special-status species and vegetation communities that may occur within or be associated with the vegetation and aquatic communities in or immediately adjacent to potential GDEs. Ecologists then consolidated these special-status species and sensitive community types into a list, along with summaries of habitat preferences, potential groundwater dependence, and reports of any known occurrences.

Wildlife species were evaluated for potential groundwater dependence using determinations from the Critical Species Lookbook (Rohde et al., 2019) or by evaluating known habitat preferences, life histories, and diets. Species GDE associations were assigned one of three categories:

- Direct—species directly dependent on groundwater for some or all water needs (e.g., cottonwood with roots in groundwater, fish using a stream interconnected with groundwater)
- Indirect—species dependent upon other species that rely on groundwater for some or all water needs (e.g., riparian birds)
- No known reliance on groundwater

Sensitive natural communities were classified as either likely or unlikely to depend on groundwater based on species composition using the same methodology as vegetation communities (Section 2.2.2.7.1). Plant species were evaluated for potential groundwater dependence based on their habitat (Jepson Flora Project, 2020) and association with vegetation communities classified as GDEs. Special-status plant GDE associations were assigned one of three categories: likely, possible, or unlikely. The "possible" category was included to classify plant species with limited habitat data or where a species may have an association with a vegetation community identified as a GDE (e.g., wet meadows, seeps, springs, and other interconnected surface waters).

Database query results for local and regional special-status species occurrences were combined with their known habitat requirements to develop a list of groundwater dependent special-status species (Section 3.2) that satisfy the following criteria: (1) documented to occur within the GDE unit, or (2) known to occur in the region and suitable habitat present in the GDE unit. There may be special-status species that occur in Sierra Valley that are recorded in sources other than those listed above, but because these sources weren't available, they were not included in the list of special-status species. The special-status species list will be updated with any additional information in subsequent drafts.

2.2.2.7.2 Results

The Sierra Valley Groundwater Basin contains 17,581 acres of potential GDEs, approximately 14% of the total basin area (Figure 2.2.2-13). About 80% of the GDEs in the basin are associated with the large wetland complex in the western half of the groundwater basin. The meadows along Carman Creek contain approximately 226 acres of the GDEs. GDEs are primarily located along the western edge of the basin where groundwater is shallower and associated with the large wetland complex. The GDEs in the wetland complex overlie clay-rich sediments with poorly drained soils. There are few wells near the GDEs, and the groundwater depths and the connection to groundwater are somewhat uncertain. Nevertheless, given that this area is supplied by interconnected surface water (see Figure 2.2.2-12) and our best estimate is that depth to groundwater is less than 30 ft, the large wetland complex is mapped as a GDE. The NHD dataset included 81 springs within the SVGB most of which are located in the uplands on the fringes of the basin, are also mapped as GDEs (Figure 2.2.2-13). Of the 81 springs shown on figure 2.2.2-13, 60 were confirmed in the field or on aerial photographs (labeled spring ISW), and 20 were in the statewide springs database but not verified (labeled spring data gap).

Due to the semi-confined nature of the aquifer system and the spatial and temporal sparseness of measurements, uncertainty in groundwater elevation is quite high. The standard deviation of 2017-2020 average groundwater elevation within a half-mile buffer of the GDEs ranges from 42 to 80 ft. Up to 9,500 acres of potential GDEs that were removed because the depth to groundwater exceeded 30 ft could be reclassified as likely GDEs if groundwater elevations increased by one standard deviation. Additional shallow groundwater monitoring well data are needed to reduce uncertainty in depth to water assessments (see Section 2.2.2.7.7)

Figure 2.2.2-13: Potential Groundwater Dependent Ecosystems in the Sierra Valley Groundwater Basin

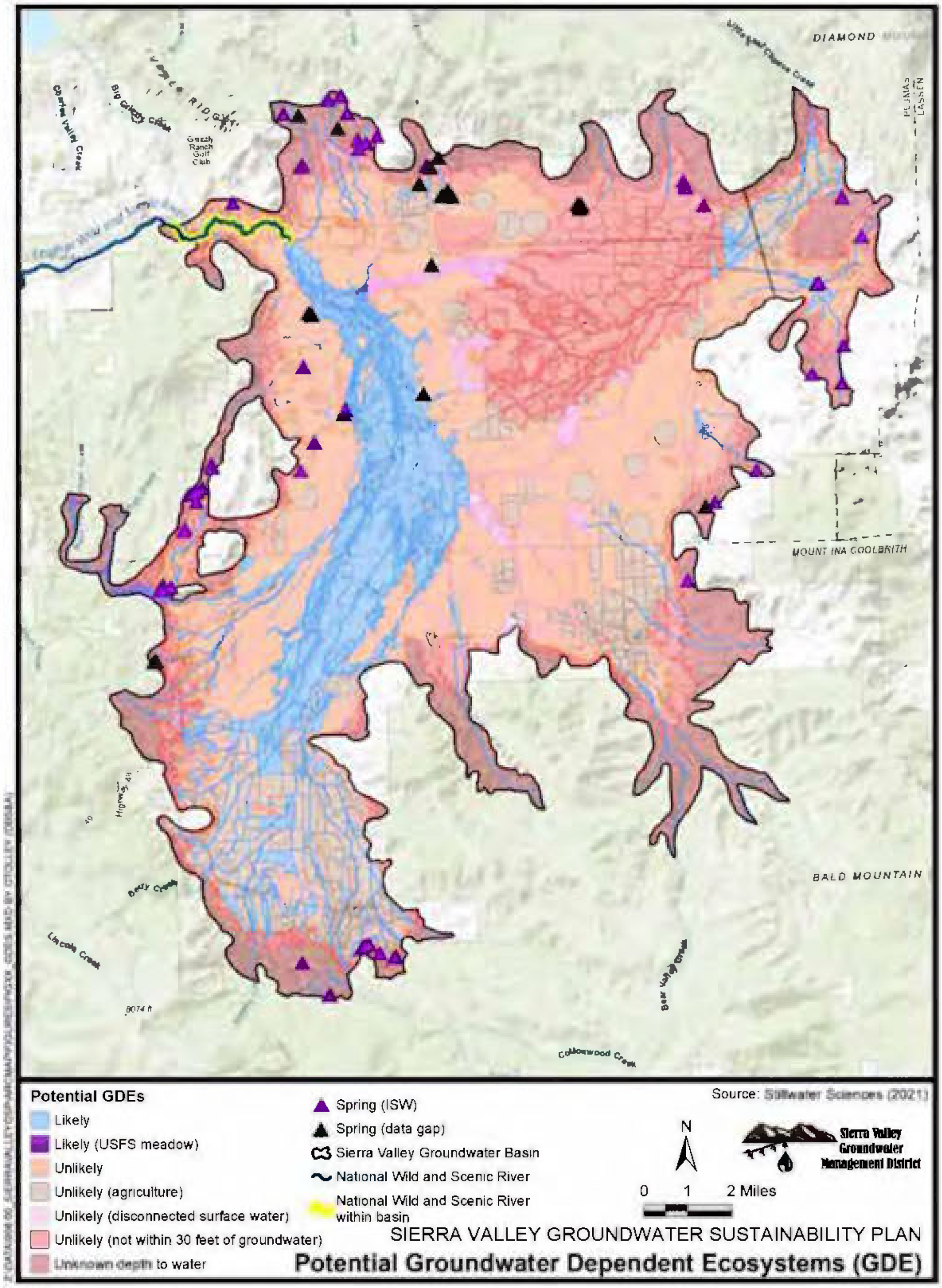


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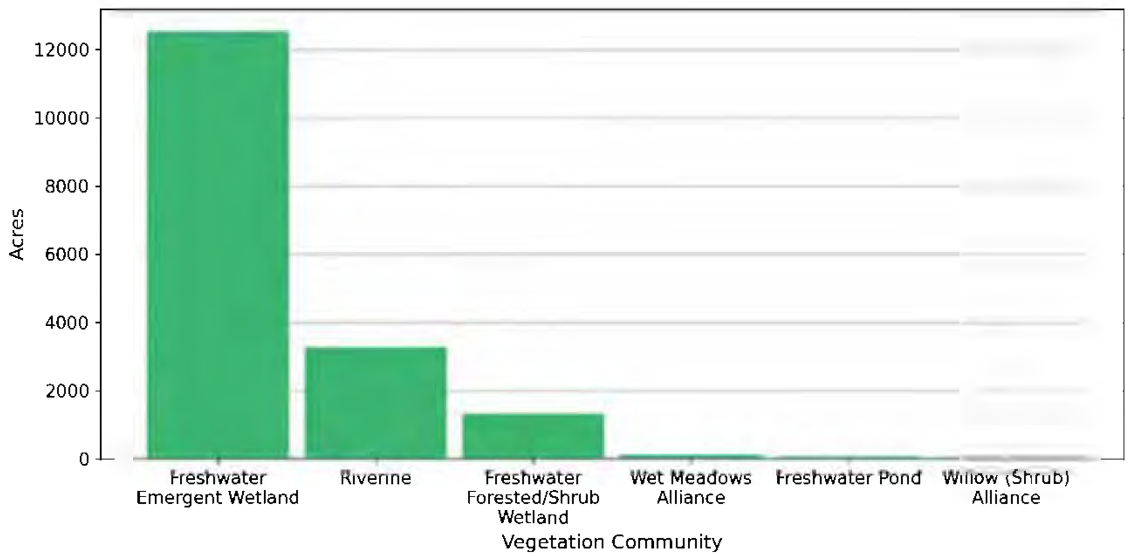
Figure ?

Freshwater emergent marshland is the most prevalent vegetation community (12,640 acres, Figure 2.2.2-14) comprising 72% of all GDE area. Riverine (3,276 acres) and freshwater forested/shrub wetland (1,329 acres) communities are also prevalent, comprising 19% and 8%, respectively, of all GDE area.

Figure 2.2.2-14: Five Most Prevalent GDE Vegetation Communities in the Sierra Valley Groundwater Basin, by Acreage



2.2.2.7.3 Hydrology near GDEs

Trends in the hydrology near the GDEs were assessed by comparing groundwater elevation contours through time. This analysis compared spring and fall groundwater levels independently but averaged over multiple years (either during fall or spring) to ensure that the contours are statistically robust. For GDEs, the spring levels define the highest elevation of the year and can help to define the GDEs, but the fall groundwater levels are crucial for maintaining health of most GDEs. In general, groundwater levels near GDEs declined during the 2012-2015 drought and subsequently recovered. Fall groundwater levels declined between 2006-2009 and 2012-2015 in the main wetland GDE area on the western side of the basin. The 2012-2015 period represents drought conditions. The decline in groundwater levels was greatest in the eastern portion of the main GDE (about 25 ft) and was smallest in the southern and western portions of the GDE. Groundwater levels rebounded to 2006-2009 levels by 2020. At the time of this GSP preparation, groundwater elevation contours were available only through Fall 2020.

Similar trends were observed outside of the main GDE area, although the magnitude of change varied. South of the main GDE, near Hamlin Creek at Sierraville groundwater levels declined by less than 5 feet between 2006-2009 and 2012-2015 before subsequently recovering. On the eastern side of the basin, near the mouth of Correco Canyon, groundwater levels declined by approximately 10 ft between 2006-2009 and 2012-2015 and have yet to recover to 2006-2009 levels. Near Little Last Chance Creek at Vinton, groundwater levels declined by approximately 15 ft and subsequently recovered to within five ft of 2006-2009 levels by 2020.

In summary, groundwater levels near the GDEs dropped during droughts but appeared to recover to their pre-drought levels in most of the GDEs. Sustained drought may impede groundwater level recovery in the future.

There is not sufficient information in the vegetation mapping to assess the rooting depth of the plants relative to the depth of groundwater and predict the impact of these changes. Interconnected surface water (Section 2.2.2.7) is the main surface water source to the GDE units, but the degree to which the GDEs are maintained by interconnected surface water or groundwater is not known. Irrigation canals may also contribute surface water to the GDE units.

2.2.2.7.4 Special-status Species

The Sierra Valley Groundwater Basin includes United States Fish and Wildlife Service (USFWS) designated critical habitat for one federally listed plant species: Webber's ivesia (*Ivesia webberi*) (2,094 acres) (USFWS, 2014). The critical habitat is located on the eastern edge of the groundwater basin near Dyson Lane and Highway 49. Habitat for Webber's ivesia—sagebrush flats—is not a GDE community. The lower 4.5 miles of the Middle Fork Feather River within the basin are part of the Wild and Scenic Reach of the river.

Nine likely groundwater-dependent special-status plant species were documented in the Sierra Valley Groundwater Basin (Table 2.2.2-3). In addition, one likely groundwater-dependent sensitive natural community (montane freshwater marsh) occurs in the Sierra Valley Groundwater Basin (Table 2.2.2-3).

In addition to the special-status plant species listed in Table 2.2.2-3, the TAC identified Sierra Valley evening primrose (*Camissonia tanacetifolia ssp. quadriperforata*) as a plant of special interest in Sierra Valley. The Sierra Valley evening primrose is unlikely to be groundwater dependent.

Table 2.2.2-3: Special-status Plant Species and Sensitive Natural Communities with Known Occurrence within the Sierra Valley Groundwater Subbasin

Common name *Scientific name*	Status[1]	Association with GDE	Jepson habitat[2]	Harnach (2016) habitat[3]	Query source
Plants					
Lemmon's milk-vetch *Astragalus lemmonii*	1B.2, S2, G2	Likely	Moist, alkaline meadows, lake shores	Common, subalkaline meadows	CNDDB and Harnach (2016)
Lens-pot milk-vetch *Astragalus lentiformis*	1B.2, S2, G2	Unlikely	Dry sandy soil, sagebrush, or pine	Dry sandy slopes and open pine forests	Harnach (2016)
Pulsifer's milk-vetch *Astragalus pulsiferae var. pulsiferae*	1B.2, S2, G4T2	Unlikely	Sandy or rocky soil, often with pines, sagebrush	Locally frequent, dry sandy granitic slopes	CNDBB and Harnach (2016)
Hillman's silverscale *Atriplex argenta var. hillmani*	2B.2, S2, G5T4	Possible	Saline or clay valley bottoms	Limited, subalkaline flats	Harnach 2016
Scalloped moonwort *Botrychium crenulatum*	2B.2, S3, G4	Likely	Saturated hard water seeps and stream margin	N/A	CNDDB
Mingan moonwort *Botrychium minganense*	2B.2, S3, G4G5	Likely	Meadows, open forest along streams or around seeps	N/A	CNDDB
Western goblin *Botrychium montanum*	2B.1, S2, G3	Possible	Shady conifer woodland, especially under *Calocedrus* spp. along streams	N/A	CNDDB
Watershield *Brasenia schreberi*	2B.3, S3, G5	Likely	Ponds, slow streams	Uncommon, shallow ponds	CNDDB and Harnach 2016
Fiddleleaf hawksbeard *Crepis runcinata*	2B.2, S3, G5	Possible	Sagebrush scrub, pinyon-juniper woodland, wetland-riparian zones	Meadows and subalkaline flats	CNDDB and Harnach 2016

Common name *Scientific name*	Status[1]	Association with GDE	Jepson habitat[2]	Harnach (2016) habitat[3]	Query source
Globose cymopterus *Cymopterus globosus*	2B.2, S1, G3G4	Unlikely	Sandy open flats	N/A	CNDDB
Oregon fireweed *Epilobium oreganum*	1B.2, S2, G2	Likely	Bogs, small streams	Rare. Moist edges of river	Harnach (2016)
Nevada daisy *Erigeron eatonii var. nevadincola*	2B.3, S2S3, G5T2T3	Unlikely	Open grassland, rocky flats, generally in sagebrush or pinyon/juniper scrub	Uncommon, rocky volcanic soils	CNDDB and Harnach (2016)
Alkali hymenoxys *Hymenoxys lemmonii*	2B.2, S2S3, G4	Possible	Roadsides, open areas, meadows, slopes, drainage areas, stream banks	Fairly frequent. Subalkaline areas	CNDDB and Harnach (2016)
Sierra Valley ivesia *Ivesia aperta var. aperta*	1B.2, S2, G2T2	Possible	Dry, rocky meadows, generally volcanic soils	Common, disturbed areas and roadsides	CNDDB and Harnach (2016)
Bailey's ivesia *Ivesia baileyi var baileyi*	2B.2, S2, G5T4	Unlikely	Volcanic crevices	Rare, volcanic cliffs	Harnach (2016)
Plumas ivesia *Ivesia sericoleuca*	1B.2, S2, G2	Likely	Dry, generally volcanic meadows	Fairly common in scattered localities. Seasonally wet clay soils. Primarily on the W side of the valley	CNDDB and Harnach (2016)
Webber's ivesia *Ivesia webberi*	1B.1, S1, G1	Unlikely	Rocky clay in sagebrush flats	Rare, volcanic scalds and cobbley areas	CNDDB and Harnach (2016)
Santa Lucia dwarf rush *Juncus luciensis*	1B.2, S3, G3	Likely	Wet, sandy soils of seeps, meadows, vernal pools, streams, roadsides	Vernally moist sands and along streams	CNDDB and Harnach (2016)
Seep kobresia *Kobresia myosuroides*	2B.2, S2, G5	Possible	Rocky seeps	Rare, drying vernal meadows	CNDDB and Harnach (2016)

Common name *Scientific name*	Status[1]	Association with GDE	Jepson habitat[2]	Harnach (2016) habitat[3]	Query source
Sagebrush loeflingia *Loeflingia squarrosa var. artemisiarum*	2B.2, S2, G5T3	Unlikely	Sand, gravel of hills, mesas, dunes, disturbed areas	Disturbed areas	CNDDB and Harnach (2016)
Tall alpine-aster *Oreostemma elatum*	1B.2, S2, G2	Likely	Peatlands, marshy areas, wet meadows, montane forest	Wet meadows, marshy areas, and peatlands	CNDDB
Susanville beardtongue *Penstemon sudans*	4.3, S4, G4	Unlikely	Open, rocky, igneous soils in sagebrush scrub, yellow-pine, and montane forests	N/A	CNDDB and Harnach (2016)
Modoc County knotweed *Polygonum polygaloides ssp. esotericum*	1B.3, S3, G4G5T3	Possible	Vernal pools, seasonally wet places, pinyon/juniper woodland	Uncommon, vernally moist areas	CNDDB and Harnach (2016)
Nuttall's ribbonleaved pondweed *Potamogeton epihydrus*	2B.2, S2S3, G5	Likely	Shallow water, ponds, lakes, streams	Limited, shallow water	CNDDB and Harnach (2016)
Sticky pyrrocoma *Pyrrocoma lucida*	1B.2, S3, G3	Possible	Alkaline clay flats, sagebrush scrub, open forest	Localized stands. Meadow areas in pines and sagebrush	CNDDB and Harnach (2016)
Green-flowered prince's plume *Stanleya viridiflora*	2B.3, S2, G4	Unlikely	Cliffs, shale, clay knolls, steep bluffs, white ash deposits	Clay flats	CNDDB and Harnach (2016)
Many-flowered thelypodium *Thelypodium milleflorum*	2B.2, S3, G5	Unlikely	Sandy soils, scrub	Sandy areas	Harnach (2016)

Common name *Scientific name*	Status[1]	Association with GDE	Jepson habitat[2]	Harnach (2016) habitat[3]	Query source
Golden violet *Viola purpurea ssp. Aurea*	2B.2, S2, G5T2T3	Unlikely	Pinyon/juniper woodland, sagebrush, sandy slopes	Rare, sagebrush and sandy soils	Harnach (2016)
Sensitive Natural Communities					
Montane Freshwater Marsh	S3.2, G3	Likely	Sites lacking significant current, permanently flooded by fresh water. Widely scattered throughout Montane California.	N/A	CNDDB

[1] Status codes:	
G = Global T = Subspecies or variety	State S = Sensitive

Rank

1. Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
2. Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
3. Vulnerable — At moderate risk of extinction or elimination due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
4. Apparently Secure — Uncommon but not rare; some cause for long-term concern due to declines or other factors.
5. Demonstrably Secure — Common; widespread and abundant.

? uncertain numeric ranking (e.g., S3? indicates the element is most likely an S3 but there is a significant chance the element could be an S2 or S4)

Ranks such as S2S3 indicate a ranking between S2 and S3

California Rare Plant Rank (CRPR)

1B Plants rare, threatened, or endangered in California and elsewhere

2B Plants rare, threatened, or endangered in California, but more common elsewhere

4 Plants of limited distribution, a watch list

CRPR Threat Ranks:

0.1 Seriously threatened in California (high degree/immediacy of threat)

0.2 Fairly threatened in California (moderate degree/immediacy of threat)

0.3 Not very threatened in California (low degree/immediacy of threats or no current threats known)

2 Source: Jespson (2020)

3 Source: Harnach (2016)

2.2.2.7.4.1 Terrestrial and aquatic wildlife

Thirty-eight special-status terrestrial and aquatic wildlife species were identified during scoping as having the potential to likely or possible occur within the Sierra Valley Groundwater Basin. Of these, twenty-one were potentially groundwater dependent species: one amphibian species, fifteen bird species, and six mammal species. Information on these groundwater dependent species, including regulatory status and habitat associations, is provided Table 2.2.2-4. The Sierra Valley groundwater basin is within the range of a recently observed gray wolf (*Canis lupus*) pack (CDFW, 2021a). The gray wolf is an endangered species in California but has been delisted by the USFWS. The gray wolf likely depends on some groundwater-dependent species for food, but the groundwater dependence of prey in Sierra Valley has not been explored.

Beyond the special status species listed in Table 2.2.2-4, additional bird and invertebrate species for which there is conservation concern and have the potential to occur in the Sierra Valley Groundwater Basin include: white-faced ibis (*Plegadis chihi*; CDFW watchlist [WL]), ferruginous hawk (*Buteo regalis*; CDFW WL, USFWS Birds of Conservation Concern [BCC]), prairie falcon (*Falco mexicanus*; CDFW WL, USFWS BCC), Cooper's hawk (*Accipiter cooperii*; CDFW WL), sharp-shinned hawk (*Accipiter striatus*; CDFW WL), long-billed curlew (*Numenius americanus*; CDFW WL; USFWS BCC), canvasback (*Aythya valisineria*; California [CA] imperiled [S2]), western pearlshell (*Margaritifera falcata*; CA critically imperiled [S1], S2), western ridged mussel (*Gonidea angulata*; CA S1, S2), brownish dubiraphian riffle beetle (*Dubiraphia brunnescens*; CA S1), and Pinnacles optioservus riffle beetle (*Optioservus canus*; CA S1) (Feather River Land Trust, n.d.; TNC, 2021).

Sierra Valley Groundwater Basin, including GDEs, provides high quality habitat that is utilized by birds for breeding, foraging, migrating, and over-wintering. Two-hundred and thirty-seven bird species have been identified in the Sierra Valley, including waterfowl, raptors, and shorebirds (Feather River Land Trust, n.d.). Habitat within the Sierra Valley Groundwater Basin includes a large montane wetland that supports large breeding colonies (e.g., white-faced ibis [*Plegadis chihi*]) and bird species not found breeding in managed wetlands (e.g., black tern [*Chlidonias niger*]) (NAS, 2008). Sierra Valley provides essential rare habitat for bird populations, including habitat critical for breeding; therefore, it is designated as an Important Bird Area by the National Audubon Society.

Fish occur in interconnected reaches of Sierra Valley streams and thus are dependent upon groundwater. There has not been a recent study of fish in SVGB streams and thus the current distribution of fish in Sierra Valley is not well known. Available information, which is largely based on fish occurrence data from a 1973 DWR report (DWR, 1973) summarized by Vestra (2005), indicates that up to 15 species of fish, both native and non-native, occur in the SVGB. These include several fish species native to other California watersheds and introduced to Sierra Valley waters accidentally through out-of-basin water diversions and non-native trout introduced intentionally (stocked) to provide angling opportunities. None of the fish species believed to currently occur in the SVGB are listed by the state or federal government as threatened or endangered.

Many coldwater upland streams within the SVGB support native rainbow trout (*Oncorhynchus mykiss*) as well as non-native brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) and potentially riffle sculpin (*Cottus gulosus*) (Rogers et al., 2018; Vestra, 2005; Moyle et al., 1996). The trout populations have historically been supported by stocking. Lahontan cutthroat trout (*O. clarki henshawi*), a native species listed as threatened under the federal Endangered Species Act that historically may have occurred in Sierra Valley streams, are no longer present in the watershed (Rogers et al., 2018). Lahontan cutthroat trout were introduced experimentally to Palen Reservoir on Antelope Creek in the mid-1990s by CDFW (Vestra, 2005), but the experimental population apparently did not persist.

Native Sacramento sucker (*Catostomus occidentalis*) and Sacramento pikeminnow (*Ptychocheilus grandis*) have been documented in the Middle Fork Feather River within the SVGB (CDFW, 2021b; USDA Forest Service, 2021). Lahontan redside (*Richardsonius egregius*), mountain sucker (*Catostomus platyrhynchus*), and mountain whitefish (*Prosopium williamsoni*), all of which are native to nearby basins but were introduced to the Sierra Valley via an irrigation canal from the Little Truckee River, are found primarily in valley floor streams and sloughs in the SVGB (Vestra, 2005; Moyle et al., 1996). Speckled dace (*Rhinichtys osculus*), which is considered native to the Feather River basin, is also found primarily in valley floor streams and sloughs (Vestra, 2005; DWR, 1998).

Introduced fish species in Sierra Valley include sportfish such as largemouth bass (*Micropterous salmoides*), green sunfish (*Lepomis cyanellus*), bluegill (*L. macrochirus*), and brown bullhead (*Ameiurus nebulosus*) as well as golden shiner (*Notemigonus crysoleucas*), common carp (*Cyprinus carpio*), and the aforementioned brown and book trout (Vestra, 2005).

Table 2.2.2-4: Groundwater-dependence of Special-status Wildlife Species with Potential to Occur or Suitable Habit in the Sierra Valley Groundwater Basin

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the SVGB[2]	Query source[3]	GDE . association[4]	Habitat Associations
Invertebrates					
Western bumble bee *Bombus occidentalis*	FSS/SCE	Possible	CNDDB	No known reliance on groundwater	Uses flowering plants in meadows and forested openings; abandoned rodent burrows are used for nest and hibernation sites for queens.
Amphibian					
Northern leopard frog *Lithobates pipiens*	–/SSC (native populations only)	Possible	CAFSD	Direct	Breeding habitat is varied and includes quiet waters along streams and rivers, permanent ponds and lakes, cattle ponds, agricultural ditches, flooded fields, and beaver ponds. Water bodies may be temporary or permanent, with or without vegetation.
Foothill yellow-legged frog *Rana boylii*	BLMS, FSS/ST	Unlikely	CNDDB	Direct	Shallow tributaries and mainstems of perennial streams and rivers, typically associated with cobble or boulder substrate; occasionally found in isolated pools, vegetated backwaters, and deep, shaded, spring-fed pools. The frog is reliant on surface water that may be fed by groundwater. Found up to 6,000 feet.
Southern long-toed salamander *Ambystoma macrodactylum sigillatum*	–/SSC	Likely	CNDDB	Direct	Inhabits coniferous forest, oak, woodland, alpine, sagebrush, and marshlands. Live underground in moist places including rotten logs and animal burrows. Utilize ponds, lakes, and streams for breeding. Adults prey on small invertebrates (e.g., worms, mollusks, insects, and spider). Larvae eat small crustaceans.
Sierra Nevada Yellow-legged frog *Rana sierrae*	FE, FSS/ST	Unlikely	CAFSD, IPAC	Direct	Found in high elevation lakes, ponds, and streams in montane riparian, lodgepole pine, subalpine conifer, and wet meadow habitats. Typical elevation ranges from 4,500 to over 12,000 feet elevation.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the SVGB[2]	Query source[3]	GDE . association[4]	Habitat Associations
Bird					
American White Pelican *Pelecanus erythrorhynchos*	–/SSC	Likely	CAFSD, eBird	Indirect	Salt ponds, large lakes, and estuaries; loafs on open water during the day; roosts along water's edge at night. Forages for small fish in shallow water on inland marshes.
Bald eagle *Haliaeetus leucocephalus*	FD, BLMS, FSS, BGEPA/ SE, SFP	Likely	CAFSD, IPAC, eBird, FRLT	Indirect	Large bodies of water or rivers with abundant fish, uses snags or other perches; nests in advanced-successional conifer forest near open water (e.g., lakes, reservoirs, rivers). Bald eagles are reliant on surface water that may be supported by groundwater and/or groundwater-dependent vegetation (Rhode et al. 2019).
Bank swallow *Riparia riparia*	BLMS/ST	Likely	CAFSD, eBird, FRLT	Indirect	Nests in vertical bluffs or banks, usually adjacent to water (i.e., rivers, streams, ocean coasts, and reservoirs), where the soil consists of sand or sandy loam. Feeds on caterpillars, insects, frog/lizards, and fruit/berries. Relies on surface water that may be supported by groundwater (Rohde et al 2019).
Black tern *Chlidonias niger*	–/SSC	Likely	CAFSD, eBird, FRLT	Indirect	Nests semi-colonially in protected areas of marshes with floating nests. Feeds on insects.
Burrowing Owl *Athene cunicularia*	FSS/SSC	Likely	eBird, FRLT	No known reliance on groundwater	Level, open, dry, heavily grazed, or low- stature grassland or desert vegetation with available burrows. Preys on invertebrates and vertebrates.
California spotted owl *Strix occidentalis*	BLMS, FSS/SSC	Unlikely	CNDDB, IPAC	No known reliance on groundwater	Typically in older forested habitats; nests in complex stands dominated by conifers, especially coastal redwood, with hardwood understories; some open areas are important for foraging. Preys on small mammals.
Golden eagle *Aquila chrysaetos*	BGEPA, BLMS/SFP	Likely	eBird, FRLT	No known reliance on groundwater	Open woodlands and oak savannahs, grasslands, chaparral, sagebrush flats; nests on steep cliffs or medium to tall trees. Primary prey are small to medium mammals and birds; also scavenge and catch fish.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the SVGB[2]	Query source[3]	GDE . association[4]	Habitat Associations
Greater sandhill crane *Antigone canadensis tabida*	BLMS, FSS/ST, SFP	Likely	CNDDB, CAFSD, eBird, FRLT	Direct	Roosts in shallow ponds, flooded agricultural fields, sloughs, canals, or lakes; nests are generally built in shallow water or on dry land near a wetland. Forages in freshwater marshes and grasslands as well as harvested rice fields, corn stubble, barley, and newly planted grain fields. Feeds on tubers and aquatic plant seeds. Relies on freshwater wetlands that may be supported by groundwater (Rohde et al 2019).
Greater white-fronted goose *Anser albifrons*	–/SSC	Likely	eBird, FRLT	Indirect	Forage in wet sedge meadows, tidal mudflats, ponds, lakes, and wetlands during migration. Diet includes sedges, grasses, berries, and plant tubers during the summer and seeds, grain, and grasses in the winter.
Long-eared owl *Asio otus*	BLMS/SSC	Likely	eBird, FRLT	Indirect	Riparian habitat; nests in dense vegetation close to open grassland, meadows, riparian, or wetland areas for foraging. Prey on small mammals.
Northern goshawk *Accipiter gentilis*	BLMS, FSS/SSC	Likely	CNDDB, eBird	No known reliance on groundwater	Mature and old-growth stands of coniferous forest, middle and higher elevations; nests in dense part of stands near an opening. May hunt in riparian corridors. Preys on birds, mammals, and reptiles.
Northern harrier *Circus hudsonius*	–/SSC	Likely	eBird, FRLT	Indirect	Nests, forages, and roosts in wetlands or along rivers or lakes, but also in grasslands, meadows, or grain fields. Eats small mammals, amphibians, reptiles, and birds.
Olive-sided flycatcher *Contopus cooperi*	–/SSC	Likely	eBird, FRLT	No known reliance on groundwater	Primarily advanced-successional conifer forests with open canopies. Prey on insects including wasps, bees, dragonflies, grasshoppers, beetles, moths, and flies
Peregrine falcon *Falco peregrinus anatum*	FD/SD, SFP	Likely	eBird, FRLT	No known reliance on groundwater	Wetlands, woodlands, cities, agricultural lands, and coastal area with cliffs (and rarely broken-top, predominant trees) for nesting; often forages near water. Diet includes birds and bats.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the SVGB[2]	Query source[3]	GDE . association[4]	Habitat Associations
Redhead *Aythya americana*	–/SSC	Likely	CAFSD, eBird, FRLT	Indirect	Freshwater emergent wetlands with dense stands of cattails (*Typha* spp.) and bulrush (*Schoenoplectus* spp.) interspersed with areas of deep, open water; forages and rests on large, deep bodies of water. Summer resident in southern California.
Short-eared owl *Asio flammeus*	–/SSC	Likely	eBird, FRLT	Indirect	Salt or freshwater marshlands, ungrazed grasslands, old pastures, and irrigated alfalfa or grain fields. Eat small mammals.
Swainson's hawk *Buteo swainsoni*	BLMS/ST	Likely	CNDDB, eBird, FRLT	Indirect	Nests in oaks or cottonwoods in or near riparian habitats; forages in grasslands, irrigated pastures, and grain fields. Swainson’s hawks rely on groundwater-dependent vegetation in riparian woodland areas for nesting (Rohde et al 2019). Preys on mammals and insects.
Tricolored blackbird *Agelaius tricolor*	BLMS, FSS/ST	Unlikely	CAFSD	Indirect	Feeds in grasslands and agriculture fields; nesting habitat components include open accessible water with dense, tall emergent vegetation, a protected nesting substrate (including flooded or thorny vegetation), and a suitable nearby foraging space with adequate insect prey.
Willow Flycatcher *Empidonax traillii*	FSS/SE	Likely	CNDDB, CAFSD, eBird, FRLT	Indirect	Dense brushy thickets within riparian woodland often dominated by willows and/or alder, near permanent standing water. Reliant on groundwater-dependent riparian vegetation, including for nest sites that are typically located near slow-moving streams, or side channels and marshes with standing water and/or wet soils (Rohde et al 2019). Feeds on insects, fruits, and berries.
Vaux's swift *Chaetura vauxi*	–/SSC	Likely	FRLT	No known reliance on groundwater	Redwood and Douglas-fir habitats with large snags, especially forest with larger basal hollows and chimney trees. Eat insects and spiders.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the SVGB[2]	Query source[3]	GDE . association[4]	Habitat Associations
Western Least Bittern *Ixobrychus exilis hesperis*	FSS/SSC	Likely	CAFSD, eBird	Indirect	Freshwater and brackish marshes with dense aquatic or semiaquatic vegetation interspersed with clumps of woody vegetation and open water. Predominantly prey on small fish.
Yellow-headed blackbird *Xanthocephalus xanthocephalus*	–/SSC	Likely	CAFSD, eBird, FRLT	Indirect	Breeds almost entirely in open marshes with relatively deep water and tall emergent vegetation, such as bulrush (*Schoenoplectus* spp.) or cattails (*Typha* spp.); nests are typically in moderately dense vegetation, in colonies; forage within wetlands and surrounding grasslands and croplands. Feeds primarily on insects and seeds, foraging in marshes, fields, or sometimes catching prey in the air.
Yellow rail *Coturnicops noveboracensis*	FSS/SSC	Unlikely	CAFSD	Indirect	Marshes. Often next in sedges. Feeds on invertebrates in wetlands (e.g., aquatic insects and mollusks).
Yellow warbler *Setophaga petechia*	–/SSC	Likely	eBird, FRLT	Indirect	Open canopy, deciduous riparian woodland close to water, along streams or wet meadows.). Reliant on groundwater-dependent riparian vegetation for breeding habitat (e.g., willows, alders, and cottonwoods). Typically eat insects.
Mammals					
American badger *Taxidea taxus*	–/SSC	Likely	CNDDB	No known reliance on groundwater	Shrubland, open grasslands, fields, and alpine meadows with friable soils.
Fringed myotis *Myotis thysanodes*	BLMS, FSS/–	Likely	CNDDB	Indirect	Roosts in crevices found in rocks, cliffs, buildings, underground mines, bridges, and large trees; found in open habitats that have nearby dry forests and an open water source. Forages along streams.
Gray wolf *Canis Lupus*	FD/SE	Likely	CDFW (2021a)	Indirect	Utilizes a variety of habitats with sufficient prey. Some of the prey may be groundwater dependent.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the SVGB[2]	Query source[3]	GDE . association[4]	Habitat Associations
Long-eared myotis *Myotis evotis*	BLMS/–	Likely	CNDDB	Indirect	Most common in woodland and forest habitats above 4,000 feet, but also found in chaparral, coastal scrub, Great Basin shrub habitats, from sea level to 11,400 feet. Feeds on flying insects, primarily moths, over water and open habitats. Drinks water, feeds over water, and may be found in riparian habitat. Facultatively groundwater dependent (Rhode et al., 2019).
Pallid bat *Antrozous pallidus*	BLMS, FSS/SSC	Likely	CNDDB	No known reliance on groundwater	Roosts in rock crevices, tree hollows, mines, caves, and a variety of vacant and occupied buildings; feeds in a variety of open woodland habitats. Habitat and prey (e.g., insects and arachnids) not associated with aquatic ecosystems.
Sierra marten *Martes caurina sierrae*	FSS/–	Likely	CNDDB	No known reliance on groundwater	Moist, multi-storied, dense coniferous forests with lots of coarse woody debris; forest meadow edges; riparian corridors for travel ways. Sierra martens prey heavily on squirrels but will also eat other small mammals, birds, reptiles, fish, insects, seeds, and fruit
Sierra Nevada red fox *Vulpes vulpes necator*	FPE, FSS/ST	Possible	CNDDB	Indirect	Depends on ground-water dependent vegetation for its habitat and foraging habitat (Rhode et al., 2019). Prefers wet meadows to forested areas; high-elevation conifer forest, and sub-alpine woodlands; dense vegetation and rocky areas for den sites. Preys on small mammals and lagomorphs (e.g., rabbits and pikas). Elevational distribution is 5,000 to 7,000 ft.
Spotted bat *Euderma maculatum*	BLMS/SSC	Likely	CNDDB	Indirect	Highly associated with cliffs and rock crevices, although may occasionally use caves and buildings; inhabit arid deserts, grasslands, and mixed coniferous forests. Feeds on moths over water and along washes. Drinks water.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the SVGB[2]	Query source[3]	GDE . association[4]	Habitat Associations
Yuma myotis *Myotis yumanensis*	BLMS/–	Likely	CNDDB	Indirect	Uses a variety of habitats, including riparian, agriculture, shrub, urban, desert, open forests, and woodlands. Distribution is strongly associated with water; drinks water and forages near or over waterbodies.

1 **Status codes:**

Federal
FD Federally delisted
FE Listed as endangered under the federal Endangered Species Act
FPE Federally proposed as endangered
BGEPA Federally protected under the Bald and Golden Eagle Protection Act
FSS Forest Service Sensitive species
BLMS Bureau of Land Management Sensitive Species

State
SE Listed as Endangered under the California Endangered Species Act
ST Listed as Threatened under the California Endangered Species Act
SCE State Candidate Endangered
SSC CDFW Species of Special Concern
SFP CDFW Fully Protected species

2 **Potential to Occur:**

Likely: the species *has* documented occurrences and the habitat is high quality or quantity
Possible: no documented occurrences and the species' required habitat is moderate to high quality or quantity
Unlikely: no documented occurrences and the species' required habitat is of low to moderate quality or quantity

3 **Query source:**

CAFSD: California Freshwater Species Database (TNC, 2021)
CNDDB: California Natural Diversity Database (CDFW, 2020b)
eBird: (eBird, 2021)
iPAC (USFWS, 2021)

4 **Groundwater Dependent Ecosystem (GDE) association:**

Direct: Species directly dependent on groundwater for some or all water needs
Indirect: Species dependent upon other species that rely on groundwater for some or all water needs

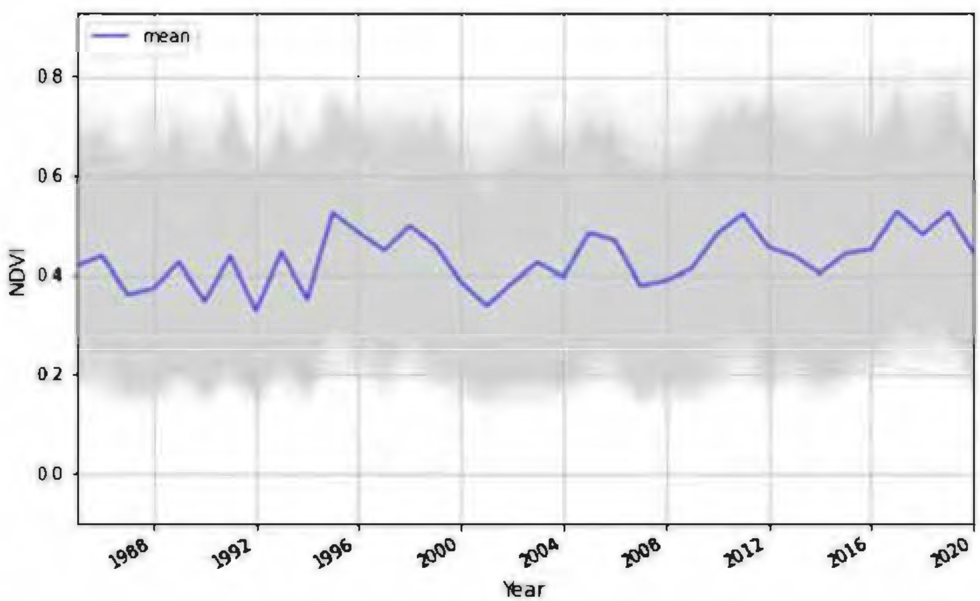
2.2.2.7.5 Changes in Vegetation Health

Assessing the impacts of groundwater changes on GDEs in Sierra Valley is complicated by a lack of data on changes to the extent of wetlands through time and any associated effects on special-status species dependent on groundwater. Instead, this section focuses on quantifying changes in vegetation through time using remote sensing data. While increases or decreases in vegetation health do not provide a definitive indication that all components of the ecosystem are thriving or under stress, the do provide a first-order check on the linkage between groundwater and the vegetation communities that compose the ecosystem.

We used the Normalized Difference Vegetation Index (NDVI) to assess changes in vegetation health. NDVI, which estimates vegetation greenness, was generated from surface reflectance corrected multispectral Landsat imagery from July 1 to September 30 of each year, which represents the summer period when GDE species are most likely to use groundwater (Klausmeyer et al., 2019). Vegetation polygons with higher NDVI values indicate increased density of chlorophyll and photosynthetic capacity in the canopy, an indicator of vigorous, growing vegetation. NDVI is a commonly used proxy for vegetation health in analyses of temporal trends in health of groundwater-dependent vegetation and is essentially a measure of the greenness of remotely sensed images (Rouse et al., 1974 and Jiang et al., 2006 as cited in Klausmeyer et al., 2019).

From 1985-2020 the mean Summer NDVI in the basin ranges from 0.33 to 0.53 (Figure 2.2.2-15). No long-term trends are apparent in Summer NDVI for the basin. Local NDVI changes near long-term monitoring points are explored in Chapter 3.

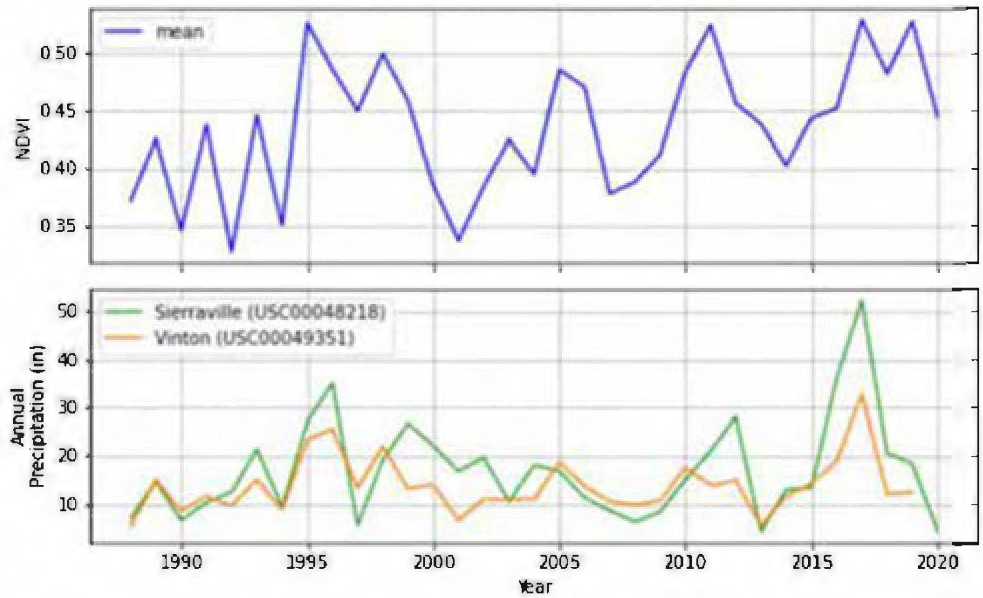
Figure 2.2.2-15: Summer NDVI Changes through time in the Sierra Valley Subbasin



Notes:
- The blue line is the mean value of the GDE polygons

Short-term changes in basin-wide NDVI are generally tied to precipitation at the Sierraville (USC00048218) and Vinton (USC00049351) stations (Figure 2.2.2-16).

Figure 2.2.2-16: Mean Summer NDVI and Annual Precipitation at Sierraville and Vinton



2.2.2.7.6 Ecological Value

The ecological value of GDEs within the Sierra Valley Subbasin was characterized by evaluating the presence and groundwater-dependence of special-status species and ecological communities, and the vulnerability of these species and their habitat to changes in groundwater levels (Rohde et al., 2018). In addition, the presence of natural or near-natural conditions and ecosystem function was also considered. Based on these parameters, the ecological value of GDEs in the Sierra Valley Groundwater Basin is high because there are nine likely groundwater dependent special-status plants, one sensitive natural community, and 30 special-status wildlife species. In addition, the lower 4.5 miles of the Middle Fork Feather River in the groundwater basin are designated as a Wild and Scenic River.

2.2.2.7.7 Data Gaps

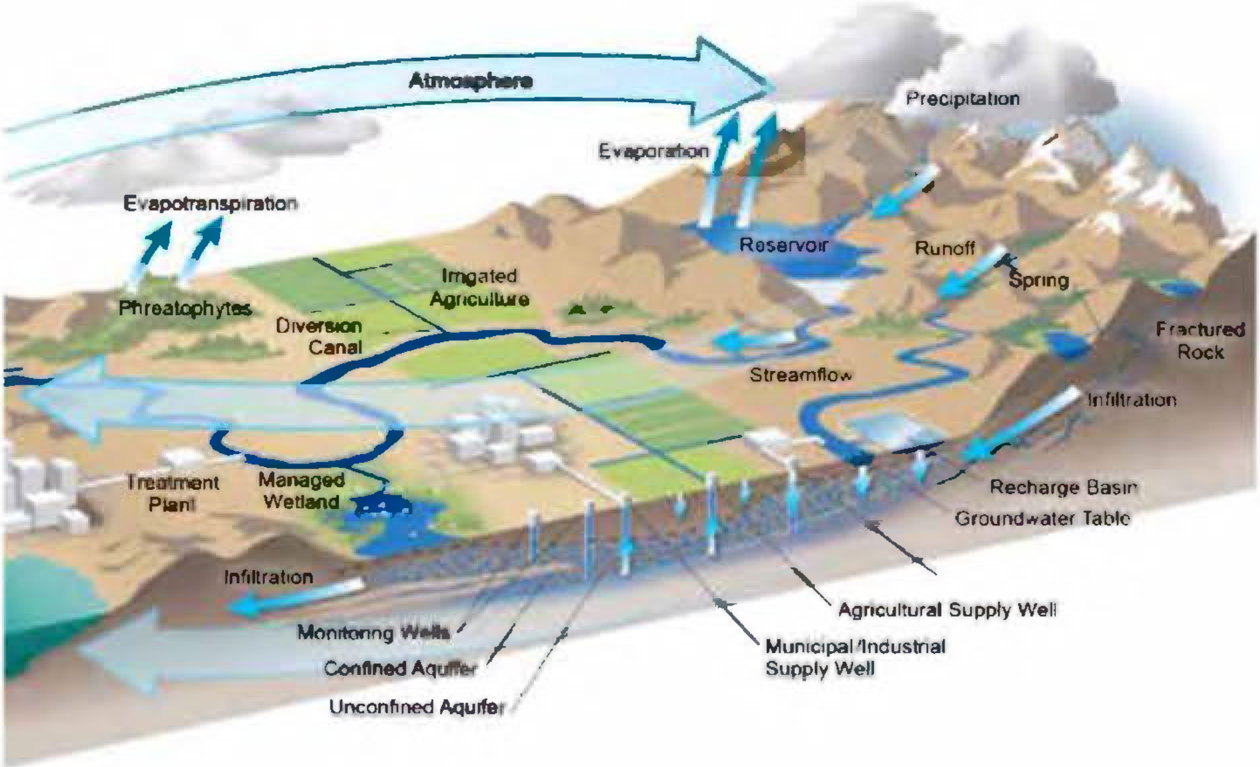
There are gaps in available data that make assessing the extent and sensitivity of GDEs to groundwater management. In particular, available vegetation maps lack sufficient detail to determine the rooting depth of vegetation to compare with groundwater depth. Instead, we need to use general rooting depths with large error bars. This is compounded by uncertainty in the depth to groundwater near the GDEs due to limited well data. Both of these data gaps can be filled in the first five years after the GSP is implemented. Expanded surface water and groundwater gages should decrease the uncertainty of groundwater depth. In addition, an updated and more detailed vegetation map was begun by CDFW, who are awaiting additional funding to complete. If this map is completed by the five-year update, it can be used to better assess the species assemblages, the source of water, and their maximum rooting depth.

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

This Plan includes a water budget (reported in tabular and graphical form) for the Basin to provide an accounting and assessment of the total annual volumes of groundwater and surface water that enter and leave the Basin, including historical, current, and projected water budget conditions, and the change in the volume of water stored (Reg. § 354.18[a]).

A water budget is a useful tool for tracking the components that contribute to or withdraw from the volume of water in storage, similar to how a bank account balance is monitored for cash deposits and withdrawals. A generalized schematic of components that can make up a water budget is shown in Figure 2.2.3-1.

Figure 2.2.3-1: Water Budget Schematic



Notes:
- Figure is modified from DWR, 2016d.

A water budget is necessary to tabulate and sum total volumes of inflows (positive values) and outflows (negative values) of water to determine whether a basin experienced an overall (net) increase, decrease, or relatively little change in the volume of water in storage.

$$Inflows - Outflows = Change\ in\ Storage$$

Water budgets operate in a similar manner as financial budgets, just with differing units. The typical unit of measure for a water budget is acre-feet per year (AFY). One AFY (i.e., 325,851 gallons per year) is more than enough water to meet the typical annual demand of the average California household. An acre-foot (AF) represents the volume required to cover one acre (approximately the size of a football field) of land with water to a depth of 1 foot. Note that storage in the context of water budgets refers to the volume of water in storage, not the physical storage capacity of the aquifer system.

Inflows

An important component of sustainability involves tracking the cumulative change in storage, making sure that the amount of negative changes in storage (i.e., during prolonged droughts) is not significantly greater than the total of positive changes in storage (i.e., during wet years). So long as the cumulative change in storage balances out (i.e., the total of annual changes tends towards zero when averaged over a long period of time), the Basin is not experiencing overdraft conditions (i.e., average inflows equal average outflows) - a critical component of demonstrating sustainable groundwater conditions.

2.2.3.1 Description of Inflows, Outflows, and Change in Storage

The Basin water budgets are conceptualized into three component subsystems:

- surface water
- land surface (unsaturated zone)
- aquifer (groundwater/saturated zone)

2.2.3.1.1 Surface Water Budget

The surface water subsystem comprises stream flows that interact with the land surface and groundwater subsystems. Surface water inflows to the groundwater basin are quantified using a Precipitation Runoff Modeling System (PRMS) model (Markstrom et al., 2015) developed for the Basin (Appendix 2-7), along with observed flows where available. Within the groundwater basin boundary, surface water flows are estimated using the stream flow routing (SFR) package in MODFLOW (Harbaugh, 2005; Prudic et al., 2004; Niswonger and Prudic, 2005).

Inflows

Inflows into the surface water system consist of:

- tributary stream flows at the Basin boundaries
- valley floor runoff (i.e., Hortonian flow, excess precipitation that does not infiltrate the land surface)
- groundwater discharge to streams (i.e., gaining stream conditions)

Gaining stream conditions are most prevalent during wet years and spatially where groundwater levels are near the land surface. Surface water flows entering the groundwater basin are estimated with the PRMS model (Appendix 2-7) due to the lack of observed flows (i.e., gauging stations) for the majority of streams. Exceptions to this are Little Last Chance Creek and Big Grizzly Creek, which are gauged for reservoir releases (i.e., have observed flows). Cold Stream PRMS flow estimates are supplemented with reported irrigation diversions from the Little Truckee River.

Outflows

Outflows from the surface water system occur as:

- stream flow out of the Basin (MFFR)
- surface water diversions
- streambed percolation (i.e., groundwater recharge or losing stream conditions)

Losing stream conditions are most prevalent immediately following extended droughts (when the most subsurface storage capacity is available due to lower groundwater levels) and spatially along the margins of the valley where alluvial fans are present and depth to water is typically greater.

Change in Storage

The surface water system is conceptualized to not exhibit significant changes in storage, because there are no significant surface water reservoirs (e.g., lakes) within the groundwater basin boundary and storage volume within stream channels is minor compared to the flux volume.

2.2.3.1.2 Land Surface Budget

The land surface water budget represents flows associated with vegetation and soil (i.e., the vadose zone) in the Basin. The land surface system acts as an interface between the surface water and groundwater systems. Flows outside of the groundwater basin boundary are quantified using the PRMS model. Within the groundwater basin boundary flows are simulated using the Soil-Water Budget Model (SWBM; Foglia et al., 2013; Tolley et al., 2019), a land-surface water balance model that simulates agricultural management practices.

<u>Inflows</u>

Inflows into the land surface water system consist of:

- precipitation
- irrigation sourced from surface water diversions
- irrigation sourced from groundwater pumping (wells)

Precipitation inputs are quantified using local meteorological data and spatially distributed across the model domain using PRISM datasets (PRISM Climate Group, 2020). Surface water and groundwater irrigation flows are estimated by the SWBM, which accounts for multiple factors (soil moisture, crop type, irrigation type, water source, etc.) on a field-scale basis. Field properties were initially assigned using the DWR crop mapping datasets (Section 2.2.1.3) and refined using local knowledge. For years when pumping records are available (2003-2020), groundwater irrigation is specified for each well. Historical pumping records are primarily a single extraction volume for the entire year, which was downscaled to monthly volumes required by the model using the distribution of ET_0 observed during the growing season.

<u>Outflows</u>

Outflows from the land surface water system occur as:

- evapotranspiration (ET) by vegetation and crops
- water percolating below the effective root capture zone (groundwater recharge)
- valley floor runoff (i.e., Hortonian or infiltration excess flow)

ET rates for the groundwater basin are quantified using relationships between reference ET values from nearby CIMIS stations and crop coefficients assigned to fields based on vegetation type (described in Section 2.2.1.3). ET rates are greater during the warmer (e.g., summer) seasons, due to higher temperatures and water demand by vegetation. Recharge processes occur when soil moisture content exceeds the soil's capillary storage capacity (field capacity). When this happens gravity drainage from the soil into the groundwater system occurs, with the amount of recharge equal to the difference between the soil's moisture content and field capacity. Valley floor runoff is estimated by specifying a maximum recharge rate, above which recharge is converted to runoff. Runoff from the valley floor only occurs during sustained or intense precipitation events.

<u>Change in Storage</u>

The change in storage of water in the land surface system reflects changes in soil moisture content. On an inter-annual (i.e., year-to-year) basis, there are relatively small changes in storage as the soil profile is typically refilled every year with winter precipitation. On an intraannual (i.e., seasonal) basis, soil moisture storage changes significantly as the land surface system experiences less precipitation (i.e., less input) and greater ET demand (i.e., more output) during the growing season and the opposite during the non-growing season. The only notable inter-annual changes in storage occur during occasional wet years or during the first year simulated by SVHSM due to initial soil moisture conditions (see Section 2.2.3.2).

2.2.3.1.3 Groundwater Budget

The groundwater budget represents flows that occur within the saturated subsurface (i.e., aquifer system), and between the land surface subsystem, surface water subsystem, and basin boundaries (i.e., surrounding bedrock). The groundwater budget is quantified using a numerical finite-difference (MODFLOW) model.

<u>Inflows</u>

Inflows into the groundwater system consist of:

- deep percolation of water from the land surface subsystem (groundwater recharge)
- mountain-front recharge
- streambed percolation (net stream exchange is positive)

Groundwater recharge that occurs throughout the valley floor area is represented by the recharge output component of the land surface water budget. The mountain-front recharge component represents inflows from the surrounding mountain watershed runoff and fractured bedrock underflow processes (Wilson and Guan, 2004). Stream exchange is considered an inflow when stream losses to groundwater are greater than groundwater discharges to streams.

<u>Outflows</u>

Outflows from the groundwater system occur as:

- pumping from water wells
- evapotranspiration (ET) from shallow groundwater
- discharge to surface water (net stream exchange is negative)

The majority of groundwater pumping in the Basin is for agricultural beneficial uses/users, with a minor component of pumping used for municipal (public) and domestic (private) drinking water supply uses. ET in the groundwater budget represents evaporation processes associated with shallow groundwater levels (i.e., when/where water levels are within about 10 inches of the land surface) not captured by transpiration processes represented in the SWBM. Stream exchange throughout the Basin is considered a groundwater outflow component when more groundwater discharges to streams (i.e., gaining stream conditions are predominant) than recharges the aquifer system.

<u>Change in Storage</u>

Changes in the volume of groundwater in storage correspond with changes in groundwater levels in the Basin (i.e., increases in storage result in increased groundwater levels, and vice versa). The relationship between average groundwater level changes and changes in storage are based on storage (hydraulic) properties of the aquifer and aquitard material represented in the MODFLOW portion of SVHSM.

2.2.3.2 Quantification of Historical Water Budget Conditions (Reg § 354.18[c][2])

Historical water budget conditions are quantified for a 16-year period (water years 2000 through 2015) - based on the surface water, land surface water, and groundwater budgets calculated using the SVHSM (Appendix 2-7) - to evaluate aquifer responses to water supply and demand trends relative to water year type. Although results from water year 2000 are presented, simulated values from that year are significantly influenced by specified initial conditions and not considered reliable. Therefore, Flux values from WY 2000 were excluded from any summary. Water year types for the Basin are designated by grouping the five water year index classifications (critical, dry, below normal, above normal, and wet) provided by DWR for the Sacramento Valley watershed into three water year type classifications: critical and dry DWR water year types are considered a "dry" year, below normal and above normal DWR water year types are considered a "normal" year, and wet DWR water year type is similarly considered a "wet" year.

2.2.3.2.1 Availability of Surface Water Supply Deliveries (Reg § 354.18[c][2][A])

The Basin receives imported surface water from the Little Truckee River. From 1959 - 2020, imported volumes have ranged from 119 to 10,600 AFY and averaged 6,600 AFY. Stream flows from Little Last Chance Creek and Big Grizzly Creek are regulated by Frenchman and Davis reservoirs, respectively. These two reservoirs are located within the watershed and therefore deliveries from them are not considered imported water.

2.2.3.3 Quantitative Assessment of the Historical Water Budget (Reg § 354.18[c][2][B])

The historical annual surface water budget for the Basin is shown with water year types in Figure 2.2.3-2, summarized with average, minimum, and maximum flows in Table 2.2.3-1, and tabulated in Appendix 2-7. The water budget reveals a wide range of surface water conditions that depend on the water year type. During dry, normal, and wet years, surface water fluxes within the Basin average about 58,000 AFY, 106,000 AFY, and 357,000 AFY, respectively.

Figure 2.2.3-2: Historical and Current Annual Surface Water Budget

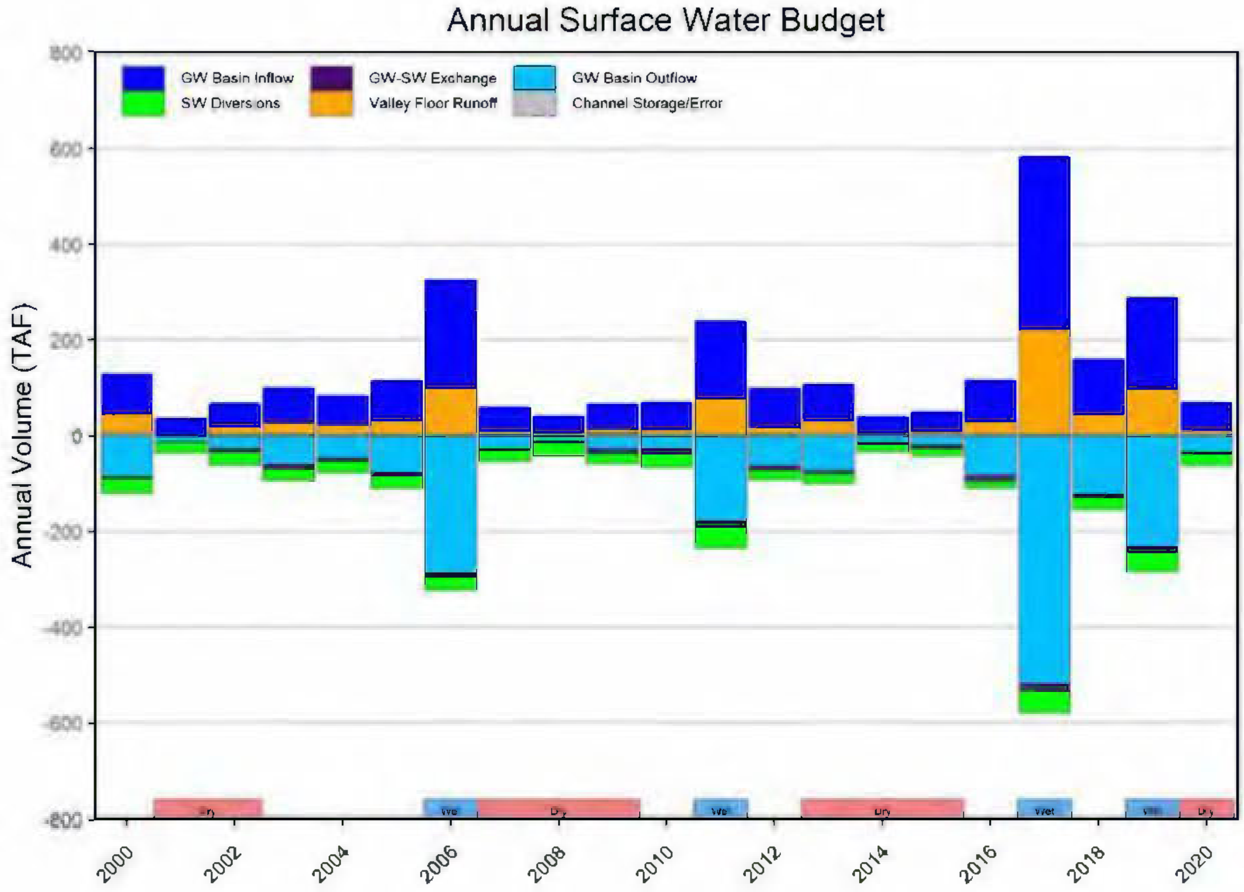


Table 2.2.3-1: Historical Surface Water Budget Summary

Flow	Component	Annual Flow (AFY)		
		Average	Minimum	Maximum
Inflow	Stream Flow	75,400	34,700	226,700
	Valley Floor Runoff	22,400	1,100	97,600
	Subtotal	**97,800**	**36,600***	**324,300***
Outflow	Stream Flow (MFFR)	-62,800	-11,900	-285,300
	SW Diversions	-25,000	-15,300	-43,300
	Subtotal	**-87,800**	**-29,400***	**-314,100***
Inflow/Outflow	GW Exchange	-7,000	-900	-13,600

Notes:
- Values represent water years 2001 through 2015. WY 2000 excluded to remove influence of assumed initial conditions.
- MFFR: Middle Fork Feather River
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Values are rounded to the nearest 100 AFY.

* Column arithmetic not applicable since values may come from different years and violate mass balance. Mass-conservative values shown.

Figure 2.2.3-3: Historical and Current Land Surface Water Budget

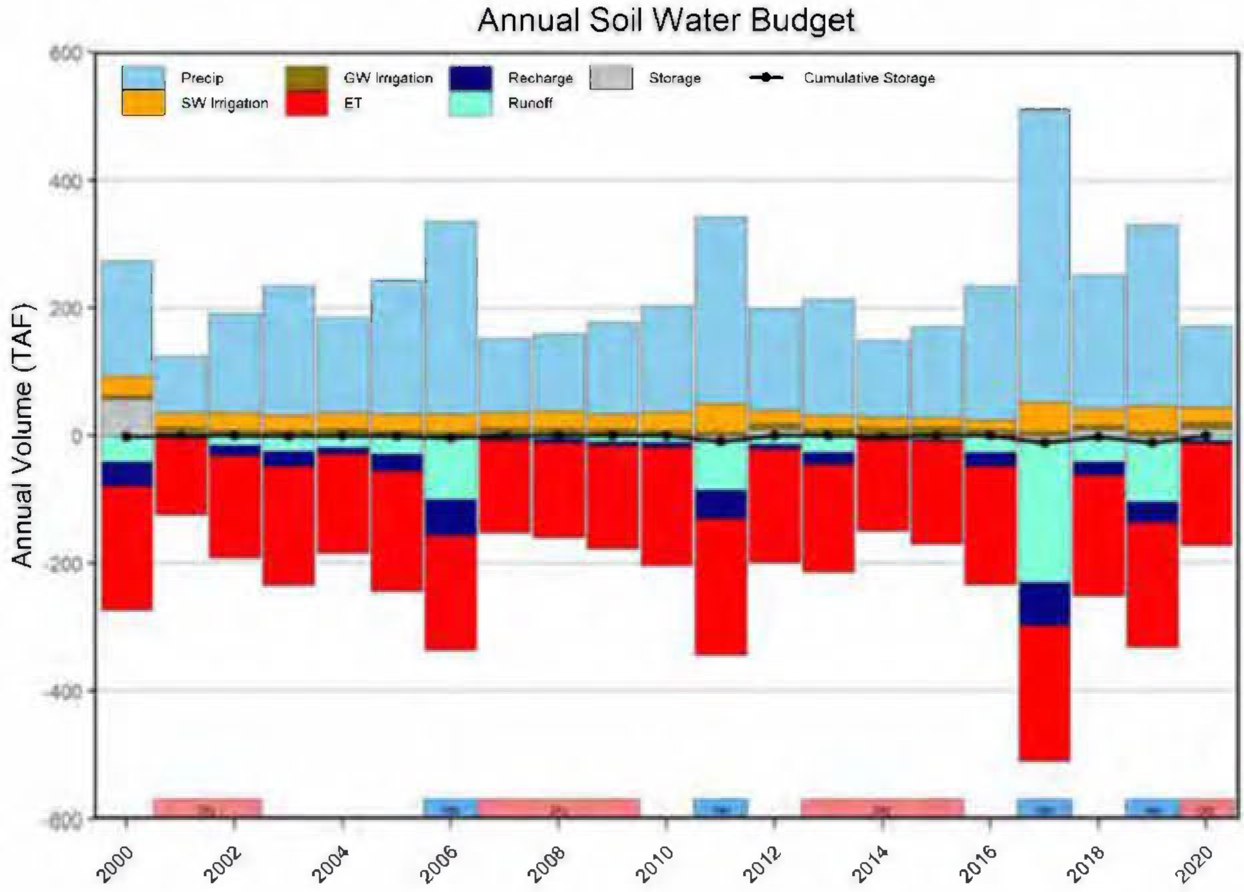


Table 2.2.3-2: Historical Land Surface Budget Summary

Flow	Component	Annual Flow (AFY) Average	Minimum	Maximum
Inflow	Precipitation	170,400	88,800	302,000
	Irrigation (from SW)	25,000	15,300	43,300
	Irrigation (from GW)	8,900	5,100	12,100
	Subtotal	**204,300**	**121,800***	**343,200***
Outflow	Evapotranspiration (Irrigated Fields)	-69,400	-57,700	-85,600
	Evapotranspiration (Non-Irrigated Fields)	-37,700	-26,200	-48,600
	Evapotranspiration (Native Vegetation)	-58,800	-36,800	-77,800
	Recharge (to GW)	-16,200	-2,400	-57,100
	Runoff	-22,400	-1,100	-97,600
	Subtotal	**-204,500**	**-124,200***	**-333,900***
Change in Storage		**-100**	**-9,600***	**9,200***

Notes:
- Values represent water years 2001 through 2015. WY 2000 excluded to remove influence of assumed initial conditions.
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Values are rounded to the nearest 100 AFY.

* Column arithmetic not applicable since values come from different years which violates mass balance. Mass-conservative values shown.

The historical annual groundwater budget for the Basin is shown with water year types in Figure 2.2.3-4, summarized with average, minimum, and maximum flows in Table 2.2.3-3, and tabulated in Appendix 2-7. The water budget reveals a wide range of conditions that depend on the water year type. During dry, normal, and wet years, groundwater fluxes within the Basin average about 25,000 AFY, 32,000 AFY, and 50,000 AFY, respectively.

Figure 2.2.3-4: Historical and Current Annual Groundwater Budget

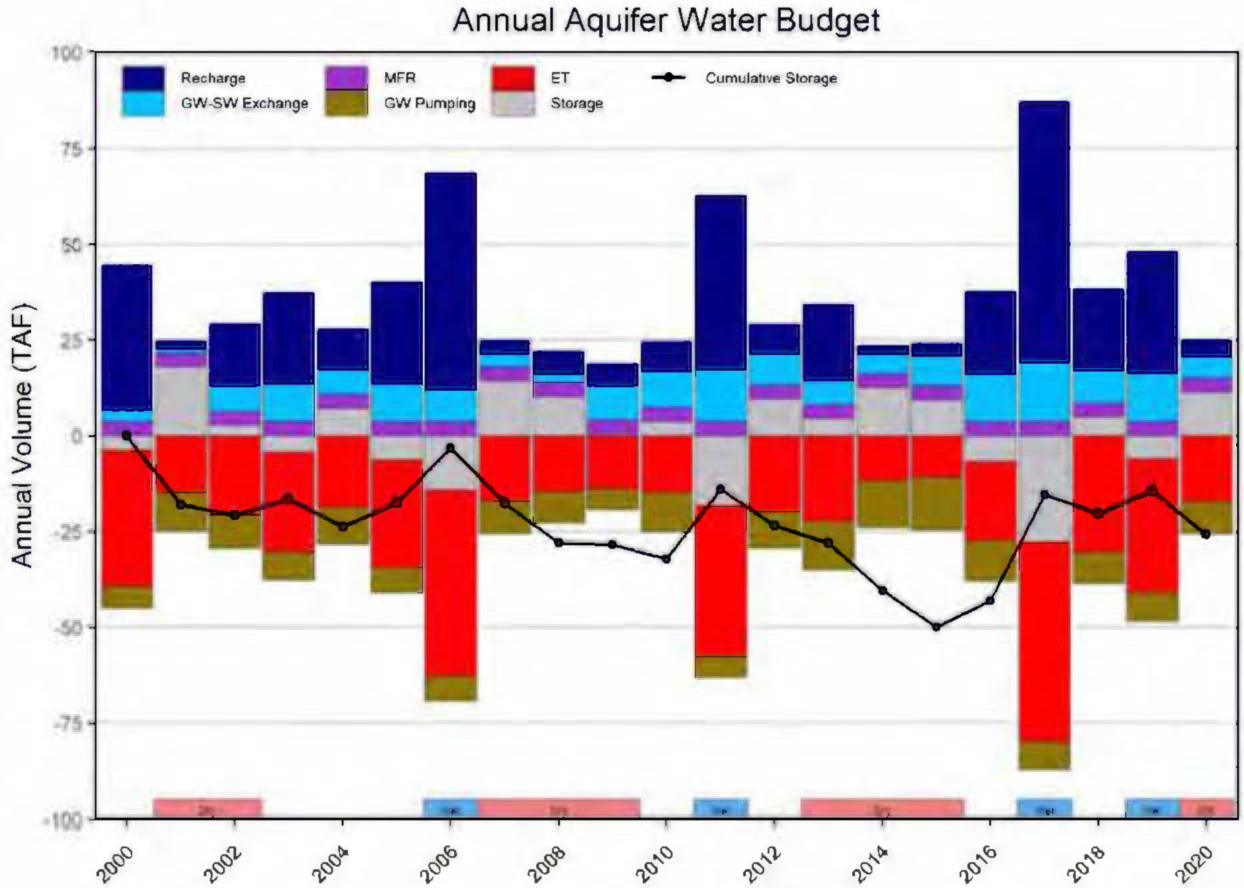


Table 2.2.3-3: Historical Groundwater Budget Summary

Flow	Component		Annual Flow (AFY) Average	Minimum	Maximum
Inflow	Recharge (Valley Floor)		16,100	2,400	56,900
	Recharge (Mountain Front)		3,700	3,700	3,700
		Subtotal	**19,800**	**6,100**	**60,600**
Outflow	Evapotranspiration		-21,800	-11,000	-48,500
	Pumping (Agricultural)		-8,600	-5,200	-12,900
	Pumping (Municipal)		-500	-200	-700
		Subtotal	**-30,900**	**-19,300***	**-55,100***
Inflow/Outflow	Stream Exchange		7,400	2,100	13,600
Change in Storage			**-3,300**	**-18,200***	**18,000***

Notes:
- Values represent water years 2001 through 2015. WY 2000 excluded to remove influence of assumed initial conditions.
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Values are rounded to the nearest 100 AFY.
- Increasing storage reported as a positive value, decreasing storage reported as a negative value.

* Column arithmetic not applicable since values come from different years which violates mass balance. Mass-conservative values shown.

The relative contributions of recharge attributed to the valley floor area versus the mountain-front area vary depending on the water year type. This is because valley floor recharge rates are calculated using the SWBM (see Appendix 2-7), while mountain-front recharge is largely unknown and currently simulated as a constant inflow (about 3,700 AFY) to the basin based on limited model calibration. During dry years, valley floor recharge varies between about 2,000 and 20,000 AFY. During normal years, valley floor recharge varies between about 8,000 and 38,000 AFY. During wet years, valley floor recharge is much greater, varying between about 32,000 and 68,000 AFY.

At the Basin scale, more surface water enters the groundwater basin than leaves via discharge from the UMFFR. Fluxes of surface water into the groundwater system are largest for average and wet years following dry periods (e.g., 2016 and 2017), when groundwater levels are low and surface water can easily percolate into the subsurface. It should be noted that some groundwater does discharge at the western Basin boundary (i.e., see Section 2.2.2.7), but these flows are small compared to the amount of stream percolation that occurs in the central and upper parts of the Basin. Underflow from outside the Basin is insignificant (modelled as essentially zero) for reasons described in Section 2.2.3.2.1.

ET is typically the largest outflow component from the groundwater system. Rates are highly correlated with water year type. The volume of water lost to ET during dry, average, and wet years in the Basin is about 16,000 AFY, 24,000 AFY, and 44,000 AFY, respectively. Groundwater pumping is the second largest outflow from the aquifer and generally decreases as water year types become wetter. Groundwater pumping during dry, average, and wet water years was about 9,900 AFY, 8,500 AFY, and 6,800 AFY, respectively.

Results from SVHSM can be used to quantify fluxes between different portions of the groundwater basin. Zonal results are presented as the average daily flux for each water year due to how the data is exported from the model and file size limitations. Although these rates can only be used to estimate annual flux volumes for each zone, they are useful for comparing relative flux rates for each zone.

Two different zonal comparisons are presented below. One compares the eastside and westside portions of the basin (Figure 2.2.3-5), believed to be hydrogeologically separated by the Loyalton and Grizzly Valley Faults. The second subdivides the eastside portion of the basin into an upper and lower aquifer zone (Figure 2.2.3-7). The upper aquifer is defined as the first three layers of SVHSM and ranges from the upper 120 ft to 330 ft of the model. Zonal comparison plots have units of average daily rate, as opposed to units of volume used in the basin-wide plots. The flux rate (units of volume/time) for the last day of each month were averaged within a water year. This is due to how data is exported from SVHSM and computer storage limitations given the high number of model cells and time-steps. While the units may differ, they offer similar functionality as the volume unit plots.

Net recharge rates and corresponding changes in groundwater storage rates are shown for the westside and eastside Basin areas in Figure 2.2.3-5. Similar interannual patterns are observed for both the eastside and westside portions on the basin. The main difference between the two zones is that the eastside portion of the basin has much greater magnitudes when net recharge is negative (i.e., outputs are greater than inputs for that year). As a result, the eastside portion of the basin has experienced a simulated storage reduction of approximately 21,600 acre-ft (60 acre-ft/day * 360 days) over the 21-year simulation, or an overdraft on the order 1,000 AFY. Storage in the westside portion appears to be in a dynamic equilibrium. This is due to the significantly greater groundwater pumping volume that occurs on the eastside of the basin compared to the westside (Figure 2.2.3-6).

Figure 2.2.3-5: Historical and Current Annual Net Recharge Rates by Geographic Area

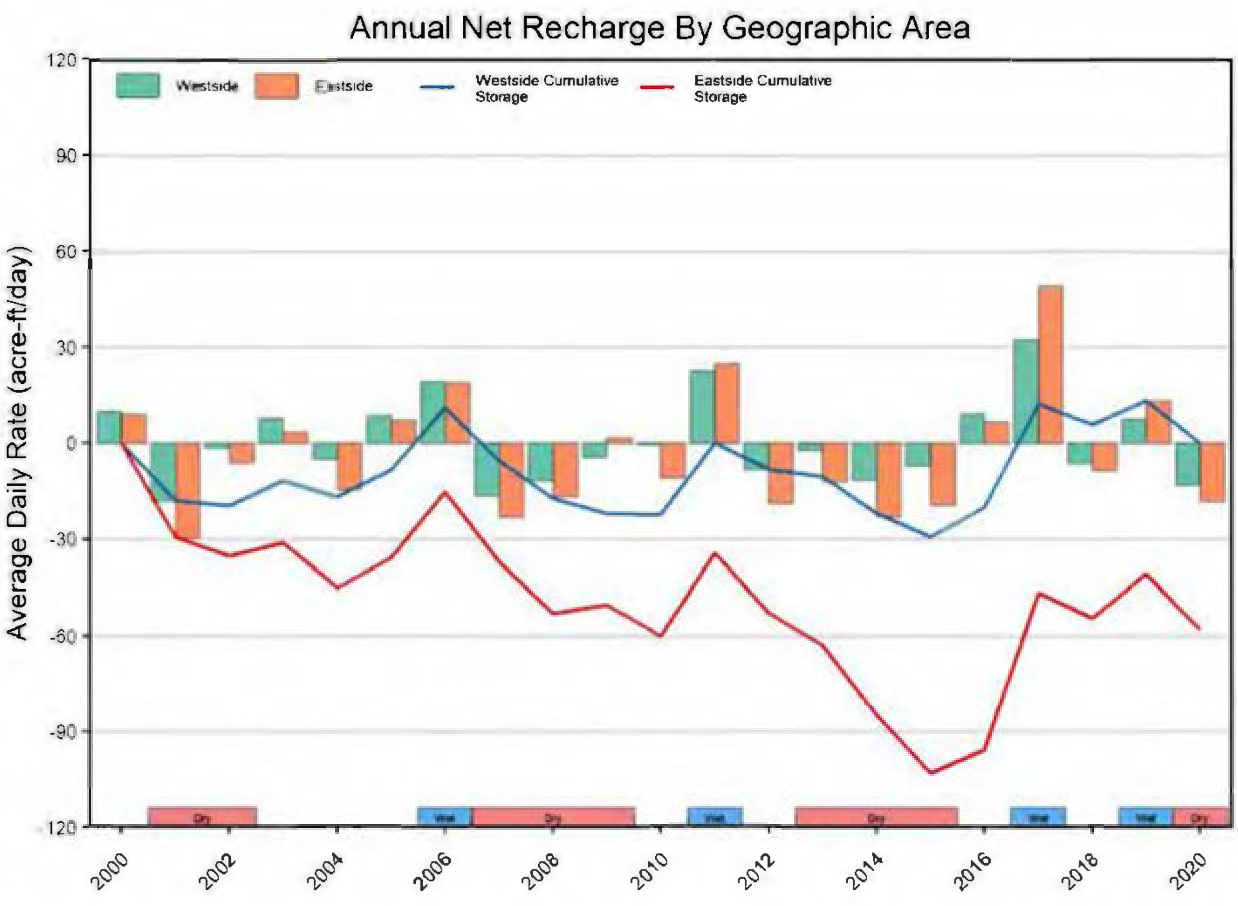
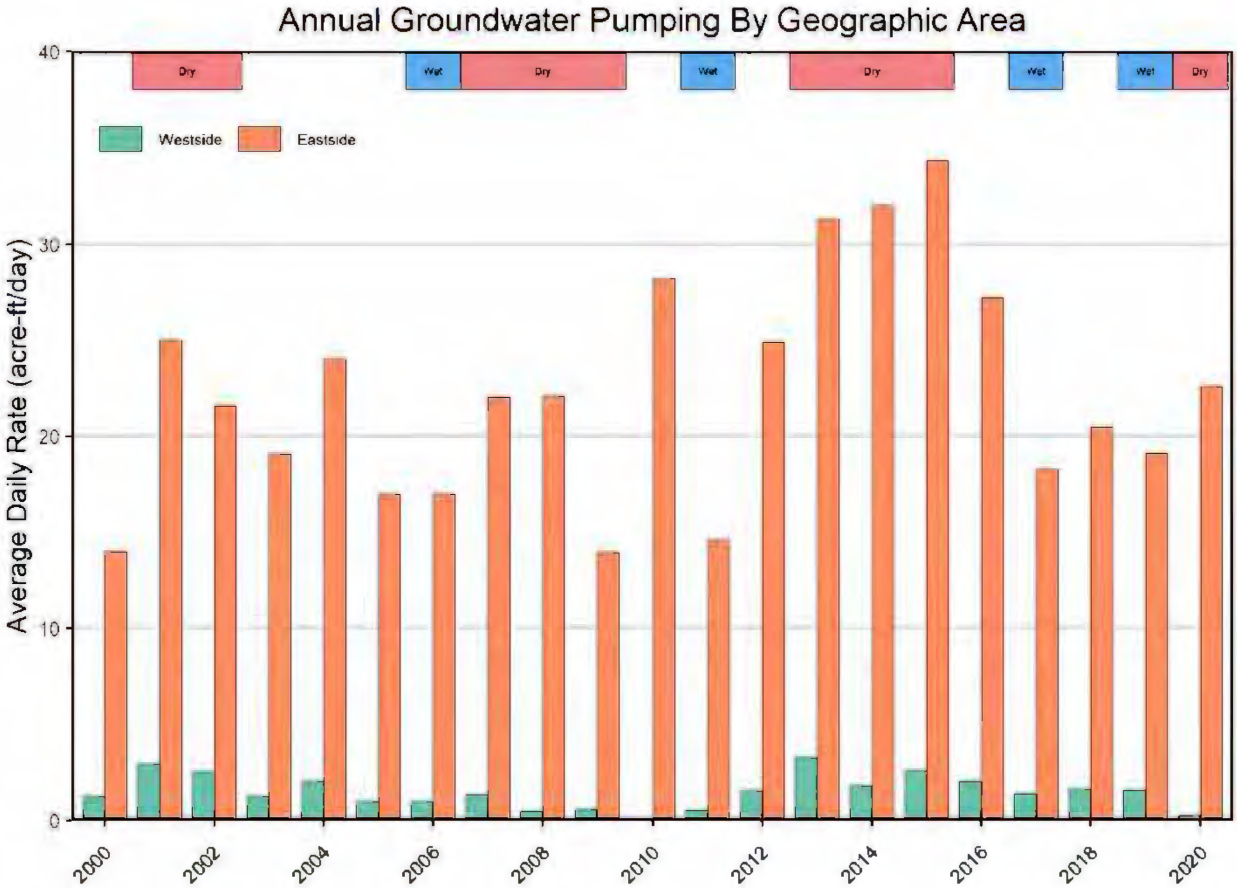


Figure 2.2.3-6: Historical and Current Annual Pumping Rates by Geographic Area



Comparison of net recharge for the eastside upper and lower aquifer zones is shown in Figure 2.2.3-7. Rates differ substantially between the eastside upper and lower aquifers, with the upper aquifer showing a much greater range of net recharge values compared to the lower. Storage for both aquifer zones has decreased during the 21-year simulation, although simulated change in storage is lower for the upper aquifer compared to the lower. This is likely due to the upper aquifer having a smaller volume compared to the lower combined with similar simulated groundwater pumping in each zone (Figure 2.2.3-8). It should be noted that total well depth is missing from about 28% of simulated wells, and screen depth information is missing from about 51% of high capacity pumping wells. Assumptions made in the absence of this data are more likely to bias well and screen depths shallow. Therefore, a greater fraction of total groundwater pumping may be occurring in the lower aquifer.

Figure 2.2.3-7: Historical and Current Annual Net Recharge by Aquifer Zone

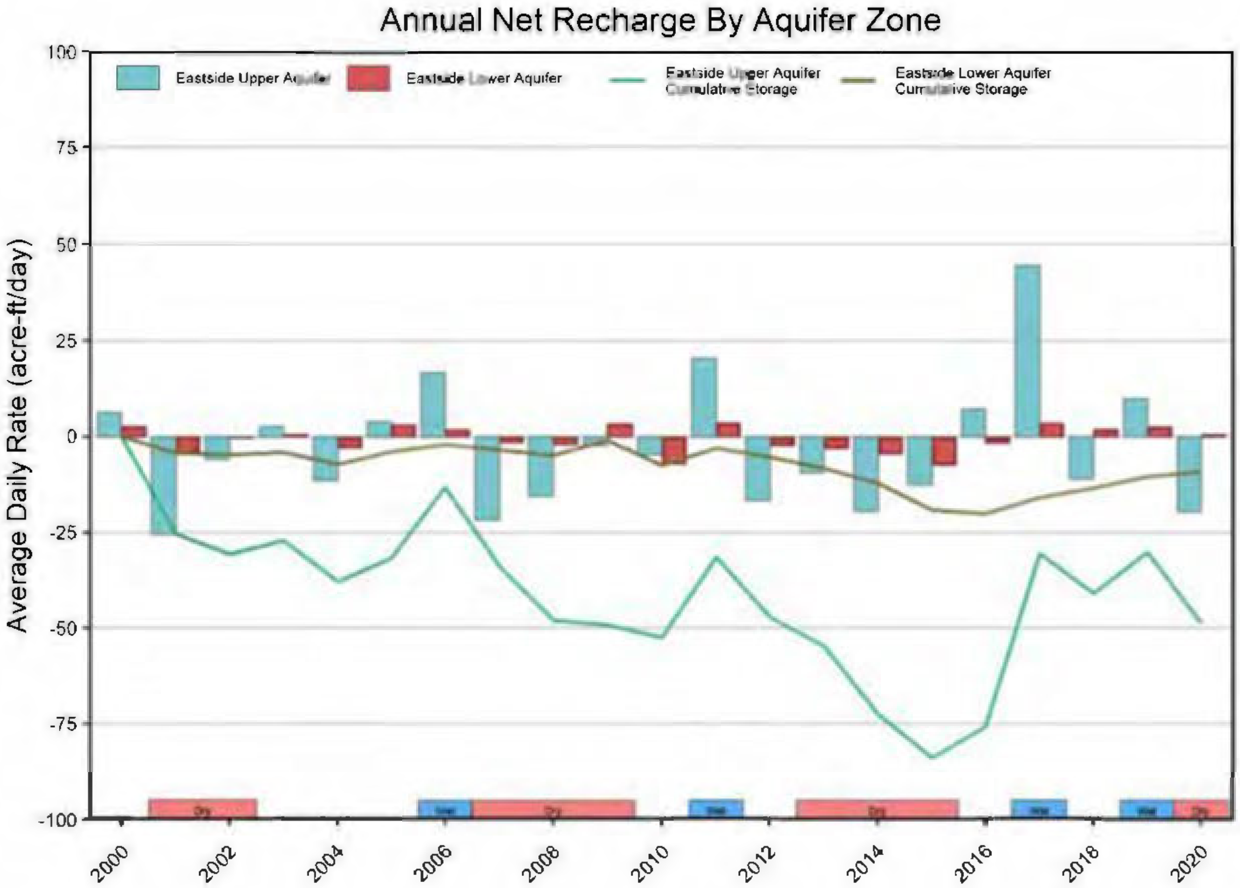
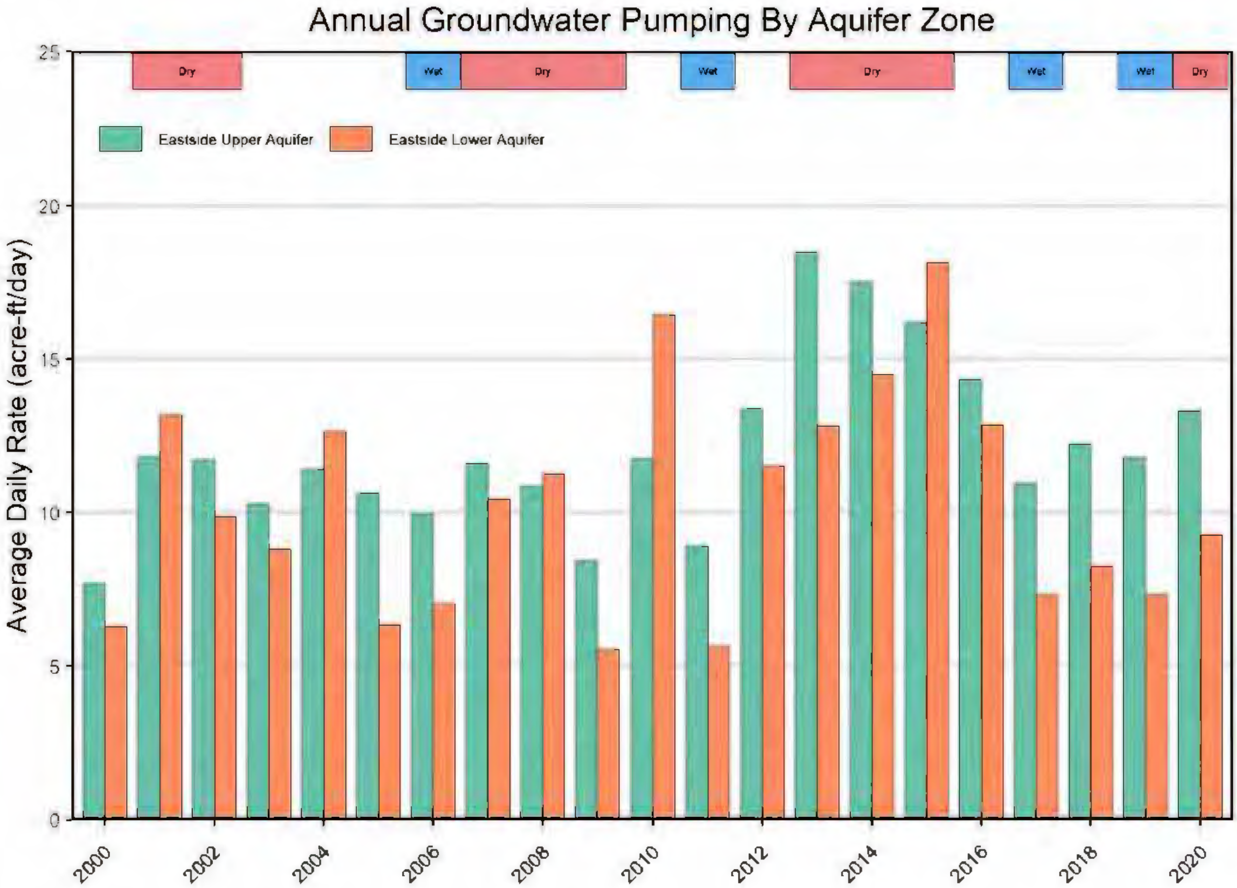


Figure 2.2.3-8: Historical and Current Annual Pumping Rates by Aquifer Zone



2.2.3.3.1 Ability of the Agency to Operate the Basin Within Sustainable Yield (Reg § 354.18[c][2][C])

In the context of observed long-term groundwater levels and the historical water budget, the Basin has historically operated with a small amount of overdraft, specifically on the eastside of the basin. Groundwater budget deficits occur during drought periods (i.e., dry and critical water years), and do not quite fully recover during subsequent wet periods. The amount of overdraft is relatively small compared to the overall water budget and suggests that recharge enhancement may be possible through management actions. The Basin sustainable yield has been estimated at about 6,000-7,000 AFY (Bachand and Carlton, 2020), consistent with SVHSM results (see Appendix 2-7). Historical groundwater pumping records indicate about 8,500 AFY water demand on average, resulting in an annual deficit of approximately 1,500 to 2,500 AFY.

2.2.3.4 Quantification of Current Water Budget Conditions (Reg § 354.18[c][1])

Current water budget conditions are represented in this Plan by the five most recent water years, 2016 through 2020. This period represents a transition in observed climate conditions from the peak of the drought (i.e., 2016) and towards less dry conditions (i.e., 2017 through 2019), corresponding to a partial recovery of groundwater levels in the Basin.

The current surface water budget is shown in Figure 2.2.3-2 (in addition to the historical water budget) and summarized in Table 2.2.3-4.

Table 2.2.3-4: Current Surface Water Budget Summary

Flow	Component	Annual Flow (AFY) Average	Minimum	Maximum
Inflow	Stream Flow	163,200	58,600	362,300
	Valley Floor Runoff	77,600	7,100	219,000
	Subtotal	**240,800**	**65,700***	**581,300***
Outflow	Stream Flow (MFFR)	-196,700	-32,500	-517,900
	SW Diversions	-30,300	-15,200	-46,100
	Subtotal	**-227,000**	**-56,600***	**-564,000***
Inflow/Outflow	GW Exchange	-10,800	-5,500	-15,300

Notes:
- Values represent water years 2016 through 2020.
- MFFR: Middle Fork Feather River
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Values are rounded to the nearest 100 AFY.

* Column arithmetic not applicable since values may come from different years and violate mass balance. Mass-conservative values shown.

Table 2.2.3-5: Current Land Surface Water Budget Summary

Flow	Component	Annual Flow (AFY) Average	Minimum	Maximum
Inflow	Precipitation	257,500	127,000	457,600
	Irrigation (from SW)	30,300	15,200	46,100
	Irrigation (from GW)	7,900	6,500	10,100
	Subtotal	**295,700**	**161,100***	**510,200***
Outflow	Evapotranspiration (Irrigated Fields)	-78,100	-68,000	-89,600
	Evapotranspiration (Non-Irrigated Fields)	-43,000	-35,000	-49,100
	Evapotranspiration (Native Vegetation)	-67,100	-52,700	-73,400
	Recharge (to GW)	-29,700	-4,700	-68,400
	Runoff	-77,600	-7,100	-219,000
	Subtotal	**-295,500**	**-171,900***	**-499,400***
Change in Storage		**300**	**-10,800***	**10,700***

Notes:
- Values represent water years 2016 through 2020.
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Values are rounded to the nearest 100 AFY.

* Column arithmetic not applicable since values come from different years which violates mass balance. Mass-conservative values shown.

The current groundwater budget is shown in Figure 2.2.3-4 (in addition to the historical water budget) and summarized in Table 2.2.3-6.

Table 2.2.3-6: Current Groundwater Budget Summary

Flow	Component	Annual Flow (AFY) Average	Minimum	Maximum
Inflow	Recharge (Valley Floor)	29,600	4,700	68,100
	Recharge (Mountain Front)	3,700	3,700	3,700
	Subtotal	**33,300**	**8,400**	**71,800**
Outflow	Evapotranspiration	-31,000	-17,100	-52,200
	Pumping (Agricultural)	-8,000	-6,800	-10,200
	Pumping (Municipal)	-400	-400	-600
	Subtotal	**-39,400**	**-25,500***	**-59,500***
Inflow/Outflow	Stream Exchange	10,800	5,500	15,300
Change in Storage		**-1,300**	**-27,700***	**11,300***

Notes:
- Values represent water years 2016 through 2020.
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Values are rounded to the nearest 100 AFY.
-Increasing storage reported as a positive value, decreasing storage reported as a negative value.
* Column arithmetic not applicable since values come from different years which violates mass balance. Mass-conservative values shown.

The number of above normal or wet year(s) recently has not been enough to completely offset the historical deficit in groundwater in storage and “refill” the Basin. Although the historical average deficit rate of 1,500 AFY is less than the current average 10,000 AFY surplus, these changes in groundwater in storage do not completely offset one another, because the historical average represents a significantly longer duration (and therefore volume) than the current average change in storage (i.e., 15 years versus five years). This is why tracking changes in groundwater in storage as the cumulative (total) of annual changes in storage is useful for comparing different time periods. The current estimated rate of recovery of groundwater in storage is similar to rates of recovery that occurred in the past, prior to full recovery of groundwater levels.

2.2.3.5 Quantification of Projected Water Budget Conditions (Reg § 354.18[c][3])

SVHSM was used to estimate water budgets for the 50 year (WY 2021-2070) planning and implementation horizon required by SGMA using the change factors from four future climate scenarios provided by DWR. These scenarios are described in greater detail in the climate change guidance provided by DWR (2018a) and are summarized in Table 2.2.3-7. Change factors are provided for precipitation, reference ET, and stream flow on a monthly basis for historical datasets. Future climate and stream flow inputs were generated using the steps below:

1. Identify historical water years with precipitation and reference ET data, as well as DWR climate change factors (WY 1990-2011 for Sierra Valley). Surface water inflows are only available from WY 2000-2011.
2. Future 50 year (WY 2021 - 2070) planning and implementation horizon created by randomly sampling years from WY 2000-2011. For example, WY 2005 used to represent WY 2050. Several iterations were performed and the dataset with the most similar statistical distribution to the historical data was selected. For historical water years where

surface water inflow data was unavailable, average inflows based on the projected water year type (i.e., dry, average, and wet) were used.

3. Values of precipitation, reference ET, and stream flow for a future month were multiplied by the change factor for the historical month used to represent it.

Table 2.2.3-7: Summary of Future Climate Scenarios

Abbreviation	Scenario	Description
2030	2030 (near future)	Central tendency of the ensemble general circulation models (GCMs).
2070	2070 (late future)	Central tendency of the GCMs.
2070DEW	2070 (late future)	Drier with extreme warming (2070 DEW) conditions (extreme scenario, single GCM: HadGEM2-ES with representative concentration pathway [RCP] 8.5)
2070WMW	2070 (late future)	Wetter with moderate warming (2070 WMW) conditions (extreme scenario, single GCM:CNRM-CM5 with RCP 4.5)

It is important to note that the projected water budget is based on assumptions of events that may occur in the future and is not intended to represent a prediction of future conditions. Instead, the projected water budgets are constructed to simulate "what-if" scenarios that incorporate uncertainty and evaluate the Agency's ability to operate the Basin sustainably (discussed in Section 3) over the 50-year planning and implementation horizon.

2.2.3.5.1 Projected Hydrology (Reg § 354.18[c][3][A])

Cumulative inputs of precipitation, reference ET, and stream inflow for the 50-year future simulation are shown for the four climate change scenarios as well as the unmodified historical inputs in Figure 2.2.3-9. In general, future climate is projected to produce greater precipitation, but with less runoff due to increased ET. Average changes from historical values for each month (Figure 2.2.3-10) show projected increases in precipitation occur during the winter months, with the majority of increased ET occurring during the growing season (April - October). Reduced stream flow inputs during the spring and early summer are from projected reductions in winter snowpack.

Figure 2.2.3-9: Cumulative Inputs of Future Climate using DWR Climate Change Factors

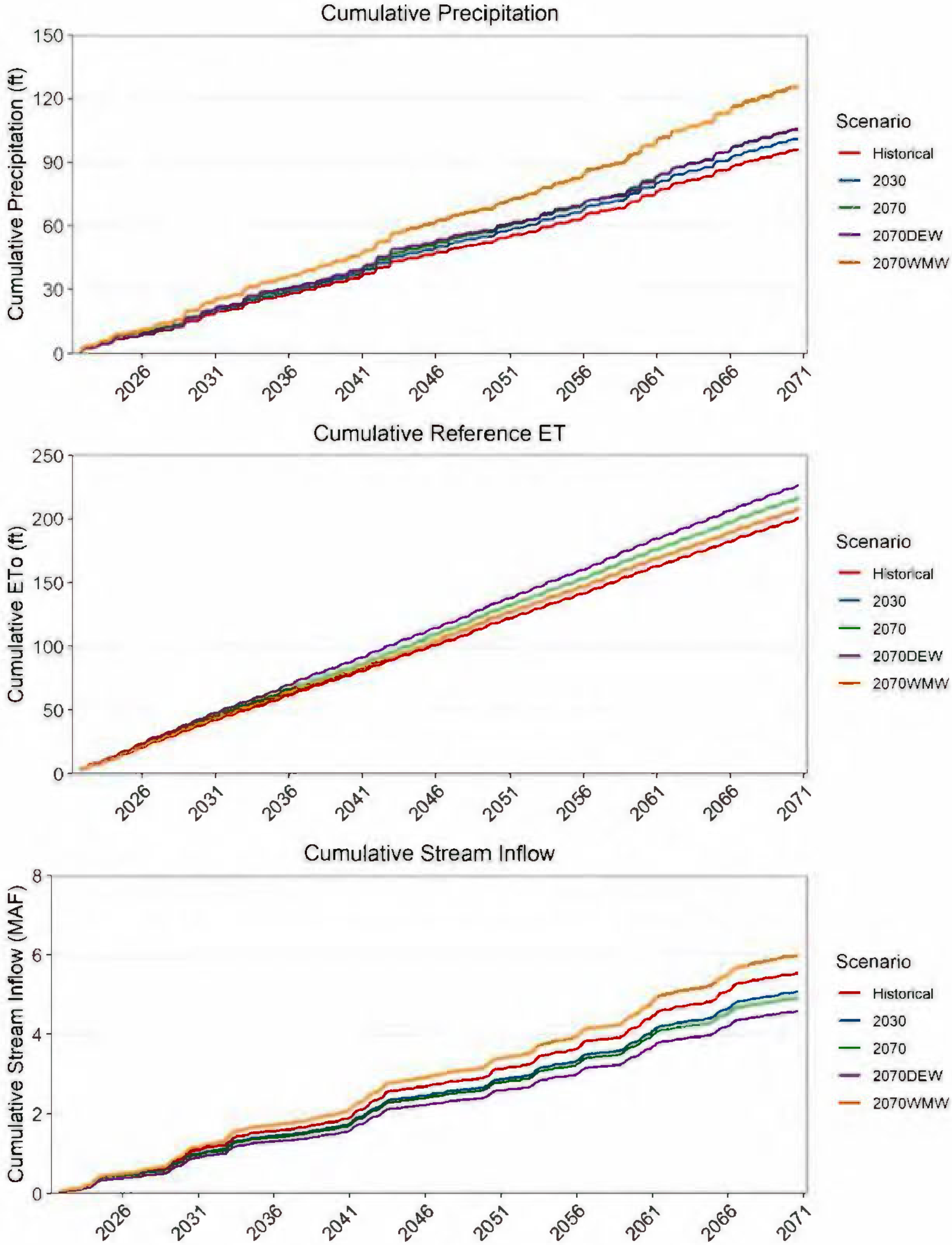
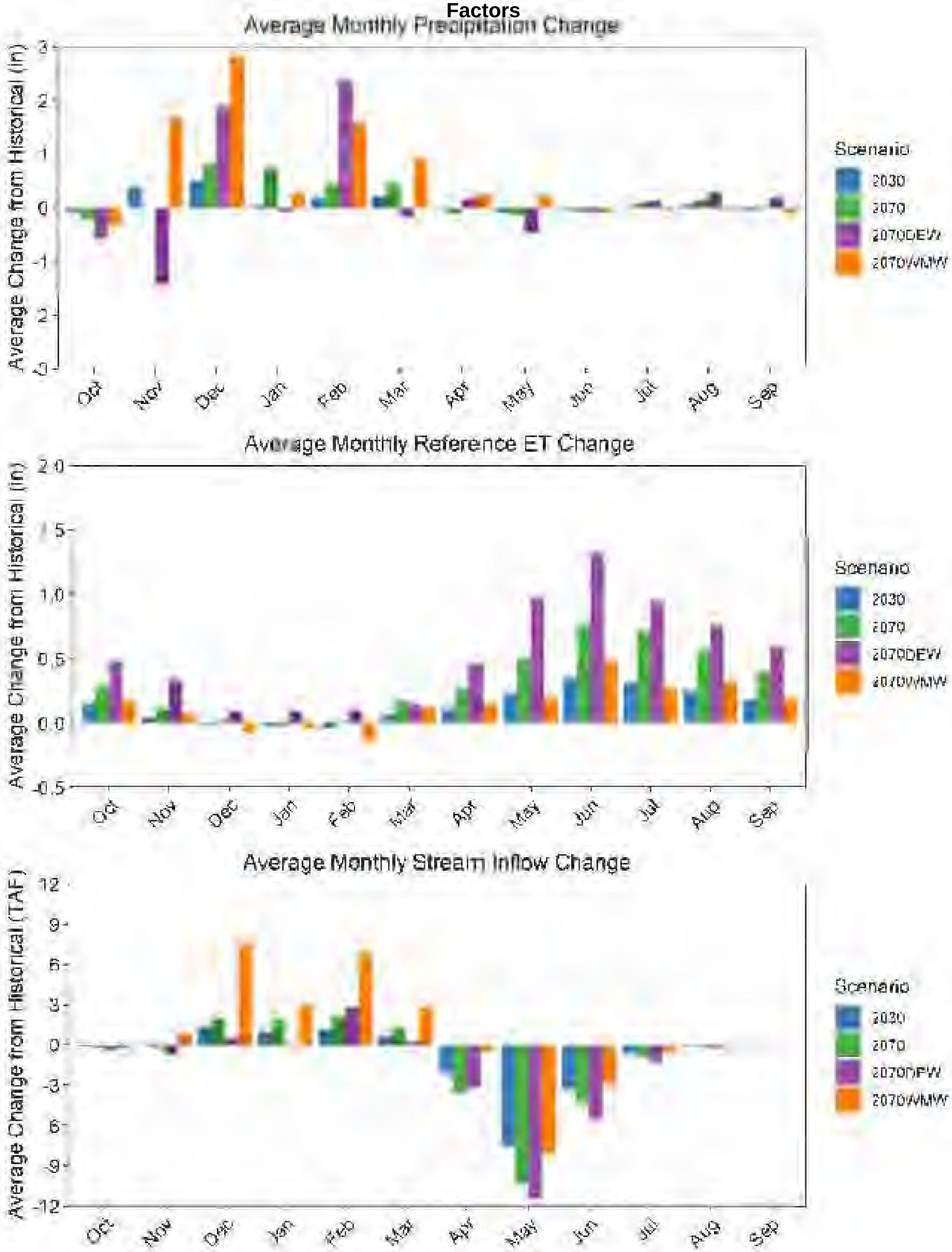


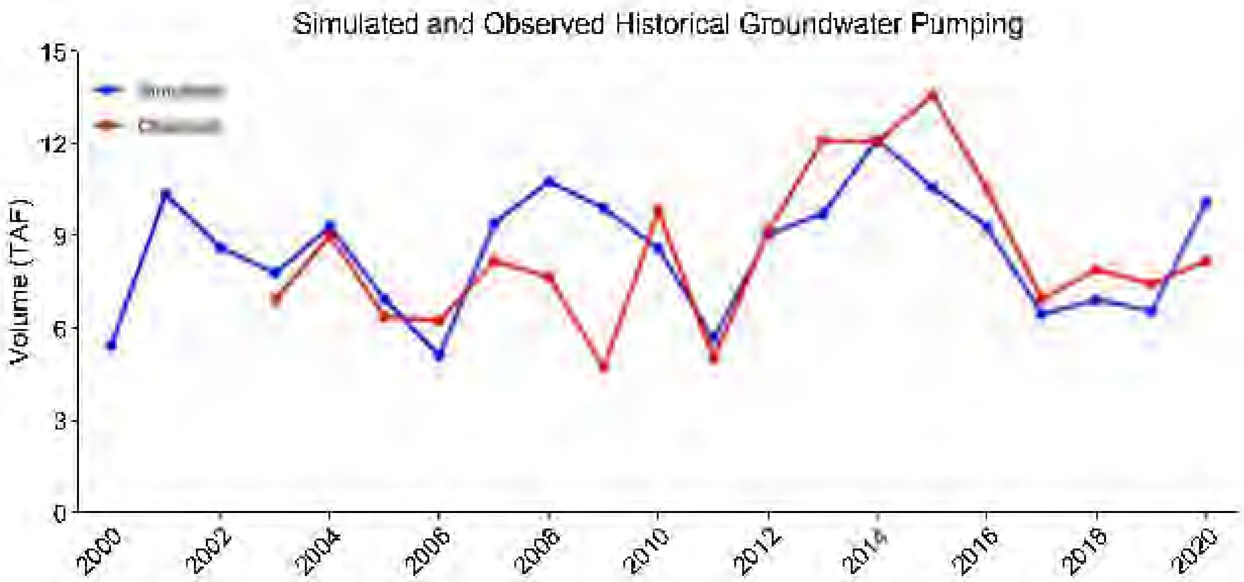
Figure 2.2.3-10: Average Change from Historical Inputs by Month using DWR Climate Change Factors



2.2.3.5.2 Projected Water Demand (Reg § 354.18[c][3][B])

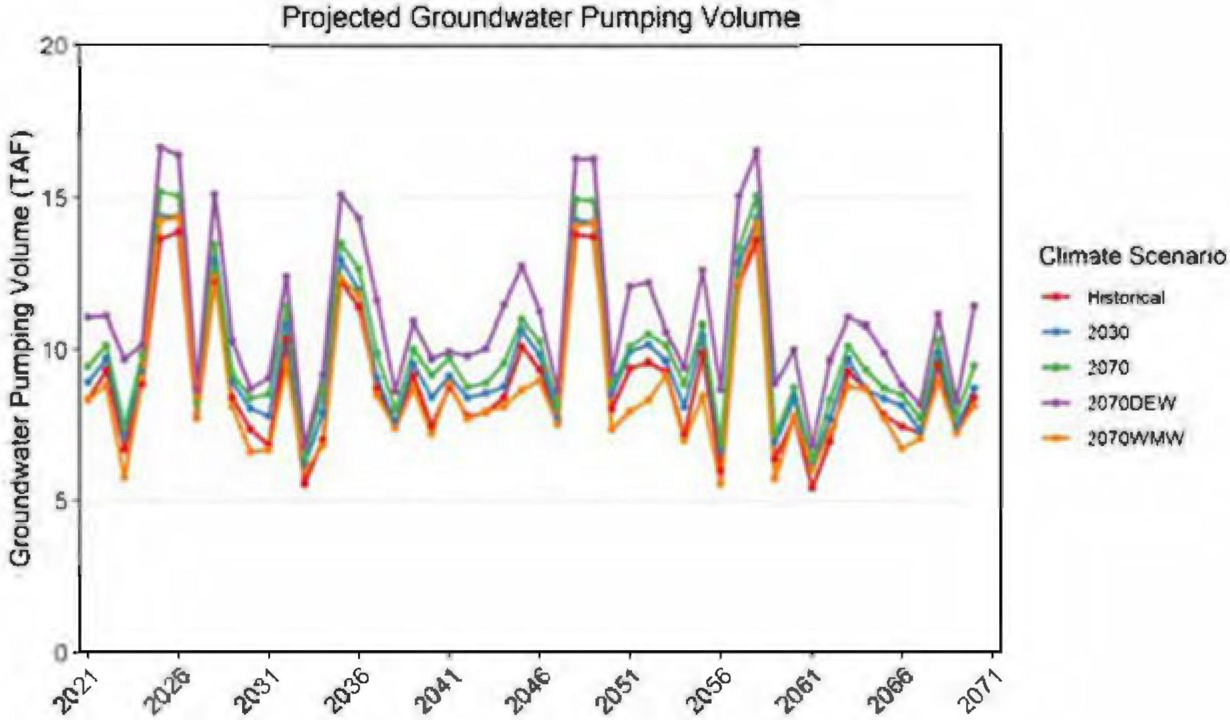
As discussed in Section 2.1.1. 4, Sierra Valley has experienced a population decline between 2010 and 2019. Therefore, changes in future water demand are only expected to occur due to greater crop water demand from increased reference ET. Future groundwater pumping is estimated using SVHSM and assumes similar land use patterns as those observed historically. Figure 2.2.3-11 shows the estimated and observed annual groundwater pumping volumes from WY 2003-2020. In general, historical pumping is well represented by SVHSM and provides confidence in estimated future pumping. Future municipal groundwater pumping was assumed to be the same as historical.

Figure 2.2.3-11: Historical Groundwater Pumping is Well Represented for Most Years by SVHSM.



Projected agricultural groundwater demand ranges from 5,500 to 16,600 AFY, with average annual pumping ranging from 8,700 to 11,000 AFY between the four climate change scenarios (Figure 2.2.3-12). This corresponds to an increase in average annual groundwater pumping ranging from 200 AFY to 2,500 AFY compared to the observed historical average of 8,500 AFY.

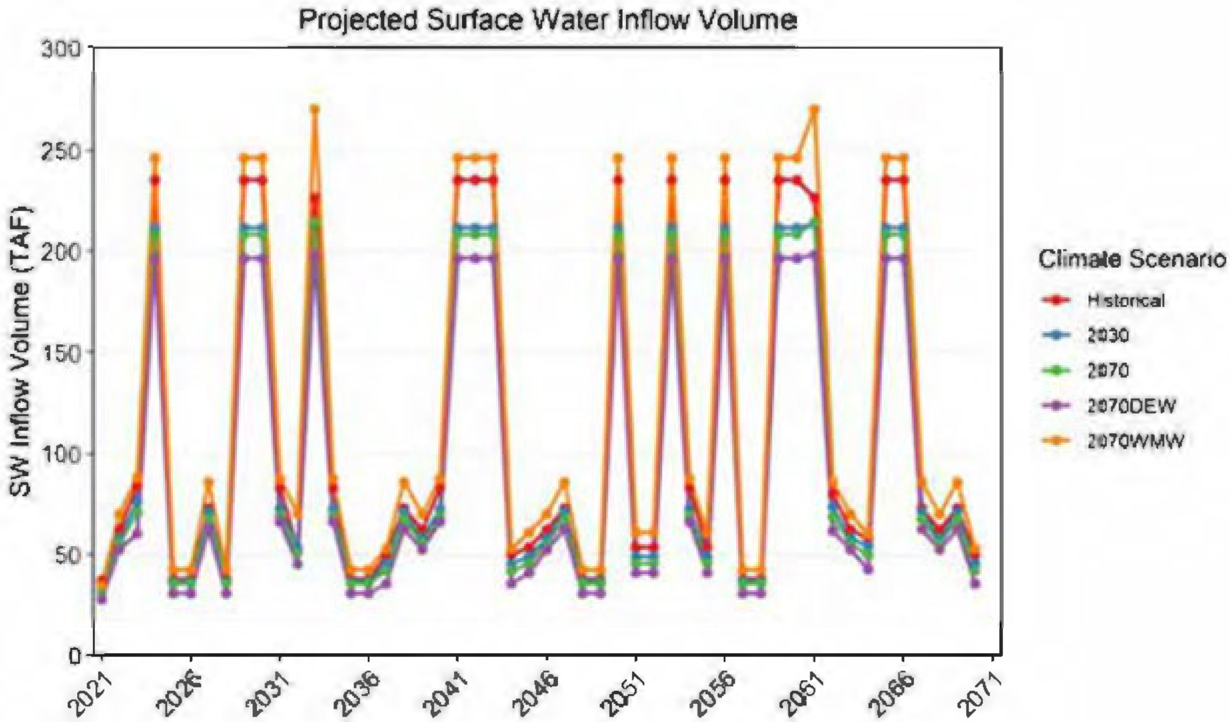
Figure 2.2.3-12: Projected Future Groundwater Demand



2.2.3.5.3 Projected Surface Water Supply (Reg § 354.18[c][3][C])

Projected surface water inputs to Sierra Valley are shown in Figure 2.2.3-13. Annual inflows range from 27,800 to 270,600 AFY across all four scenarios. Annual average surface water inflows range from 91,500 to 120,100 AFY which represents a change of -5,000 to +23,400 AFY from the historical annual average of 96,700 AFY.

Figure 2.2.3-13: Projected Surface Water Inflow to Sierra Valley



2.2.3.5.4 Projected Future Water Budgets

Surface water subsystem budgets over the 50-year (WY 2021-2070) planning and implementation horizon for each climate change scenario are shown in Figure 2.2.3-14 and summarized in Table 2.2.3-8. Tabulated water budgets are presented in Appendix 2-7. As mentioned in Section 2.2.3.5.3, average annual inflows range from 5,000 AFY lower to 23,400 AFY higher when compared to the historical annual average of 96,700 AFY. Average annual surface water irrigation volumes range from 29,600 to 30,500 AFY across all scenarios, which represents a decrease of approximately 0-3% compared to annual estimated historical surface water irrigation volume. Surface water outflows from the UMFFR are projected to increase on average between 0 and 57,000 AFY on average across all scenarios, largely due to increased valley floor runoff from increased storm intensity. Projected future land surface (soil zone) water budgets for the groundwater basin are shown in Figure 2.2.3-15 and summarized in Table 2.2.3-9.

In general, both the magnitude and variance of the annual average of the budget components increase. This mean that more water moves through the system on average, but interannual variability also increases. In other words, wet years are projected to be wetter and dry years are projected to be drier, with fewer years that would be considered “average.” Results from the SWBM indicate that overall groundwater recharge for the basin is projected to increase by about 5,800 to 16,700 AFY, while groundwater irrigation is projected to increase approximately 100 to 2,500 AFY.

Projected future water budgets for the groundwater subsystem are shown in Figure 2.2.3-16 and summarized in Table 2.2.3-10. Groundwater pumping is projected to increase from about 0 to 2,300 AFY on average due to increased ET. However, projected increases in recharge due to increased precipitation offset increased pumping demand. Long-term changes in storage are projected to range from -500 to +100 AFY, which is a reduction from the -1,300 AFY simulated by SVHSM for WY 2001-2020. Figure 2.2.3-17 shows the time series of cumulative change in storage since the beginning of the model run for each future climate scenario. Changes in storage recover for the 2070WMW and 2030 scenarios during the latter 15 years of the future simulation following a simulated dry period that lasts for about seven years. Partial recovery is observed for the 2070 and 2070DEW scenarios.

Figure 2.2.3-14: Projected Future Surface Water Budgets

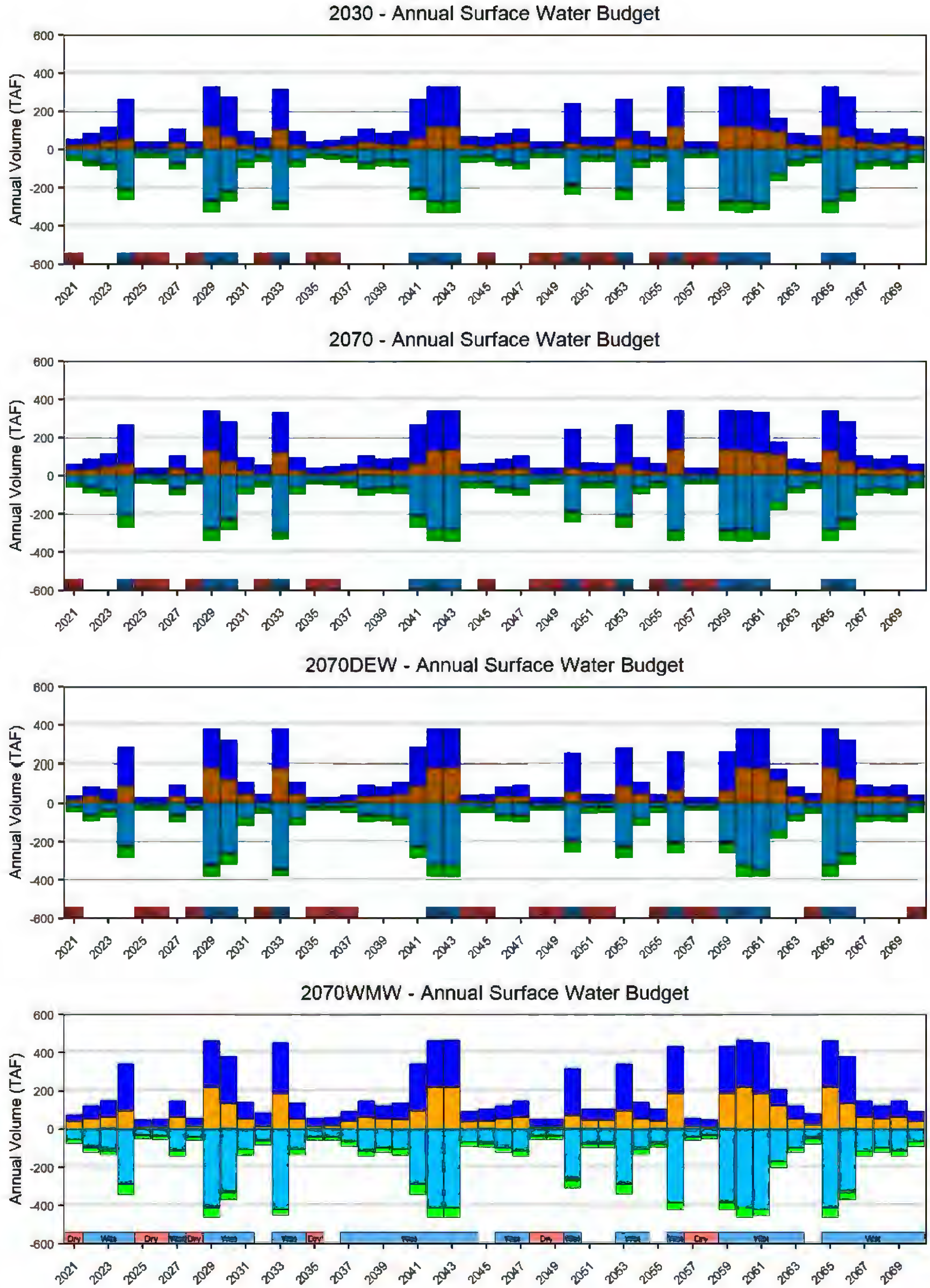
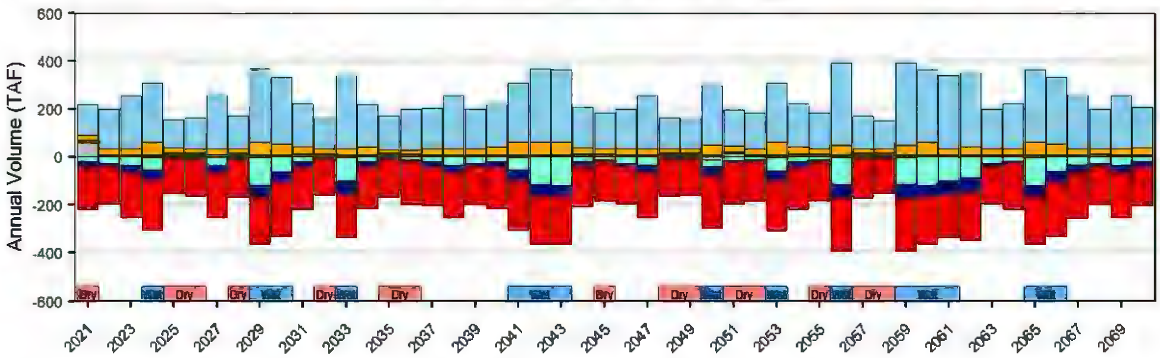


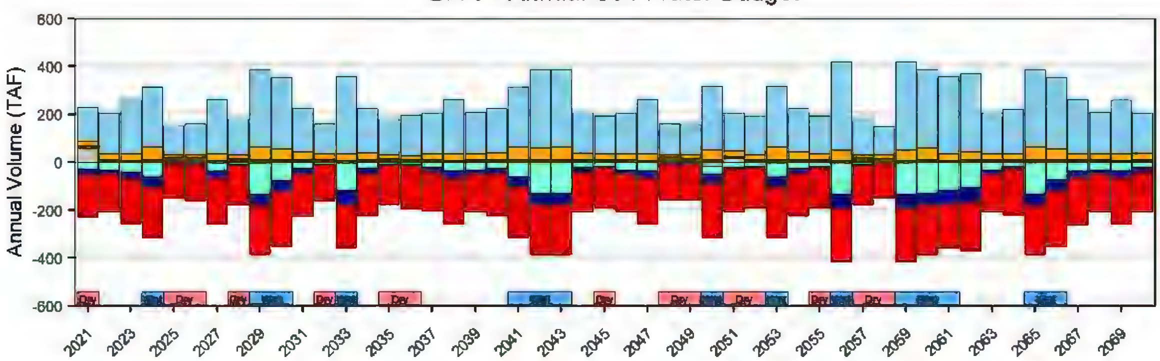
Table 2.2.3-8: Summary of Projected Surface Water Budgets

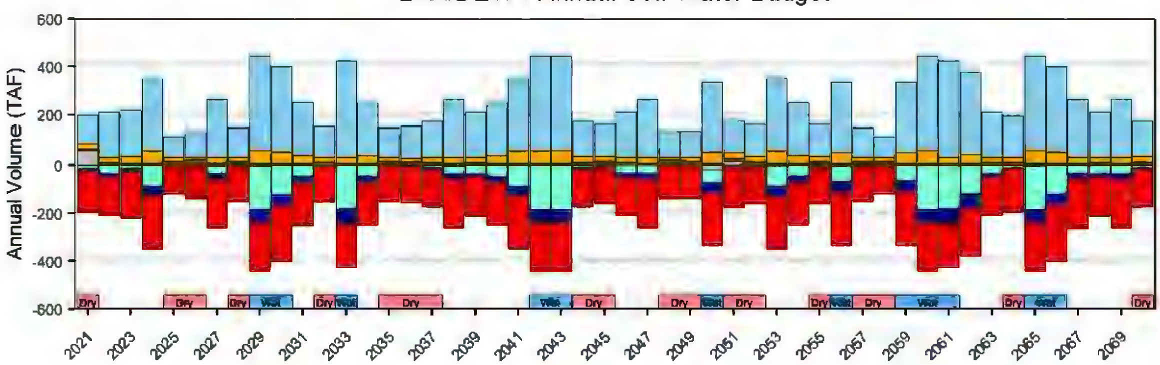
Scenario	Flow	Component	Annual Flow (AFY)		
			Average	Minimum	Maximum
2030	Inflow	Stream Flow	102,700	36,600	213,600
		Runoff	41,400	3,300	132,500
		Subtotal	**144,100**	**39,900**	**346,100**
	Outflow	Stream Flow (MFFR)	-105,200	-16,500	-280,700
		SW Diversions	-30,600	-16,300	-52,200
		Subtotal	**-135,800**	**-32,800**	**-332,900**
	Inflow/Outflow	GW Exchange	**-7,200**	**-900**	**-15,900**
2070	Inflow	Stream Flow	100,000	35,700	214,300
		Runoff	47,400	3,700	132,500
		Subtotal	**147,400**	**39,400**	**346,800**
	Outflow	Stream Flow (MFFR)	-110,200	-18,200	-300,100
		SW Diversions	-30,300	-14,500	-52,700
		Subtotal	**-140,500**	**-32,700**	**-352,800**
	Inflow/Outflow	GW Exchange	**-5,900**	**1,000**	**-13,900**
2070DEW	Inflow	Stream Flow	92,800	30,900	198,100
		Runoff	55,700	1,900	184,400
		Subtotal	**148,500**	**32,800**	**382,500**
	Outflow	Stream Flow (MFFR)	-111,700	-13,300	-347,300
		SW Diversions	-29,800	-14,300	-51,600
		Subtotal	**-141,500**	**-27,600**	**-398900**
	Inflow/Outflow	GW Exchange	**-7,000**	**100**	**-15,800**
2070WMW	Inflow	Stream Flow	121,800	42,500	270,600
		Runoff	77,100	6,900	218,000
		Subtotal	**198,900**	**49,400**	**488,600**
	Outflow	Stream Flow (MFFR)	-162,900	-27,700	-422,900
		SW Diversions	-29,900	-15,300	-53,600
		Subtotal	**-192,800**	**-43,000**	**-476,500**
	Inflow/Outflow	GW Exchange	**-4,700**	**1,300**	**-11,800**

Notes:
- Values represent projections for WY 2022-2070. WY 2021 excluded to remove influence of assumed initial conditions.
- MFFR: Middle Fork Feather River
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Annual flow values (in acre-feet per year [AFY]) are rounded to the nearest 100 AFY; therefore, a discrepancy of 100 AFY may occur.

Figure 2.2.3-15: Projected Groundwater Basin Future Land Surface Water Budgets







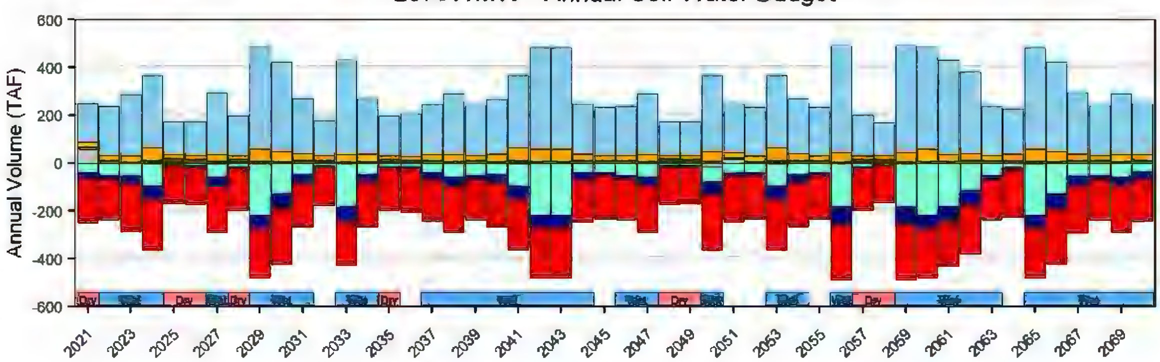


Table 2.2.3-9: Summary of Projected Groundwater Basin Land Surface Water Budgets

Scenario	Flow	Component	Annual Flow (AFY) Average	Minimum	Maximum
2030	Inflow	Precipitation	207,900	118,000	345,500
		Irrigation (from SW)	30,600	16,300	52,200
		Irrigation (from GW)	9,500	5,900	14,800
		Subtotal	**248,000**	**140,200**	**412,500**
	Outflow	Evapotranspiration (Irrigated Fields)	-78,100	-63,300	-101,300
		Evapotranspiration (Non-Irrigated Fields)	-38,900	-32,200	-51,500
		Evapotranspiration (Native Vegetation)	-63,100	-47,900	-77,400
		Recharge to GW	-26,300	-3,800	-59,400
		Runoff	-41,400	-3,300	-118,000
		Subtotal	**-247,800**	**-150,500**	**-407,600**
		Change in Storage	**200**	**-13,500***	**12,300***
2070	Inflow	Precipitation	216,600	117,700	368,700
		Irrigation (from SW)	30,300	14,500	52,700
		Irrigation (from GW)	10,100	6,200	15,600
		Subtotal	**257,000**	**138,400**	**437,000**
	Outflow	Evapotranspiration (Irrigated Fields)	-78,800	-61,400	-103,600
		Evapotranspiration (Non-Irrigated Fields)	-39,200	-31,800	-52,000
		Evapotranspiration (Native Vegetation)	-63,900	-47,400	-79,600
		Recharge to GW	-27,600	-4,000	-61,000
		Runoff	-47,400	-3,700	-132,500
		Subtotal	**-256,900**	**-148,300**	**-428,700**
		Change in Storage	**100**	**-17,000***	**15,700***
2070DEW	Inflow	Precipitation	217,700	86,800	392,000
		Irrigation (from SW)	29,800	14,300	51,600
		Irrigation (from GW)	11,200	6,700	17,200
		Subtotal	**258,700**	**107,800**	**460,800**
	Outflow	Evapotranspiration (Irrigated Fields)	-78,400	-53,400	-106,300
		Evapotranspiration (Non-Irrigated Fields)	-38,400	-24,400	-52,700
		Evapotranspiration (Native Vegetation)	-60,900	-34,800	-75,700
		Recharge to GW	-25,300	-2,200	-65,500
		Runoff	-55,700	-1,900	-184,400
		Subtotal	**-258,700**	**-116,700**	**-484,600**
		Change in Storage	**0**	**-17,100***	**16,300***
2070WMW	Inflow	Precipitation	260,500	136,000	445,700
		Irrigation (from SW)	29,900	15,300	53,600
		Irrigation (from GW)	8,800	5,300	14,800
		Subtotal	**299,200**	**156,600**	**514,100**
	Outflow	Evapotranspiration (Irrigated Fields)	-79,000	-64,000	-101,600
		Evapotranspiration (Non-Irrigated Fields)	-40,800	-33,700	-56,300
		Evapotranspiration (Native Vegetation)	-65,900	-55,000	-81,700
		Recharge to GW	-36,200	-5,600	-79,200
		Runoff	-77,100	-6,900	-218,000
		Subtotal	**-299,000**	**-165,200**	**-536,800**
		Change in Storage	**200**	**-15,400***	**13,800***

- WY 2021 excluded to remove influence of assumed initial conditions

- MFFR: Middle Fork Feather River
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Values are rounded to the nearest 100 AFY
- Increasing storage reported as a positive value, decreasing storage reported as a negative value.

* Column arithmetic not applicable since values come from different years which violates mass balance. Mass-conservative values shown.

Figure 2.2.3-16: Projected Future Groundwater Budgets

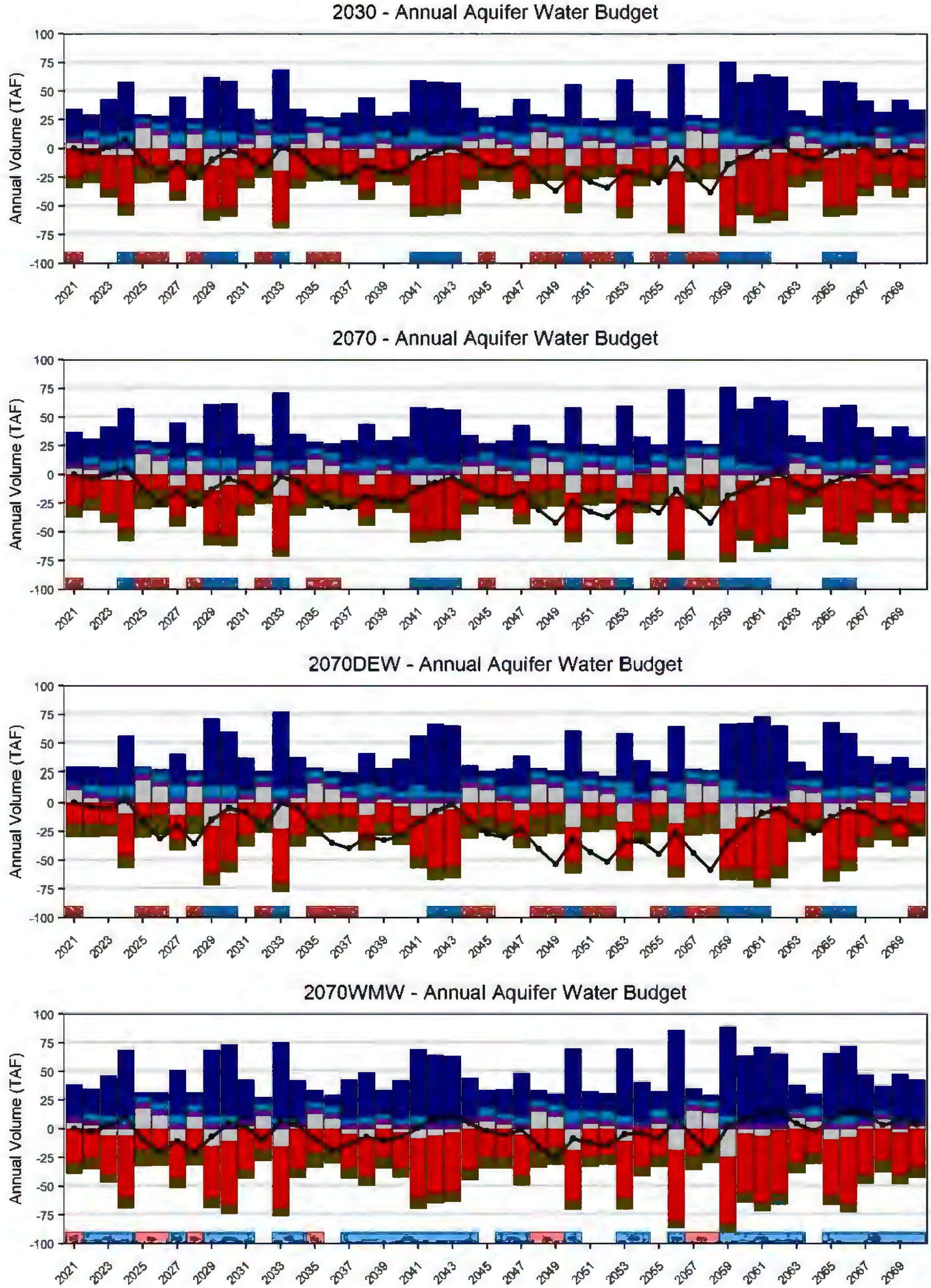
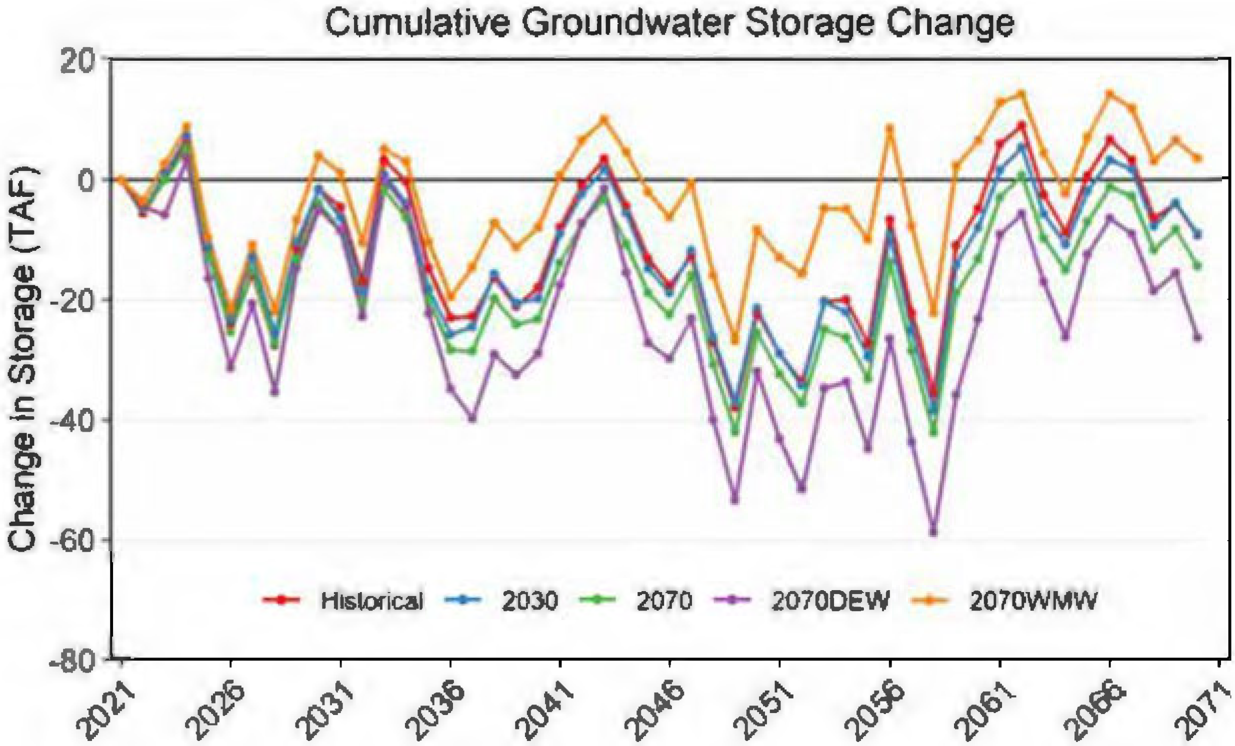


Table 2.2.3-10: Summary of Projected Groundwater Budgets

Scenario	Flow	Component	Annual Flow (AFY)		
			Average	Minimum	Maximum
2030	Inflow	Recharge (Valley Floor)	26,200	3,800	59,200
		Recharge (Mountain Front)	3,700	3,700	3,700
		Subtotal	**29,900**	**7,500**	**29,900**
	Outflow	Evapotranspiration	-27,900	-12,300	-51,200
		Pumping (Wells)	-9,500	-6,100	-14,400
		Subtotal	**-37,400**	**-18,400**	**-65,600**
	Inflow/Outflow	Stream Exchange	**7,200**	**900**	**15,900**
		Change in Storage	**-200**	**-18,500**	**24,400**
2070	Inflow	Recharge (Valley Floor)	27,500	4,000	60,800
		Recharge (Mountain Front)	3,700	3,700	3,700
		Subtotal	**31,200**	**7,700**	**64,500**
	Outflow	Evapotranspiration	-28,300	-12,000	-52,400
		Pumping (Wells)	-10,000	-6,300	-15,200
		Subtotal	**-38,300**	**-18,300**	**-67,600**
	Inflow/Outflow	Stream Exchange	**5,900**	**-1,000**	**13,900**
		Change in Storage	**-500**	**-17,800**	**22,500**
2070DEW	Inflow	Recharge (Valley Floor)	25,200	2,200	65,300
		Recharge (Mountain Front)	3,700	3,700	3,700
		Subtotal	**28,900**	**5,900**	**69,000**
	Outflow	Evapotranspiration	-25,500	-10,200	-52,200
		Pumping (Wells)	-11,100	-6,800	-16,700
		Subtotal	**-36,600**	**-17,000**	**-68900**
	Inflow/Outflow	Stream Exchange	**7,000**	**-100**	**15,800**
		Change in Storage	**-500**	**-20,000**	**22,900**
2070WMW	Inflow	Recharge (Valley Floor)	36,100	5,600	79,000
		Recharge (Mountain Front)	3,700	3,700	3,700
		Subtotal	**39,800**	**29,900**	**82,700**
	Outflow	Evapotranspiration	-35,700	-15,500	-62,300
		Pumping (Wells)	-8,800	-5,500	-14,300
		Subtotal	**-44,500**	**-21,000**	**-76,600**
	Inflow/Outflow	Stream Exchange	**4,700**	**-1,300**	**11,800**
		Change in Storage	**100**	**-18,500**	**24,600**

Notes:
- Values represent projections for WY 2022-2070. WY 2021 excluded to remove influence of assumed initial conditions.
- MFFR: Middle Fork Feather River
- Inflows are represented by positive values; outflows are represented by negative values.
- Minimum and maximum values represent the smallest and largest magnitudes of annual flows, respectively.
- Increasing storage reported as a positive value, decreasing storage reported as a negative value.

Figure 2.2.3-17: Projected Change in Groundwater Storage from Climate Change Scenarios



Comparison of cumulative change in groundwater storage rates between the eastside and westside portions of the basin (Figure 2.2.3-18) show similar interannual patterns between the two zones, but the magnitude of change is much greater for the eastside. Annual average change in storage rates range from about -0.1 to -1.6 acre-ft/day for the westside, compared to about -0.8 to -2.7 acre-ft/day for the eastside of the basin. Both sides of the basin exhibit the same pattern in storage rate changes as that observed in the basin wide change in storage volume (Figure 2.2.3-19).

Differences in cumulative changes in storage rates are much more apparent when comparing the eastside upper aquifer to the eastside lower aquifer (Figure 2.2.3-19). The eastside upper aquifer follows a similar interannual pattern to that observed when comparing the eastside of the basin to the westside or looking at the change in volumetric storage for the groundwater basin as a whole. In contrast, changes in eastside lower aquifer storage are much more subdued on an interannual basis. Recovery of storage following the seven-year dry period is not observed in the eastside lower aquifer for any of the scenarios, although the 2070WMW scenario does come close. This indicates that groundwater levels in the eastside lower aquifer would continue to decline if current groundwater management practices were continued in the future.

Figure 2.2.3-18: Eastside Portion of the Subbasin Projected to Experience Greater Declines in Groundwater Storage than the Westside in the Future

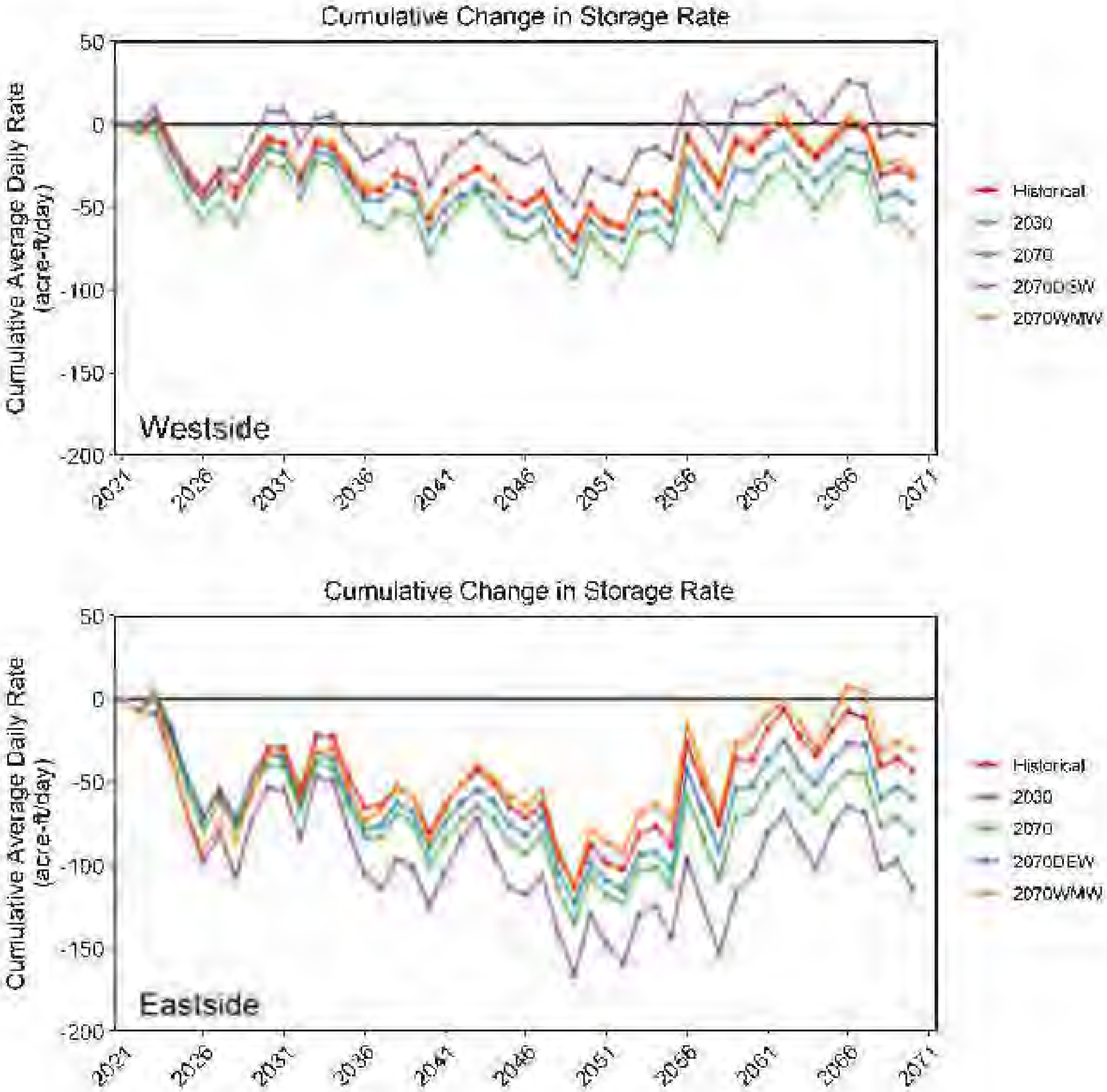
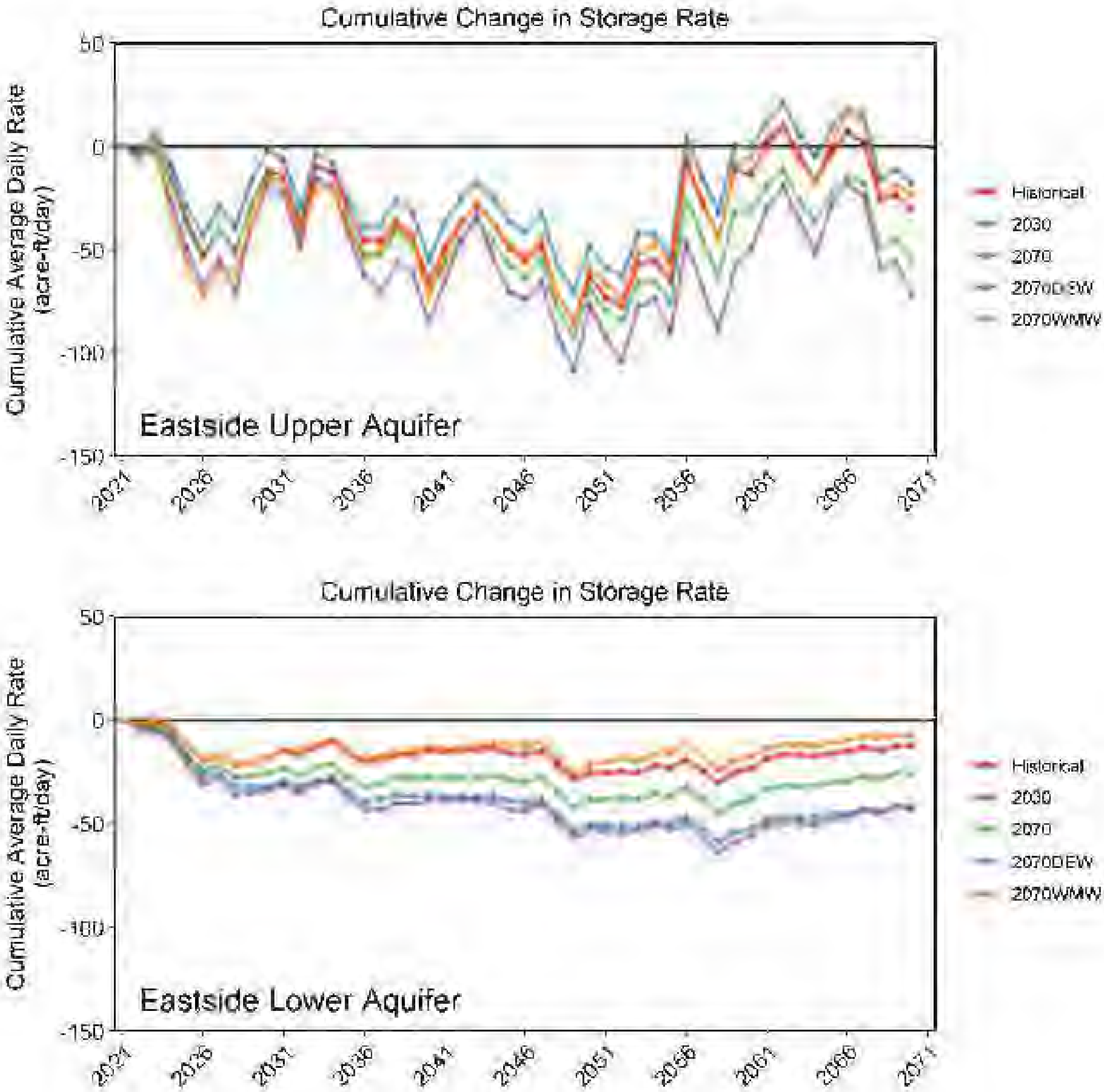


Figure 2.2.3-19: Continued Declines in Groundwater Storage are Expected for the Eastside Lower Aquifer in the Absence of Management Changes



2.2.3.6 Quantification of Overdraft (if applicable) (Reg. § 354.18[b][5])

Based on observed long-term water level declines that average out to approximately 1 ft/yr over the last two decades in wells located in the eastern portion of the groundwater basin, along with results from SVHSM, the Sierra Valley groundwater basin is overdrafted by approximately 1,300 to 3,000 AFY on average. Compared to the overall water budget, this is a relatively small amount (see Figure 2.2.3-4). However, when compared to annual average groundwater pumping it represents approximately 10-30% of extractions.

The range of 1,300 to 3,000 AFY of overdraft was obtained using two different methods. The first used the long-term (WY 2001-2020) overdraft estimated by SVHSM, which was equal to 1,300 AFY (see Appendix 2-7). The second method reduced agricultural pumping in the historical version (WY 2000-2020) of SVHSM by 25%, 50%, 75% and 100% and examined resulting changes in groundwater storage. Figure 2.2.3-20 and Figure 2.2.3-21 indicate that a reduction in groundwater pumping of approximately 25 to 35% would stabilize groundwater conditions for the basin and the eastside lower aquifer. This corresponds to an average annual groundwater pumping rate between 5,500 and 6,500 AFY, which is 2,000 - 3,000 AFY less than the current average annual pumping of 8,500 AFY. This estimate strongly agrees with the estimate of 6,000 AFY of sustainable yield proposed by Kenneth D. Schmidt and Associates (2017) and Bachand and Associates (2020).

Figure 2.2.3-20: SVHSM Predicts a 25-35% Reduction in Agricultural Groundwater Pumping would Arrest Declining Storage for the Entire Subbasin

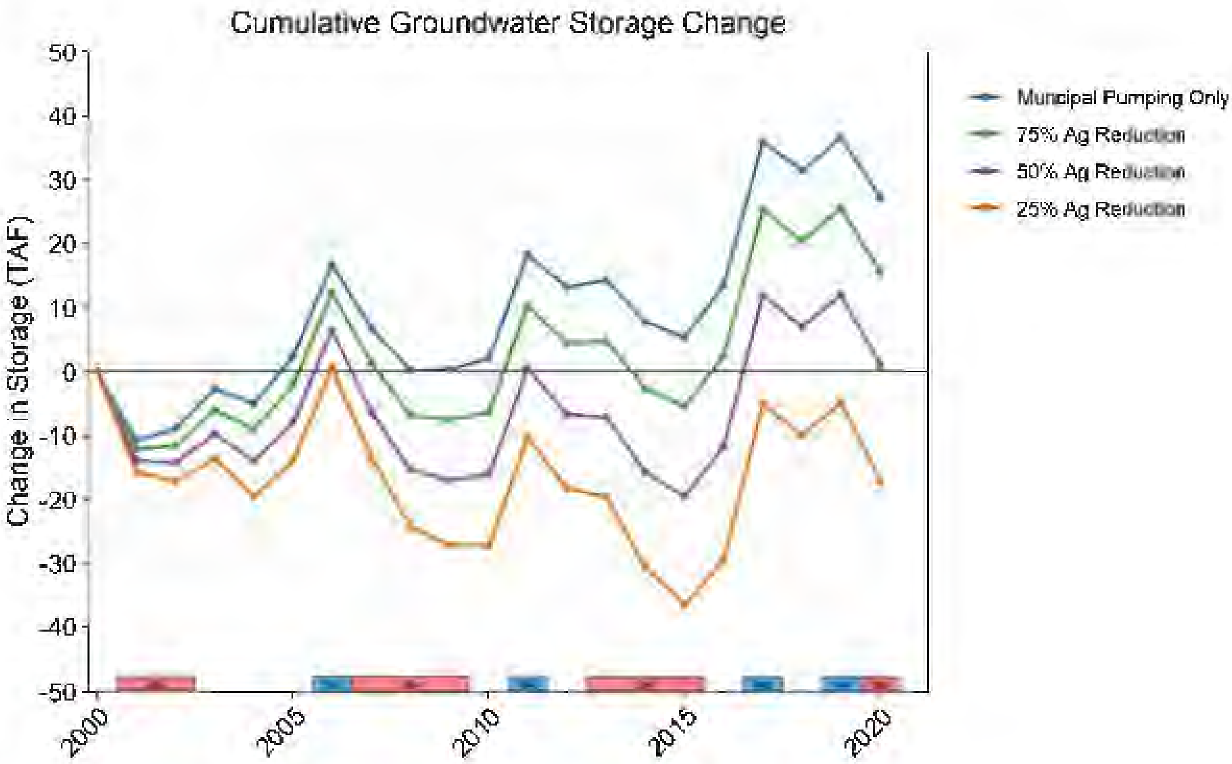
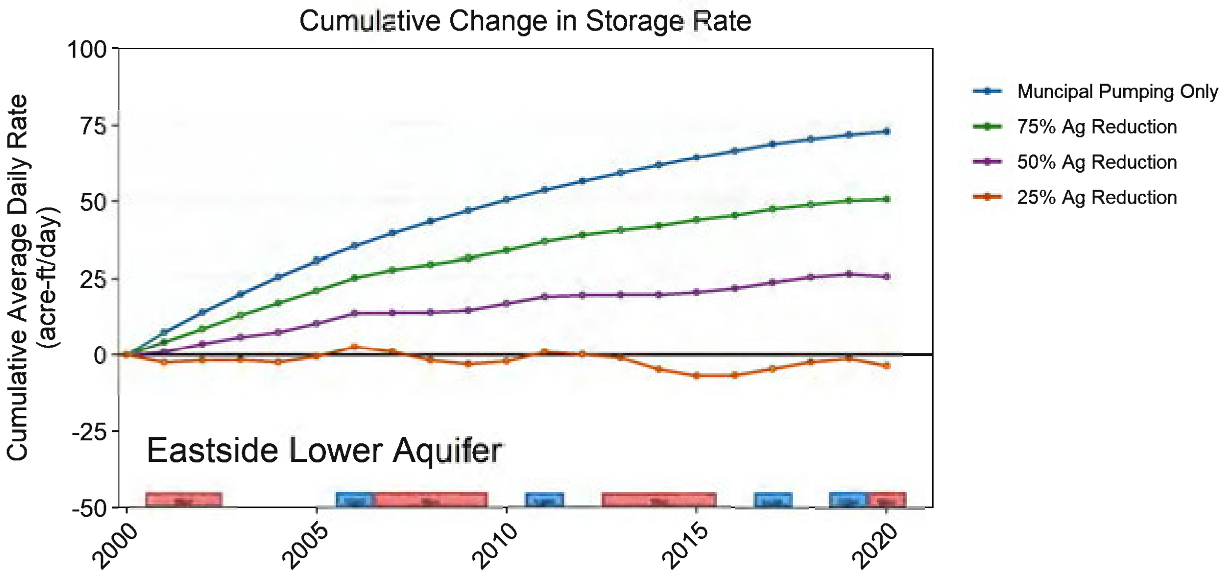


Figure 2.2.3-21: SVHSM Predicts a 25-35% Reduction in Agricultural Groundwater Pumping would Arrest Declining Storage in the Eastside Lower Aquifer



2.2.3.7 Estimate of Sustainable Yield (Reg. § 354.18[b][7])

The Basin sustainable yield has been estimated to be between about 5,500 and 6,500 AFY based on a combination of observed water level declines, pumping data, and SVHSM results (see Section 2.2.3.6). Historical groundwater pumping averages about 8,500 AFY on average. The higher annual average groundwater pumping than sustainable yield indicates the Basin is over drafted by about 1,300 - 3,000 AFY over the long-term.

The sustainable yield represents the average pumping volume for the 50-year SGMA planning horizon that corresponds with zero long-term changes in groundwater storage. Pumping is expected to vary interannually based on water year type, however the long-term average should be less than or equal to the sustainable yield estimate. Consideration of this sustainable yield estimate in the context of other undesirable results is discussed in Section 3.

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

The Subbasin is not currently divided into separate management areas.