2.3.7 Groundwater Dependent Ecosystems

Vegetative groundwater dependent ecosystems (GDEs) are a beneficial user of groundwater that rely on a connection to saturated groundwater over some vertical displacement, typically characterized by the land surface elevation, the depth to groundwater, and the vegetation rooting depth. GDEs were mapped and characterized, and special status species that rely on these ecosystems were cataloged. Analysis of GDEs informed the creation of quantitative management criteria to identify the occurrence of significant and unreasonable changes to GDEs. These details are covered in **Appendix 3-D: Groundwater Dependent Ecosystems in the South American Subbasin**, and a brief summary of historical and present day GDE locations and characteristics are presented here.

Data assimilation and analysis

All available datasets were used to identify potential wetland and non-wetland GDEs, including:

- Natural Communities Commonly Associated with Groundwater Vegetation (NCCAG-V) developed by a working group comprised of California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) and distributed by California DWR[6]
- South Sacramento Habitat Conservation Plan (SSHCP) landcover[7]
- CDFW Vegetation augmented with project-based mapping for a landscape management scenario analysis[8]
- National Wetlands Inventory (NWI) developed and distributed by US Fish & Wildlife[9]
- California Aquatic Resource Inventory (CARI) developed and distributed by the San Francisco Estuary Institute[10]

Datasets were analyzed to prevent overlap and double counting of potential GDEs, and a conservative rooting depth of 30 feet was assigned to each potential GDE polygon.

The maximum reported rooting depths of the plant species found in the SASb range from near-surface for grasses like creeping wildrye (3.8 feet) to deep-rooted trees like the Valley Oak (24.3 feet). Rooting depths of species within the SASb were evaluated, and the Valley Oak (*Quercus lobata*) was found to exhibit the largest rooting depth[11]. Because plants can extract moisture from pore spaces away from the roots themselves, a threshold depth of 30 feet was

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[6] *Available at* https://data.cnra.ca.gov/dataset/natural-communities-commonly-associated-with-groundwater.

[7] This dataset is referred to as SSHCP/Underwood as the data was provided by E. Underwood and R. Hutchinson. *Available at* https://escholarship.org/uc/item/8700x95f.

[8] *Available at* https://wildlife.ca.gov/Data/VegCAMP.

[9] *Available at* https://www.fws.gov/wetlands/Data/Data-Download.html.

[10] *Available at* https://www.sfei.org/cari.

[11] Coast Live Oak (*Querus agrifolia*) is also present in the SASb and has an average maximum rooting depth of 35.1 feet, however, it occupies 2.3 acres, and is thus neglected. By comparison, Valley Oak (*Quercus lobata*) has an area of 2,937 acres, thus we use the Valley Oak to set the upper bound of maximum rooting depth expected in the SASb.

used as a cutoff for the maximum depth of groundwater that could reasonably be accessed by a GDE within the SASb. Areas within the SASb where depth to groundwater is consistently greater than 30 feet are therefore assumed incapable of supporting non-wetland GDE communities and by extension, any GDEs. In the context of identifying GDEs, this 30-foot depth threshold is very conservative and overly inclusive as shallower groundwater is likely required to support a broader array of healthy GDEs in most circumstances.

Like ISW, GDE location varies depending on groundwater level. The same seasonal groundwater levels from 2005-2018 described in the ISW section above were used to evaluate trends in GDE area and evaluate historical inter-seasonal changes in the range of GDE area (**Figure 2.3-46**).

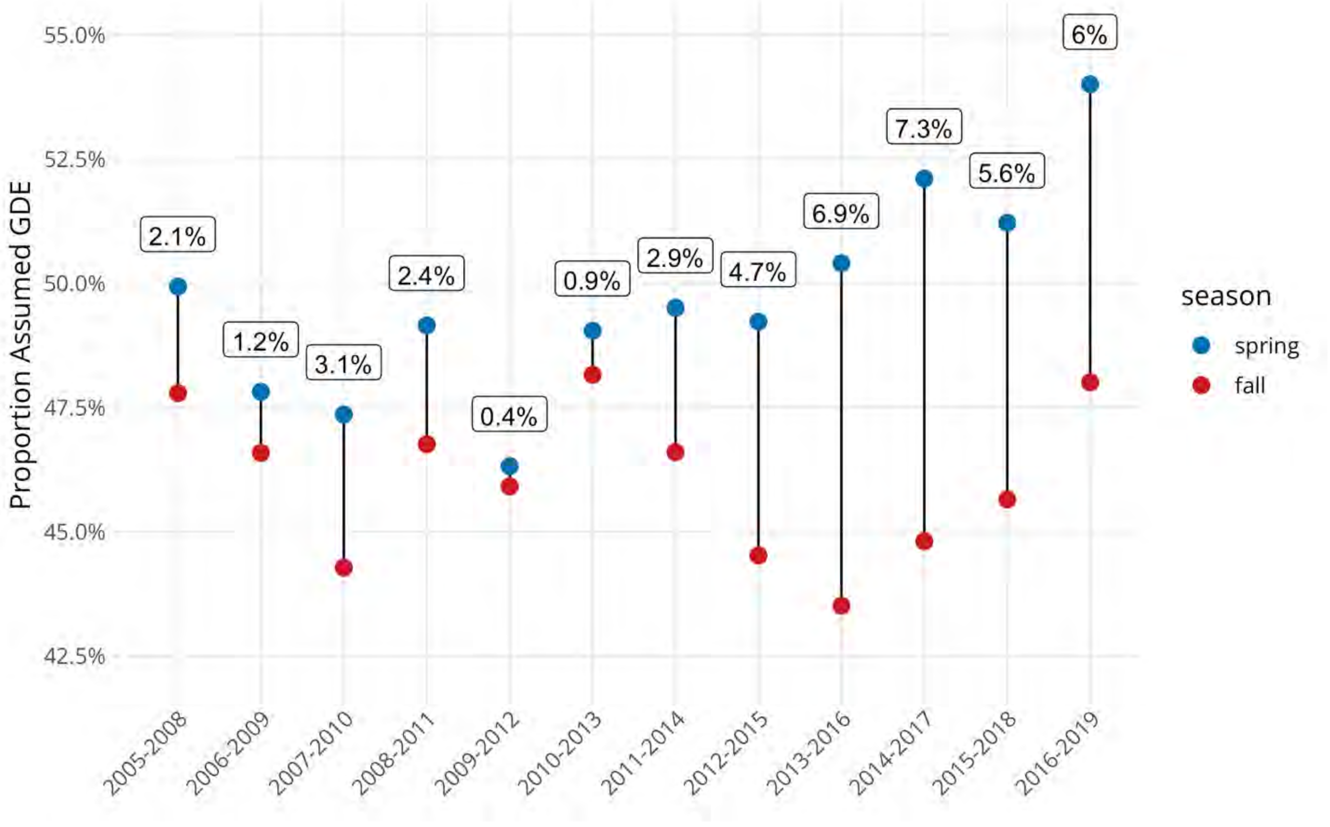

Figure 2.3-46: GDE classification based on the application of a 30-foot depth to groundwater threshold on mapped potential GDEs. Text labels indicate the range between the spring and fall GDE area (relative to all potential GDEs).

Locations of groundwater dependent ecosystems

Long-term historical relationships between potential GDE polygons and groundwater were used to classify all potential GDEs into four (4) categories and estimate the average area and location of potential GDEs occupied by each category (**Table 2.3-2, Figure 2.3-47**):

- GDE – Potential GDEs connected 100% of seasons
- Potential GDE – Likely: potential GDEs connected ≥ 50% and < 100% of seasons
- Potential GDE – Unlikely: potential GDEs connected > 0% and < 50% of seasons
- Not GDE – Potential GDEs connected 0% of seasons

Table 2.3-2: GDE likelihood categorization based on all groundwater elevation from 2005-2019

Category	Area (acres)	% of Potential GDE Area
GDE	11,340	43.2%
Potential GDE - Likely	1,695	6.5%
Potential GDE - Unlikely	914	3.5%
Not GDE	12,296	46.9%
Total	26,245	100%

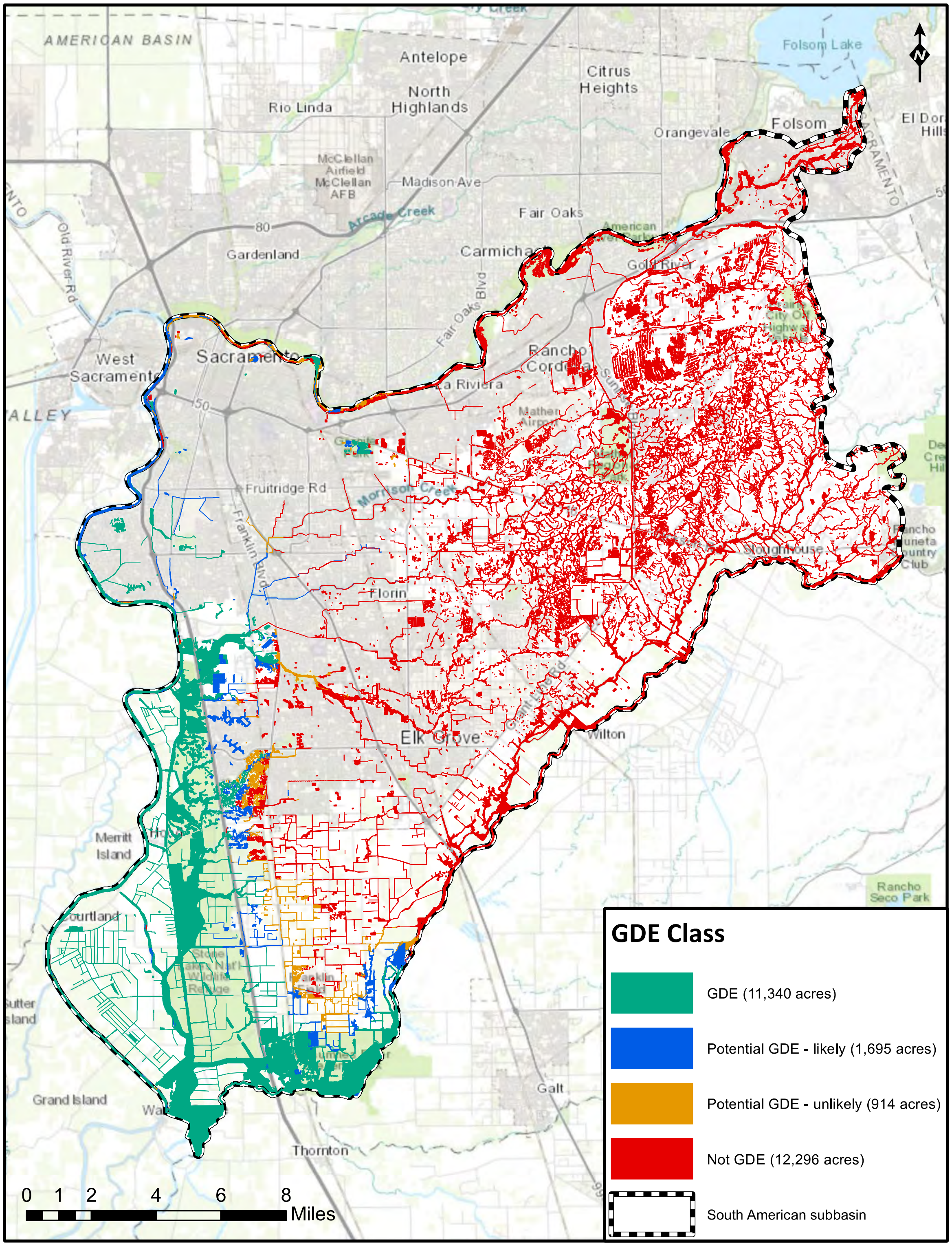

Figure 2.3-47: GDE likelihood classification of potential GDEs from 2005-2018

2.3.8 Data Gaps

Data gaps were identified for groundwater conditions during the development of the GSP. Many of the data gaps associated with the HCM also affect the understanding of groundwater conditions. Many of these data gaps will be addressed during GSP implementation (see **Section 5**). Additional data gaps are summarized below:

- Vertical gradients in many parts of the subbasin are not well understood due to the lack of wells with completions at different depths located near each other. While hundreds of multiple completion wells are present at the contaminated sites in the northeastern portions of the SASb and SCWA is thought to maintain several multiple completion wells near their facilities, only two multiple completion wells had readily available measurement data within the Subbasin. Both of these wells were located on the eastern portion of the Subbasin and are shallower than 165 feet bgs. Given the limited spatial distribution and well completion depths of these multiple completion wells, vertical gradients could not be analyzed in other areas of the Subbasin and in deeper stratigraphic layers. The development of additional multi-completion wells or cluster wells are recommended, as is efforts to better disseminate data from existing multiple completion monitoring wells. Further, there is inconsistent recent monitoring data in many wells, with a lack of consistency regarding when measurements are taken.

- Certain reaches of the Cosumnes River show sub-seasonal connection but are disconnected on a seasonal level, and are hence identified as a Data Gap (**Figure 2.3-44**). Paired high-frequency streamflow and groundwater level measurements along this reach will improve understanding of this important natural ecosystem and resource.

2.4 Water Budget

This section provides the data used in water budget development, discusses how the budget was calculated, and provides water budget estimates for historical conditions, current conditions and projected conditions.

2.4.1 Water Budget Information

Water budgets were developed to provide a quantitative account of water entering and leaving the South American Subbasin (SASb). Water entering the Subbasin includes water entering at the surface and through the subsurface. Similarly, water leaving the Subbasin leaves at the surface and through the subsurface. Water enters and leaves naturally, such as precipitation and streamflow, and through human activities, such as pumping and recharge from irrigation or outdoor water use. **Figure 2.4-1** highlights the interconnectivity of stream, surface, and groundwater components of the natural and human related hydrologic system used in this analysis.

The water budget provides information on historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate change, groundwater and surface water interaction, and subsurface groundwater flow. This information can assist in management of the Subbasin groundwater and surface water resources, by identifying the scale of different uses, highlighting potential risks, and identifying potential opportunities to improve water supply conditions, among others.

Water budgets can be developed on different scales. In agricultural use, water budgets may be limited to the root zone, improving irrigation techniques by estimating the inflows and outflows of water from the upper portion of the soil accessible to plants through their roots. In a pure groundwater study, water budgets may be limited to water flow within the subsurface. Global climate models simulate water budgets that incorporate atmospheric water, allowing for simulation of climate change conditions. In this document, consistent with the Regulations, the water budget investigates the combined land surface, stream, and groundwater systems for the South American Subbasin.

Water budgets can also be developed at different temporal scales. Daily water budgets may be used to demonstrate how evaporation and transpiration increase during the day and decrease at night. Monthly water budgets may be used to demonstrate how groundwater pumping increases in the dry, hot summer months and decreases in the cool, wet winter months. In this document, consistent with the Regulations, water budgets were developed for monthly periods during a Water Year, which start with October and end with September, because the wet season occurs from November to March.

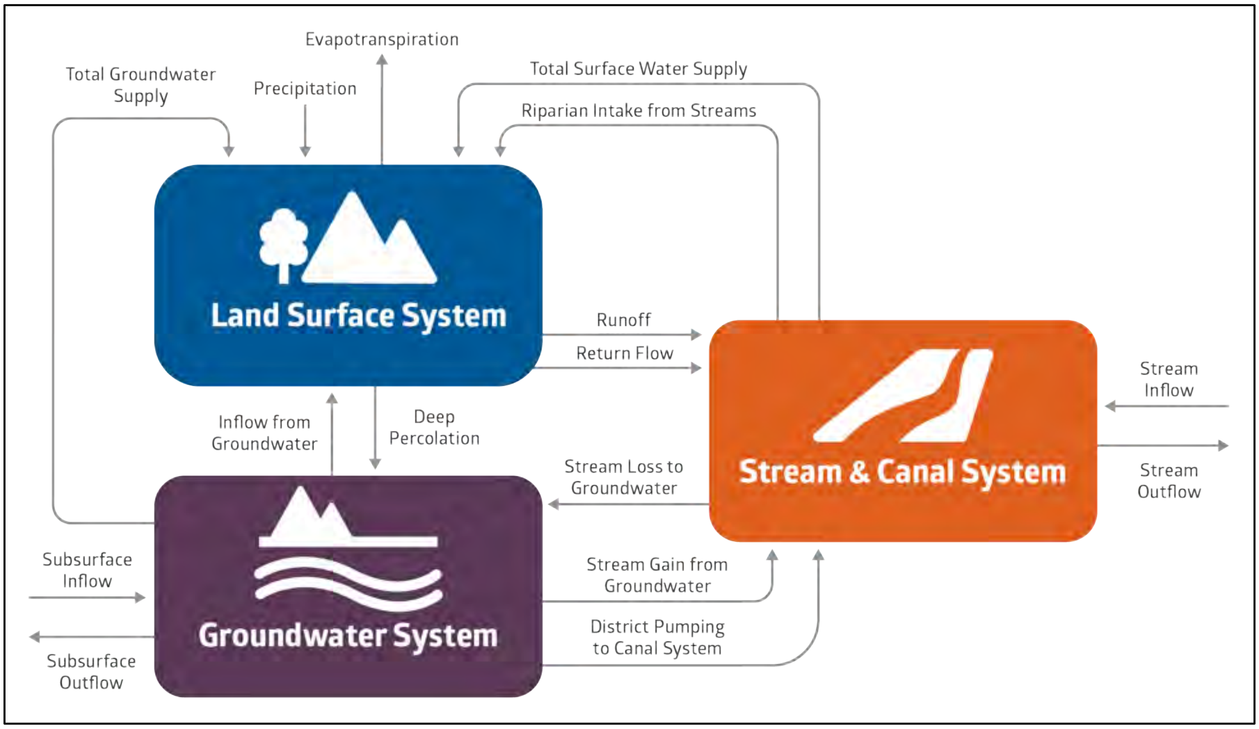

Figure 2.4-1: Generalized Water Budget Diagram

The Regulations require the annual water budgets be based on three different levels of development: historical, current, and projected conditions. Budgets are developed to capture typical conditions during these time periods. Typical conditions are developed through averaging hydrologic conditions that incorporate droughts, wet periods, and normal periods. By incorporating these varied conditions within the budgets, analysis of the system under certain hydrologic conditions, such as drought, can be performed along with analysis of long-term averages. Information is provided in the following subsections on the hydrology dataset used to identify time periods for budget analysis, the usage of the Cosumnes-South American-North American (CoSANA) model and associated data in water budget development, and on the budget estimates.

2.4.1.1 Identification of Hydrologic Periods

Hydrologic periods were selected to meet the needs of developing historical, current, and projected water budgets. The Regulations require that the projected water budget reflect a 50-year hydrologic period in order to reflect long-term average hydrologic conditions. Precipitation for the South American Subbasin was used to identify hydrologic periods that would provide a representation of wet and dry periods and long-term average conditions needed for water budget analyses.

Rainfall data for the Subbasin is derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) dataset of the DWR’s CALSIMETAW (California Simulation of Evapotranspiration of Applied Water) model. Identification of periods with a balance of wet and dry periods was performed by evaluating the cumulative departure from mean precipitation. Under this method, the long-term average precipitation is subtracted from annual precipitation within each water year to develop the departure from mean precipitation for each water year. Wet years have a positive departure and dry years have a negative departure; a year with exactly average precipitation would have zero departure. Starting at the first year analyzed, the departures are added cumulatively for each year. So, if the departure for Year 1 is 5 inches and the departure for Year 2 is -2 inches, the cumulative departure would be 5 inches for Year 1 and 3 inches (5 plus -2) for Year 2. **Figure 2.4-2** illustrate the cumulative departure of the spatially averaged of the rainfall within the Subbasin. The chart includes bars displaying annual precipitation for each water year from 1970 through 2019 and a horizontal line representing the mean precipitation of 20.2 inches. This mean is less than 1 inch per year greater than the long-term (1922-2019) average of 19.3 inches. The cumulative departure from mean precipitation is displayed as a line that starts at zero and highlights wet periods with upward slopes and dry periods with downward slopes. More severe events are shown by steeper slopes and greater changes. Thus, the period from 1976 to 1977 illustrates a short period with a dramatically dry condition (23-inch decline in cumulative departure over 2 years). In addition to the 1976-1977 drought, the 1970-2019 period also includes the extended drought periods of 1987-1992 and 2012-2016 and the historical wet periods of 1982-1983 and 1995-1998.

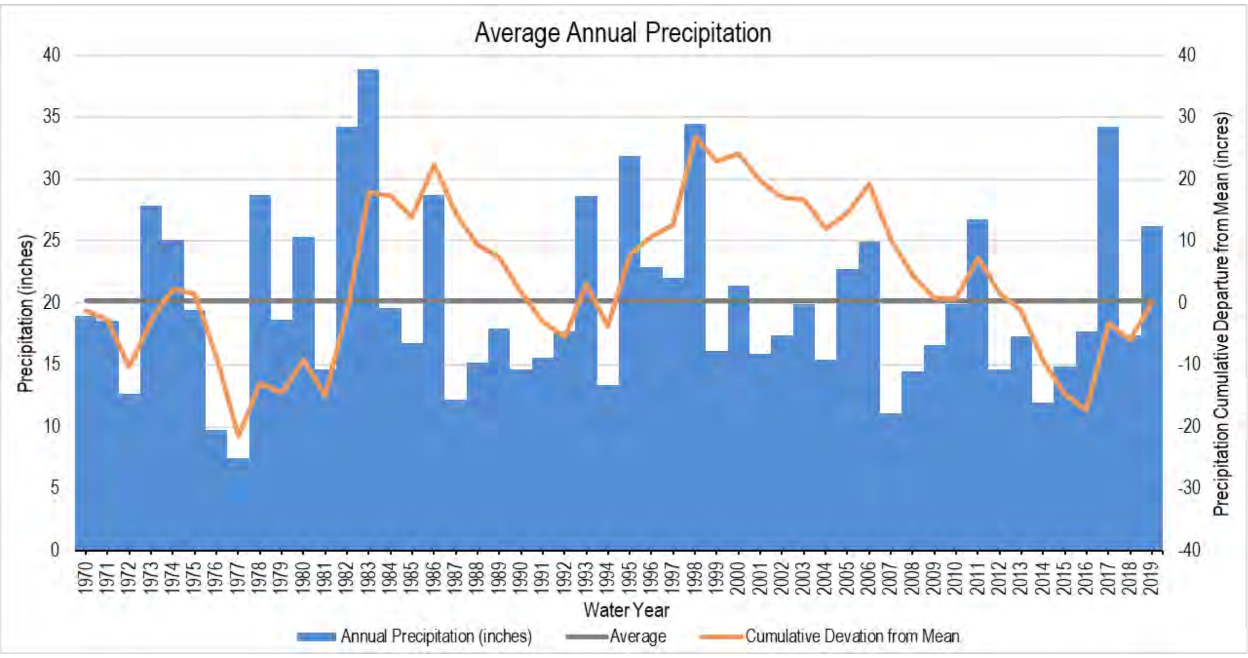

Figure 2.4-2: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation in the South American Subbasin

2.4.1.2 Usage of the CoSANA Model and Associated Data in Water Budget Development

Water budgets were developed utilizing the CoSANA model, a fully integrated surface and groundwater flow model that covers the entire South American Subbasin as well as the adjoining North American and Cosumnes Subbasins. CoSANA was developed with the Regional Water Authority (RWA) as the lead agency with collaboration by GSAs in each respective Subbasin. CoSANA is a quasi-three-dimensional finite element model that was developed using the Integrated Water Flow Model (IWFM) 2015 software package to simulate the relevant hydrologic processes prevailing in the region. CoSANA integrates the groundwater aquifer with the surface hydrologic system and land surface processes and operations. Using data from federal, state, and local resources, CoSANA was calibrated for the hydrologic period of October 1994 to September 2018 by comparing simulated evapotranspiration, groundwater levels, and streamflow records with historical observed records. Development of the model involved the study and analyses of hydrogeologic conditions, agricultural and urban water demands, agricultural and urban water supplies, and an evaluation of regional water quality conditions. Two Baseline models were developed reflecting the Current and Projected levels of development for each Subbasin to support the respective GSPs.

Additional information on the data and assumptions used to develop the CoSANA model is included as **Appendix 2-B** to the GSP.

With the CoSANA model as the underlying framework, model simulations were conducted to allow for the estimation of water budgets. Three model simulations were used to establish the water budgets for historical, current, and projected conditions, which are discussed in detail below:

- The **historical water budget** is based on a simulation of historical conditions in the South American Subbasin.
- The **current water budget** is based on a simulation of current (2015) land and water use over historical hydrologic conditions, assuming no other changes in population, water demands, land use, or other conditions.
- The **projected water budget** is based on a simulation of future land and water use over historical hydrologic conditions.

2.4.1.3 Water Budget Definitions and Assumptions

Definitions and assumptions for the historical, current, and projected water budgets are provided below.

2.4.1.3.1 Historical Water Budget

The historical water budget is intended to evaluate availability and reliability of past surface water supply deliveries, aquifer response to water supply, and demand trends relative to water year type. The hydrologic period of WY 1990 through 2018 was analyzed to provide a period of representative hydrology while capturing recent operations in the Subbasin. For reporting purposes, the period of 2009 through 2018 was selected to provide the best representation of recent historical conditions. The 10-year period WY 2009 through 2018 has an average annual precipitation of approximately 19.1 inches, compared to the long-term average of 20.2 inches and includes the recent 2012-2016 drought, the wetter years of 2011 and 2017, and periods of normal precipitation.

2.4.1.3.2 Current Water Budget

While a budget indicative of current conditions could be developed using the most recent historical conditions, like the historical water budget, such an analysis would be difficult to interpret due to the extreme weather conditions of the past several years and its effect on local water system operations. Instead, in order to analyze the long-term effects of current land and water use on groundwater conditions and to accurately estimate current inflows and outflows for the basin, a Current Conditions Baseline scenario is developed using the CoSANA model. This baseline applies current land and water use conditions to historical hydrology.

The Current Conditions Baseline includes the following conditions:

- Hydrologic period:
  - Water Years 1970-2019 (50-year hydrology)
- River flow based on:
  - Historical records from the United States Geological Survey (USGS) and California Data Exchange Center (CDEC), and the simulation of small-stream watersheds

- Land use based on:
    - 2014 statewide California crop mapping
    - 2015 Sacramento County land use survey
    - Local ground truthing and refinement

- Urban water demand based on:
    - 2015 demands as reported in the 2015 Urban Water Management Plan (UWMP)
    - Municipal Pumping Records

- Agricultural water demand based on:
    - 2015 Land use and cropping conditions, adjusted for urban growth areas based on General Plans
    - Irrigation practices are assumed to be similar to those in the 2019 conditions

2.4.1.3.3 Projected Water Budget

The projected water budget is intended to assess the conditions of the Subbasin for estimated projected conditions of water supply, agricultural and urban demand, including quantification of uncertainties in the projected water budget components. The Projected Conditions Baseline applies future land and water use conditions and uses the 50-year hydrologic period of WY 2020-2069, corresponding to historical hydrological conditions from WY 1970-2019. The Project Conditions Baseline is analyzed with and without climate change.

The Projected Conditions Baseline includes the following conditions:

- Hydrologic period:
    - Water Years 1970-2019 (50-year hydrology)

- River flow based on:
    - Historical records from the United States Geological Survey (USGS) and California Data Exchange Center (CDEC), and the simulation of small-stream watersheds

- Land use based on:
    - 2014 statewide California crop mapping
    - 2015 Sacramento County land use survey
    - Agricultural Water Management Plan projections
    - Direct communication on future projections with local agencies

- Urban water demand based on:
    - Decadal population projections from 2015 Urban Water Management Plans (UWMPs) for most users; Sacramento County Water Agency demand is based on draft 2020 UWMP and 2021 Zone 40 Water Supply Master Plan Amendment (SCWA 2021)

- Agricultural water demand based on:
    - 2015 Land use and cropping conditions, adjusted for urban growth areas based on General Plans
    - Irrigation practices are assumed to be similar to those in the 2019 conditions

Table 2.4-1: Summary of Groundwater Budget Assumptions

Water Budget Type	Historical	Current	Projected
Scenario	Historical Simulation	Current Conditions Baseline	Projected Conditions Baseline
Hydrologic Years	WY 1995-2018	WY 1970-2019	WY 1970-2019
Level of Development	Historical	Current	General Plan buildout
Agricultural Demand	Historical Records	Current Conditions	Projected based on projected land use changes
Urban Demand	Historical Records	Current Conditions	Projected based on local UWMP data
Water Supplies	Historical Records	Current Conditions	Projected based on local UWMP data

2.4.2 Water Budget Estimates

For each baseline condition, water budgets have been developed for the stream and canal system, the land surface system, and for the groundwater system.

The water budget components for the stream and canal system are shown separately for the following river reaches:

- American River from Folsom Lake to the confluence with Sacramento River **(Table 2.4-2)**
- Cosumnes River from the Sierra foothills (at SASb boundary) to the Mokelumne River plus the Lower Mokelumne River from the Cosumnes River confluence to the confluence with the Sacramento-San Joaquin Delta (Delta) at the lower SASb boundary **(Table 2.4-3)**
- Sacramento River from the American River to the confluence with the Sacramento-San Joaquin Delta (Delta) at the lower SASb boundary **(Table 2.4-4)**

A composite water budget for these stream reaches is shows in **Table 2.4-5**. The primary components that are reported in each of these tables are:

- Inflows:
    - Upstream inflows
    - Tributary inflows
    - Stream gain from the groundwater system
    - Surface runoff to the stream system
    - Return flow to stream system
- Outflows:
    - Stream losses to groundwater
    - Surface water diversions
    - Riparian evapotranspiration
    - Stream outflows

The primary components of the land surface system in the South American Subbasin (**Table 2.4-6**) are:

- Inflows:
    - Precipitation
    - Surface water supplies
    - Groundwater supplies
    - Recycled water supplies
    - Riparian intake from streams

- Outflows:
    - Evapotranspiration
    - Surface runoff to the stream system
    - Return flow to the stream system
    - Deep percolation

The primary components of the groundwater system in the South American Subbasin (**Table 2.4-7**) are:

- Inflows:
    - Deep percolation
    - Stream losses to the groundwater system
    - Subsurface inflow

- Outflows:
    - Stream gain from the groundwater system
    - Groundwater production
    - Subsurface outflow

- Change in groundwater storage

The estimated water budgets are provided below for the historical, current, and projected water budgets in acre-feet per year (AFY) in the tables below.

Table 2.4-2: Average Annual Water Budget – American River (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Inflows				
Upstream Inflow	2,524,600	2,688,100	2,688,100	2,337,800
Tributary Inflows[1]	57,400	58,400	66,800	69,100
Stream Gain from Groundwater	24,200	29,400	26,100	24,900
Surface Runoff	-	-	-	-
Direct Return Flow to Streams	15,800	17,800	17,800	17,800
Total Inflow	2,622,100	2,793,700	2,798,700	2,449,500
Outflows				
Stream Losses to Groundwater	46,300	43,900	52,500	53,700
Surface Water Diversions	46,000	43,000	62,900	62,900
Riparian Evapotranspiration[2]	N/A	N/A	N/A	N/A
Flow into Sacramento River	2,529,800	2,706,800	2,683,400	2,333,000
Total Outflow	2,622,100	2,793,700	2,798,700	2,449,500

Notes:

[1] *Local Tributaries include Alder Creek and Buffalo Creek*

[2] *Riparian evapotranspiration is not modeled explicitly on the American River.*

Table 2.4-3: Average Annual Water Budget – Cosumnes River and Lower Mokelumne River (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Inflows				
Upstream Cosumnes R Inflow	350,900	378,100	378,100	332,400
Mokelumne R Flow at Cosumnes R Confluence	567,100	615,600	616,400	451,700
Tributary Inflows[1]	188,600	204,300	208,000	201,500
Stream Gain from Groundwater	11,500	12,200	12,000	11,200
Surface Runoff	7,200	7,300	8,900	9,200
Direct Return Flow to Streams	45,900	51,900	53,300	50,700
Total Inflow	1,171,400	1,269,500	1,276,800	1,056,700
Outflows				
Stream Losses to Groundwater	33,200	30,500	31,800	36,500
Surface Water Diversions	9,300	9,500	9,100	9,300
Riparian Evapotranspiration	4,400	4,200	4,200	4,800
Flow into Sacramento-San Joaquin Delta	1,124,500	1,225,200	1,231,700	1,006,100
Total Outflow	1,171,400	1,269,500	1,276,800	1,056,700

Note:

[1] *Local Tributaries include Deer Creek, Badger Creek and Laguna Creek*

Table 2.4-4: Average Annual Water Budget – Sacramento River (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Inflows				
Sacramento River at Confluence with American R	11,294,000	13,404,800	13,463,900	11,460,500
Upstream Inflow – American River	2,529,800	2,706,800	2,683,400	2,333,000
Tributary Inflows[1]	134,700	142,200	189,100	184,600
Stream Gain from Groundwater	-	-	-	-
Surface Runoff	43,700	44,500	65,400	65,800
Direct Return Flow to Streams	78,000	82,000	84,900	77,700
Total Inflow	14,080,200	16,380,400	16,486,800	14,121,600
Outflows				
Stream Losses to Groundwater	73,600	70,700	75,100	82,700
Surface Water Diversions	55,800	55,300	78,700	78,700
Riparian Evapotranspiration[2]	N/A	N/A	N/A	N/A
Flow into Sacramento-San Joaquin Delta[3]	13,950,800	16,254,400	16,333,000	13,960,200
Total Outflow	14,080,200	16,380,400	16,486,800	14,121,600

Notes:

[1] *Local Tributaries include Morrison Creek*

[2] *Riparian evapotranspiration is not modeled explicitly on the Sacramento River*

[3] *Sacramento River flows into the Delta do not include Lower Mokelumne River flows*

Table 2.4-5: Average Annual Water Budget – Composite of All Major Rivers (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Inflows				
Upstream Inflow[1]	14,736,700	17,086,600	17,146,500	14,582,300
Tributary Inflows[2]	380,700	404,900	463,900	455,200
Stream Gain from Groundwater	35,800	41,600	38,100	36,000
Surface Runoff	51,000	51,900	74,300	75,000
Direct Return Flow to Streams	139,700	151,800	156,000	146,200
Total Inflow	15,343,800	17,736,800	17,878,900	15,294,800
Outflows				
Stream Losses to Groundwater	153,000	145,100	159,400	172,900
Surface Water Diversions	111,200	107,800	150,600	150,900
Riparian Evapotranspiration	4,400	4,200	4,200	4,800
Flow into Sacramento-San Joaquin Delta	15,075,300	17,479,600	17,564,700	14,966,300
Total Outflow	15,343,800	17,736,800	17,878,900	15,294,800

Notes:

[1] *Upstream inflows include Sacramento River, American River, Cosumnes River, and Mokelumne River flows into the South American Subbasin*

[2] *Local Tributaries include Alder Creek, Badger Creek, Buffalo Creek, Deer Creek, Laguna Creek and Morrison Creek*

Table 2.4-6: Average Annual Water Budget – Land Surface System, South American Subbasin (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Inflows				
Precipitation	399,000	411,100	411,100	397,200
Total Surface Water Supply				
Municipal and Domestic	86,600	93,900	167,700	167,700
Agricultural	45,100	44,800	44,400	45,200
Total Groundwater Supply				
Municipal and Domestic	67,600	69,200	101,700	101,700
Agricultural	96,200	93,400	86,900	97,400
Ag Residential	22,600	22,600	18,000	19,200
Total Other Water Supply				
Remediated Municipal and Industrial	600	900	17,200	17,200
Agricultural Reuse	500	600	600	600
Recycled Water	-	-	-	-
Other Flows[1]	2,800	(5,600)	2,300	2,600
Total Inflow	***721,000***	***730,800***	***849,800***	***848,800***
Outflows				
Evapotranspiration				
Municipal and Domestic	90,700	92,400	146,200	149,400
Agricultural	147,900	143,700	135,700	147,100
Refuge, Native, and Riparian	54,700	53,300	40,800	41,300
Runoff to the Stream System	209,400	220,000	239,000	228,900
Return Flow to the Stream System				
Agricultural	7,700	7,300	6,900	7,600
Municipal and Domestic	91,100	93,000	159,800	159,800
Deep Percolation				
Precipitation	44,500	44,900	35,300	32,200
Applied Surface Water				
Urban and Industrial	20,300	22,000	33,400	31,200
Agricultural	10,600	10,500	8,800	8,400
Applied Groundwater				
Urban and Industrial	15,900	16,200	20,300	18,900
Agricultural	22,600	21,900	17,300	18,100
Ag Residential	5,300	5,300	3,600	3,600

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Applied Other Water Supplies				
Remediated Municipal and Industrial	100	200	3,400	3,200
Agricultural Reuse	100	100	100	100
Recycled Water	-	-	-	-
Total Outflow	***721,000***	***730,800***	***849,800***	***848,800***

Notes:

[1] *Other flows is a closure term that captures the gains and losses due to land expansion and seasonal storage in the root-zone.*

Table 2.4-7: Average Annual Water Budget – Groundwater System, South American Subbasin (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Inflows				
Deep Percolation				
Precipitation	44,500	44,700	34,300	31,300
Applied Surface Water				
Municipal and Industrial	20,300	22,000	33,400	31,200
Agricultural	10,600	10,500	8,800	8,400
Applied Groundwater				
Municipal and Industrial	15,900	16,200	20,300	18,900
Agricultural	22,600	21,900	17,300	18,100
Ag Residential	5,300	5,300	3,600	3,600
Applied Recycled Water				
Agricultural	100	100	100	100
Municipal and Industrial	100	200	3,400	3,200
Applied Remediated Water				
Municipal and Industrial	-	-	-	-
Groundwater Gain from Streams				
American River	24,000	22,100	27,600	28,600
Cosumnes River	19,200	18,200	18,800	20,900

Component	Historical Condition Water Budget	Current Condition Water Budget	Projected Condition Water Budget	Projected Condition Water Budget with Climate Change
Hydrologic Period	**WY 2009-2018**	**WY 1970 - 2019**	**WY 1970 - 2019**	**WY 1970 – 2019**
Sacramento River	38,600	37,200	41,200	48,400
Local Tributaries[1]	35,400	36,000	38,100	39,300
Groundwater Injection (from ASR and Remediation)	200	200	200	200
Other Recharge	40	30	30	30
Subsurface Inflow	38,500	40,200	44,900	46,700
Total Inflow	***275,400***	***274,800***	***292,100***	***298,900***
Outflows				
Groundwater Discharge to Streams				
American River	6,200	7,300	6,800	6,600
Cosumnes River	300	400	400	300
Sacramento River	1,800	3,200	2,700	3,200
Local Tributaries[1]	9,800	11,300	10,200	9,000
Groundwater Production				
Urban and Industrial[2]	67,600	69,200	101,700	101,700
Ag Residential	22,600	22,600	18,000	18,000
Agricultural	96,200	93,400	86,900	98,600
Remediation	21,000	27,600	27,600	27,600
Subsurface Outflow	42,300	37,600	39,000	40,000
Total Outflow	***267,700***	***272,600***	***293,200***	***305,100***
Change in Storage	***7,700***	***2,200***	***(1,100)***	***(6,200)***

Notes:

[1] *Local Tributaries include Alder Creek, Deer Creek, Morrison Creek, Beacon Creek, Elder Creek, Buffalo Creek and Laguna Creek.*

[2] *Under the projected condition with climate change, it is assumed that the total outdoor use is reduced, resulting in no net increase in urban and industrial water use.*

2.4.2.1 Historical Water Budget

The historical water budget is a quantitative evaluation of the historical surface and groundwater supply covering the 10-year period from WY 2009 to 2018. This period was selected as the most recent representative hydrologic period to represent recent historical conditions in the subbasin, and is a subset of the CoSANA model calibration period of WY 1995 to 2018. The goal of the historical water budget analysis is to characterize the supply and demand, while summarizing the hydrologic flow within the Subbasin, including the movement of all primary sources of water such as rainfall, irrigation, streamflow, and subsurface flows.

The existing stream and canal network supplied multiple water users and agencies in the South American Subbasin, including the City of Sacramento, California American Water Company, Golden State Water Company, City of Folsom, Sacramento County Water Agency, and Rancho Murrieta Community Services District. When analyzing the stream and canal system, it is important to note potentially significant effects resulting from the natural interactions and managed operations of adjacent groundwater subbasins. However, because the CoSANA model covers multiple subbasins, it is not always possible to distinguish between stream system inflows and outflows by subbasin. Because of this, the water budget in **Table 2.4-2** through **Table 2.4-4** above attempt to not only quantify the total inflows and outflows on the segments of major rivers adjoining the SASb (i.e. the American, Sacramento, Cosumnes and Mokelumne Rivers). **Figure 2.3-2** below shows the composite inflows and outflows for portions of the American, Cosumnes, Mokelumne and Sacramento Rivers that are adjacent to the SASb.

During the historical period, average annual surface water inflows of about 14,740,000 acre-feet (AF) entered the CoSANA model boundary via the American, Cosumnes, Mokelumne and Sacramento Rivers. These flows were supplemented by tributary inflows (380,000 AFY), gain from groundwater (36,000 AFY), runoff (51,000 AFY), and direct return flows (140,000 AFY). These volumes were offset by a nearly equal quantity of stream outflows on these river reaches. Most of the streamflows exited the SASb to the Sacramento-San Joaquin Delta (15,080,000 AFY). However, water exited the stream system as Seepage to Groundwater (153,000 AFY), surface water diversions (111,000 AFY), and riparian evapotranspiration (4,000 AFY).

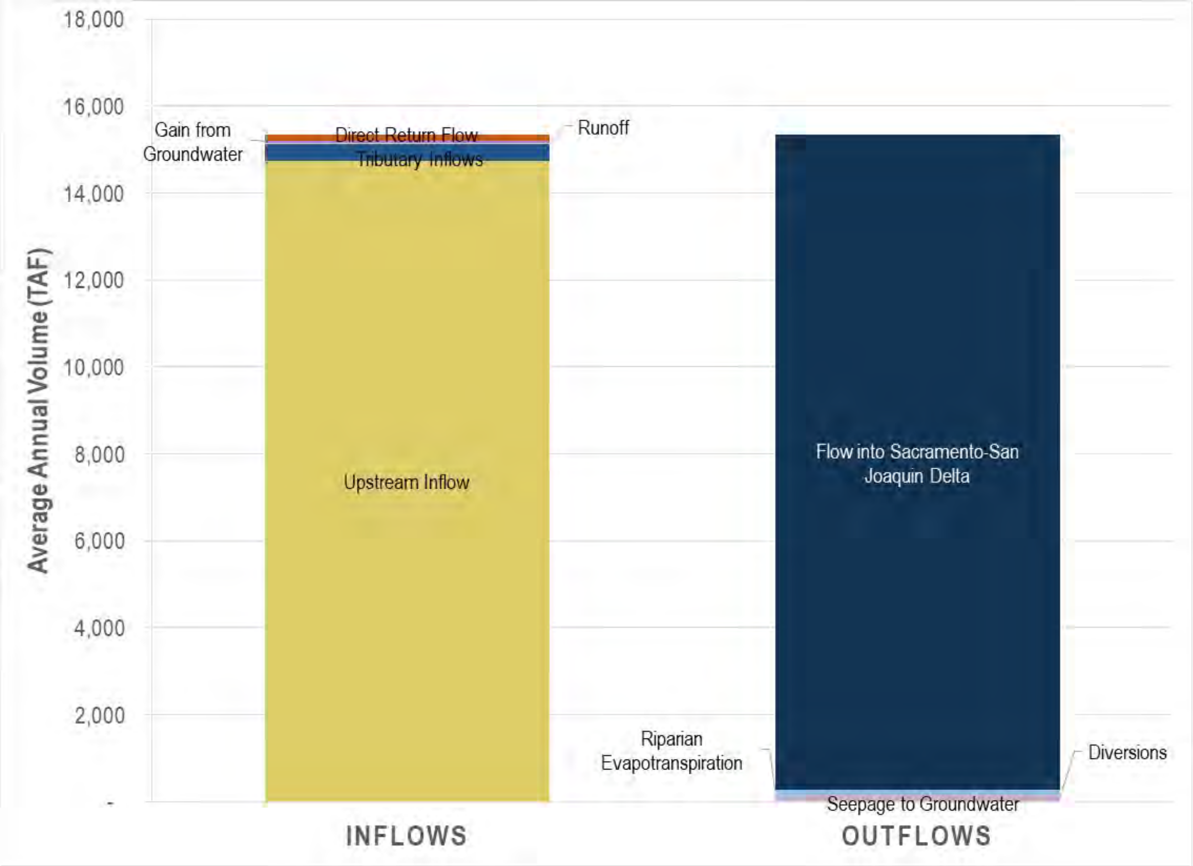

Figure 2.4-3: Historical Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

The land surface system of the SASb, shown below in **Figure 2.4-4**, experienced approximately 721,000 AF of inflows each year, a combination of precipitation (399,000 AF), surface water deliveries (131,700 AF), groundwater pumping (186,400 AF), other water supply (1,100 AF) and other flows (2,800 AF). Equivalent to the inflows in magnitude, outflows from the land surface system were comprised of evapotranspiration (293,300 AF), surface runoff (209,400 AF), return flow (98,700 AF) to the stream and canal system, and deep percolation (119,500 AF).

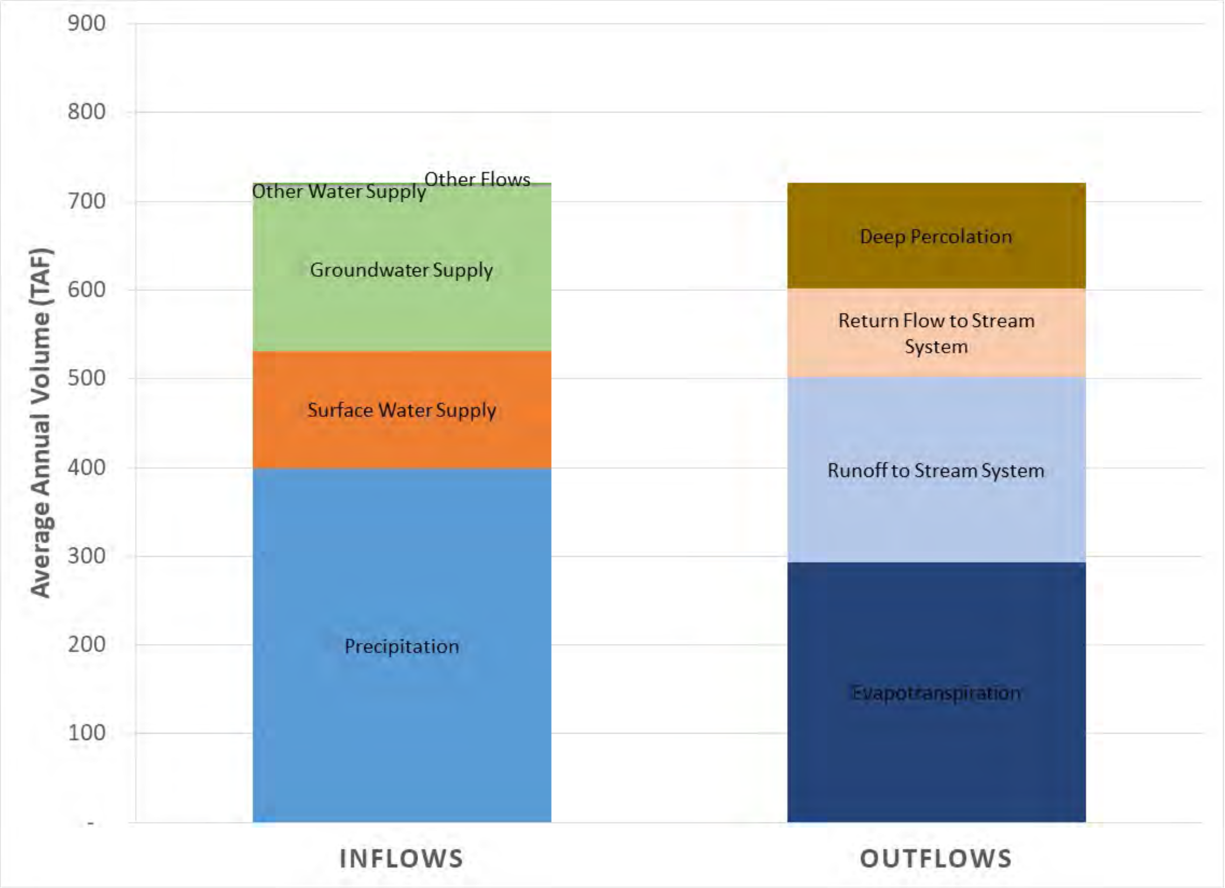

Figure 2.4-4: Historical Average Annual Water Budget – Land Surface System, South American Subbasin

The groundwater system of the South American Subbasin experienced approximately 275,400 AF of inflows each year, of which 119,500 AF was deep percolation. In addition, streamflow recharged groundwater (117,200 AF), and subsurface inflows (38,500 AF) occurred from the foothills and the neighboring subbasins (primarily North American, Cosumnes and Yolo).

On average, the inflows exceeded the entire groundwater demand. The primary outflow of the groundwater system was pumping (207,400 AF), followed by subsurface flow into neighboring subbasins (42,300 AF) and losses due to local stream-groundwater interaction (18,000 AF).

The SASb average historical groundwater budget has greater inflows than inflows, leading to an average annual increase in groundwater storage of about 7,700 AF. **Figure 2.4-5** summarizes the average historical groundwater inflows and outflows in the SASb.

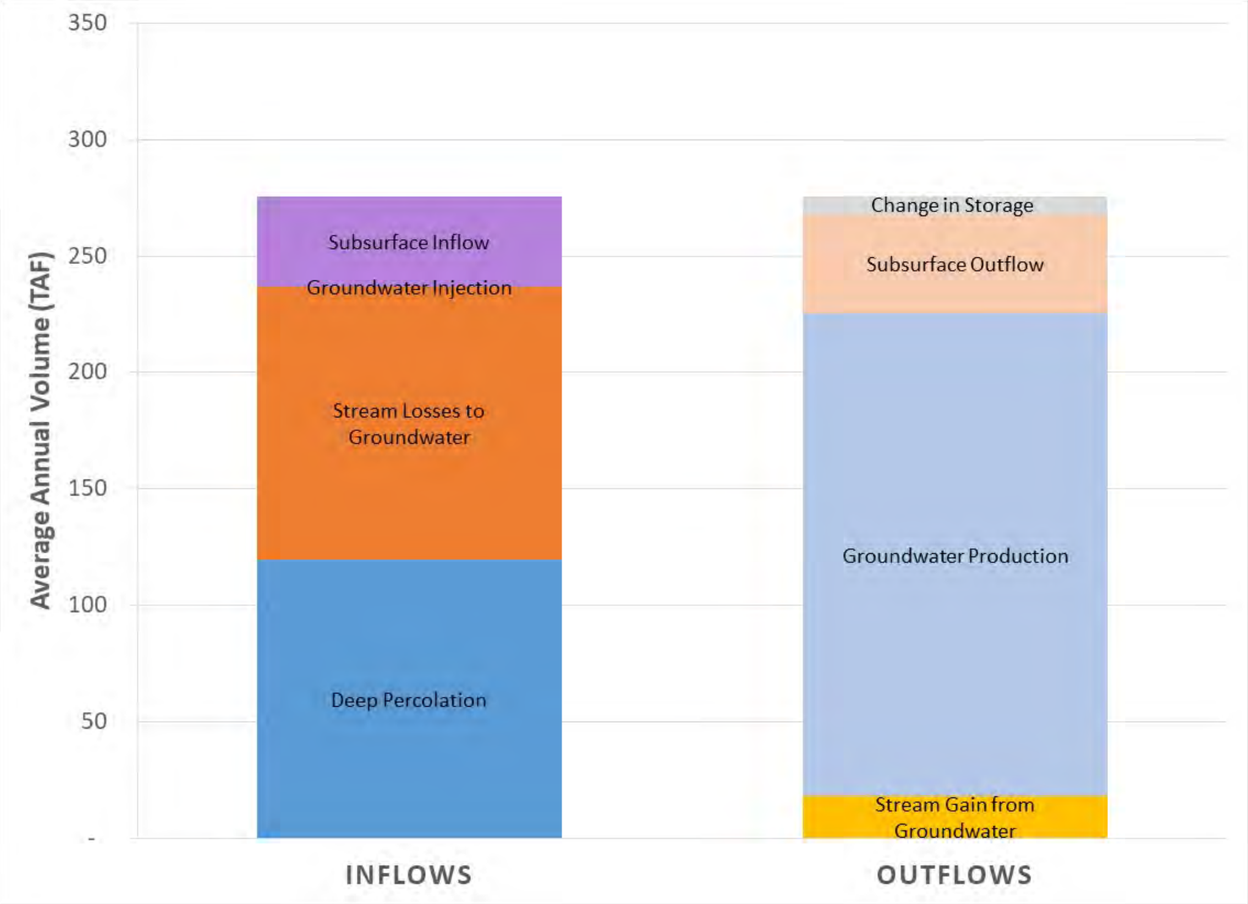

Figure 2.4-5: Historical Average Annual Water Budget – Groundwater System, South American Subbasin

The historical inflows and outflows changed by water year type. In wet years, precipitation met some of the water demand, and greater availability to surface water reduced the need for groundwater. However, in dry years, more groundwater was pumped to meet the agricultural demand not met by surface water or precipitation, which lead to an increase in groundwater storage in wet years and a decrease in dry years. While demand of applied water increased in dry years due to lack of precipitation, surface water supply remained consistent in most non-critical years. Note the surface water supply in this water budget is reflective of the volume available to the grower, and thus does not include operational spills, canal seepage or evaporative losses. **Table 2.4-8** breaks down the average historical water supply and demand by water year type for the 2009-2018 period.

Table 2.4-8: Average Annual Values for Key Components of Water Budget by Year Type (AFY)

Component	Water Year Type (Sacramento River Index)					
	Wet	Above Normal	Below Normal	Dry	Critical	10-Year Average WY 2009-2018
Water Demand						
Ag Demand	171,100	176,600	173,300	182,600	183,800	163,900
Urban Demand	175,700	184,500	186,000	187,400	171,000	177,400
Total Demand	***346,800***	***361,100***	***359,300***	***370,000***	***354,800***	***341,300***
Water Supply						
Total Surface Water Supply						
Agricultural	44,400	45,600	45,100	45,300	46,100	45,100
Urban	84,100	89,500	90,400	92,900	84,100	86,600
Total Groundwater Supply						
Agricultural	106,000	110,300	107,500	116,600	117,000	98,100
Ag Residential	20,700	20,700	20,700	20,700	20,700	20,700
Urban	72,800	76,200	73,900	73,500	70,000	67,600
Remediation	18,800	18,800	21,700	21,000	16,900	23,200
Total Supply	***346,800***	***361,100***	***359,300***	***370,000***	***354,800***	***341,300***
Change in GW Storage	***50,500***	***2,600***	***(10,900)***	***(20,800)***	***(15,300)***	***7,700***

2.4.2.2 Current Water Budget

The current water budget quantifies inflows to and outflows from the basin using 50-years of hydrology in conjunction with 2015 water supply, demand, and land use information. These conditions are incorporated in the Current Conditions Baseline simulation of the CoSANA model. **Figure 2.4-9** summarizes the average projected inflows and outflows in the South American Subbasin surface water network.

In the Current Conditions Baseline, average annual surface water inflows of about 17,090,000 acre-feet (AF) enters the CoSANA model boundary via the American, Cosumnes, Mokelumne and Sacramento Rivers. These flows are supplemented by tributary inflows (400,000 AFY), gain from groundwater (42,000 AFY), runoff (52,000 AFY), and direct return flows (152,000 AFY). These volumes are offset by a nearly equal quantity of stream outflows on these river reaches. Most of the streamflows exit the SASb to the Sacramento-San Joaquin Delta (17,480,000 AFY). However, water exited the stream system as seepage to groundwater (145,000 AFY), surface water diversions (108,000 AFY), and riparian evapotranspiration (4,000 AFY).

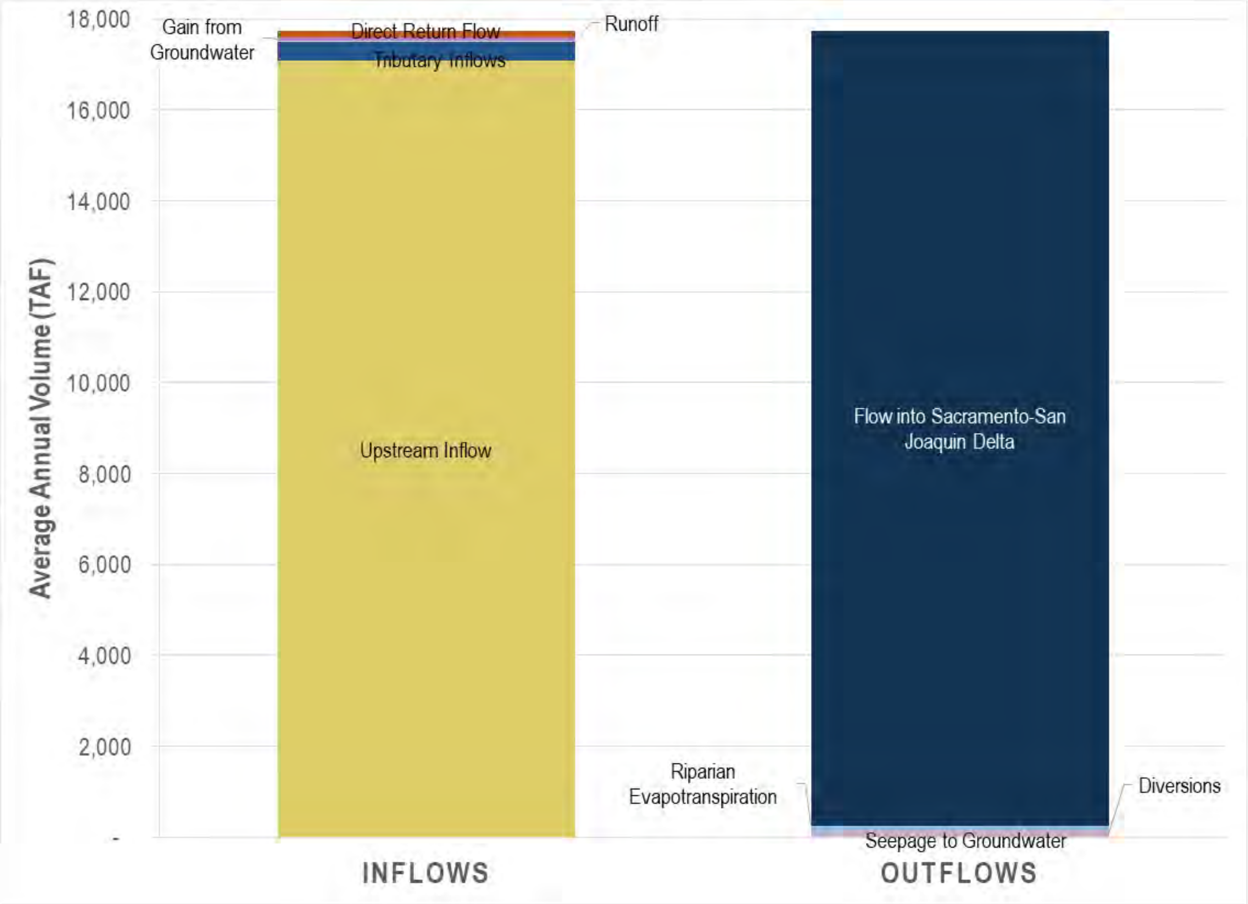

Figure 2.4-6: Current Conditions Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

Based on pre-drought cropping patterns and 2015 urban buildout, over the simulation period, the Current Conditions land surface water budget includes annual inflows of 730,800 AF, including 411,100 AF of precipitation and 325,300 AF of applied water (138,700 AF of surface water, 185,200 AF of groundwater, and 1,400 AF of other water supplies). To balance the Current Conditions Baseline land surface water budget, the 730,800 AF of outflows includes evapotranspiration (289,500 AF), surface runoff to the stream system (220,000 AF), return flow to the stream system (100,300 AF), deep percolation (120,900 AF), and other flows (5,600 AF). **Figure 2.4-7** summarizes the average annual current condition inflows and outflows in the SASb land surface budget.

There are small but important differences between the historical and current conditions land surface system water budget. First, the current conditions baseline uses a 50-year hydrology that is more similar to long-term average precipitation conditions in the SASb, while the 2009-2018 recent historical period is slightly drier. The more normal conditions are shown as higher precipitation inflows under the current conditions baseline. Surface water supplies increased by approximately 8%, largely due to the current conditions baseline's incorporation of SCWA's Vineyard Surface Water Treatment Plant throughout the full simulation period, while this facility was only online for the last eight years of the historical simulation. Water supplies under the current condition baseline showed a small shift from agricultural uses to urban uses, as the current condition baseline represented recent development across the full simulation. These changes in land use are also reflected in changes in evapotranspiration, runoff, and return flow. These differences are relatively small, but can have impacts over longer timeframes.

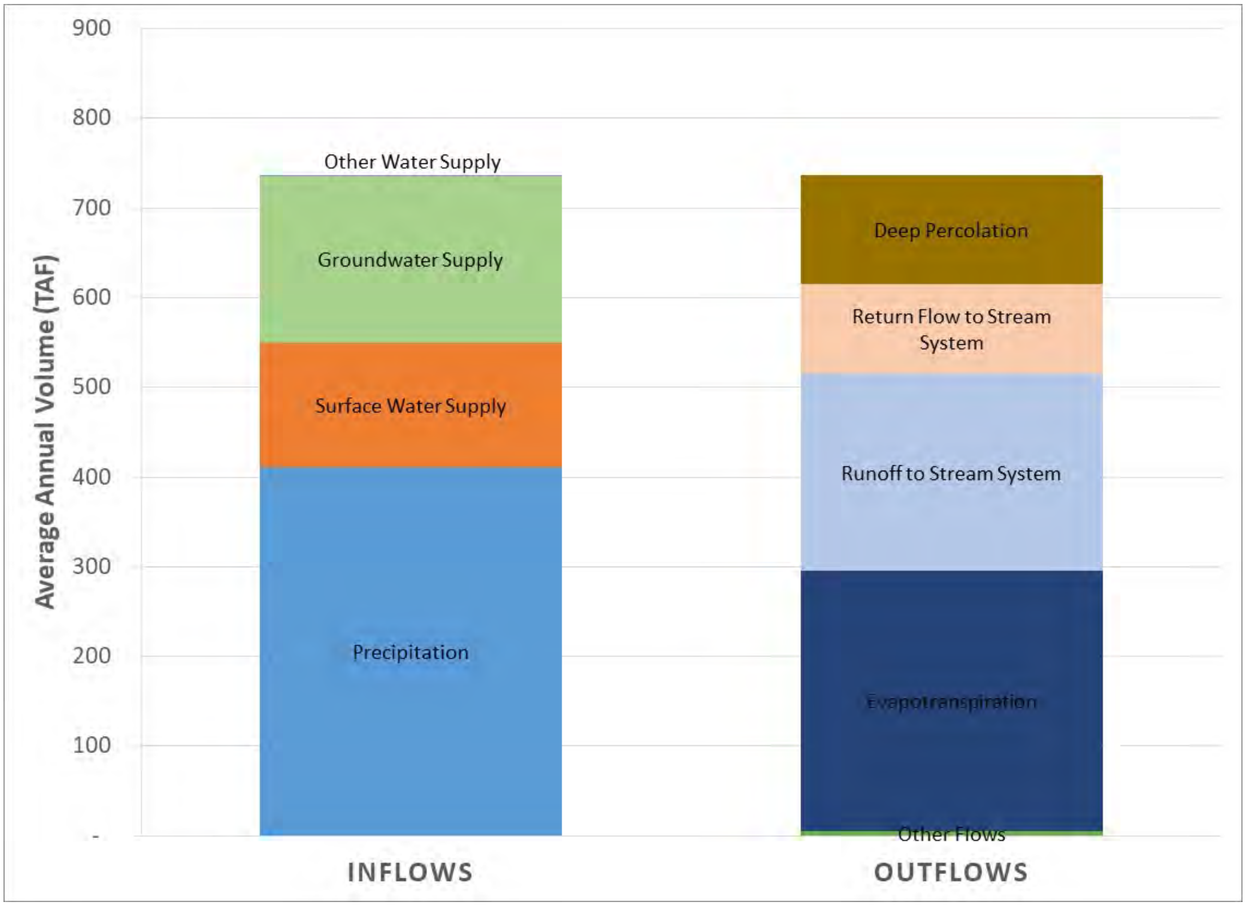

Figure 2.4-7: Current Conditions Average Annual Water Budget – Land Surface System, South American Subbasin

Over the 50-year simulation period, the Current Conditions groundwater water budget includes annual inflows of 274,800 AF, including 120,900 AF of deep percolation, 113,500 AF of stream and canal seepage, subsurface inflows totaling 40,200 AF, and groundwater injection of 200 AF.

Similar to the historical water budget, average aquifer inflows exceed the outflows under Current Conditions. Groundwater production (212,800 AF) remained the largest point of aquifer discharge, with losses to the local stream system (22,100 AF), and subsurface outflows (37,600 AFY) bringing the total system outflows to 272,600 AF annually.

The SASb Current Conditions groundwater budget has an average annual surplus in groundwater storage of about 2,200 AF. **Figure 2.4-8** summarizes the average current conditions groundwater inflows and outflows in the South American Subbasin.

Similar to the land surface system water budget, the groundwater system water budget shows the influences of slightly different hydrologic conditions, increased surface water use, and conversion of agricultural land to urban land uses between the historical conditions and current conditions, but also shows influences of slightly higher groundwater levels. Deep percolation from precipitation is higher in the current conditions baseline compared to historical conditions due to the drier conditions in the historical conditions time period. Increased urban surface water use is largely driven by SCWA's Vineyard Surface Water Treatment Plant, which came online in the early portions of the historical condition time period (2012), but is included across the full simulation in the current condition baseline. Finally, conversion of agricultural land to urban land occurring during the historical period is phased in during the historical simulation, but included as urban throughout the current condition baseline, resulting in more urban applied water and groundwater pumping in the current condition and less agricultural applied water and groundwater pumping. The current conditions groundwater system water budget also shows slightly lower levels of stream losses and higher levels of stream gains, likely due to higher groundwater levels under current conditions compared to those in the historical conditions. These differences are relatively small, but can have impacts over longer timeframes.

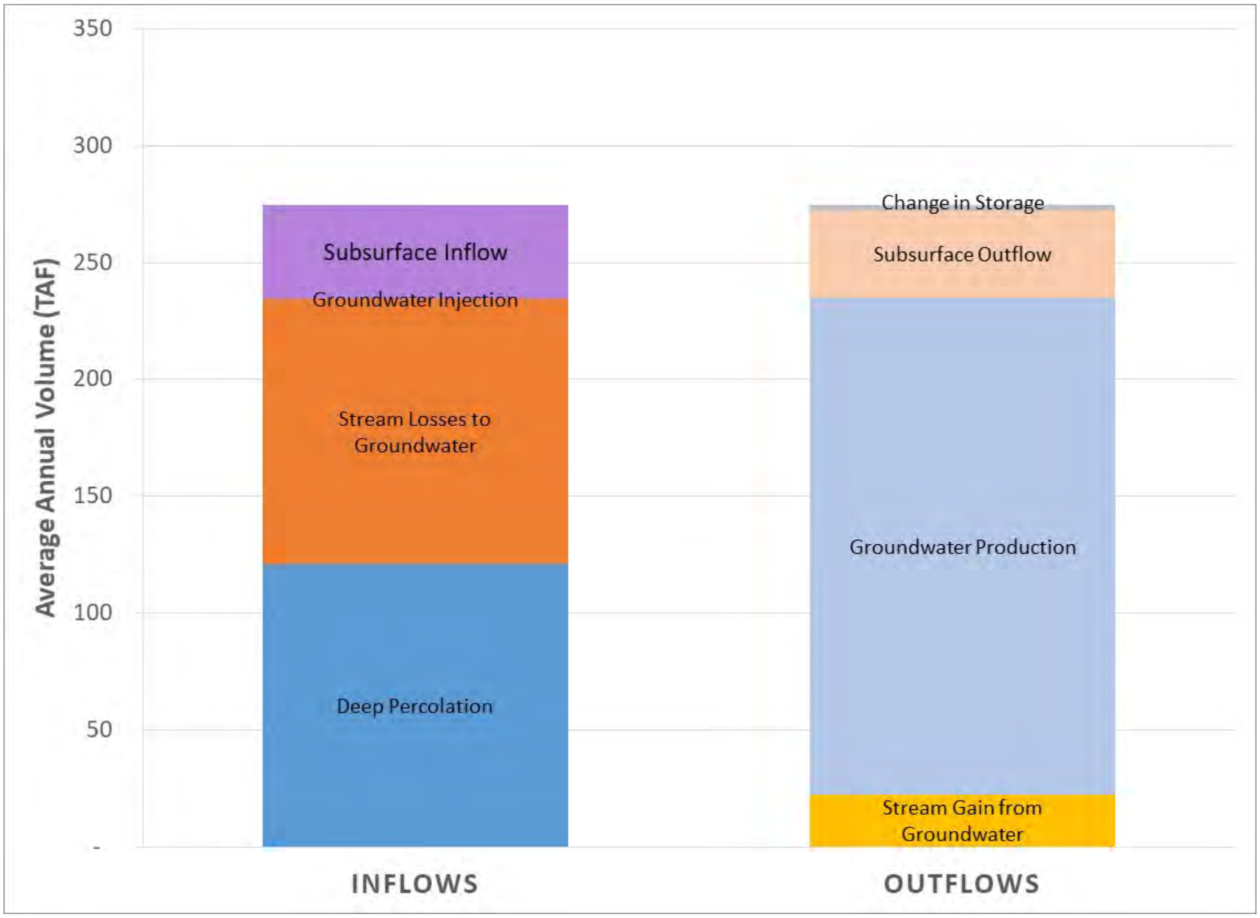

Figure 2.4-8: Current Conditions Average Annual Water Budget – Groundwater System, South American Subbasin

2.4.2.3 Projected Water Budget without Climate Change

The projected water budget is used to estimate future baseline conditions of supply, demand, and aquifer response to plan implementation. The Projected Conditions Baseline without climate change simulation of the CoSANA model is used to evaluate the projected conditions of the water budget using the unadjusted hydrology from 1970 to 2019. As previously discussed, this approach utilizes a hydrologic period of 50 years and has average precipitation similar to the long-term average. Development of the projected water demand is based on the population growth trends reported in 2015 UWMPs, general plans, and other planning documents, or current information provided by purveyors.

In the Projected Conditions Baseline without climate change, average annual surface water inflows of about 17,150,000 acre-feet (AF) enter the CoSANA model boundary via the American, Cosumnes, Mokelumne and Sacramento Rivers. These flows are supplemented by tributary inflows (464,000 AFY), gain from groundwater (38,000 AFY), runoff (74,000 AFY), and direct return flows (156,000 AFY). These volumes are offset by a nearly equal quantity of stream outflows on these river reaches. Most of the streamflows exit the Sacramento-San Joaquin Delta (17,560,000 AFY) and water also exits the stream system as seepage to groundwater (160,000 AFY), surface water diversions (151,000 AFY), and riparian evapotranspiration (4,000 AFY).

Figure 2.4-9 summarizes the average projected inflows and outflows in the South American Subbasin surface water network.

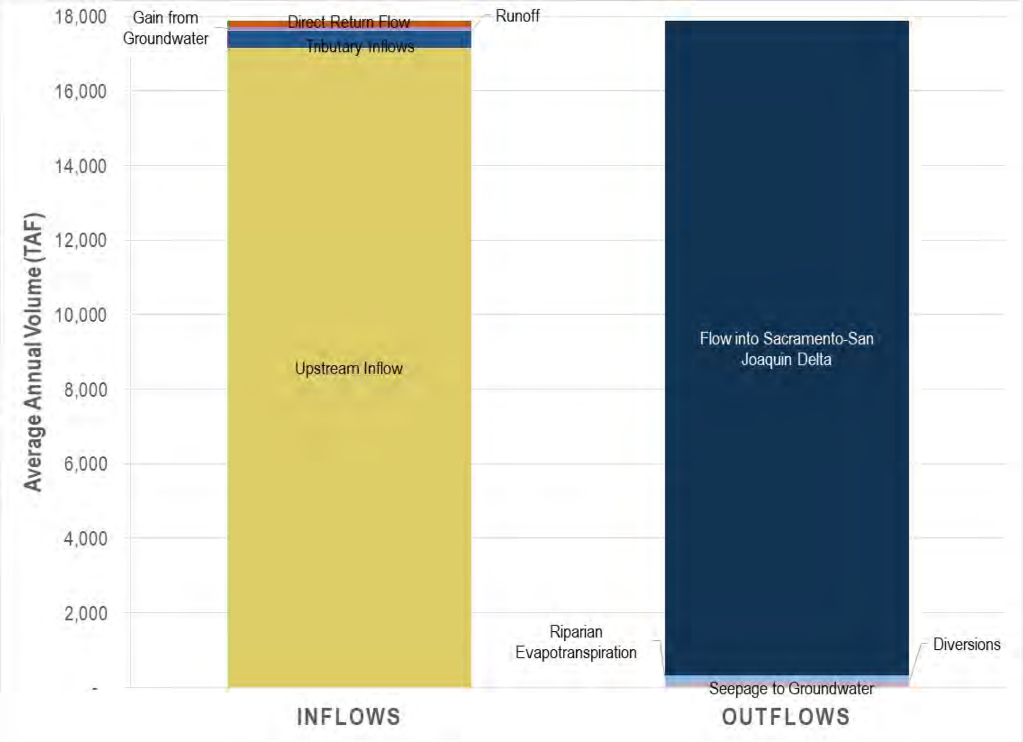

Figure 2.4-9: Projected Conditions Without Climate Change Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

Based on pre-drought cropping patterns and projected urban buildout, over the simulation period, the Projected Conditions without climate change land surface water budget simulates annual inflows of 849,800 AF, including 411,100 AF of precipitation, 436,400 AF of applied water (212,000 AF of surface water. 206,600 AF of groundwater, and 17,800 AF of other water supplies), and 2,300 AF of other flows. To balance the Projected Conditions without climate change Baseline land surface water budget, the 859,800 AF of outflows include evapotranspiration (322,800 AF), surface runoff to the stream system (239,000 AF), return flow to the stream system (166,700 AF), and deep percolation (121,300 AF). A summary of these flows can be seen below in **Figure 2.4-10.**

There are several key differences between the current and projected conditions land surface system water budget. The conversion from agricultural and native to urban land uses increases urban water supplies from both groundwater and surface water sources, with the bulk of increased surface water use at the Vineyard Surface Water Treatment Plant and from developments within the City of Folsom and Golden State Water Company. Some of this additional urban supply is met by remediation water, which shows a large increase over current conditions. Agricultural water supplies decline due to reduced acreage in cultivation. These changes in inflows are also reflected in the outflows, with increased urban land and water use resulting in increased urban evapotranspiration, urban return flow, and runoff. Conversely, reduced agricultural uses and native lands results in lower levels of evapotranspiration and return flow from these areas.

Figure 2.4-10: Projected Conditions Without Climate Change Average Annual Water Budget – Land Surface System, South American Subbasin

Over the simulation period, the Projected Conditions without climate change groundwater water budget include annual inflows of 292,100 AF, including 121,300 AF of deep percolation, 125,700 AF of stream and canal seepage, and subsurface inflows totaling 44,900 AF.

In contrast to the current conditions water budget, average aquifer outflows exceed the inflows under Projected Conditions without climate change. Groundwater production (234,200 AF) remains the largest point of aquifer discharge, with losses to the local stream system (20,000 AF), and subsurface outflows (39,000 AFY) bringing the total system outflows to 293,200 AF annually.

The SASb Projected Conditions without climate change groundwater budget has an average annual deficit in groundwater storage of about 1,100 AF. **Figure 2.4-11** summarizes the average projected groundwater inflows and outflows in the South American Subbasin.

Similar to the land surface system water budget, the groundwater system water budget shows the influences of land conversion and changes to water supplies when compared to the current conditions budget. Deep percolation from precipitation is lower in the projected conditions baseline compared to current conditions largely due to the changes in land use and increase in impervious surfaces that comes with urban development. Changes in deep percolation of applied water are largely the result of changes in volumes of water supplies, as noted within the land surface system budget. Stream losses increase in the projected condition baseline in comparison to the current condition baseline due to lower groundwater levels caused largely by increases in pumping for urban uses and increases in runoff from urban land.

Figure 2.4-11: Projected Conditions Without Climate Change Average Annual Water Budget – Groundwater System, South American Subbasin

2.4.2.4 Projected Water Budget with Climate Change

The Projected Conditions Baseline with climate change simulation of the CoSANA model is used to evaluate the projected conditions of the water budget using the hydrology from 1970 to 2019, adjusted for projected climate change. As previously discussed, this approach utilizes a hydrologic period of 50 years and has average precipitation similar to the long-term average. In order to incorporate the climate change conditions, precipitation, stream inflow, and evapotranspiration time series data from the projected conditions baseline were modified using the findings from the American River Basin Study (ARBS) (Reclamation, in press). Other model data did not change from the Projected Conditions Baseline without climate change.

The ensemble of climate models used in the ARBS found clear trends with projected temperature changes. Precipitation trends were not found to be as consistent with around half of the projections indicating an increase in precipitation, and the other half indicating a decrease in precipitation. The study includes a suite of future climate scenarios that include three future periods: 2040-2069, 2055-2084, and 2070-2099. For each of these periods, a suite of five climate scenarios was developed, based on percentiles of projected changes to simulate possible temperature and precipitation effects: Warm-Wet, Warm-Dry, Hot-Wet, Hot-Dry, and Central-Tendency scenarios. Upon evaluation of the five climate scenarios, the Central Tendency (CT) was selected for the purpose of groundwater sustainability planning, because it was determined that the CT has the highest probability and likelihood to be experienced. Other climate scenarios are subject to significantly more uncertainty and less likely to occur. Therefore, the 2070 Central-Tendency (2070CT) conditions was selected as the representative future climate change scenario. Additionally, a sensitivity of the Subbasin conditions to the 2070 Hot and Dry scenario was assessed and is described in **Section 2.4.2.5**.

In the Projected Conditions Baseline with climate change, average annual surface water inflows of about 14,580,000 acre-feet (AF) travel enter the CoSANA model boundary via the American, Cosumnes, Mokelumne and Sacramento Rivers. These flows are supplemented by tributary inflows (460,000 AFY), gain from groundwater (36,000 AFY), runoff (75,000 AFY), and direct return flows (146,000 AFY). These are offset by a nearly equal quantity of stream outflows on these river reaches. Most of the streamflows exits the Sacramento-San Joaquin Delta (15,000,000 AFY), and water also exits the stream system as seepage to groundwater (173,000 AFY), surface water diversions (151,000 AFY), and riparian evapotranspiration (5,000 AFY).

Figure 2.4-12 summarizes the average projected inflows and outflows in the South American Subbasin surface water network.

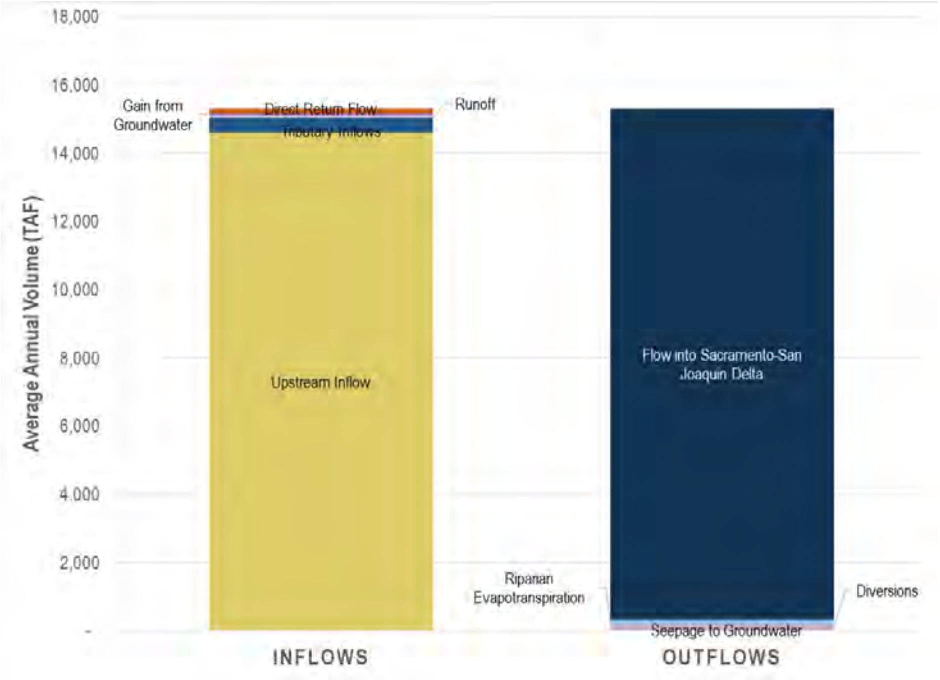

Figure 2.4-12: Projected Conditions With Climate Change Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

Based on pre-drought cropping patterns and projected urban buildout along with climate change, over the simulation period, the Projected Conditions with climate change land surface water budget includes annual inflows of 848,800 AF, including 397,200 AF of precipitation, 443,900 AF of applied water (212,800 AF of surface water, 218,300 AF of groundwater, and 17,800 AF of other water supplies), and 2,600 AF of other flows. To balance the Projected Conditions without climate change Baseline land surface water budget, the 848,800 AF of outflows include evapotranspiration (337,800 AF), surface runoff to the stream system (228,900 AF), return flow to the stream system (167,300 AF), and deep percolation (114,700 AF). A summary of these flows can be seen below in **Figure 2.4-13.**

With land and water use conditions the same between the projected conditions baseline and the projected conditions with climate change baseline, the differences between the two associated land surface systems budgets are the result of climate change hydrology. The most substantial changes in the budget are a decrease in precipitation and an increase in agricultural evapotranspiration. These factors result in an increase in irrigation needs for agricultural lands and an associated increase in agricultural groundwater production.

Figure 2.4-13: Projected Conditions With Climate Change Average Annual Water Budget – Land Surface System, South American Subbasin

Over the simulation period, the Projected Conditions with climate change groundwater water budget includes annual inflows of 298,900 AF, including 114,700 AF of deep percolation, 137,200 AF of stream and canal seepage, and subsurface inflows totaling 46,700 AF.

As with the Projected Conditions without climate change water budget, average aquifer outflows exceed the inflows under Projected Conditions with climate change. Groundwater production (246,000 AF) remains the largest point of aquifer discharge, with losses to the local stream system (19,100 AF), and subsurface outflows (40,000 AFY) bringing the total system outflows to 305,100 AF annually.

The SASb Projected Conditions with climate change groundwater budget has an average annual deficit in groundwater storage of about 6,200 AF. **Figure 2.4-14** summarizes the average projected groundwater inflows and outflows in the South American Subbasin.

Similar to the land surface system water budget, the groundwater system water budget shows the influences of climate change when compared to the projected conditions budget. Changes are largely the result of increased agricultural pumping resulting from climate increases in demand. This increase in outflow is a large component of increased stream losses, which is the largest change to inflows and is the result of lowered groundwater levels near the rivers and streams due primarily to increased pumping and decreased deep percolation.

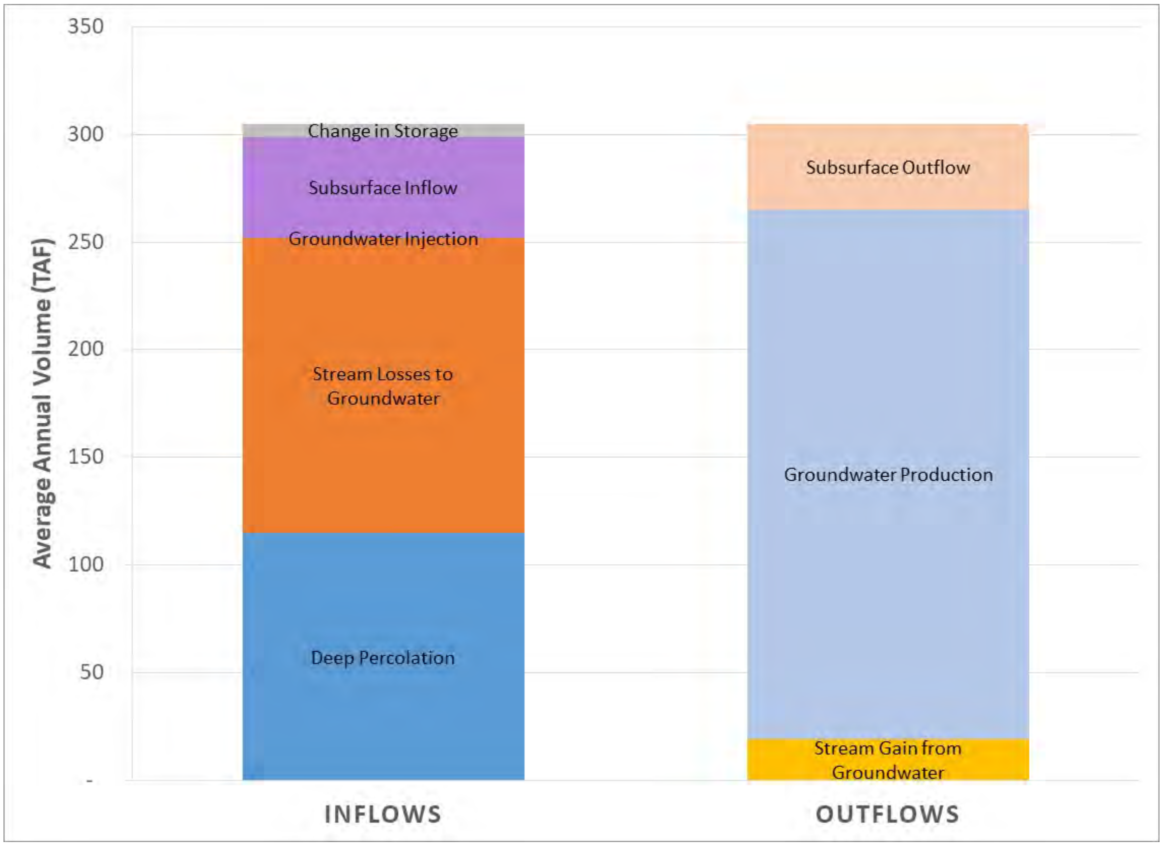

Figure 2.4-14: Projected Conditions With Climate Change Average Annual Water Budget – Groundwater System, South American Subbasin

2.4.2.5 Hot-Dry Climate Change Scenario Sensitivity Analysis

To assess the effects of a hot and dry future climate, a climate-change sensitivity analysis was performed using the 2070 Hot-Dry (2070HD) conditions to simulate more extreme changes to hydrology. The 2070HD scenario was analyzed as an extreme case to determine the potential effects of the 2070HD scenario on the groundwater and surface water systems. 2070HD climate scenario indicates a potentially lower overall precipitation, and higher temperature than the 2070CT. A comparison of the SASb groundwater budget under the 2070CT and 2070HD climate scenarios is shown in **Table 2.4-9** below.

Table 2.4-9: Projected Conditions Groundwater Budgets under the 2070 Central Tendency and Hot-Dry Climate Scenarios

Model Scenario	Groundwater Pumping (AFY)	Deep Percolation (AFY)	Gain from Stream (AFY)	Boundary Inflows (AFY)	Subsurface Inflow (AFY)	Change in Storage (AFY)
PCBL+CC (2070CT)	245,800	114,700	118,200	6,200	400	-6,200
PCBL+CC (2070HD)	250,400	110,600	122,800	7,100	600	-9,400

The 2070HD scenario can potentially result in an overall increase in pumping of ~2% above the 2070CT. This is largely due to increased evapotranspiration resulting in an increase in agricultural demand. Decreases in deep percolation are largely attributable to decreasing precipitation percolation. Increases in stream seepage, boundary inflows, and subsurface inflows are all due to lower projected groundwater levels expected under the 2070HD scenario. The overall average annual groundwater storage deficit changes from 6,200 AFY to 9,400 AFY. It is noteworthy that the level of uncertainty with the climate change scenarios are significant, and the 2070HD scenario projects a much more unlikely scenario. Therefore, the groundwater sustainability planning is based on the Projected Baseline conditions with less uncertainty relative to climate conditions.

2.5 Sustainable Yield Estimate

2.5.1 Background

The sustainable yield for the Sacramento Central groundwater basin has been previously estimated and established as part of the Sacramento Water Forum basin yield analysis in 1997. This work was conducted using criteria established at the time for the purposes of management of the Sacramento area groundwater basins. The geographic area for the Sacramento Central groundwater basin is similar to the current boundaries of the South American Subbasin (shown in **Figure 2.1-1**), with differences generally south of the Cosumnes River and in the Delta.

The Sacramento Water Forum defined sustainable yield as the amount of water that can be extracted from the groundwater system over a long period without producing unacceptable effects. At the time, the Water Forum identified the unacceptable effects as declines in groundwater levels and storage to an extent that lowering groundwater levels would result in degradation of water quality, dewatering of wells, increase in cost of pumping, and land subsidence. The Water Forum analysis involved use of the Sacramento Integrated Water Resources Model (SacIWRM) and other analysis of reported and observed water level and quality data to arrive at a sustainable yield of 273,000 AFY for the basin. Additional details on the history, approach and process for establishment of Water Forum sustainable yield is provided in the Sacramento Central Groundwater Authority (SCGA) Groundwater Management Plan (SCGA, 2006).

The Water Forum sustainable yield value has been established and engraved in much of the groundwater and water supply planning process and work over the past 20 years. Adherence of planning process by SCGA and member agencies to the Water Forum sustainable yield has resulted in management of the groundwater demand in the basin, as well as implementation of many water supply projects, that overall has resulted in a well-managed groundwater basin. This is especially evident in the relatively stable groundwater trends observed over the past decade.

2.5.2 Sustainable Yield Under SGMA

Sustainable yield is defined for SGMA purposes as “the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.” (CWC §10721(w)).

Sustainable yield for the South American Subbasin is estimated for this GSP using analysis of data and information from a number of CoSANA modeling scenarios for historical, baseline and project conditions reflecting various hydrologic and operational conditions in the Subbasin. The scenarios use a 50-year hydrologic period, which represents reasonably long-term conditions in the Subbasin. The goal of the analysis is to establish a sustainable yield to avoid causing undesirable results as defined and established as part of the GSP Sustainable Management Criteria (SMC). Of the six SGMA Sustainability Indicators (SI), five are applicable to the South American Subbasin (SASb), which are discussed in section 3 of the GSP. The sustainable yield analysis uses the CoSANA model to address the three SI that can directly be analyzed using the CoSANA model. The three SI considered are: Reduction of groundwater storage, chronic lowering of groundwater levels, and depletion of interconnected surface water.

Consistent with the undesirable results statements included in the SMC section of the GSP (**Section 3**), the following criteria have been used to evaluate the sustainable yield of the SASb:

- **Chronic Lowering of Groundwater Levels –** Significant and unreasonable chronic lowering of GWL occurs when 25% (12/45 wells) of RMP fall below their MTs for 3 consecutive years

- **Reduction of Groundwater Storage –** The minimum threshold for changes in groundwater storage is triggered off of changes in groundwater levels as a proxy. It is however, assumed that the groundwater storage sustainability indicator can be addressed when Subbasin-wide change in storage is approximately zero over the 50-year planning horizon

- **Depletion of Interconnected Surface Water –** Significant and unreasonable chronic lowering of GWL occurs when more than 25% (3/10 wells) of ISW RMP fall below their MTs for 3 consecutive years. Additionally, significant and unreasonable depletion of ISW occurs when ISW reach length is reduced by more than 5%

It is important to recognize various uncertainties that can contribute to the assessment and evaluation of sustainable yield, including the following:

- **Historical Data –** Historical data are based on recorded measurements of observed data and are subject to significant uncertainties in measurement methods, instruments, and devices, timing and frequency of measurements and potential data gaps, spatial resolution of data and spatial interpolation made to analyze data at appropriate scales needed for analysis.

- **Projected Data –** Projected data and analysis are subject to uncertainties, including future and projected hydrologic conditions, population growth patterns and rates of development over time and geographic areas, economic factors affecting growth and development, factors affecting land use and trends in agricultural crops, spatial and temporal resolution of data projections, and formulations and assumptions used in modeling analysis.

- **SMC Thresholds –** The minimum thresholds and measurable objectives set in the SMC section (**Section 3**) of the GSP are based on observed data, modeling scenarios and analysis, and inter-relationships among the sustainability indicators, and are subject to significant uncertainties.

- **Sustainable Yield Analysis Approach –** The methodology, formulation, and assumptions used for establishing sustainable yield are subject to uncertainties.

The following analysis resulting in sustainable yield incorporates the above uncertainties based on the information available on the sensitivity of modeling and data analysis on parameters, assumptions and data uncertainties. Future climate change presents additional uncertainty regarding the availability of water and of water demands in the future, which could affect the Basin sustainable yield going forward. The approach to establishing sustainable yield is to define a range of groundwater pumping for the SASb that does not cause significant and unreasonable results based on the set SMC criteria. See **Section 3** for additional explanation of the GSP sustainability criteria. **Figure 2.5-1(a)** to **Figure 2.5-1(c)** show the relationship between groundwater pumping and the three sustainability indicators considered for sustainable yield analysis (groundwater levels, groundwater storage, and change in ISW stream reach connection). Each point on these charts represents the relationship between long-term average annual groundwater pumping and the value of respective sustainability indicator under a model scenario. **Figure 2.5-1(a)** shows the subbasin scale average annual groundwater pumping for each of the scenarios and the resulting long-term average annual groundwater levels under that scenario. The scenarios considered are same as those outlined in the PMA section (**Section 4**) of the GSP. Based on modeling analysis, a range of uncertainty in the sustainability indicator is assigned to each SI. Sustainable yield of the basin is estimated as the long-term mean groundwater pumping within the uncertainty range of the groundwater level sustainability indicator; in this case, 235,000 AFY. This value is further verified to be within reasonable range of uncertainty for the other two sustainability indicators (groundwater storage and interconnected surface water), as shown in **Figures 2.5-1(b)** and **2.5-1(c)**. **Figures 2.5-1(b)** and **2.5-1(c)** indicate that the groundwater pumping of 235,000 AFY is well within the acceptable range of the other two sustainable indicators of groundwater storage and interconnected surface water. The sustainable yield of 235,000 AFY, therefore, meets the criteria for all three sustainability indicators used in the modeling. As such, the sustainable yield is established at 235,000 AFY. Although, the groundwater quality and land subsidence sustainability indicators are not directly used in this analysis, in the absence of an analytical tool for these sustainability indicators, it is expected that a sustainable yield defined based on the groundwater levels, storage, and interconnected surface water would also meet the criteria for groundwater quality and land subsidence as well.

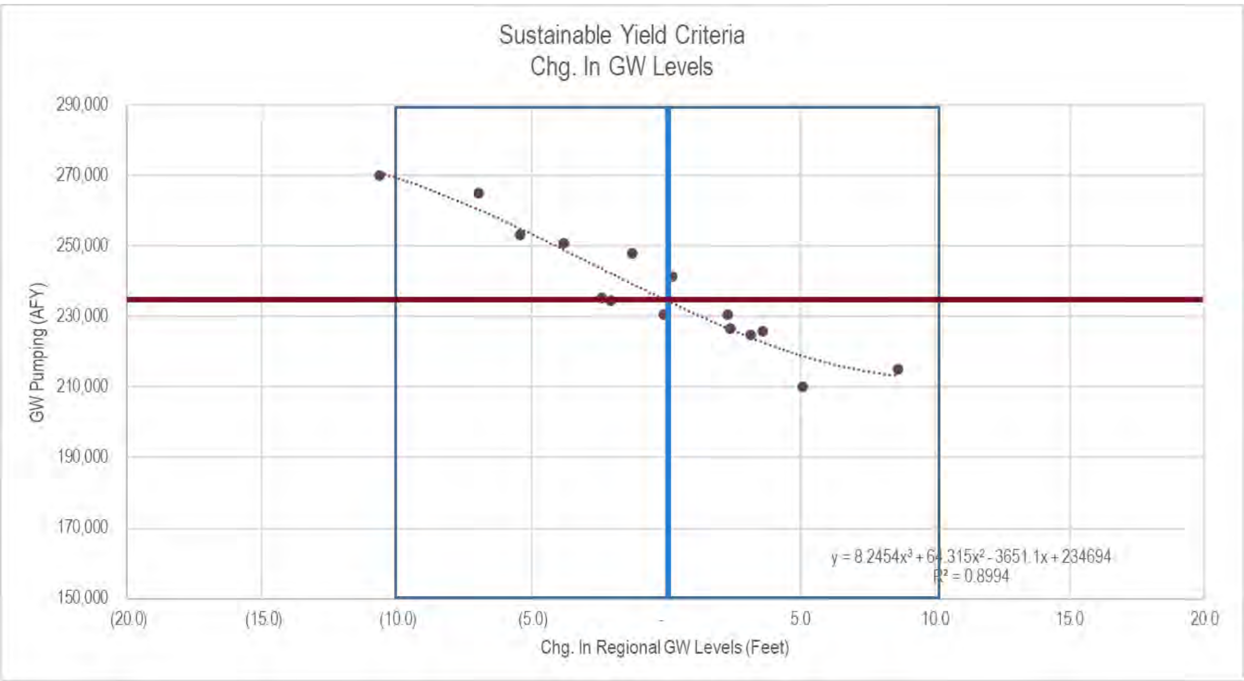

Figure 2.5-1(a) **Relationship between Groundwater Pumping and Change in Groundwater Levels**

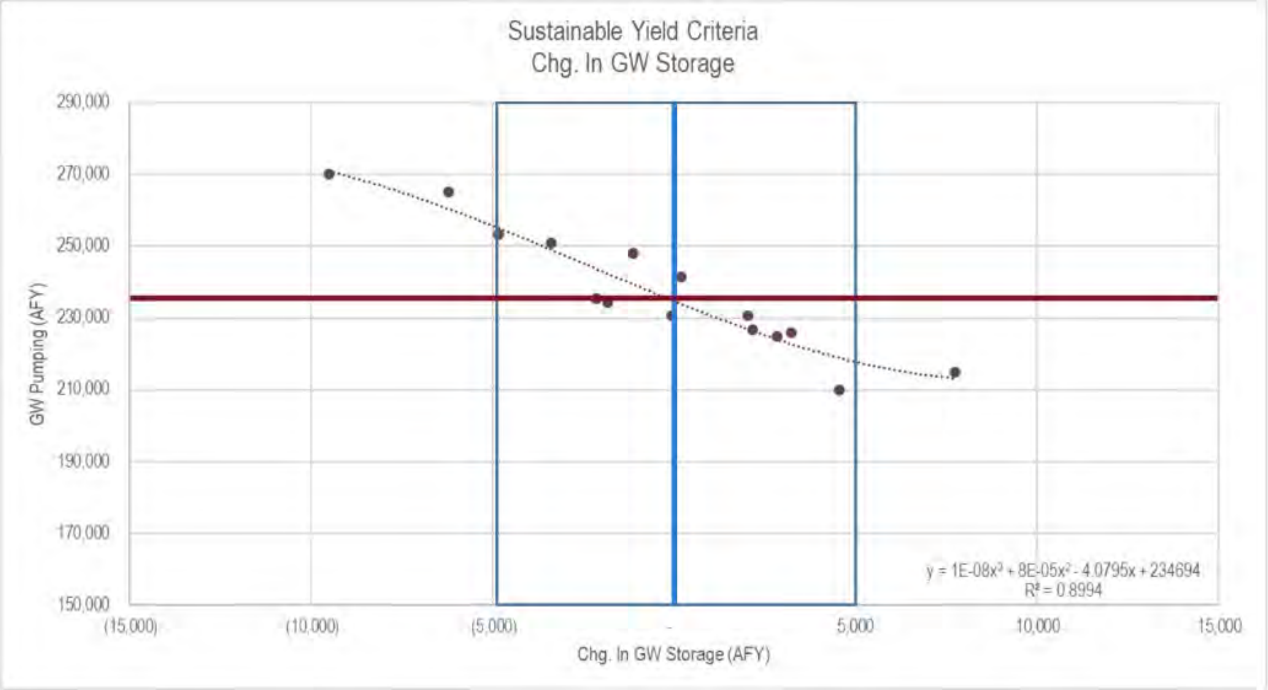

Figure 2.5-1(b) **Relationship between Groundwater Pumping and Change in Groundwater Storage**

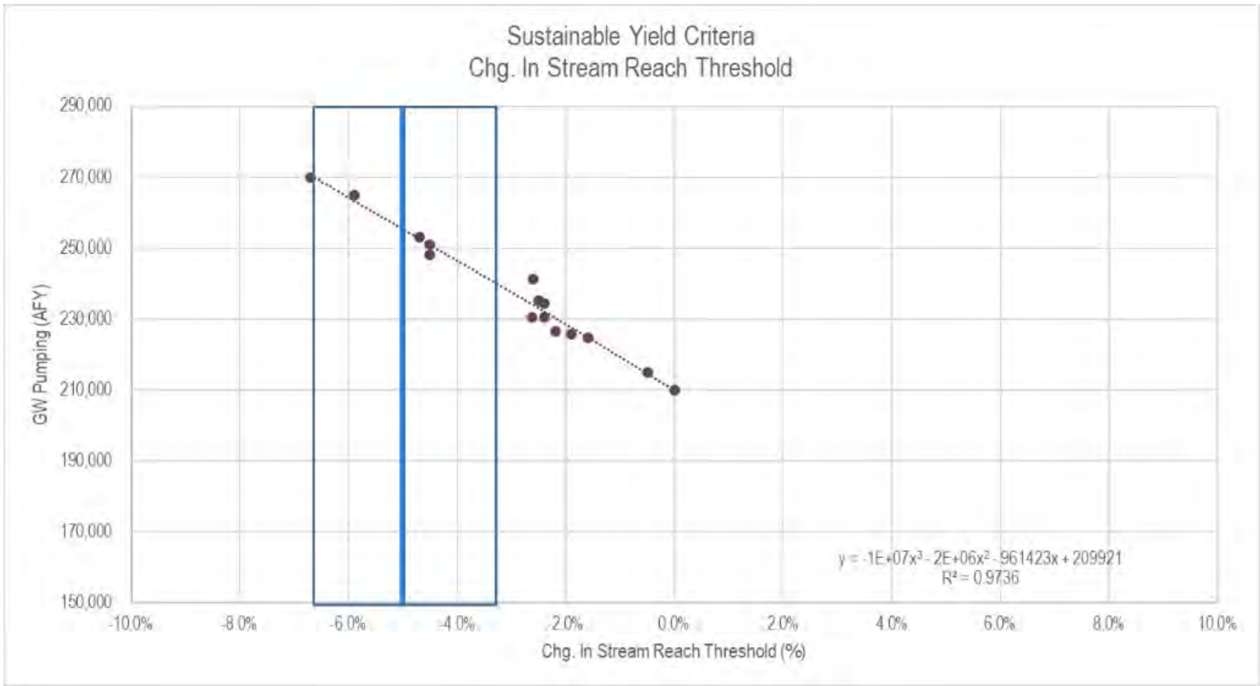

Figure 2.5-1(c) Relationship between Groundwater Pumping and Change in ISW Stream Reach

The sustainable yield of SASb (235,000 AFY) represents the long-term average annual groundwater pumping for the SASb that would not result in significant and unreasonable impacts. **Figures 2.5-1(a)** through **2.5-1(c)** also indicate that a sustainable range of groundwater pumping in SASb includes typical variation in pumping in any given year ranging from about 210,000 AF in a wet year to about 270,000 AF in a dry year, with the long-term average annual target of 235,000 AFY continuing to be maintained. **Figure 2.5-2** shows the sustainable yield and ranges of groundwater pumping that can potentially be used as a guideline for various year types (according to the Sacramento River index). This groundwater pumping range can be used as a guideline and not a requirement by the groundwater users in order to provide the operational flexibility for variabilities in hydrologic conditions, monthly and annual water demand needs, and maintaining operational needs for urban water purveyors to provide safe drinking water to the population served. Although the range of groundwater pumping from the Subbasin needs to be within the general range of sustainable yield, the metrics for monitoring and measuring the sustainability conditions of the Subbasin are based on the sustainability indicators, as discussed in **Section 3**.

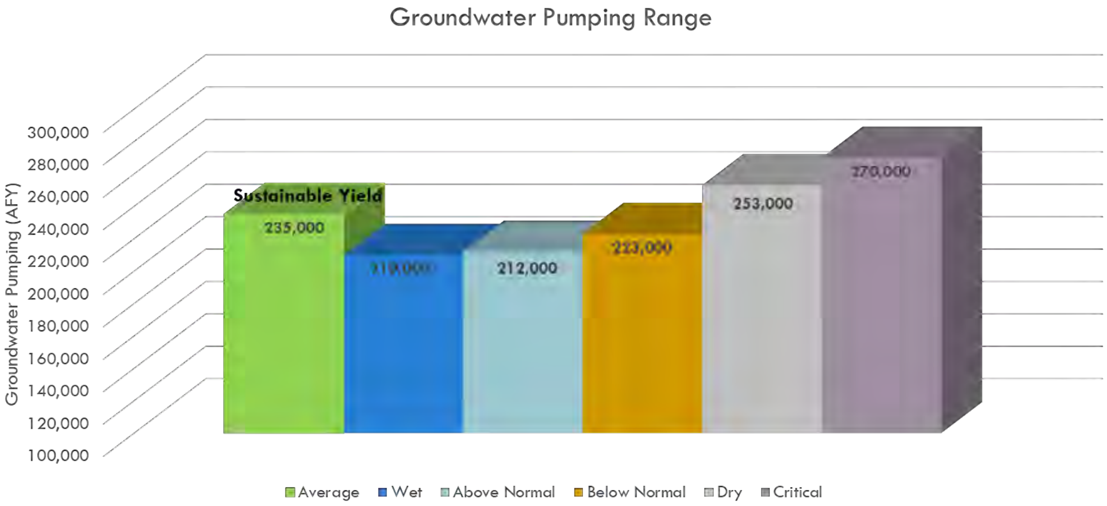

Figure 2.5-2: Operational Flexibility Provided by the SASb Sustainable Yield

Section 3: Sustainable Management Criteria

> *23 CCR § 354.22. Introduction to Sustainable Management Criteria: This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.*

The Sustainable Groundwater Management Act (SGMA) requires each Groundwater Sustainability Agency (GSA) to develop a Groundwater Sustainability Plan (GSP, or Plan) that outlines definitions of “significant and unreasonable” impacts to sustainability indicators (California Water Code [CWC] § 10727(a)). Furthermore, SGMA defines Sustainable Management Criteria (SMC) as measurable steps towards a Sustainability Goal, which culminates in the absence of undesirable results within 20 years of Plan implementation.

SGMA defines six sustainability indicators (CWC § 10721(x)), which are used to determine if “significant and unreasonable” impacts occur for beneficial users and uses of groundwater:

1. Chronic Lowering of Groundwater Levels,
2. Reduction of Groundwater Storage
3. Seawater Intrusion
4. Degraded Water Quality
5. Land Subsidence
6. Depletions of Interconnected Surface Water (ISW)

This Section focuses on all sustainability indicators except for “Seawater Intrusion” which does not apply to the Basin. The avoidance of significant and unreasonable impacts to sustainability indicators is guided by SMC, which include three components:

- Minimum thresholds (MTs): “a numeric value for each sustainability indicator used to define undesirable results” (23 CCR § 351(t))

- Measurable Objectives (MOs): “specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin” (23 CCR § 351(s))

- Interim Milestones (IMs): “a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan” (Title 23, California Code of Regulations (23 CCR § 351(q)))

SMC are thus “management goalposts” that inform discrete actions to be taken over the management and implementation horizon and provide a quantitative means to evaluate progress towards the Sustainability Goal. The scientifically-informed SMC presented herein have been designed to protect beneficial uses and users of groundwater in the basin against significant and unreasonable impacts that may be caused by unsustainable groundwater management, and reflect the values expressed in stakeholder-driven discussions. The specific beneficial uses and users this Plan emphasizes include domestic, agricultural, and public wells,[1] groundwater dependent ecosystems (GDE),[2] and interconnected surface waters (ISW) that support sensitive aquatic habitats and species such as salmonids.[3] Detailed Technical Memoranda for each of these uses and users are provided as Appendices to this Section; within this Section, an overview of these uses and users and the specific, quantitative criteria that demonstrate the avoidance of significant and unreasonable impacts to these users is presented and explained.

The SMC for groundwater levels, storage, and interconnected surface water have been co-developed within an integrated approach to promote ease and efficiency of monitoring and interpretation. As more information is collected, and understanding of the Basin improves over time, certain SMC may change, for instance, during five-year Plan updates. However, at the time of Plan submission, the SMC in this Section reflect the best available science applied to the sustainable management of groundwater in the Basin. These SMC will ensure the Basin operates in a steady condition over the implementation horizon, and achieves then maintains the Sustainability Goal beyond the implementation period ending in 2042.

This Section of the Plan first presents the Sustainability Goal (**Section 3.1**). Next, significant and unreasonable definitions for each of the six sustainability indicators are presented and discussed (**Section 3.2**), followed by SMC for each sustainability indicator – these include MTs (**Section 3.3**), followed by MOs and IMs (**Section 3.4**). Finally, the network of Representative Monitoring Points at which SMC will be measured for each sustainability indicator (**Section 3.5**) is described, and data gaps to be addressed during the implementation period are reviewed.

3.1 Sustainability Goal (23 CCR § 354.24)

> *23 CCR § 354.24. Sustainability Goal: Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.*

The Sustainability Goal of the Basin is to protect and ensure the long-term viability of groundwater resources for domestic, urban, agricultural, industrial, and environmental beneficial users of groundwater. The Sustainability Goal will be achieved by rigorous assessment of potential impacts to these beneficial users, and scientifically-informed management that avoids significant and unreasonable impacts to beneficial uses and users of groundwater.

The overarching Sustainability Goal of the Basin is rooted in a vision of cooperative, multi-benefit, multi-stakeholder coordination to protect all beneficial uses and users of groundwater

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[1] See **Appendix 3-C: Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria** (October 1, 2021)

[2] See **Appendix 3-D: Groundwater Dependent Ecosystems in the South American Subbasin** (April 21, 2021)

[3] See **Appendix 3-A: Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management** (June 18, 2021)

and maintain a healthy, sustainable groundwater basin through the implementation period and beyond. This Plan acknowledges that climate change, unplanned growth, and complex inter-basin coordination all challenge sustainable groundwater management. Thus, this Plan advances solutions to these challenges via:

- SMC rigorously tested on data and modeling of historical and projected groundwater use, analyzed specifically with respect to the most sensitive groundwater users (vulnerable wells, GDEs, and ISW) and designed to avoid significant and unreasonable impacts to these users;
- the shared use of a regional integrated surface and groundwater model that spans the Basin and neighboring basins to the north and south (North American and Cosumnes basins), thus accounting for inter-basin flows, regional conjunctive use, and projected water use in each basin;
- improved monitoring and scientific studies across the Basin to refine models and address data gaps;
- substantial inter-basin and inter-agency coordination on conjunctive use projects and management actions already underway (**Section 4**) that are estimated to increase net basin storage over the implementation period and that will support sustainable pumping, bolster well reliability, improve GDE water access, and maintain critical surface water flows.

Next, undesirable results for beneficial users of groundwater are defined and quantified, which informs the following sections detailing SMC designed to avoid these undesirable results.

3.2 Undesirable Results (23 CCR § 354.26)

> *23 CCR § 354.26. Undesirable Results*
> - *(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*
> - *(b) The description of undesirable results shall include the following:*
>   - *(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*
>   - *(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*
>   - *(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.*
> - *(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

(d) *An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.*

SGMA states that Undesirable Results occur “when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin”. Definitions for undesirable results that pertain to each of the six sustainability indicators are qualitatively presented in this section, and quantitatively defined in the following sections on SMC, including MTs (**Section 3.3**), and MOs and IMs (**Section 3.4**).

3.2.1 Undesirable Results for Chronic Lowering of Groundwater Levels

3.2.1.1 Potential Causes of Undesirable Results

Undesirable Results due to chronic lowering of groundwater levels in the Basin may be caused by an *increase in outflows from groundwater*, a *decrease in inflows to groundwater*, or *a combination of both* that results in substantial groundwater level decline and significant and unreasonable impacts to beneficial users.

Undesirable Results may be caused by a combination of factors, such as excessive groundwater pumping, climate change with increased evapotranspiration and reduced recharge, and unsustainable management of groundwater use in neighboring subbasins.

Sustained groundwater pumping can create undesirable results when it exceeds the basin sustainable yield,[4] which is the “maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.” (CWC § 10721(x)(1)). Major uses of groundwater in the Basin include pumping for agricultural, urban, industrial, and rural domestic use. Hence, expansion of groundwater use associated with irrigated agriculture, groundwater substitution transfers, urban development, industry, and/or rural residential growth (although *de minimis* extractors are unlikely to substantially impact the overall water budget) that outstrips the Basin’s sustainable yield may cause Undesirable Results. Importantly, the Basin may stay within the limits of the sustainable yield, but still cause Undesirable Results in a subarea of the Basin if the spatial distribution of pumping and recharge in the subarea significantly changes and creates local water budget conditions that lead to persistent groundwater level decline.

Climate change is expected to bring an increasingly drier and warmer California climate (Diffenbaugh et al., 2017; Cook et al., 2015) characterized by more frequent, more spatially extensive heat waves and extended droughts (Tebaldi et al., 2006; Lobell et al. 2011) which typically occur during dry summer months. In addition to putting pressure on groundwater extraction to supplement lost surface water supply, an increasingly drier climate will increase evapotranspiration (ET), which may result in increased agricultural demand and less groundwater recharge.

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[4] The Basin sustainable yield in the SASb is expected to increase over time, as conjunctive use projects and management actions add water to groundwater storage during wet years, which may be recovered later as needed during dry years. At the time of writing, sustainable yield estimates are still preliminary.

Extended droughts and heat waves may also reduce precipitation and streamflow, and thus reduce recharge and stream leakage into the Basin from these inputs. Furthermore, streamflow reduction may reduce imported surface water diversions and by extension, recharge from irrigation return flow.

Finally, water management decisions made in adjacent basins may alter cross-basin hydraulic gradients and thus reduce stream leakage and subsurface inflow from adjacent basins or reverse the flow direction altogether. Inter-basin coordination and cross-boundary flow management is critical.

The GSAs in the Basin will coordinate with the relevant agencies and stakeholders – both in the Basin and in adjacent basins – to set SMC and implement projects and management actions that avoid Undesirable Results related to the chronic lowering of groundwater levels.

3.2.1.2 Criteria to Define Undesirable Results

Stakeholder-driven discussions that considered impacts to beneficial users of groundwater helped define the criteria to classify Undesirable Results due to the chronic lowering of groundwater levels. Potential impacts and the extent to which they are considered significant and unreasonable were determined by the GSAs with input by technical advisors and members of the public. During GSP development, potential Undesirable Results (specifically related to groundwater level decline) for beneficial users of groundwater identified by stakeholders included the following issues:

- percentage of domestic, agricultural, or public wells going dry,
- need for well rehabilitation (lowering pumps and deepening wells),
- reduction in the pumping capacity of existing wells,
- financial burden to beneficial users of groundwater,
- adverse impacts to environmental uses and users, including interconnected surface water (ISW) and groundwater-dependent ecosystems (GDEs),
- substantial reduction of surface water flows that threaten salmonid habitat and migration;
- substantial loss of GDEs;
- land subsidence that impacts critical infrastructure (canals and roads).

Based on these values (and the absence of existing or anticipated land subsidence, see **Section 3.2.5**), the level of impact to beneficial users of groundwater level that constitute undesirable results for chronic lowering of groundwater were summarized to three quantitative criteria for vulnerable wells, GDEs, and ISW:

1. **percentage of impacted domestic, agricultural, or public wells exceeds 5% for any well type**

2. **percentage decrease in potential GDE area exceeds 5%**

3. **percentage decrease in ISW reach length exceeds 5%; percentage decrease in the 50th percentile of ISW streamflow exceedance during October-December spawning months exceeds 10% of historical conditions**

The scientific rationale behind Undesirable Results is based on a determination of impact analyses to beneficial users of groundwater and discussed in detail in **Section 3.3.1.1**.

Criteria to define undesirable results for chronic lowering of groundwater are:

> ***Significant and unreasonable chronic lowering of groundwater levels resulting from groundwater extraction occurs when more than 25% (12/45 wells) of representative monitoring wells for groundwater levels and storage in the Basin fall below their MTs for 3 consecutive years.***

As discussed in **Section 3.3.1**, MTs for groundwater level are based on historic and projected groundwater lows, which occur during the 2012-2016 drought and the drought based on repeated hydrology (a modeling assumption). Thus, declines beyond MTs at 25% of monitoring wells for 3 consecutive years is designed to reflect the anticipated return of a 4 year drought similar in intensity to the 2012-2016 drought, plus an additional 3 years of drought to account for hydrologic uncertainty. Importantly, impacts to beneficial users at these thresholds were tested and do not suggest the presence of significant and unreasonable impacts.

Moreover, SGMA specifies that “chronic lowering of groundwater levels” indicates continued groundwater level decline over the implementation horizon.

> *(CWC § 10721(x)(1)): Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.*

Thus, the quantitative *criteria* to identify Undesirable Results consider reasonable hydrologic variability (e.g., water year type) that may be experienced in the Basin, the interaction of this hydrologic variability with projected water use and climate change at an inter-basin scale, and the long-term trajectory of groundwater levels in non-drought periods.

3.2.1.3 Potential Effects of Undesirable Results on Beneficial Uses and Users of Groundwater

Undesirable Results that stem from chronic lowering of groundwater levels will primarily impact shallow well users, ISW, and GDEs. If lowering groundwater levels in confined clays causes land subsidence, critical infrastructure could be impacted, and subsurface contaminants may be mobilized, but projected groundwater budgets do not suggest either of these will happen in the Basin.

If groundwater levels decline, shallow domestic, agricultural, public, and industrial wells that supply groundwater may become partially or fully dewatered and require physical rehabilitation such as pump lowering and well deepening (Gailey et al, 2019; Pauloo et al, 2020; EKI, 2020; Pauloo et al., 2021). Shallow, domestic wells tend to be impacted first as groundwater levels fall, and rural residents may be faced with the significant financial burden of well rehabilitation. Lower groundwater levels also imply increased pumping costs for all groundwater well users, but these costs tend to be negligible compared to the costs of well rehabilitation (EKI, 2020).

The magnitude and direction of depletions of ISW depend on hydraulic gradients between the surface water and adjacent groundwater. Hence, lowering groundwater levels that propagate to streams may steepen hydraulic gradients and cause additional depletions of ISW that reduce in-stream flows, prevent salmonid migration, impact riparian ecosystems, and reduce surface water availability for downstream beneficial users of surface water with riparian or appropriative surface water rights. These beneficial users of surface water may be GSAs and associated users within the Plan area, or users outside of the Plan area.

GDEs are “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” (23 CCR § 354.24(m)). Hence, lowering groundwater levels may disconnect vegetative GDEs from saturated groundwater or reduce baseflow to streams that depend on groundwater baseflow (especially during dry months), thus impacting riparian ecosystems and aquatic species associated with GDEs.

3.2.1.4 Relationship to Other Sustainability Indicators

Sustainable management of groundwater levels can directly address the avoidance of other sustainability indicators that correlate with groundwater levels. Chronic lowering of groundwater level may impact the other sustainability indicators and GDEs in the following ways:

- **Reduction of Groundwater Storage**: Groundwater level is a two-dimensional representation of groundwater storage (three-dimensional). Lowering groundwater levels generally indicate groundwater storage reduction.

- **Seawater Intrusion**: This sustainability indicator is not applicable in the Basin.

- **Degraded Water Quality**: As in the case of depletions of ISW, lowering groundwater levels may alter hydraulic gradients and thus change groundwater flow paths and cause contaminant migration to previously unimpacted areas. Moreover, lowering of groundwater levels may also leach arsenic-rich water from fine-grained sediments (Smith et al., 2018) in localized areas.

- **Land Subsidence**: Lowering groundwater levels and reduction of storage in certain fine-grained sediments can cause land subsidence and deformation of the land surface that damages critical infrastructure such as canals and roads. Land subsidence is a combination of *elastic* and *inelastic* subsidence. In the latter case, the subsidence incurred is permanent. Such impacts are not anticipated in the Basin.

- **Depletions of ISW**: Groundwater level defines the steepness of the hydraulic gradient between ISW and saturated groundwater, and hence the rate, volume, and direction of ISW depletion. Dropping groundwater levels can result in increased ISW depletion.

- **Impacts to GDEs**: Although not technically a sustainability indicator according to SGMA, GDEs are still a beneficial user of groundwater. Lowering groundwater levels may disconnect GDEs from saturated groundwater or reduce baseflow to streams that depend on groundwater baseflow, thus impacting GDE-associated aquatic species.

3.2.2 Undesirable Results for Reduction of Groundwater Storage

3.2.2.1 Potential Causes of Undesirable Results

Chronic lowering of groundwater levels is directly correlated with reduction of groundwater storage. Thus, groundwater levels may be used as a proxy for groundwater storage, and the potential causes of Undesirable Results related to reduction in groundwater storage are identical to those related to chronic lowering of groundwater levels (**Section 3.2.1.1**).

3.2.2.2 Criteria to Define Undesirable Results

Due to the direct correlation between groundwater levels and storage, the quantitative criteria used to determine Undesirable Results due to reduction of groundwater storage are identical to those for chronic lowering of groundwater levels (**Section 3.2.1.2**):

> ***Significant and unreasonable reduction of groundwater storage resulting from groundwater extraction occurs when more than 25% (12/45 wells) of representative monitoring wells for groundwater levels and storage in the Basin fall below their MTs for 3 consecutive years.***

Additionally, GSAs will track and project groundwater storage with the CoSANA model, and calibrate groundwater storage estimates based on data collected throughout the Basin.

3.2.2.3 Potential Effects of Undesirable Results on Beneficial Uses and Users of Groundwater

As before, potential effects of Undesirable Results on beneficial uses and users of groundwater due to reduced groundwater storage are identical to those outlined due to chronic lowering of groundwater levels (**Section 3.2.1.3**).

3.2.2.4 Relationship to Other Sustainability Indicators

Potential effects of Undesirable Results on beneficial uses and users of groundwater due to reduced groundwater storage are identical to those outlined due to chronic lowering of groundwater levels (**Section 3.2.1.4**), except that storage and groundwater levels are related in the following manner:

- **Chronic Lowering of Groundwater Levels**: Groundwater storage is the three-dimensional equivalent of groundwater level (two-dimensional) over a depth. Reduction in groundwater storage generally indicates groundwater level decline, and vice versa.

3.2.3 Undesirable Results for Degraded Groundwater Quality

Significant and unreasonable degradation of groundwater quality is the degradation of water quality that would impair beneficial uses of groundwater within the South American Subbasin (SASb) or result in failure to comply with groundwater regulatory thresholds including state and federal drinking water standards and Basin Plan water quality objectives.

The violation of water quality objectives, which are established in accordance with the CWC to protect beneficial uses of waters, is arguably significant and unreasonable. Also, based on the

State's 1968 antidegradation policy,[5] water quality degradation inconsistent with the provisions of Resolution No. 68-16 may also be significant and unreasonable. In the Subbasin, the Central Valley Water Board and the State Water Board enforce compliance with water quality objectives and determine if water quality degradation is inconsistent with Resolution No. 68-16.

Federal and state water quality standards, water quality objectives defined in the Basin Plan, and the management of known and suspected contaminated sites within the Basin will continue to be the jurisdictional responsibility of the relevant regulatory agencies. The role of the GSAs is to provide additional local monitoring and oversight of groundwater quality, report issues to appropriate parties with jurisdiction over water quality, and to evaluate and monitor, as needed, water quality effects of projects and actions implemented to meet the requirements of other sustainability management criteria.

As noted above, groundwater in the Basin is used for a variety of beneficial uses including agricultural, industrial, domestic, and municipal water supply. Groundwater supports groundwater-dependent ecosystems (GDEs) and instream environmental resources in some areas. These beneficial uses, among others, are protected, in part, by the CVRWQCB through the water quality objectives adopted in the Basin Plan. Projects and management actions implemented as a result of the GSP need to consider, and monitor for, potential impacts to groundwater quality that could cause degradation below these water quality objectives and affect beneficial uses of groundwater in the Basin.

The constituents of concern in the Basin, and their associated regulatory thresholds, are listed in **Section 2.3.4**. The quantification of an undesirable result is included in the discussion of maximum thresholds in **Section 3.3.3**.

3.2.3.1 Criteria to Define Undesirable Results

> **More than 10% of groundwater quality wells exceed maximum thresholds in each aquifer zone (1/10 wells and 1/11 wells in the upper and lower zones respectively).**

Maintaining high water quality is important to GSAs, and these conservative criteria reflect that value.

3.2.3.2 Potential Causes of Undesirable Results

Future activities by the SASb GSAs with potential to negatively affect water quality may include changes to pumping in the Basin, declining groundwater levels, and recycled water projects. Altering the location or rate of groundwater pumping could change the direction of groundwater flow, which may result in a change in the overall direction in which existing or future contaminant plumes move and thus, potentially compromise remediation efforts.

The ongoing contaminated site remediation efforts in the Basin as described in **Section 2.1** are effectively managed and are regulated by agencies with jurisdiction over the monitoring, reporting and compliance activities. In the Basin, existing leaks from underground storage tanks (USTs) are currently being managed and additional degradation is not anticipated from these

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[5] State Water Resources Control Board. "Resolution No. 68-16: Statement of Policy with Respect to Maintaining High Quality of Waters in California", California, October 28, 1968.

known contaminant sources. New leaks from USTs may locally impact groundwater quality, depending on the contents of the UST, which may include petroleum hydrocarbons, solvents, or other contaminants. Such sources will be regulated by the State Water Board. Agricultural activities in the Basin are dominated by vineyards and pasture production. The risk for fertilizer nitrate leaching from these activities is considered low (Harter et al., 2017). The Basin is not currently categorized as a priority subbasin for nitrates under the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program managed by the Central Valley Water Board.

3.2.3.3 Potential Effects of Undesirable Results on Beneficial Uses and Users

Concerns over potential or actual non-attainment of the beneficial uses designated for groundwater in the Basin are related to certain constituents measured at elevated or increasing concentrations, and the potential local or regional effects that degraded water quality can have on such beneficial uses.

The following provides greater detail regarding the potential impact of poor groundwater quality on several major classes of beneficial users:

- Municipal Drinking Water Users – Under California law, agencies that provide drinking water are required to routinely sample groundwater from their wells and compare the results to state and federal drinking water standards for individual chemicals (primary and secondary MCLs). Groundwater quality that does not meet state drinking water standards may render the water unusable for that use or may cause increased costs for treatment. For municipal suppliers, impacted wells may potentially be taken offline until a solution is found, depending on the configuration of the municipal system in question. Where this temporary solution is feasible, it will add stress to and decrease the reliability of the overall system.

- Rural and/or Agricultural Residential Drinking Water Users – Residential users not located within the service areas of the local municipal or private water suppliers will typically obtain their water supply through private domestic groundwater wells. Such wells may not be monitored routinely, and their groundwater quality may be unknown unless the landowner has initiated testing and shared the data with other entities. Degraded water quality in such wells can lead to rural residential use of groundwater that does not meet potable water standards and may result in the need for installation of new or modified domestic wells and/or well-head treatment that will provide groundwater of acceptable quality.

- Agricultural Users – Irrigation water quality is an important factor in crop production and has a variable impact on agriculture due to different crop sensitivities. Impacts from poor water quality (e.g., elevated salinity) may include declines in crop yields, crop damage, changes in crops that can be grown in an area, and other effects. Salinity levels in ambient groundwater in the SASb are generally deemed to be high quality and not impacting agricultural uses.

- Environmental Uses – In gaining streams, poor quality groundwater could possibly affect GDEs, instream environments, and their resident species by supplying nutrients to streamflow. However, there are limited gaining stream reaches in the SASb and ambient groundwater has low nutrient levels, greatly reducing such concerns in the Basin.

3.2.3.4 Relationship to Other Sustainability Indicators

Groundwater quality typically cannot be used to predict responses of other sustainability indicators. However, groundwater quality can, in some circumstances, be affected by changes in groundwater levels and reductions in groundwater storage or can affect ISW quality, as described below.

- Groundwater Levels – In some basins, declining groundwater levels potentially can lead to increased concentrations of constituents of concern in groundwater and may alter the existing hydraulic gradient, which can result in the movement of contaminated groundwater plumes. Changes in water levels may also mobilize some contaminants that may be present in unsaturated soils. In such cases, the maximum thresholds established for groundwater quality may influence groundwater level minimum thresholds by affecting the location or number of projects, such as groundwater recharge or conjunctive use projects. In the SASb, these issues are not of general concern. Contaminated plumes are highly regulated and sufficiently managed in the SASb, as described in **Section 2**, including the use of groundwater wells as barriers to prevent plume migration and use of extensive ongoing monitoring networks. Recharge projects will use high quality surface water, which will have a positive impact on nitrate and specific conductivity in the SASb. The Harvest Water project (**Section 4.4.1**) will introduce recycled water with higher nitrate and specific conductivity concentrations than ambient groundwater, but will not cause groundwater quality to exceed maximum thresholds for these constituents of concern (Ascent Environmental, 2020).

- Groundwater Storage – Groundwater quality at or near the maximum threshold for nitrate in specific wells may result in limited use of those wells. The groundwater quality evaluation described in **Section 2.3** indicates that such occurrences in SASb would be rare and would not impact attainment of groundwater storage SMC in SASb. Minor net reductions in groundwater pumping where surface water replaced groundwater supply to address elevated nitrate concentrations would be insignificant.

- Depletion of ISW – Groundwater quality at or near maximum thresholds may affect stream water quality. However, most of the stream reaches within the SASb are losing reaches and, therefore, groundwater quality will not influence surface water quality in these reaches. There are, however, gaining stream reaches, especially within the southern Cosumnes and Mokelumne Rivers. The GSAs and Regional San will evaluate the relationship between surface and groundwater quality data from wells in this area, including Harvest Water monitoring wells, when these data become available. The results of this evaluation will be included in the next five-year evaluation report.

- Seawater Intrusion – This sustainability indicator is not applicable in this Subbasin.

- Subsidence – Subsidence has been evaluated and is not a problem in SASb. Conditions will continue to be monitored but no impacts associated with groundwater quality are anticipated.

3.2.4 Undesirable Results for Depletions of Interconnected Surface Water

3.2.4.1 Potential Causes of Undesirable Results

Depletions of ISW are related to chronic lowering of groundwater levels via changes in the hydraulic gradient. Darcy's Law is a fundamental tenet of groundwater hydrogeology that explains this ISW depletion.[6] It states that the amount of water that flows through an aquifer (e.g., ISW depletion) is proportional to the hydraulic gradient (in this case, the difference between stream stage elevation and adjacent groundwater elevation).

Hence, declines in groundwater level which increase the hydraulic gradient also increase ISW depletion. Due to the strong dependence of increased ISW depletion on lowering of groundwater levels, the potential causes of Undesirable Results due to depletions in ISW are identical to those for groundwater level decline (**Section 3.2.1.1**).

Interestingly, increased streamflow due to climatic variability (or conjunctive use that leaves more water in streams) may increase the duration of stage elevation at times and thus increase the stream to groundwater hydraulic gradient and hence, ISW depletion. In fact, the CoSANA integrated hydrologic model shows that wet periods are associated with increased seepage into groundwater along major surface water bodies. However, increases in stream seepage due to relatively wet conditions should not be confused with ISW depletion caused by unsustainable groundwater management, but rather, hydrologic and streamflow variability. Taking this hydrologic behavior into consideration, monitoring of near-stream groundwater levels which represent the impacts of *pumping*, are used to develop SMC and monitor for ISW depletion, instead of the hydraulic gradient. Reduced streamflow and reduced baseflow to streams, particularly during dry critical salmonid migration months (October – December) may threaten aquatic ecosystems, thus special attention is paid towards the maintenance of flows during these dry months in projected management scenarios.

3.2.4.2 Criteria to Define Undesirable Results

> *23 CCR § 351(o): "Interconnected surface water" refers to 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.*

Active ISW depletion is occurring in the basin according to CoSANA-calculated stream seepage and data analysis that indicates losing conditions (i.e., groundwater elevation less than stream stage elevation along major surface water reaches at seasonal time scales (**Appendix 3-A: Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management**). ISW depletion shown in the CoSANA model and data analyses are explained by historical groundwater pumping in the Basin and adjacent basins. Therefore, this Plan acknowledges that ISW depletion is occurring in the Basin, and extends the assumptions and methodology of Hall, Babbitt, Saracino, and Leake (2018), that a basin with active ISW

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[6] Darcy's Law, $Q = K \cdot A \cdot i$ states that the volumetric rate of flow *Q* is proportional to the hydraulic conductivity (*K*, or resistance to flow), the cross-sectional area (*A*, in this case, of the streambed), and the hydraulic gradient *i* (in this case, the difference between stream stage and adjacent groundwater level). Thus, as the difference in stream stage and groundwater level increases, say due to groundwater pumping, the hydraulic gradient (*i*) increases, which makes streamflow depletion (*Q*) increase.

depletion should emphasize management actions that arrest groundwater levels, which arrest hydraulic gradients, and finally, arrest streamflow depletion.

Given the practical difficulty of measuring stream seepage (it must be modeled), and the strong dependence of ISW beneficial users on streamflow during critical months, the criteria to define undesirable results for ISW depletion are based on maintaining ISW locations (not disconnecting ISW) and maintaining ISW flows (not depleting surface flows), rather than maintaining ISW seepage (although this is calculated and discussed).

First, historical and present-day groundwater and surface water data (**Section 2.2**) are used to classify surface water reaches as “Interconnected” or “Disconnected,” in order to separate ISW from surface water that is *not* “hydraulically connected at any point by a continuous saturated zone to the underlying aquifer.” Disconnected reaches are considered out of the scope of sustainable groundwater management due to persistent disconnection from groundwater over the period of record from spring 2005 to present-day fall 2019 (**Appendix 3-A**). Depths to groundwater along Disconnected reaches are significantly lower than the bottom of the streambed clogging layer, and thus disconnected from actions that affect the groundwater levels in the Basin. Actions developed for groundwater management by the GSAs are not expected to have an impact on Disconnected reaches. After reaches are classified as Interconnected (ISW) or Disconnected, SMC are developed for ISW reaches.

CoSANA was used to estimate ISW locations, depletion volume, rate, and streamflow near the groundwater level MT (**Section 3.3.1**), which represents a worst-case ISW depletion scenario. Then, MTs for ISW depletion (**Section 3.3.4**) are defined at representative wells consistent with groundwater level and groundwater storage MTs such that hydraulic gradients are maintained at or above critical levels to avoid significant and unreasonable impacts. Importantly, the wells selected to monitor ISW depletion were chosen because they represent changes in groundwater level caused by groundwater pumping, and not near-stream influences, like stream seepage. Each ISW monitoring well is assigned to particular stream reach, and paired with stream gages. Three locations lack adequate, high-frequency, stream gage and groundwater monitoring and these are discussed in the Data Gap subsection, **Section 3.5.5**. Finally, a detailed monitoring well selection criteria is available in **Appendix 3-A**.

Significant and unreasonable depletion of ISW occurs when the percentage decrease in ISW reach length exceeds 5%, or when percentage decrease in the 50th percentile of ISW streamflow exceedance during October-December spawning months exceeds 10% of historical conditions. The rationale behind these criteria is that anything less than a maintenance of roughly current conditions plus reasonable hydrologic variability constitutes an undesirable result. Impacts to ISW were simulated at groundwater level MTs to confirm the avoidance of undesirable results. Using groundwater level at wells as a proxy:

> ***Significant and unreasonable depletion of interconnected surface water resulting from groundwater extraction occurs when more than 25% (3/10 wells) of representative monitoring wells for ISW fall below their MTs for 3 consecutive years.***

Importantly, MTs associated with ISW depletion are measured at a subset (10 wells) of the groundwater level monitoring network (see **Appendix 3-A** for details), and thus, a particular reach may temporarily experience impacts but the Basin as a whole does not experience undesirable results. It is important therefore, to remember that over the implementation period and beyond, modeling suggests that ISW conditions are expected to remain similar to current conditions or improve, although climate change uncertainties may pose challenges.

3.2.4.3 Potential Effects of Undesirable Results on Beneficial Uses and Users of Surface Water

Depletions of ISW caused by groundwater level decline may impact riparian and wetland ecosystems, habitat, fish, special species, recreation, and other environmental users of surface water. Moreover, beneficial users of surface water inside and outside of the basin (e.g., water rights holders) may be impacted by streamflow reduction caused by ISW depletion resulting from unsustainable groundwater management. Lowering groundwater levels may disconnect vegetative GDEs from saturated groundwater or reduce baseflow to streams that depend on groundwater baseflow. A detailed overview of the beneficial users and uses of surface waters is provided in **Appendix 3-A**.

3.2.4.4 Relationship to Other Sustainability Indicators

Increased ISW depletion results from chronic lowering of groundwater levels when lowering groundwater levels and reduction of groundwater storage lead to an increase in the stream-aquifer hydraulic gradient, and hence, increased depletion. Therefore, by effectively managing groundwater levels that reflect an expanding cone of depression in centers of pumping, ISW depletion can also be managed. Moreover, monitoring and forecasting basin-wide storage also provides a big picture view of how ISW depletion may be impacted, although spatially distributed changes in groundwater level are much more useful in isolating local-scale ISW impacts.

3.2.5 Undesirable Results for Land Subsidence

An undesirable result occurs when subsidence substantially interferes with beneficial uses of groundwater and surface land uses.

3.2.5.1 Potential Causes of Undesirable Results

Subsidence occurs due to of compaction of (typically) fine-grained aquifer materials (i.e., clay) resulting from groundwater overdraft, however these aquifer materials are only moderately present in the Subbasin, mainly constricted to the western side of the Basin, and groundwater depletion estimates are not sufficient to lead to significant land subsidence.

3.2.5.2 Criteria to Define Undesirable Results

Significant and unreasonable subsidence is not historically observed in the Basin. The aquifer materials are only moderately likely to present such a risk and only in certain areas of the Basin. Therefore, it is reasonable to declare that any moderate land subsidence caused by the chronic lowering of groundwater levels at a greater magnitude than historically observed occurring in the Basin would be considered significant and unreasonable.

Pumping-induced inelastic subsidence of greater than 0.1 foot [0.03 m] in any single year and a cumulative 0.5 foot [0.15 m] in any five-year period (across the region of greatest land subsidence in the basin) could significantly interfere with surface land use if left unmonitored.

This is set at the same magnitude of estimated error in the Interferometric Synthetic Aperture Radar (InSAR) data (+/- 0.1 foot [0.03 m]), which is currently the only tool consistently available for this Basin for measuring subbasin-wide land subsidence consistently each year.

3.2.5.3 Potential Effects of Undesirable Results on Beneficial Uses and Users

Undesirable Results would occur when substantial interference with land use occurs, including significant damage to critical infrastructure such as building foundations, roadways, other urban infrastructure elements, canals, pipes, and other water conveyance facilities, including flooding agricultural practices.

3.2.5.4 Relationship to Other Sustainability Indicators

By mainly managing groundwater pumping and avoiding the undesirable result of chronic lowering of groundwater levels, the possibility of land subsidence will be mitigated. Mitigating land subsidence through sustainably managed groundwater levels in the Basin will also mitigate impacts to undesirable groundwater storage declines.

3.2.6 Undesirable Results Summary

Table 3-1: Summary of Criteria to Identify Undesirable Results for Each Sustainability Indicator

Sustainability Indicator	Criteria to Identify Undesirable Results
Chronic lowering of Groundwater Levels	*More than 25% (12/45 wells) of representative monitoring wells for groundwater level and storage in the Basin fall below their MTs for 3 consecutive years.*
Reduction of Groundwater Storage	*Criteria for Chronic Lowering of Groundwater Levels (above) used as proxy (**Section 3.3.2**).*
Degraded Groundwater Quality	*More than 10% of groundwater quality wells exceed maximum thresholds in each aquifer zone (1/10 wells and 1/11 wells in the upper and lower zones respectively).*
Depletion of Interconnected Surface Water	*More than 25% (3/10 wells) of representative monitoring wells for ISW fall below their MTs for 3 consecutive years.*

3.3 Minimum Thresholds (23 CCR § 354.28)

23 CCR § 354.28. Minimum Thresholds

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

> (2) *The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.*
> (3) *How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.*
> (4) *How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.*
> (5) *How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.*
> (6) *How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.*

Minimum thresholds (MTs) are numeric values set at Representative Monitoring Points (RMPs), that quantitatively define the values that may cause Undesirable Results for a given Sustainability Indicator if exceeded during the planning and implementation horizon. This section presents MTs for each Sustainability Indicator in the Basin.

3.3.1 Minimum Threshold for Chronic Lowering of Groundwater Levels

23 CCR § 354.28. Minimum Thresholds

> (c) *Minimum thresholds for each sustainability indicator shall be defined as follows:*
>   (1) *Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:*
>   (A) *The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.*
>   (B) *Potential effects on other sustainability indicators.*

Of all the sustainability indicators, groundwater levels are the easiest to understand and monitor, they directly relate to key beneficial uses of water, they can be used to interpolate groundwater level maps over space and time which are key for analysis, and they provide valuable calibration targets for groundwater flow models. For these reasons, this Plan emphasizes MTs and a monitoring approach built on groundwater level data, and relating the groundwater storage and ISW depletion sustainability indicators to the chronic lowering of groundwater levels, and GDE beneficial users. This, in this subsection, MT development for chronic lowering of groundwater is related to vulnerable wells, GDEs, and ISW.

3.3.1.1 Minimum Threshold Development

Minimum thresholds for chronic lowering of groundwater levels in the Basin were defined based on an analysis of historical, present-day, and projected groundwater level trends. Moreover, MT development considered climate change and extended drought conditions that may pose challenges to achieving the Plan’s MOs during the implementation time horizon, as well as simulations of projects and management actions that improve basin storage and increase groundwater levels.

CWC §10727.2(b)(4) states that "The plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015". Thus, the starting assumption in setting Basin MTs is that a return to previously experienced historically low groundwater level conditions observed after 2015-01-01 would *not* result in significant and unreasonable impacts to beneficial uses and users of groundwater. By contrast, groundwater level declines *in excess* of relatively recent groundwater level lows experienced in the Basin around 2015-01-01 could represent unknown, significant and unreasonable impacts to beneficial uses and users.

First, these assumptions were tested with modeling and data analysis to estimate impacts to beneficial users (i.e., vulnerable wells, ISW, GDEs) assuming a return to historically low groundwater level conditions observed after 2015-01-01 (henceforth, post-2015 low)[7]. Results suggest minimal impact to beneficial uses and users of groundwater and support the assertion that a return to the post-2015 low would not lead to significant and unreasonable impacts on beneficial uses and users of groundwater.

However, future projected water use, inter-basin changes in flow, and climatic variability may put strain on SASb groundwater levels and cause even lower groundwater levels that those experienced after 2015-01-01. Therefore, a second round of analyses were conducted on 4 scenarios run by the CoSANA model, to "stress test" MTs lower than the post-2015 low caused by the combined effect of projected groundwater use, the impacts of climate change, and the benefits offered by regional conjunctive use and groundwater banking projects[8]. Across all scenarios evaluated, climate change reduced groundwater levels with impacts most acutely observed in ISW and GDEs; vulnerable wells were largely unaffected owing to their relatively deep depths compared to groundwater levels. Being closer to the land surface, GDEs and ISW are more easily impacted. Conversely, projects and management actions (PMA) substantially contributed to basin sustainability by offsetting the impacts of climate change and leading to the avoidance of significant and unreasonable impacts to ISW, GDEs, and vulnerable wells.

Thus, in this Plan, MTs are set at each RMP (**Table 3-4**) at the post-2015 low or the lowest groundwater level in the projected scenario with PMA and climate change, whichever is lower.[9]

The MT can be interpreted as the *lowest anticipated groundwater level assuming moderate temperature increases due to climate change, the best estimate of future water demand from water agencies, and the continued implementation of projects and management actions* (**Figure 3-1**).

Furthermore, because Undesirable Results due to chronic lowering of groundwater occur when "more than 25% (12/45 wells) of representative monitoring wells for groundwater levels and storage in the Basin fall below their MTs for 3 consecutive years" (**Section 3.2.1.2**), and numerical model simulations suggest the lowest groundwater levels during hydrologic conditions experienced from 2012-2016, the definition of, and criteria used to identify Undesirable Results,

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[7] The post-2015 low typically occurs in the fall of 2015 at most RMPs and is thus at times referred to as the "2015 fall low".

[8] For GSP planning purposes, only projects with adequate funding and a high probability of implementation (i.e., Harvest Water, OHWD recharge, regional conjunctive use – see Section 4) were considered. Henceforth these highly feasible, in-motion projects and management actions are referred to as PMA.

[9] In about half of representative monitoring points for groundwater 53% (25/45 wells), projected management and climate change resulted in lower groundwater levels than the post-2015 low, although declines were minimal. The range (0 - 15.3 ft), median (0.5 ft), and mean (2.8 ft) values by which post-2015 lows are exceeded by those implied under the projected scenario tend to occur away from ISW and GDEs and are shown to not impact vulnerable wells.

can be interpreted as *groundwater level conditions comparable to the combined impact of a 7 year-long extended drought*.

Importantly, groundwater levels may at times decline beyond MTs, but in non-drought years and over the long-term 20-year implementation time horizon of the Plan (and beyond), the basin is projected stay above MTs, trend towards Measurable Objectives (MOs), and achieve the Sustainability Goal. The Plan may also be granted an extension of five years beyond the 20-year sustainability timeframe if there is need for an extension, and if the Basin has made progress towards MOs and adopts a feasible work plan for achieving the Sustainability Goal within the extension timeframe (CWC Section 10727.2(b)(3)).

3.3.1.2 Groundwater Level Analysis: trends, water year type, projected water use, well protection, impacts to GDEs, ISW depletion

Groundwater level analysis and interpolation were used to evaluate the impact of historically observed groundwater conditions (and MTs based historical conditions) on well failure (i.e., domestic, agricultural, and public wells), depletions of ISW, and impacts to groundwater dependent ecosystems (GDEs). Although some Basin RMPs have historical groundwater level data as far back as 1970, these monitoring well data are sparse and insufficient for basin-wide interpolation and analysis. However, from spring 2005 to fall 2019, groundwater level data density is adequate for interpolation, thus data during this period were analyzed at a seasonal level (**Figure 3-2**) and used to define MTs.[10] The impact of these MTs on well protection measures, ISW depletion, and impacts to GDEs were assessed and found to not lead to significant and unreasonable impacts.

Trends: Trends, or linear projections based on groundwater level hydrographs over a time frame, were considered but not used to define MTs for two reasons. First, most groundwater level trends at RMPs in the Basin (**Figure 3-4**) are not unambiguously upwards or downwards across the period of record, and hence, in this Basin the direction and magnitude of the resulting trendline is highly sensitive to the selected historical period.[11] Second, the period of record at RMPs are often not equivalent and contain missing data points, which give the points that are present excessive leverage (i.e., outlier influence over the slope of the resulting trendline). Therefore, the approach to define MTs developed in this Plan is based on observed groundwater conditions, water year type, projected water use, well protection, and the avoidance of impacts to ISW and GDEs.

Water Year Type: Hydrographs and interpolated groundwater elevation maps demonstrate seasonal oscillations that correspond to recharge and pumping (**Figure 3-3**), increasing groundwater levels during above normal and wet water year types (**Figure 3-1**), and declining groundwater levels during dry and critical water year types (**Figure 3-1**). Prolonged dry and critical water year types have historically led to increased groundwater use to supplement unavailable surface water supply in the Basin. Conjunctive use and other projects and management actions (see **Section 4**) during wet periods are expected to bolster groundwater levels and thus and reduce groundwater level drawdown in the Basin during dry and critical water year types.

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[10] These groundwater level analyses extend the historical and current groundwater level summary presented in Chapter 2.

[11] Strong dependence of the trendline on the historical period chosen is demonstrated in hydrologic research, which shows that differences in the historical period used to project groundwater level trends can result in significantly different modeling results. For example, Pauloo et al., 2000 demonstrate that the difference between 1998-2017 and 2008-2017 linear groundwater level projections leads to a doubling of estimated well failure in California's Central Valley.

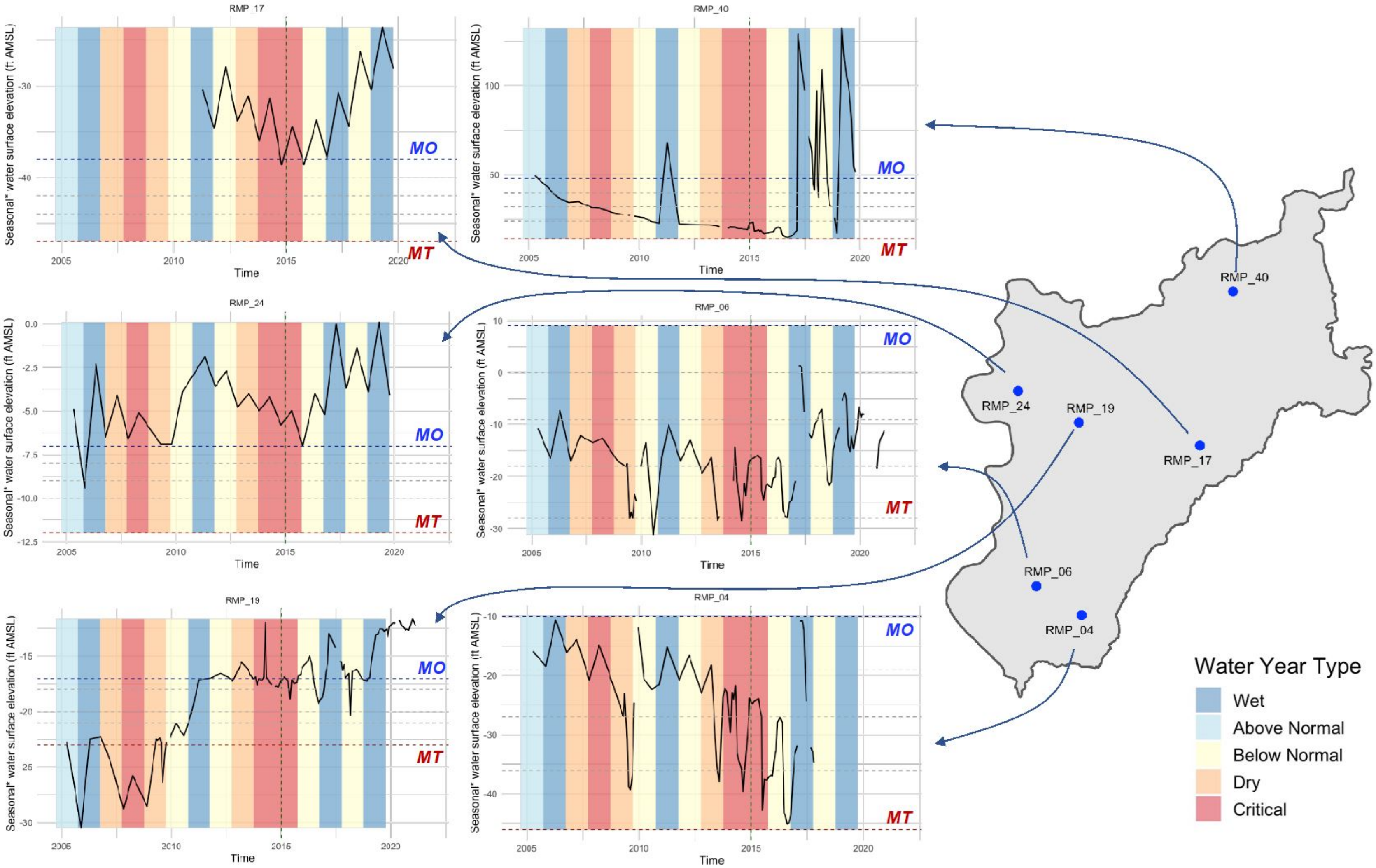

Figure 3-1: MTs, MOs, and IMs at 6 example RMPs in the GSP groundwater elevation monitoring network (Figure 3-13).
MTs (red vertical dashed lines) are set at the lowest level in the projected budget (first column of hydrographs) or the 2015 low (second column of hydrographs), whichever is lower. MOs are set at the mean post-2015 low groundwater level and adjusted by the head difference between the 2015 low and the projected budget – for instance, this difference is negative where declines are expected, and positive within and near the Harvest Water plan area (a groundwater mound is expected). Interim milestones are spaced at integer values between the MT and MO. A green vertical dashed line at 2015-01-01 is drawn for reference.

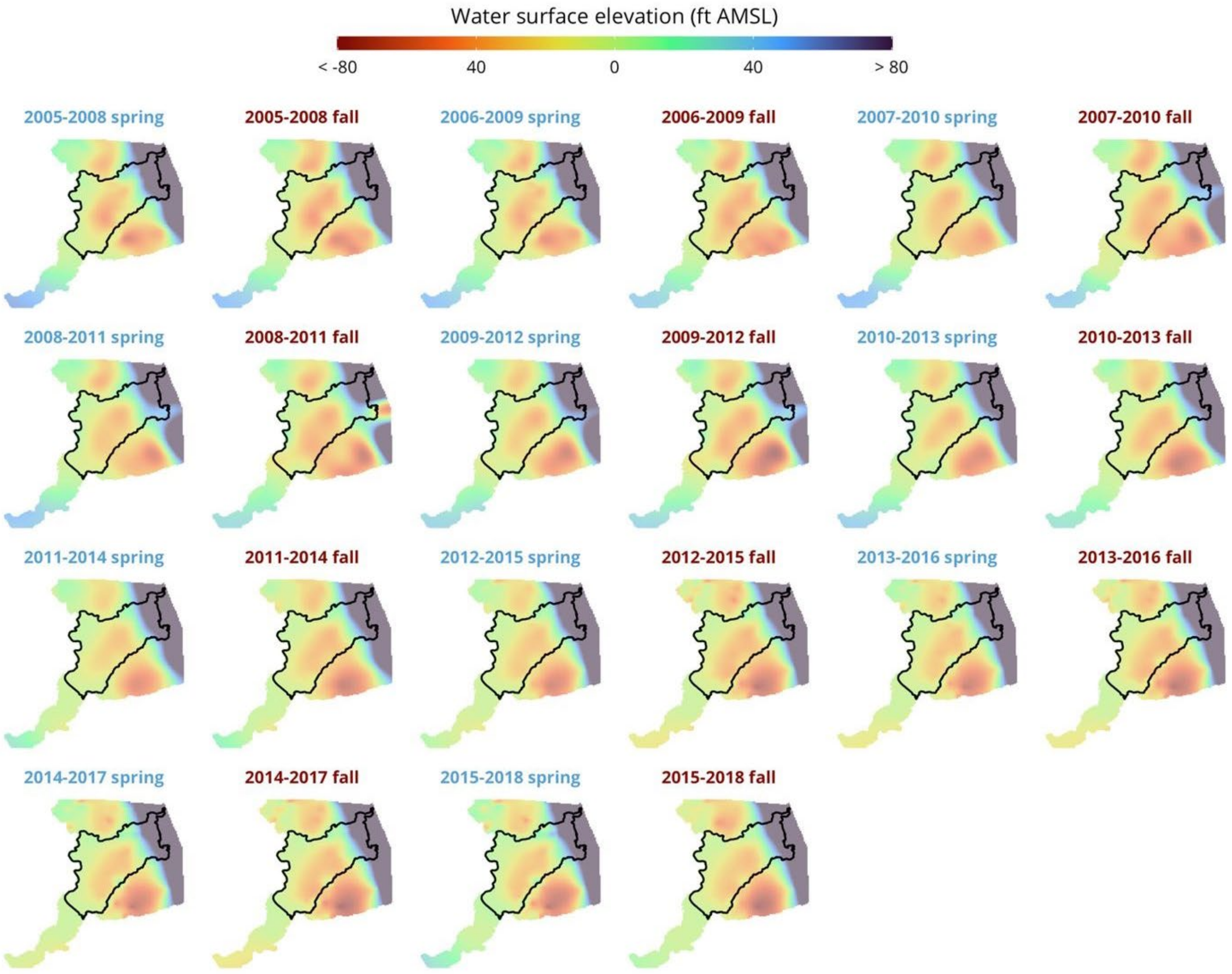

Figure 3-2: **Seasonal, 4 year running mean interpolated groundwater elevations in the Basin from spring 2005 to fall 2018.** Levels show seasonal oscillation, with generally higher (blue) groundwater elevation in spring, and generally lower (red) groundwater elevation in the fall. Higher elevations occur along surface water corridors (north, south and west basin boundaries). Groundwater flows from areas of high (blue) to low (red) elevation. Mapping suggests groundwater flow inwards towards the center of the basin, coincident with areas of groundwater pumping.

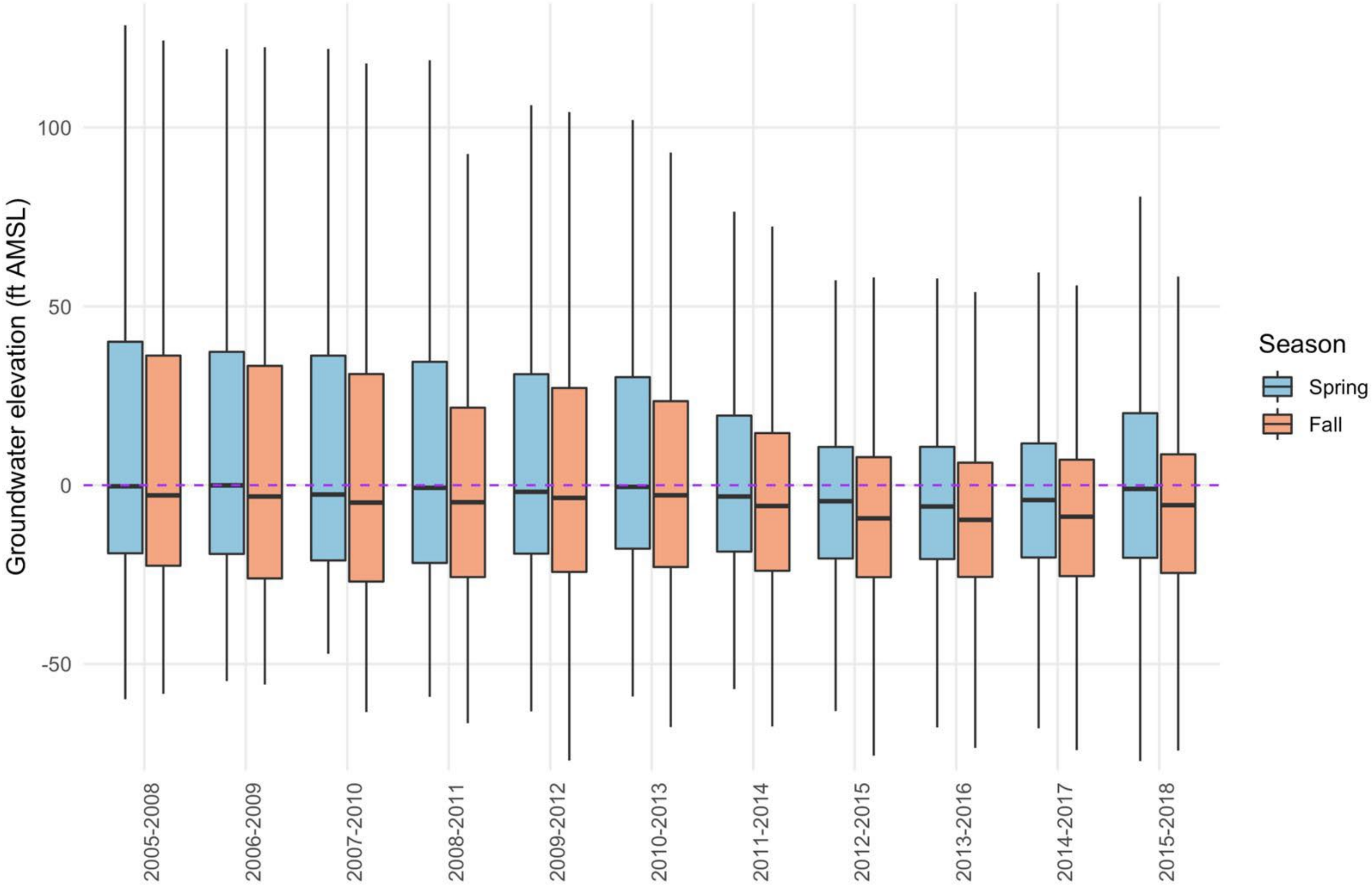

Figure 3-3: **Seasonal summary of interpolated groundwater elevations in the Basin** show oscillating seasonal medians, with consistently higher groundwater elevation in spring, and lower groundwater elevation in fall. Median fall groundwater elevation decreases over the period of record and reaches its lowest value during the average period of 2013-2016 due to the combined impact of 4 years of drought. After this minimum, spring and fall median groundwater levels trend upward. A purple, horizontal dashed line is shown at mean sea level elevation (0 feet) for reference.

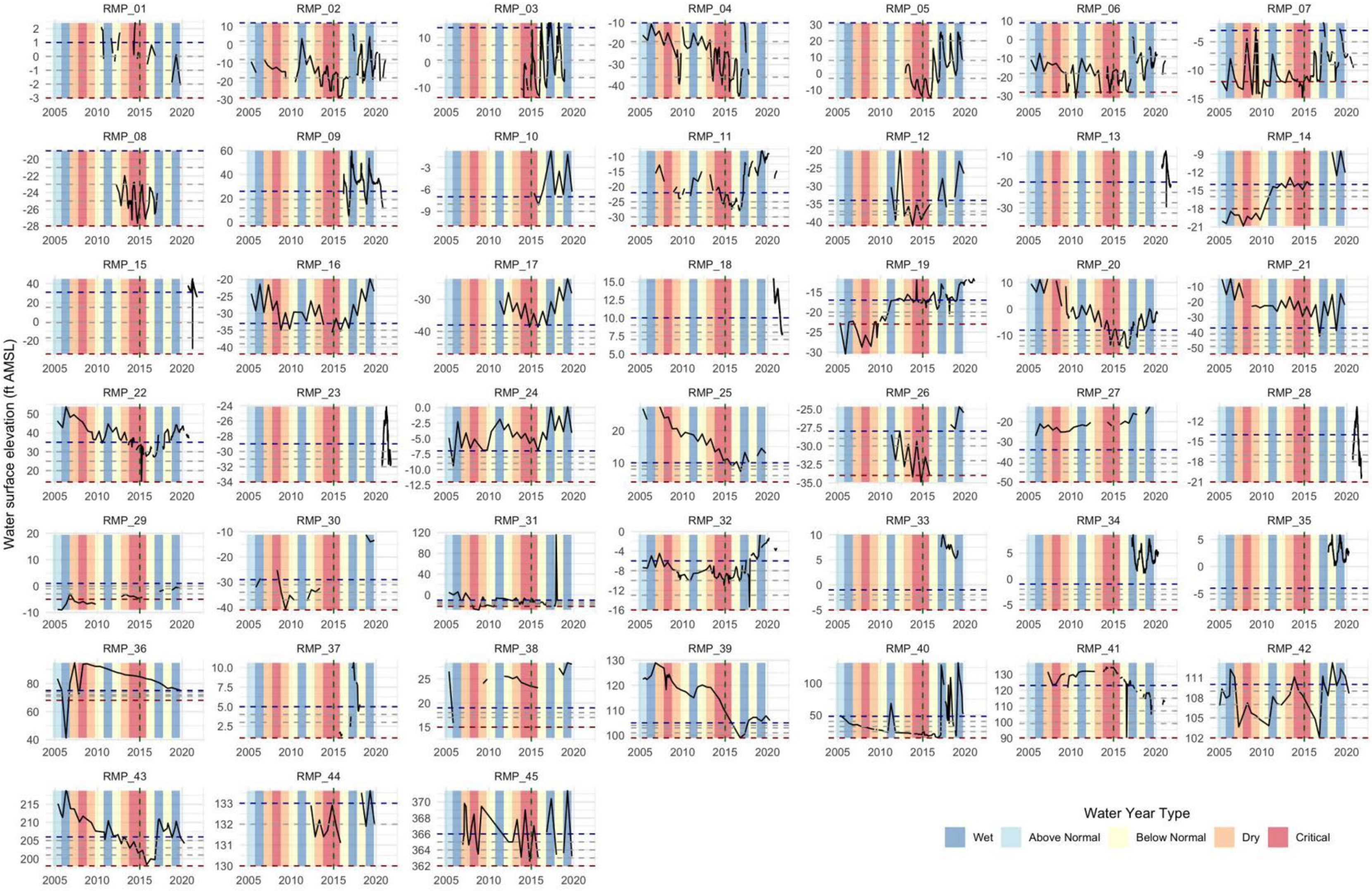

Figure 3-4: **Groundwater elevation and SMC at all 45 RMPs in the Basin.**
SMCs (Table 4) are drawn as horizontal dashed lines and indicate the MO, IMs and MT. In cases when the MT and MO differ by 3 feet or less, the operational flexibility is small, and an interim milestone may overlap with the MT or MO (**Table 3-4**). A green vertical dashed line at 2015-01-01 is drawn for reference. Of these wells, 10 double as ISW monitoring wells. c

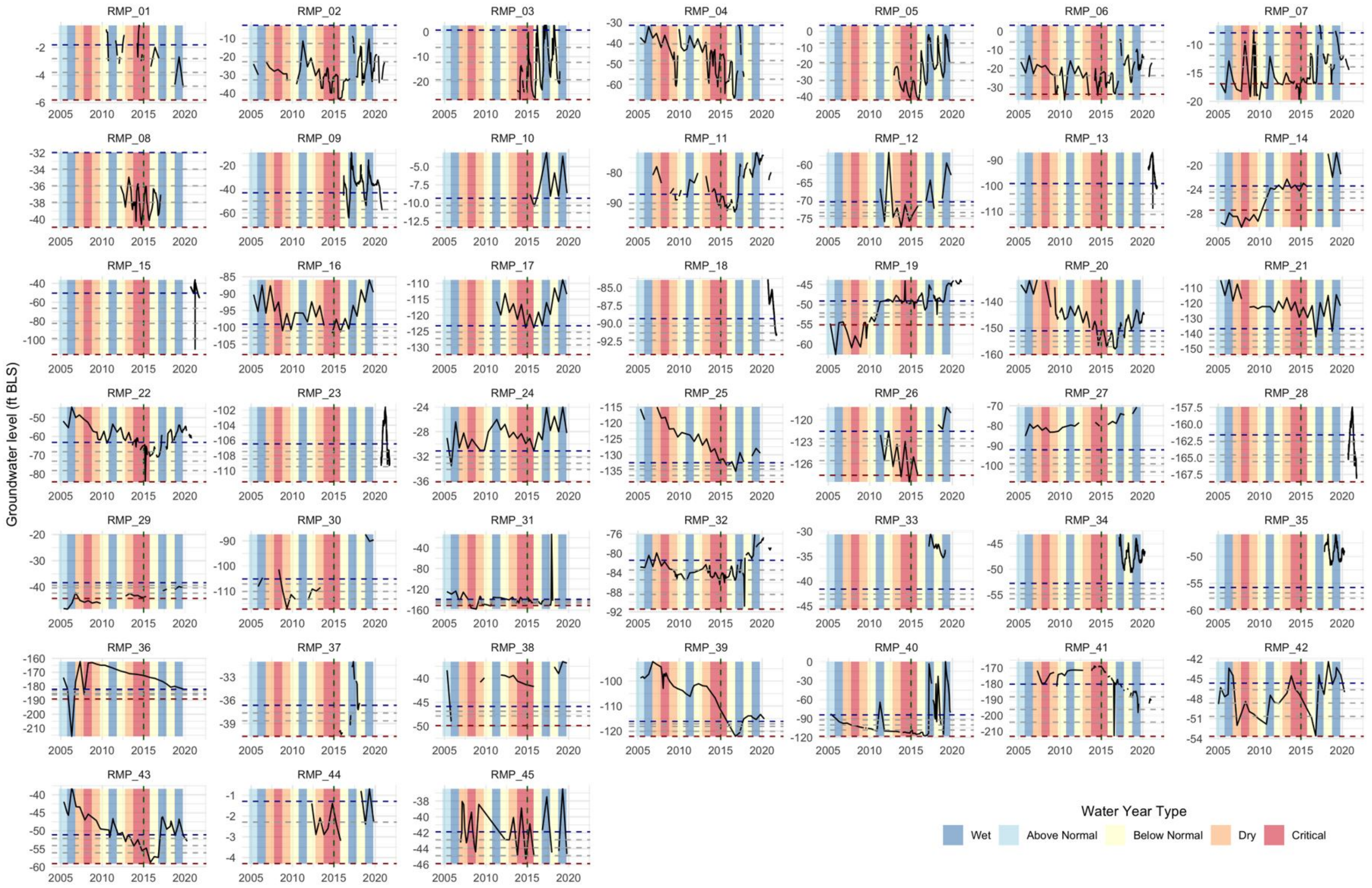

Figure 3-5: **Depth to groundwater and SMC for all 45 RMPs in the Basin.** See **Appendix 3-B** for an RMP ID to SITE CODE key.

Projected Water Use: The CoSANA model was used to simulate:

- the combined effects of projected water use in the Basin;
- projects and management actions (PMA) already underway (Harvest Water, OHWD recharge, and regional conjunctive use); and
- climate change.

Estimates of future groundwater basin storage, groundwater level, and seepage from streams were then used to analyze impacts to key beneficial users of groundwater including: vulnerable wells (**Figure 3-6**), GDEs (**Figure 3-7**), and ISW (**Figure 3-9, Figure 3-10**). Results show minimal impacts to vulnerable wells, GDE area, and ISW locations and flow assuming projects and management actions occur, and median climate change outcomes are experienced.[12] Due to their importance as beneficial users of groundwater that the GSAs aim to protect, three attached technical memoranda detail in-depth studies and recommended management criteria for vulnerable wells, GDEs, and ISW.[13]

In all subsections that follow, groundwater level conditions at Fall 2015 are compared to groundwater level conditions at Fall 2015 in the repeated hydrology and corresponding to Fall 2065 (**Figure 3-16**). Scenario abbreviations are:

- ***Baseline***: fall 2015
- ***Projected***: projected groundwater use
- ***Projected CC***: projected groundwater use with a median climate change warming scenario
- ***Projected PMA***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use)
- ***Projected PMA CC***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use) and with a median climate change warming scenario

Climate change (CC) scenarios are driven by changes in temperature and streamflow provided by the American River Basin Study (USBR, 2020) “central tendency” scenario, which reflect median temperature and precipitation outcomes. See **Section 2.4** for a more detailed description of this climate change scenario and the rationale for its use.

Well Protection: A detailed analysis of well protection is presented in **Appendix 3-C: Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria**, and a summary is given here.

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[12] Significant variation in climate change scenarios is controlled for by evaluating the median outcome. Temperature primarily drives water consumption in conjunction with a land use model and assumes no intervention or land use change. Thus, modeled water use is conservative.

[13] See **Appendix 3-C: Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria** (October 1, 2021), **Appendix 3-D: Groundwater Dependent Ecosystems in the South American Subbasin** (April 21, 2021), and **Appendix 3-A: Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management** (June 18, 2021).

The impact of a return to post-2015 low groundwater levels on wells in the Basin was evaluated and did not suggest significant and unreasonable impacts to wells exceeding 5% for any well type measures. Next, projected groundwater levels for each of the forward-simulated scenarios were analyzed alongside well construction information; results did not suggest a significant and unreasonable increase in impacts to wells (**Figure 3-6**). These results are unsurprising, as no wells were reported dry in the Basin during the 2012-2016 drought according to data from Cal OPR (Pauloo et al., 2020).

Well Completion Reports (CA-DWR, 2020) in the Basin were analyzed alongside groundwater elevation data to estimate the number of active wells (i.e., by filtering out wells older than a specified retirement age) assumed to be in operation at present-day groundwater level initial conditions (i.e., wells not already dry at initial groundwater level conditions). Next, potential significant and unreasonable impacts to vulnerable wells were evaluated at the lower of the post-2015 low or the lowest projected groundwater level (MTs). The count, cost, and location of impacted wells was estimated assuming MT levels were reached across the entire Basin.

The initial set of active wells included all wells completed on or after 1989-01-01 (31-year retirement age) with pump locations (estimated as 30 feet of operating margin above the total completed depth) below the present-day groundwater level (following Pauloo et al., 2021). To evaluate the sensitivity of retirement age on impacted wells, a second analysis was conducted for all wells completed on or after 1980-01-01 (40-year retirement age).

Results across all scenarios evaluated suggest a range of 7-15 wells would be impacted under 31-year and 40-year retirement ages, and accounting for uncertainty in projected management and climate change (**Figure 3-6**). For a conservative estimate of PMA with climate change, impacted well count is around 2-3% of domestic wells and 1-2% of public wells, and 1-2% of agricultural wells, primarily in the greater Sacramento urban area. This is unsurprising, as groundwater level simulations indicate drawdown in these areas – areas which are also far away from the agriculture-rural interface where most vulnerable domestic wells are located. These well impact percentages align with GSA-driven definitions of unreasonable results to vulnerable wells.

Further, unacceptable well impacts are defined as dewatering or lost access to groundwater at a well that requires well deepening or pump lowering. Well rehabilitation costs for impacted wells, assuming a return to the MT at all RMPs, were estimated at around $300,000 - $700,000 following the cost structure of Pauloo et al. (2021), EKI (2020), and Gailey (2019), but would likely be less, as significant and unreasonable impacts occur when 25% of RMPs exceed MTs (**Section 3.2.1.2**), and less expensive rehabilitation costs such as pump lowering may be more appropriate in some situations (e.g., when operating margin exists). Estimated well impacts and their associated rehabilitation costs have been discussed with GSAs and shared during public meetings to solicit feedback from groundwater users in the basin, including domestic well users. The GSAs are committed to using information gleaned in these conversations and public meetings, and the insights in these analyses to design a shallow well rehabilitation fund to address well protection costs in the Basin (**Appendix 3-C**).

Furthermore, GSAs in the Basin are committed to engaging and coordinating with vulnerable well owners to anticipate, mitigate, and help remediate impacts to wells that directly result from unsustainable groundwater management.

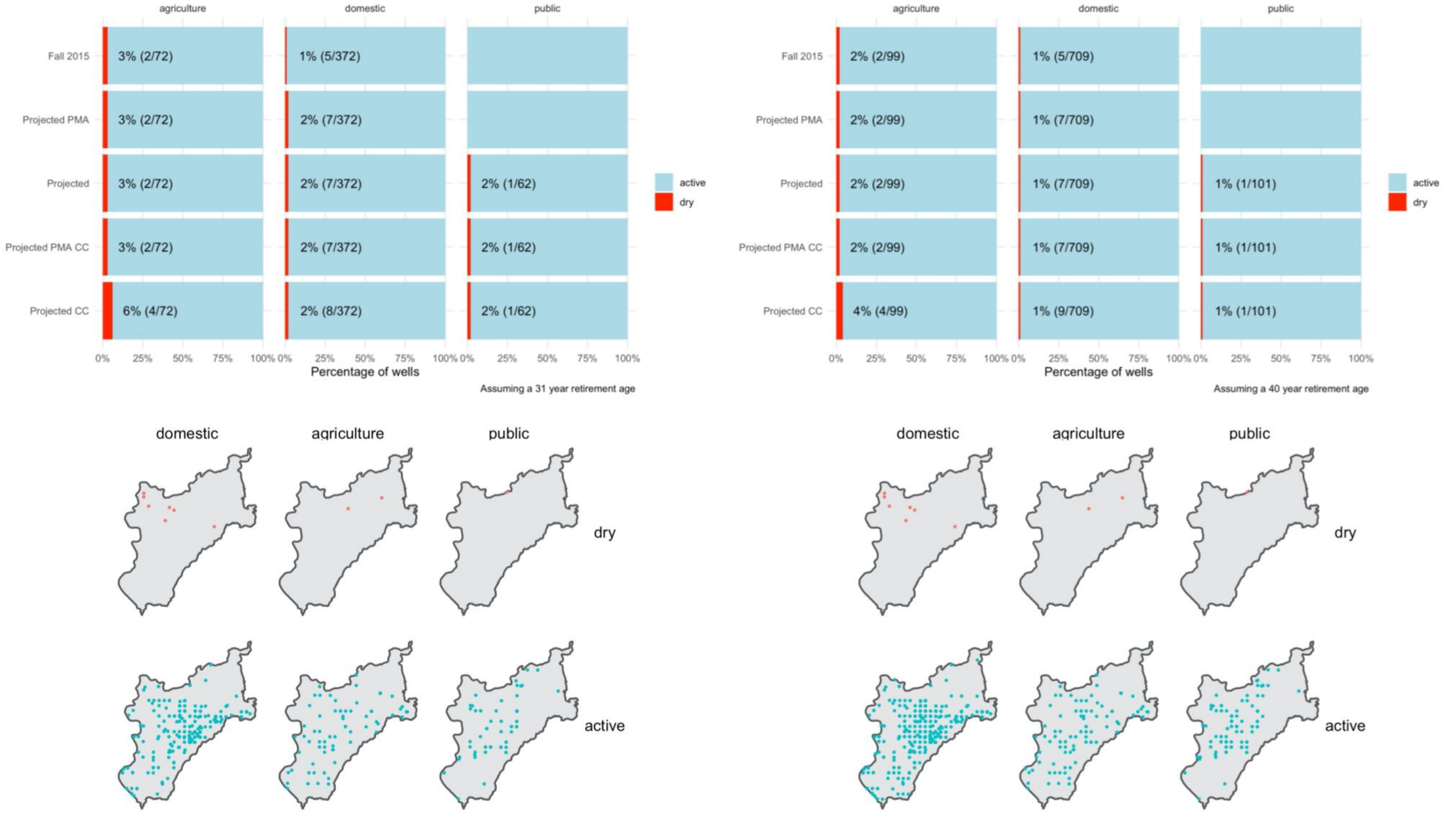


Figure 3-6: Vulnerable well impact analysis of a Fall 2015 baseline and 4 projected management conditions show little appreciable difference, even when accounting for a 31-year (left) and 40-year (right) well retirement age. Projected = Projected water use in the Basin. PMA = projects and management actions including Harvest Water, OHWD recharge, and regional conjunctive use. CC = climate change. Bar plots show well impact summary statistics for all scenarios and well types. Maps show results for the “Projected PMA CC” scenario on which groundwater level MTs are based.

GDE Protection: A detailed analysis of well protection is presented in **Appendix 3-D: Groundwater Dependent Ecosystems in the South American Subbasin**, and a summary is given here.

GDEs were mapped using best available datasets across the Basin, and special status species were cataloged. The analysis focused on plant species which provide habitat for these special status species, in addition to providing valuable ecosystem functions and recreational benefits. The maximum reported rooting depths of the plant species found in the Basin range from near-surface for grasses like creeping wildrye (3.84 feet) to deep-rooted trees like the Valley Oak (24.31 feet). Rooting depths of species within the Basin show that the Valley Oak (Quercus lobata) was found to exhibit the largest rooting depth. Because plants can extract moisture from pore spaces away from the roots themselves, a threshold depth of 30 feet was used as a cutoff for the maximum depth of groundwater that could reasonably be accessed by a GDE within the Basin. Areas within the Basin where depth to groundwater is consistently greater than 30 feet are assumed incapable of supporting non-wetland GDE communities and by extension, any GDEs. In the context of identifying GDEs, this 30-foot depth threshold is conservative and overly inclusive as shallower groundwater is required to support a broader array of healthy GDEs for most plant species.

The historical areas occupied by potential GDEs were then classified into 4 categories (GDE, Potential GDE – likely, Potential GDE – unlikely, Not GDE) by relating observed, interpolated historical groundwater levels to GDE polygons and an assumed 30-foot rooting depth. Over the historical period analyzed (2005-2018), GDEs are found to occupy 43.2% of Potential GDE polygons considered (11,340 / 26,245 acres).

Next, NDVI was calculated across the 4 categories described above to determine historical variance in vegetation health. NDVI in GDE categories is consistently higher than non-GDE categories, which suggests remotely sensed estimates of plant health capture significant differences between GDE and non-GDE polygons.

These analyses informed the development of two quantitative criteria which may be used during Plan implementation to detect if GDE area or health fall below historically observed values (**Table 3-2**).

Table 3-2: Criteria to determine changes in GDE area and health that exceed historically observed minima

Criteria	Historical minimum observed	Quantitative metric
A: Proportion of Mapped Potential GDE Classified as "Assumed GDE" in Tier 1 GDE Likelihood Analysis	2013-2016 Fall	44%
B: Lowest Median NDVI for "GDE" in Tier 2 GDE Likelihood Analysis	June 2009	0.023

If either criteria A or B are observed for 3 consecutive years, Undesirable Results for GDEs occur. Importantly, 44% represents the minimum area of Potential GDE polygons classified as GDEs in the historical record and occurs during the 2012-2016 drought. Thus, a decline in GDE area (determined by a 30 ft depth to groundwater) exceeding 44% indicates a deviation from historically observed values and an undesirable result.

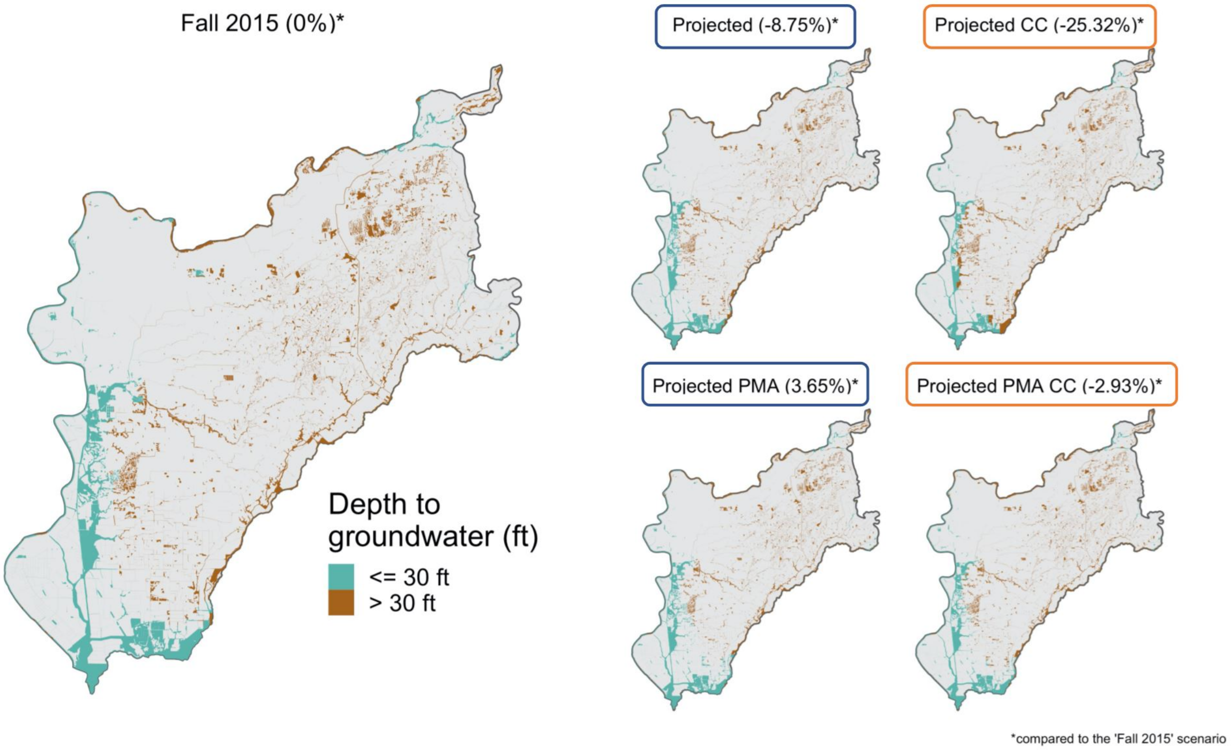


Figure 3-7: Impact analysis of projected groundwater level scenarios (described in **Figure 3-6**) shows appreciable GDE impacts without PMA. However, PMA substantially buffer against impacts to GDEs, even given climate change, and especially in the southern portion of the Basin near the Harvest Water project. Percent changes reported are with respect to the Fall 2015 GDE area. For example, the “Projected PMA” scenario (projected conditions with projects and management actions) results in a 3.65% increase in potential GDE area compared to Fall 2015. The “Projected” and “Projected PMA” scenarios (blue border) should be compared, and the “Projected CC” and “Projected PMA CC” scenarios (orange border) should be compared. In each pair of comparable scenarios, scenarios with PMA lead to a less than 5% reduction of GDE area, and are generally more protective of GDEs than scenarios without PMA.

Projected management changes groundwater elevation, which directly impacts groundwater access for plants. Results indicate that PMA result in a 3.65% increase in potential GDE area to a -2.93% decrease in GDE area, depending on climate change. Without PMA, GDE area may decrease from -8.75% to -25.32%, depending on climate change. Percent change in all scenarios was evaluated with respect to a Fall 2015 baseline. Overall, considering climate uncertainties, results suggest that projected groundwater use with PMA is likely to maintain GDE area consistent with historical levels and thus avoid undesirable results experienced at the 44% area criteria for historical GDEs.

GSAs in the Basin are committed to cooperative, multi-benefit projects in coordination with land trusts, resource conservation agencies, neighboring basins, and other stakeholders to anticipate and mitigate impacts to GDEs that directly result from unsustainable groundwater management.

Avoidance of ISW Depletion: A detailed analysis of the scientific studies that led to the development of ISW SMC are presented in **Section 3.2.4** and **Appendix 3-A**, and a summary is given here.

A return to post-2015 low groundwater levels was evaluated and did not suggest significant and unreasonable reduction in ISW location, streamflow, or seepage. Compared to a Fall 2015 baseline, ISW locations in each of the projected scenarios evaluated do not appreciably change (**Figure 3-9**). These analyses indicate that significant and undesirable impacts to ISW are avoided at groundwater level MTs set at the lower of the post-2015 low (typically occurring in Fall 2015) or the low under projected management with PMA and climate change.

SGMA defines 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” (23 CCR § 351(o)). Thus, seasonal groundwater elevation mapping was used to separate persistently disconnected, stream nodes from connected nodes, and reach-level “Disconnected” and “Interconnected” classifications were assigned based on connection history (**Figure 3-8**). SMCs were then developed for Interconnected reaches. ISW characterization is consistent with ISW characterization in The Nature Conservancy’s ICONS web tool (TNC, 2021) and those in adjacent basins (North American and Cosumnes basins) that share boundaries with the South American Subbasin.

At Interconnected reaches in the Basin, CoSANA-calculated stream seepage indicates present-day and historical ISW depletion (**Section 3.2.4**). The magnitude of ISW depletion is controlled by the relative elevation between ISW and adjacent groundwater (i.e., the hydraulic gradient) – thus a management approach that arrests groundwater level decline also arrests the hydraulic gradient and places an upper limit on expected ISW depletion. However, for this monitoring approach to work, wells must be selected to capture the effects of an expanding cone of depression and a steepening of the hydraulic gradient which will eventually propagate to ISW and cause depletion. Hydraulic gradient analysis along transects from ISW were used to identify an appropriate distance (3,000 ft) from ISW at which to monitor hydraulic gradients, and this informed the subset of shallow groundwater level monitoring wells to use. Then, groundwater levels at these wells in projected management scenarios were related to impacts to ISW locations, streamflow, and seepage.

Projected management with PMA leads to a -2.62% to 0% reduction in ISW reach length depending on climate change and calculated over CoSANA stream nodes, which is within the 5% reduction in ISW reach length determined as significant and unreasonable. Note that the metrics to calculate ISW reach connection depend on sufficient groundwater level elevation data nearby and under ISW, as well as accurate ISW streambed elevation. Some uncertainty exists in these data which may be addressed in the future with high-resolution mapping and site surveys (**Section 3.5.5**).

Furthermore, ISW streamflow exceedance during the Chinook salmon fall-run (October – December) spawning migration was evaluated (**Figure 3-10**) under each projected scenario and compared to baseline flow conditions (e.g., current long-term fall conditions from 1969-2018). Maintenance of flows (especially during dry months) is most important in the undammed Cosumnes River which is a focal point of local conservation efforts. By contrast, flows in the American and Sacramento rivers are heavily managed. Findings suggest sufficient flows to support spawning migration in Projected and Projected PMA scenarios, and importantly, that projected groundwater management will increase streamflow in the lower Cosumnes River compared to the current conditions baseline scenario and scenarios without PMA. Climate change has a substantial negative impact on streamflow that would cause greater than 10% change in the 50th percentile of exceedance flows in all rivers. Importantly, streamflow declines result from climate-driven changes in stream inflow (USBR, 2020), not unsustainable groundwater management. Reduced impacts to streamflow in the Cosumnes (compared to the American and Sacramento rivers) is largely due to benefits from the Harvest Water recharge project. This underscores the importance of multi-benefit conjunctive use and groundwater banking projects to offset the impacts of climate change (e.g., reduced streamflow).

Table 3-3: October-December simulated streamflow for the American, Cosumnes, and Sacramento rivers under current conditions (Baseline), and projected scenarios (also see Figure 3-10).

River	Scenario	10th percentile (cfs)	25th percentile (cfs)	50th percentile (cfs)	75th percentile (cfs)	90th percentile (cfs)	% Difference in 50th percentile exceedance compared to Baseline
American	Baseline	4037	2714	2025	1283	914	0%
American	Projected PMA	4019	2699	2005	1266	892	-1%
American	Projected PMA CC	2346	2181	701	584	507	-65%
American	Projected	4020	2692	2000	1261	888	-1%
American	Projected CC	2337	2177	694	579	503	-66%
Cosumnes	Baseline	1662	523	154	47	35	0%
Cosumnes	Projected PMA	1695	564	178	59	45	16%
Cosumnes	Projected PMA CC	1752	462	143	52	37	-7%
Cosumnes	Projected	1679	537	164	52	40	6%
Cosumnes	Projected CC	1742	443	134	48	34	-13%
Sacramento	Baseline	36150	19323	13857	11294	8554	0%
Sacramento	Projected PMA	36441	19537	13969	11424	8672	1%
Sacramento	Projected PMA CC	24794	14612	11300	8206	6822	-18%
Sacramento	Projected	36421	19514	13943	11401	8648	1%
Sacramento	Projected CC	24763	14585	11270	8181	6797	-19%

A general concern is that groundwater management in the Basin may negatively impact critical flows for fish passage. Multiple studies report minimum flow targets at Michigan Bar for fish passage on the Cosumnes River. Anderson et al. (2004), Fleckenstein et al., (2004), Mount et al. (2001), which estimate flows of 32.8, 54.7, and between 40-45 cfs, respectively. Most recently, hydraulic modeling by US Fish and Wildlife Service (USFWS) as part of an initial passage analysis identified 180 cfs as the minimum bypass flow condition for both the McConnell and Michigan Bar locations along the Cosumnes River. Therefore, at the time of writing, the range of flow conditions required for fish passage based on the best available science ranges from 32-180 cfs. A 90% exceedance probability for the 32 cfs flow target reported by Anderson et al. (2004) is achieved in current conditions and in all scenarios evaluated (**Table 3-3**). Further, a 75% exceedance probability for the 45 cfs target from Mount et al (2001) is met across all scenarios. The projected PMA scenario has a median exceedance probability at 177 cfs, which is close to the USFWS estimate of 180 cfs needed for fish passage. Climate change has outsized effects of simulated streamflow and deserves more attention.

Future studies may investigate functional flow metrics for the river, but insofar as SGMA pertains to flow in the Cosumnes, modeling suggests that projected management will not appreciably change streamflow from current conditions, thus avoiding significant and unreasonable impacts to beneficial users of groundwater. More work is needed to assess climate change impacts to ISW (**Section 3.5.5**) and will be completed before the 5 year plan update (2027).

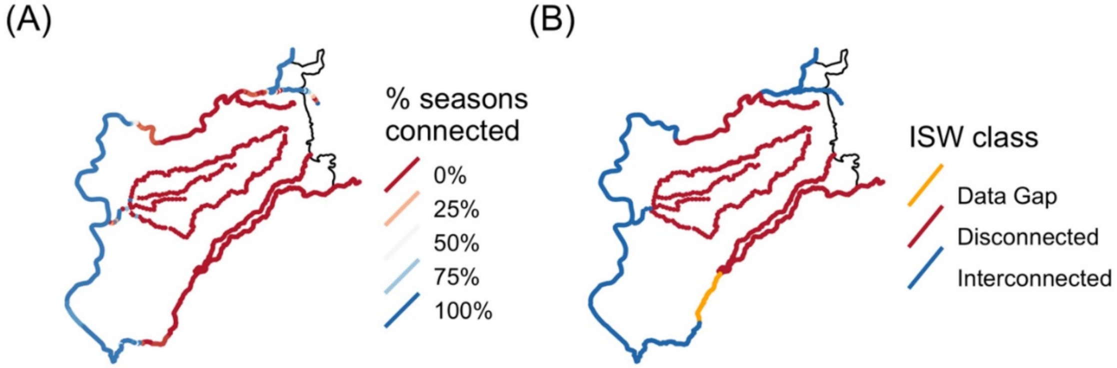
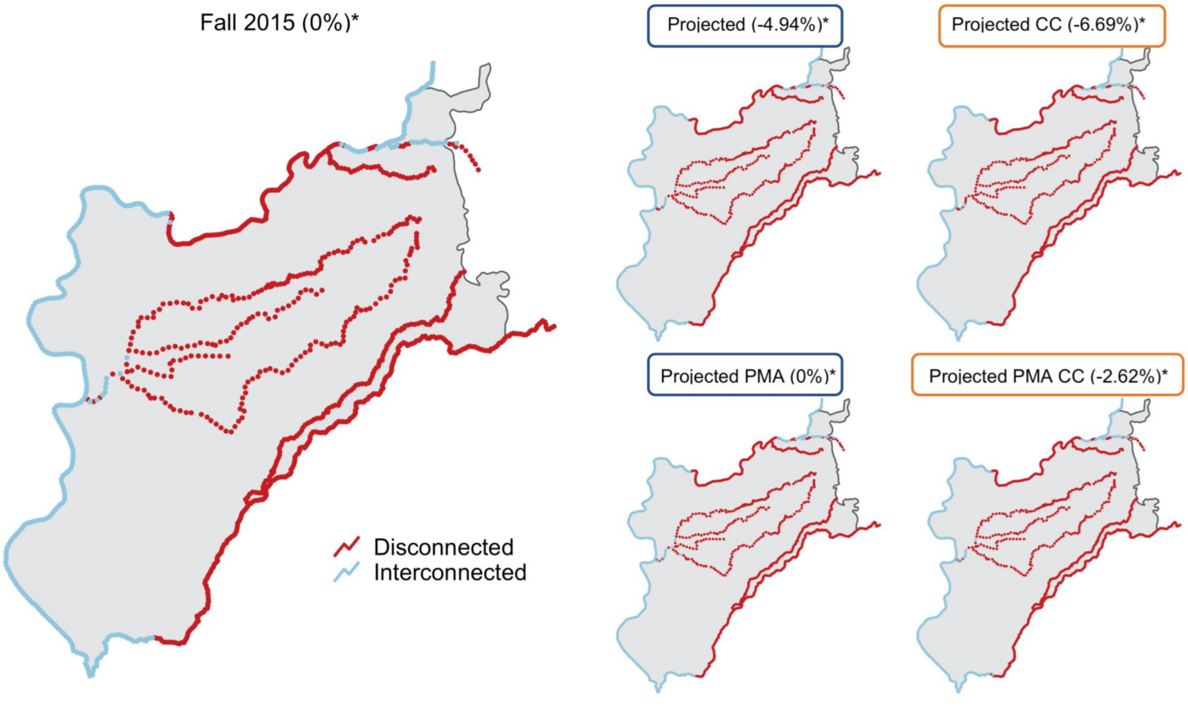


Figure 3-8: **Interconnected and Disconnected stream nodes and reaches** are defined by computing (A) the percentage of seasons evaluated from 2005 – 2018 where average groundwater elevation intersects the clogging layer of the streambed. (B) Disconnected stream reaches have a majority of stream nodes that are persistently disconnected from groundwater at all seasons evaluated, whereas Interconnected reaches are conservatively defined as having a majority of nodes connected for > 0% of all seasons evaluated. The Cosumnes River approximately between Deer Creek and Twin Cities Road is disconnected on a seasonal level, but some evidence of sub-seasonal connection exists, thus it is considered a data gap for planning purposes and more research is needed to understand stream-aquifer interactions in this region.



*compared to the 'Fall 2015' scenario

Figure 3-9: Impact analysis of projected groundwater level scenarios (described in **Figure 3-6**) shows minimal impacts to ISW reach length across scenarios suggesting the avoidance of significant and unreasonable disconnection events. As with GDEs, the introduction of PMA prevents stream disconnection compared to scenarios without PMA. The "Projected" and "Projected PMA" scenarios (blue border) should be compared, and the "Projected CC" and "Projected PMA CC" scenarios (orange border) should be compared. In each pair of comparable scenarios, scenarios with PMA lead to a less than 5% reduction of ISW reach length compared to a 2015 baseline, and are generally more protective of ISW than scenarios without PMA.

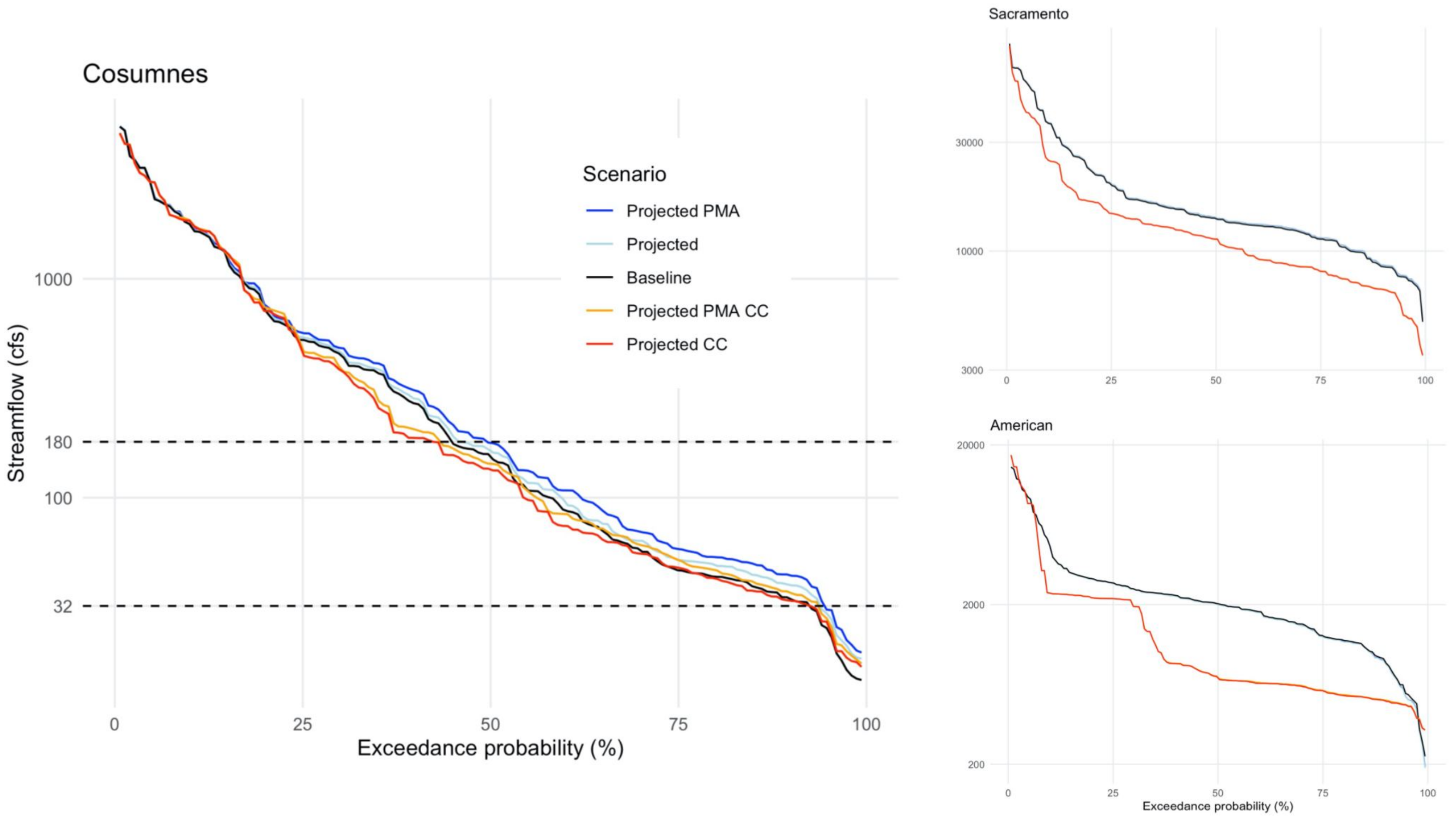
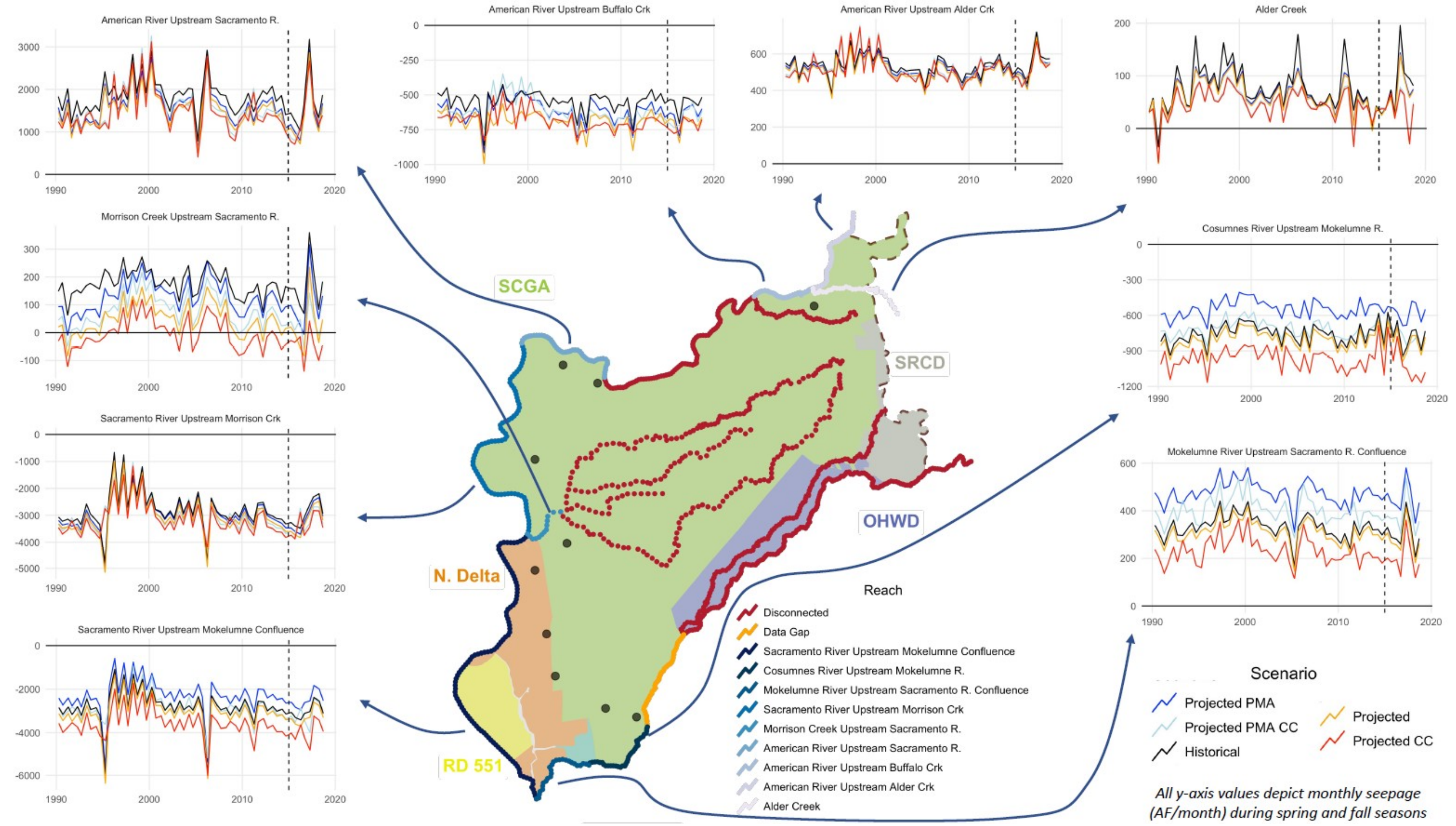


Figure 3-10: All projected scenarios (described in **Figure 3-6**) show minimal impacts to October-December streamflow exceedance (**Table 3-3**) at ISW locations along the Cosumnes, Sacramento, and American rivers when compared to current conditions baseline flows (black solid line). American and Sacramento flows are only impacted by climate change and the absence of PMA (overlapping red and orange lines). In the Cosumnes, PMA introduction improves flow conditions, and projected management does not differ from current conditions. Black dashed horizonal lines on the leftmost plot indicate the envelope of flow target values reported by literature to support fish passage during low-flow October-December spawning months. The lower bound of this envelope (32 cfs) has a 90% exceedance probability across all scenarios which implies fish passage during spawning months. Due to modeling constraints, flows are estimated at the downstream outlets of the Cosumnes and Sacramento Rivers in the model domain. American River flows are estimated at H Street Bridge. Note the log-scale y-axis.

Figure 3-11: Probable ISW reaches by name, Probable Disconnected reaches, and GSAs in the Basin.
Classification of reaches follows the methodology summarized in **Section 3.3.1.2**, **Figure 3-8**, and **Appendix 3-A**. Grey points indicate the locations of ISW RMPs in the GSP monitoring network.



All y-axis values depict monthly seepage (AF/month) during spring and fall seasons

Figure 3-12: Seasonally averaged ISW depletion estimated by CoSANA at ISW designated reaches
over the current conditions baseline model simulation is relatively constant. Negative numbers indicate losing stream conditions (stream loss to groundwater) and positive numbers indicate gaining stream conditions (stream gain from groundwater). Spring (February - April) and fall (August - October) depletion rates are averaged per month in each 3-month seasonal window. A black vertical dashed line at 2015-01-01 is drawn for reference, and a black solid horizontal line at y = 0 indicates the transition from

gaining to losing conditions. Most scenarios have little impact on seepage. The Cosumnes and Mokelumne gain more under projected conditions, even with climate change. Morrison Creek loses more in all scenarios.

Notably, reaches of the Cosumnes River approximately between Deer Creek and Twin Cities Road are disconnected on an average seasonal timescale, but evidence of short-term, flashy, sub-seasonal connection has been found. The role of these short-term connection events, and the prevalence of significant subsurface heterogeneity and perched zones make this region difficult to model and monitor. Thus, these reaches of the Cosumnes are considered a data gap for planning purposes, and more research and inter-basin coordination is needed to determine the nature of surface and groundwater interactions in this region. It is expected that by the next plan update (2027), a revised determination of ISW in this area will be developed (**Section 3.5.5**).

GSAs in the Basin are committed to cooperative, multi-benefit projects in coordination with land trusts, resource conservation agencies, neighboring basins, and other stakeholders to anticipate and mitigate impacts to ISW – and the beneficial users they support – that directly result from unsustainable groundwater management.

Impacts to adjacent basins: MTs were developed in coordination with the neighboring North American Subbasin and Cosumnes Subbasin. GSAs in these three basins will continue to coordinate the details of their Plans to model and evaluate the impact of MTs, and more broadly, MOs and project and management actions (PMAs) on achieving joint sustainability goals. No significant and unreasonable impacts resulting from management actions in the SASb are noted in adjacent basins.

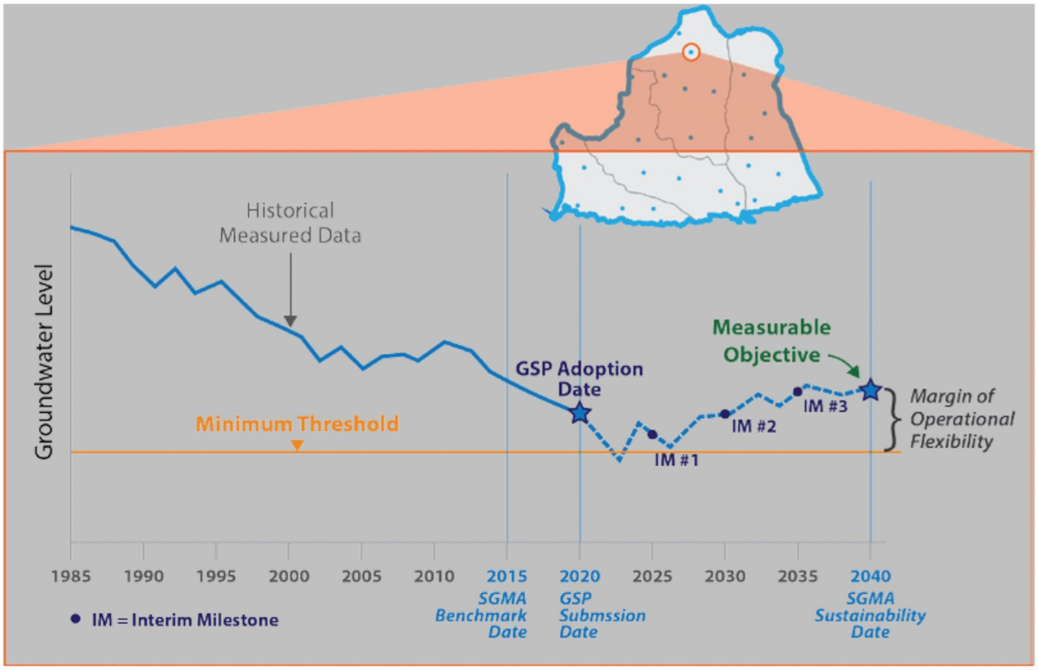


Figure 3-13: Minimum threshold, measurable objective, interim milestones, and operational flexibility at an example representative monitoring point, drawn from DWR Best Management Practices (CA-DWR, 2017).

3.3.1.3 Developed Minimum Thresholds

As discussed in **Section 3.3.1**, developed minimum thresholds for chronic lowering of groundwater levels (**Table 3-4**) are based on a consideration of analyses that find the absence of significant and unreasonable dewatering of vulnerable wells (e.g., domestic, agricultural, and public wells), depletions of ISW, impacts to GDEs, and impacts to adjacent basins. The Basin's developed minimum thresholds are expressly designed with beneficial users of groundwater in mind. They represent groundwater levels which, if reached across the entire basin would result in significant and unreasonable impacts to these beneficial users. However, the identification of Undesirable Results which occurs when 25% of monitoring wells exceeds MTs for 3 consecutive years is also designed to be conservative: analyses of impacts to beneficial users assume 100% of the Basin reaches the MT surface. Thus, the impacts actually experienced if criteria to identify Undesirable Results are observed are likely to be less severe than analyses suggest (25% versus 100% of RMPs exceeding MTs).

Importantly, some RMPs are in critical monitoring locations, but may lack historical data or perforation interval information. These data gaps will be addressed during the Plan implementation by collecting monitoring data and performing field investigations (**Section 3.5.5**); thus, the MTs presented herein (**Table 3-4**, **Figure 3-15**) may change in the five-year Plan update pending new information.

To ease interpretation and implementation, MTs are rounded to the nearest integer value.

Table 3-4: **Sustainable management criteria for groundwater level decline, storage, and ISW depletion.**

All 45 RMP wells in the network are used to track groundwater level and storage sustainability indicators, and a subset of 10 wells is used to track ISW depletion ("ISW RMP" column). For a graphical view of MOs, MTs, and IMs, see **Figure 3-4**. See **Appendix 3-B** for an RMP ID to SITE CODE key.

				Interim milestones (ft AMSL) (c)									
Well ID	MT (ft AMSL)	Date last measured	Last measured elevation (ft AMSL)	IM (2027)	IM (2032)	IM (2037)	MO (ft AMSL)	Operational flexibility (ft)	ISW RMP(d)	Depth (ft)	Perforated interval (ft)	Lng (NAD83)	Lat (NAD83)
RMP_01(a)	-3	10/8/20	-3	-2	-1	0	1	4		20	NA-NA	-121.467	38.2604
RMP_02	-29	2/10/21	-8	-18	-8	2	12	41	TRUE	334	NA-NA	-121.39	38.2939
RMP_03	-14	12/8/18	-3	-6	1	7	14	28		39.5	30-40	-121.382	38.2967
RMP_04	-46	10/16/17	-35	-36	-27	-19	-10	36	TRUE	165	NA-NA	-121.422	38.3009
RMP_05	-15	9/4/19	8	-3	8	20	31	46		43	38-43	-121.379	38.31263
RMP_06	-28	2/11/21	-11	-18	-9	0	9	37	TRUE	125	88-125	-121.474	38.327
RMP_07	-12	10/14/20	-10	-9	-7	-5	-3	9	TRUE	200	NA-NA	-121.483	38.361
RMP_08	-28	1/23/17	-24	-25	-23	-21	-19	9		200	NA-NA	-121.455	38.3728
RMP_09	-3	10/29/20	12	5	12	19	26	29		97	57-97	-121.31944	38.379167
RMP_10	-11	10/16/20	-8	-9	-8	-8	-7	4	TRUE	175	135-175	-121.495	38.4125
RMP_11	-33	2/10/21	-15	-30	-27	-25	-22	11		NA	125-250	-121.324	38.415
RMP_12	-41	11/6/19	-27	-38	-37	-35	-34	7		508	NA-NA	-121.374	38.4202
RMP_13	-37	9/27/21	-21	-32	-28	-24	-20	17		119	90-119	-121.2396	38.4322723
RMP_14	-18	10/21/20	-12	-16	-16	-15	-14	4	TRUE	170	NA-NA	-121.462	38.4343
RMP_15	-34	9/27/21	26	-17	-1	15	31	65		121.5	73-113	-121.25129	38.439918
RMP_16	-42	10/14/20	-25	-39	-37	-35	-33	9		210	NA-NA	-121.303	38.4425
RMP_17	-47	10/14/20	-30	-44	-42	-40	-38	9		300	NA-NA	-121.286	38.4532
RMP_18	5	9/27/21	8	7	8	9	10	5		111.5	70-111.5	-121.20294	38.471742
RMP_19	-23	2/10/21	-12	-21	-20	-18	-17	6		382	149-375	-121.425	38.4738
RMP_20	-17	10/15/20	-8	-14	-12	-10	-8	9		NA	130-655	-121.231	38.478
RMP_21(b)	-54	10/14/20	-41	-49	-45	-41	-37	17		340	NA-NA	-121.261	38.4798
RMP_22	14	10/15/20	37	20	25	30	35	21		135	68-135	-121.18	38.493
RMP_23	-34	9/25/21	-32	-32	-31	-30	-29	5		216	196-206	-121.31398	38.500392
RMP_24(a)	-12	10/16/20	-5	-10	-9	-8	-7	5	TRUE	172	NA-NA	-121.495	38.5021
RMP_25	4	10/14/20	11	6	8	9	10	6		130	NA-NA	-121.22	38.5038
RMP_26	-34	10/21/20	-25	-32	-30	-29	-28	6		425	132-140	-121.302	38.519
RMP_27	-50	10/7/20	-34	-45	-41	-38	-34	16		164	132-164	-121.363	38.5223
RMP_28	-21	9/27/21	-20	-18	-17	-15	-14	7		420	275-420	-121.25873	38.527911
RMP_29	-5	10/7/20	19	-3	-1	0	1	6		72	NA-NA	-121.428	38.5343
RMP_30(a)	-41	10/21/20	-13	-37	-34	-31	-29	12		236	150-231	-121.339	38.5469
RMP_31(a)	-22	1/23/18	-13	-18	-15	-12	-10	12		562	302-462	-121.259	38.5543
RMP_32(a)	-16	2/10/21	-4	-13	-10	-8	-6	10		125	63-125	-121.32401	38.558
RMP_33(a)	-5	2/18/19	7	-3	-3	-2	-1	4	TRUE	215	27-47	-121.43028	38.5637222
RMP_34(a)	-6	4/10/20	5	-4	-3	-2	-1	5		215	185-205	-121.42397	38.5671944
RMP_35(a)	-8	4/3/20	3	-6	-5	-5	-4	4		310	175-195	-121.42581	38.5679444
RMP_36(a)	68	10/14/20	74	71	72	74	75	7		675	180-200	-121.187	38.5707
RMP_37(a)	1	2/16/18	5	3	4	5	5	4	TRUE	240	200-229	-121.466	38.5784
RMP_38	15	10/7/20	26	17	18	18	19	4		85	NA-NA	-121.317	38.5849
RMP_39	99	4/8/20	106	101	103	104	105	6		NA	79-102	-121.2051	38.5889223
RMP_40	14	10/10/19	52	24	32	40	48	34		150	NA-NA	-121.248	38.5914
RMP_41	90	1/20/21	113	99	107	115	123	33		285	197-269	-121.162	38.592
RMP_42	102	4/7/20	109	105	107	109	110	8	TRUE	NA	67-72	-121.20659	38.6260795
RMP_43	198	4/8/20	204	201	203	205	206	8		NA	128-138	-121.17881	38.6358326
RMP_44	130	10/20/20	131	132	132	133	133	3		170	135-165	-121.188	38.6578
RMP_45	362	10/15/20	362	363	364	365	366	4		85	55-85	-121.117	38.6895

(a) These 8 RMPs are in critical monitoring locations, but data is only available after 2018, thus data gaps cause MTs and MOs to be set close to or at present day levels. MTs, MOs, and interim milestones (IMs) for these points are based on the best available information at these monitoring locations but are expected to change in the Plan update as more information becomes available. Moreover, most of these sites are 15-minute interval stations what will provide valuable insight into stream-aquifer interactions.

(b) The MT for this data point is based on the 2009 fall low due to a significant data gap between 2014 and 2019.

(c) When the operational flexibility, or difference between MOs and MTs is 3 feet or less, one or more IMs may be the same as MOs due to rounding of SMCs to integer values.

(d) When TRUE, this indicates the well is also used to monitor for ISW depletion in addition to groundwater level and storage sustainability indicators.

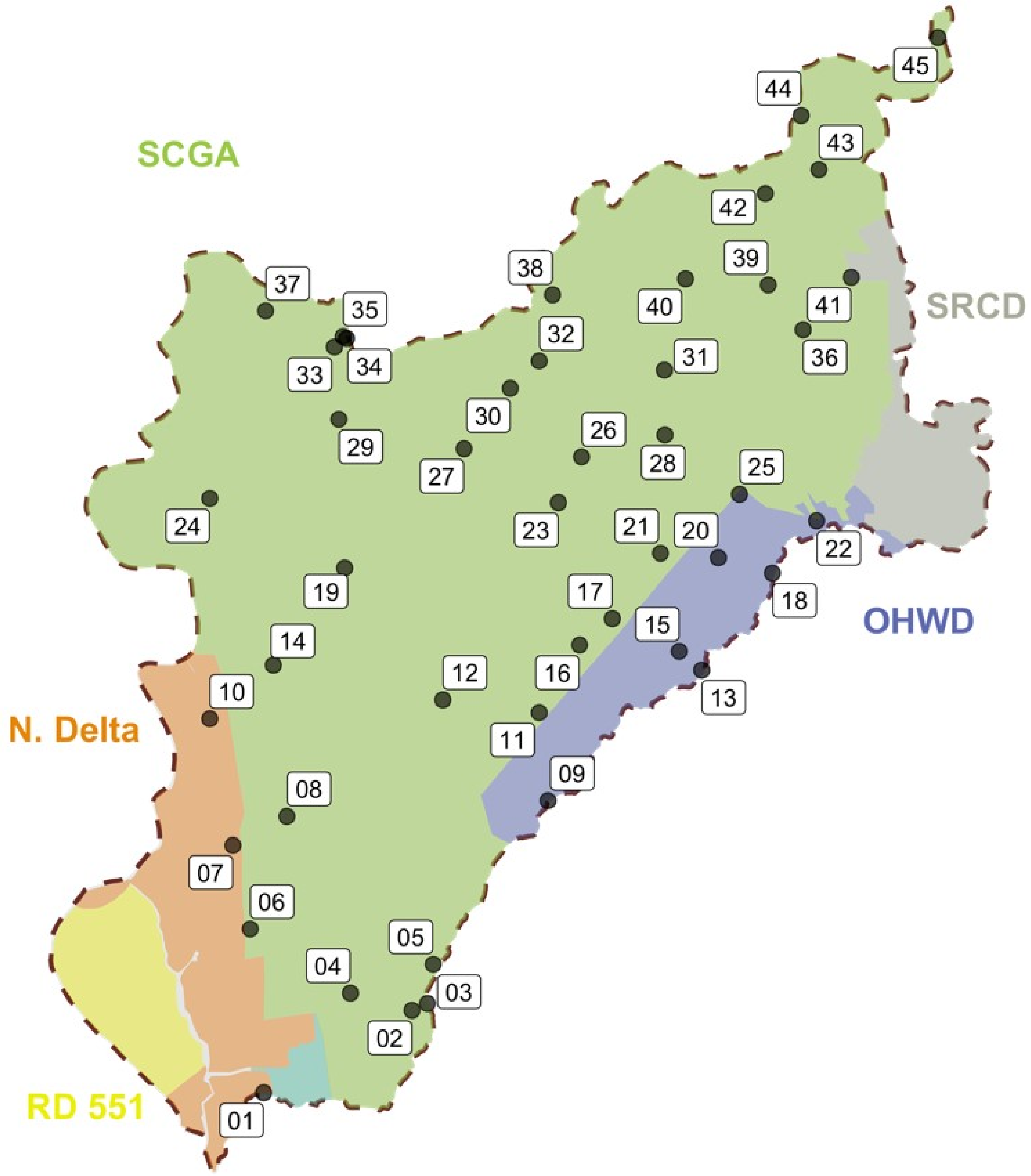


Figure 3-14: **RMP IDs from Table 3-4 are ordered from South to North to permit easy interpretation. Note that "RMP_" prefixes are removed to aid visualization.** See **Appendix 3-B** for an RMP ID to SITE CODE key.

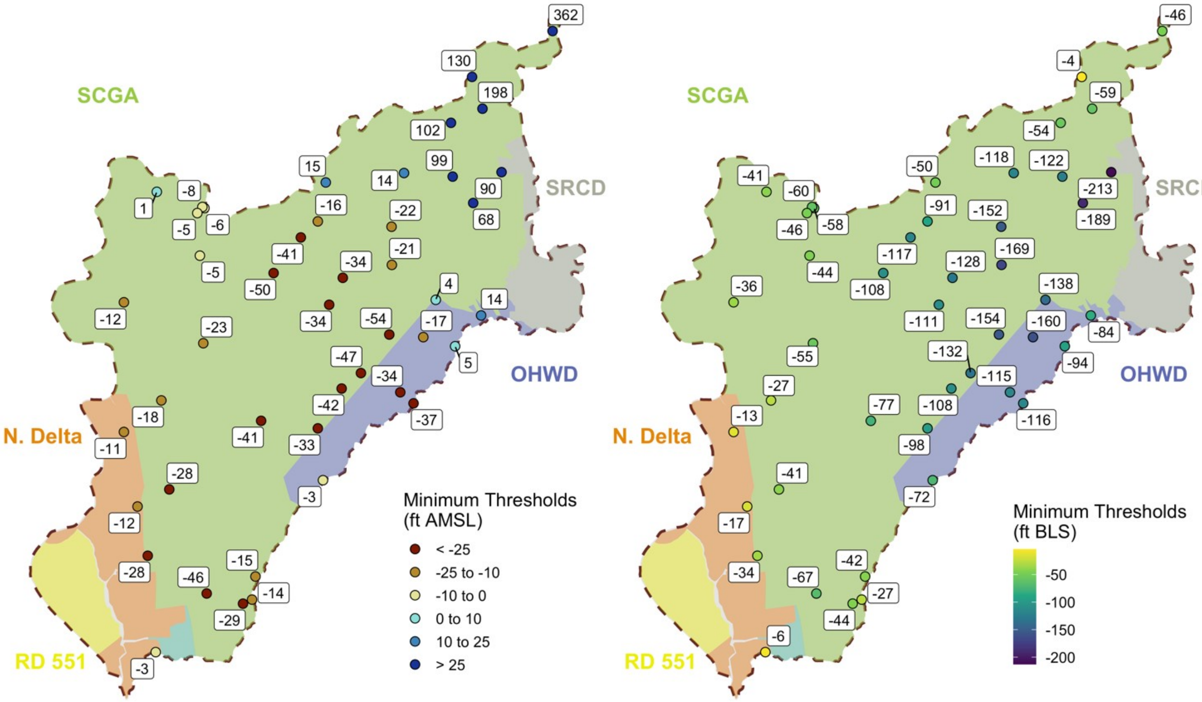


Figure 3-15: **Groundwater level and storage minimum thresholds at 45 RMPs in the Basin.**

3.3.2 Minimum Threshold for Reduction of Groundwater Storage

> *23 CCR § 354.28. Minimum Thresholds*
>
> *(c) Minimum thresholds for each sustainability indicator shall be defined as follows:*
> *(2) Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.*
> *(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.*

The minimum threshold for the reduction in groundwater storage is the rate or volume of groundwater which can be withdrawn from the Basin without leading to undesirable results. Groundwater storage change is not directly measurable. Rather, it is estimated by the CoSANA groundwater flow model, which depends on accurate groundwater levels and a robust HCM. Groundwater storage is the three-dimensional equivalent of groundwater level (two-dimensional) over a depth, and reduction of groundwater storage generally indicates (and is associated with) groundwater level decline.

Given that the MT for chronic lowering of groundwater (**Section 3.3.1**) protects beneficial uses and users of groundwater, and that groundwater level and storage are directly correlated, groundwater level MTs are used as a proxy for the reduction of groundwater storage sustainability indicator MTs.

The use of groundwater level as a proxy for the reduction of groundwater storage requires that “minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of [reduction in groundwater storage] will be prevented” according to CA-DWR Best Management Practices, (CA-DWR, 2017).

To demonstrate that SMC for the chronic lowering of groundwater level protect against significant and unreasonable reduction in groundwater storage, the change in groundwater storage under the current conditions baseline was compared to the change in storage implied under projected groundwater management and climate change scenarios (**Figure 3-16**). In three of four scenarios evaluated, the lowest basin storage experienced occurs around simulation year 2065 (a repeat of 2015 hydrology), yet at this global minimum in the storage estimate, the basin storage still exceeds the fall 2015 low. The Basin has historically avoided overdraft, and through substantial investment in conjunctive use and recharge projects, is on track to avoid overdraft during and after Plan implementation. As before only currently implemented projects are considered in these storage projections (Harvest Water, OHWD recharge, regional conjunctive use).

Because groundwater level SMC are set based on spatially distributed modeled head differences which are then applied to observed groundwater level data, the spatial un-evenness of changes in groundwater storage are captured at RMPs, and it is unlikely that the Plan’s groundwater level MTs would lead to significant and unreasonable reduction of groundwater storage. Hence, MTs for reduction of groundwater storage in the Basin are identical to those related to chronic lowering of groundwater level.

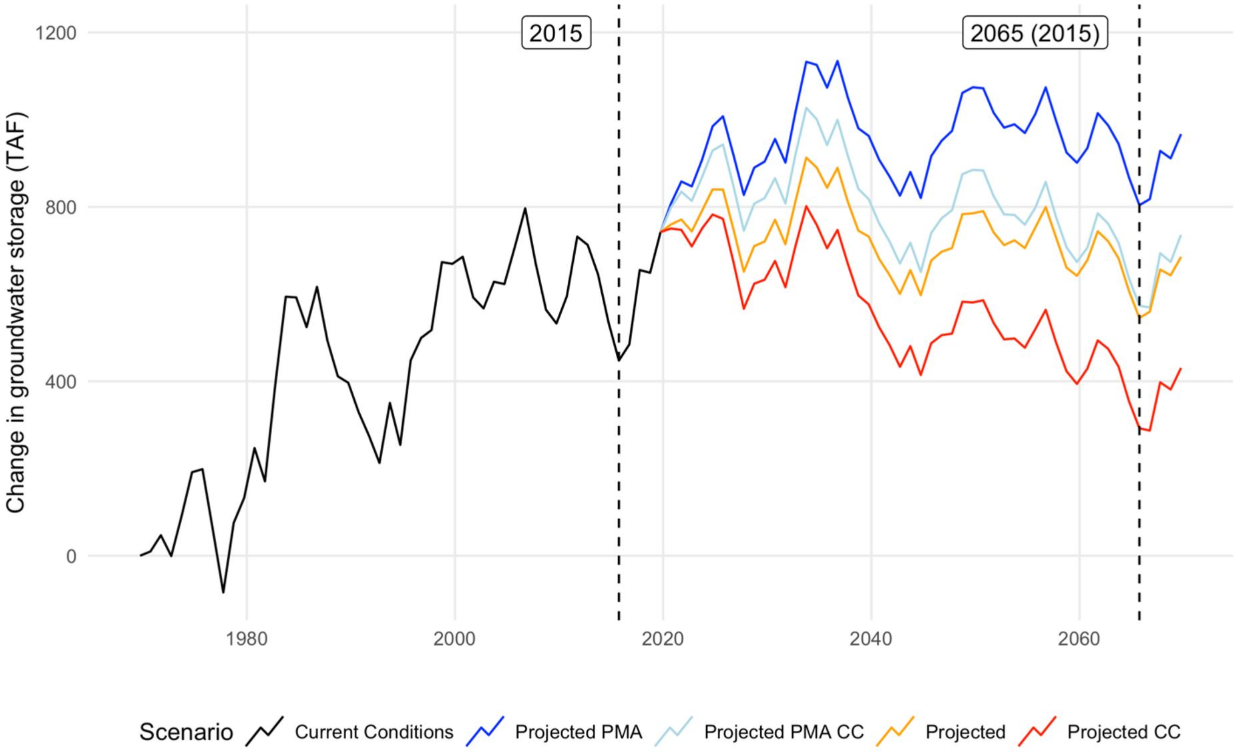


Figure 3-16: Cumulative change in groundwater storage under the current conditions baseline (black line), and the four scenarios (dark blue, light blue, orange, and red line) evaluated to aid in development of Basin SMC. Importantly, projects and management actions (PMA) increase storage, and climate change (CC) reduces storage. For consistency, all points represent September groundwater storage changes.

3.3.3 Maximum Threshold for Degraded Groundwater Quality

Because water quality degradation is typically associated with increasing, rather than decreasing concentration of constituents, the GSAs have decided to not use the term “minimum threshold” in the context of water quality, but instead use the term “maximum threshold” for the water quality sustainability indicator.

Maximum thresholds for groundwater quality in the Subbasin have been defined using existing groundwater quality data, beneficial uses of groundwater in the Subbasin, and existing pertinent water quality regulations, including water quality objectives defined under the Sacramento-San Joaquin Basin Plan, Title 22 Primary and Secondary MCLs, and consultation with the GSP Working Group members and stakeholders (see **Section 2.2.3**). As a result of this process, SMCs were developed for two of the constituents of concern in the Subbasin: nitrate and specific conductivity. The selected maximum thresholds for the concentration of each of the constituents of concern and their associated regulatory thresholds are shown in **Table 3-5**.

Significant and undesirable results are experienced if these maximum thresholds are exceeded in 10% of the monitoring wells.

Table 3-5: **Constituents of concern and the associated maximum thresholds. Maximum thresholds also include no more than 10% of wells exceeding the maximum threshold for concentration listed here.**

Constituent	Maximum Threshold	Regulatory Threshold
Nitrate as Nitrogen	5 mg/L, trigger only 9 mg/L, trigger only 10 mg/L, MT	10 mg/L (Title 22 Primary MCL)
Specific Conductivity	900 micromhos/cm, trigger only 1600 micromhos/cm, MT	900 – 1600 micromhos/cm (Title 22 SMCL)

Triggers

The GSAs will use concentrations of the identified constituents of concern (nitrate and specific conductivity) below the maximum threshold as triggers for action in order to proactively avoid the occurrence of undesirable results. Trigger values are identified for both nitrate as nitrogen and specific conductivity, as shown in **Table 3-5**. The trigger value and associated definition for specific conductivity is the 90% upper limit or 90th percentile value for a calendar year. The trigger value for nitrate is 90% of the Title 22 MCL. Approaching or exceeding a trigger will be reported to the Regional Water Board in the annual reports and the five-year evaluations to solicit their recommendations.

Information and Methodology Used to Establish Maximum Thresholds and Measurable Objectives

Two constituents of concern (nitrate and specific conductivity) were identified as such due to measured exceedances of water quality standards or water quality objectives during the past 30 years and/or stakeholder input and prevalence as a groundwater contaminant of concern in California. A detailed discussion of the concerns associated with elevated levels of each constituent of concern is described in **Section 2.2.3**. Because the constituents of concern were identified using current and historical groundwater quality data, the list may be reevaluated during future GSP updates. In establishing maximum thresholds for groundwater quality, the following information was considered:

- Feedback about water quality concerns from stakeholders.
- An assessment of available current and historical groundwater quality data from production and monitoring wells in the Subbasin.
- An assessment of historical compliance with federal and state drinking water quality standards and water quality objectives.
- An assessment of trends in groundwater quality at selected wells with adequate data to perform an assessment.

- Information regarding sources, control options, and regulatory jurisdiction pertaining to constituents of concern.
- Input from stakeholders resulting from the consideration of the above information in the form of recommendations regarding maximum thresholds and associated management actions.

The current and historical groundwater quality data used in the effort to establish groundwater quality maximum thresholds are discussed in **Section 2.2.3**. Based on a review of these data, applicable water quality regulations, Subbasin water quality needs, and information from stakeholders, the GSAs reached a determination that the state drinking water standards (MCLs/SMCLs) are appropriate to define maximum thresholds for groundwater quality (**Table 3-5**). The established maximum thresholds for groundwater quality protect and maintain groundwater quality for existing or potential beneficial uses and users. Maximum thresholds align with the state standards for nitrate and specific conductivity, and the Title 22 MCLs and SMCLs.

New constituents of concern may be added with changing conditions and as new information becomes available.

Method for Quantitative Measurement of Maximum Thresholds

Groundwater quality will be measured in representative monitoring wells as discussed in **Section 3.5**. Statistical evaluation of groundwater quality data obtained from available water quality data obtained from the monitoring network will be performed. The maximum thresholds for constituents of concern are shown in **Table 3-5** and **Figure 3-30**, which shows “rulers” for each of the two identified constituents of concern in the Subbasin with the associated maximum thresholds, measurable objectives, and triggers.

3.3.4 Minimum Threshold for Depletions of Interconnected Surface Water

Like reduction of groundwater storage, it is not possible to directly measure depletions of ISW. Rather, these depletions are estimated by the CoSANA integrated surface and groundwater flow model. Importantly, the depletion volume and rate depend on the hydraulic gradient, or relative elevation, between ISW bodies and groundwater.

As before, the use of groundwater level as a proxy for depletions of ISW requires that “minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of [depletions of ISW] will be prevented” (CA-DWR, 2017).

As detailed in **Section 3.3.1**, MTs based on the fall 2015 low groundwater level and groundwater levels based on projected use do not suggest significant and unreasonable depletions of ISW or deviations in streamflow compared to the current conditions baseline. Groundwater level MTs (**Figure 3-15 and Table 3-4**) arrest hydraulic gradients at the lower of post-2015 groundwater levels or projected low groundwater levels in the PMA CC scenario. ISW depletion rates assuming MTs are reached were evaluated and found to not appreciably differ from present day conditions (**Figure 3-12**). In fact, the lower Cosumnes River and Mokelumne

River become more gaining over time due to benefits from the Harvest Water recharge site. Morrison creek becomes more losing in all projected scenarios due to increased pumping in the Sacramento urban area, but it remains interconnected, and the reduced baseflow from surrounding areas is not considered a significant and undesirable result.

Notably, the depletion rate may temporarily increase during wet years when surface water stage increases, which increases the hydraulic gradient and drives stream seepage into groundwater. The CoSANA model captures this hydrologic response during wet year types, but for the purposes of this Plan, which concerns the deleterious impact of groundwater extraction on stream depletion, monitoring of groundwater level measurements that indicate an expanding cone of depression are prioritized. Nonetheless, to better understand complex, sub-seasonal stream-aquifer interactions, high frequency (i.e., 15-minute interval) flow gauges have been installed in reaches immediately upstream of interconnected surface waters along the southern Cosumnes River (**Figure 3-25**).

There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Subbasin.

3.3.5 Minimum Threshold for Land Subsidence

The minimum threshold for land subsidence in the Basin is set at no more than 0.1 foot [0.03 m] in any single year and a cumulative 0.5 foot [0.15 m] in any five-year period, resulting in no long-term permanent subsidence. This is set at the same magnitude of estimated error in the InSAR data (+/- 0.1 foot [0.03 m]), which is currently the only tool available for this subbasin for measuring subbasin-wide land subsidence consistently each year.

The minimum thresholds selected for land subsidence for the Basin area have been selected as a preventative measure to ensure the maintenance of current ground surface elevations and as an added safety measure for potential future impacts not currently present in the Basin and nearby basins. This avoids significant and unreasonable rates of land subsidence in the Basin, which are those that lead to a permanent subsidence of land surface elevations that impact infrastructure and agricultural production in the Basin and neighboring groundwater subbasins.

Given that the Basin is currently at the measurable objective and not expected to experience significant or unreasonable subsidence, it is not anticipated that the land subsidence minimum threshold will significantly affect any of the interests of beneficial uses and users of groundwater or land uses and property interests. However, it is possible that if the current subsidence rates steepen, that there might be an impact to groundwater pumping (e.g., wells could be physically damaged, or conservation measures enacted). However, given the specific nature of the variable aquifer geology across the Basin, it would likely be confined to a subarea of the Basin where a combination of groundwater overdraft and localized clay layers would operate together to display an inelastic subsidence signal (potentially on the west side of the Basin). However, either of these cases are not currently anticipated to coexist in the Basin at significant and unreasonable levels.

There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Basin.

Land subsidence in the Basin will be quantitatively measured by use of primarily InSAR data (DWR-funded TRE Altamira or other similar data products). If there are areas of concern for inelastic subsidence in the Basin (i.e., exceedance of minimal thresholds) observed in the InSAR data, then ground-truthing studies could be conducted to conclude if the signal is potentially related to changes in land use and agricultural practices, or from groundwater extraction. If it is determined to be resulting from groundwater extraction and is significant and unreasonable, then ground-based elevation surveys might be needed to monitor the situation more closely.

The single CGPS (Continuous Global Positioning System) station in the Basin (UNAVCO station #P274) does not show significant and unreasonable inelastic subsidence during its period of record from 2005-2020 (see **Figure 2.3-41**) The CGPS station is also on the very edge of the Basin boundary, as well as near the larger subsidence subareas within the Basin (i.e., Delta and Elk Grove subareas). The InSAR and CGPS data at the location of the CGPS station compare well with one another (see **Figure 2.3-41**), demonstrating that the InSAR data product is an adequate management tool for land subsidence in the Basin.

The minimum threshold applies to the entire Basin area.

3.4 Measurable Objectives and Interim Milestones (23 CCR § 354.30)

23 CCR § 354.30. Measurable Objectives

- *(a) Each Agency shall establish measurable objectives, including interim milestones in*
- *(b) increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.*
- *(c) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.*
- *(d) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.*
- *(e) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.*
- *(f) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.*
- *(g) Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.*
- *(h) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.*

Measurable objectives (MOs) are “specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin” (23 CCR § 351(s)). Interim milestones are “target value[s] representing measurable groundwater conditions, in increments of five years” (23 CCR § 351(q)) used to chart progress towards the Sustainability Goal quantified in the MOs.

Importantly, MOs provide a “margin of operational flexibility under adverse conditions” (23 CCR § 354.30(d)), quantified by the difference between MOs and MTs at each RMP. Operational flexibility is especially important in the Basin, as significant recharge-intensive projects and anticipated conjunctive use management actions require operational space to fill and drawn down the aquifer in wet and dry periods respectively.

Attainment of MOs not only ensures that the Basin avoids undesirable results for beneficial uses and users of groundwater, but also that the Basin is put on a long-term path of sustainable groundwater management. MOs developed herein achieve the Basin’s stated Sustainability Goal.

3.4.1 Measurable Objective and Interim Milestones for Chronic Lowering of Groundwater Levels

Like MTs (**Section 3.3.1.1**), MOs were quantified following evaluation of historical groundwater levels at RMPs. MOs were defined as the average post-2015 groundwater level at RMPs (**Figure 3-17**), which can be interpreted as the average spring and fall groundwater level over a roughly present-day period (2015-2019), which contains 1 critical year, 2 below normal years, and 2 wet years. Moreover, if the MT was reduced because projected groundwater levels (in the PMA CC scenario) show a decline, the MO was also reduced by a proportional amount. Lastly, MOs were *increased* in 8 RMPs within or nearby the Harvest Water recharge project[14], where model simulations indicate groundwater levels will increase upwards of 25 feet in the main recharge zone. Increasing MOs near the Harvest Water recharge site reflects an aspirational goal of increasing groundwater levels in the southern SASb to provide multiple benefits: higher groundwater levels to exercise this portion of the Basin, increased baseflow to streams, and improved flows in the lower reaches of the Cosumnes River, and the Mokelumne and Sacramento Rivers.

Thus, MOs are generally near present-day groundwater levels: some MOs are greater than the last-measured value at RMPs, and others are less than the last measured value. Because MOs are established based on historically observed variation in groundwater elevation at RMPs, the operational flexibility, or difference between MTs and MOs (**Table 3-4**, **Figure 3-18**) also varies per RMP based on local site-specific conditions.

Three Interim Milestones (IMs) at five-year intervals were defined by dividing the range of operational flexibility between the MO and MT at each RMP into 4 regions, such that the Basin makes linear progress towards MOs in each five-year increment. For clarity, in five years following Plan submission (2027), it is projected that the Basin will make 25% progress towards MOs; in 10 years following Plan submission (2032), it is projected that the Basin will make 50% progress; in 15 years following Plan submission (2037) it is projected that the Basin will make

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[14] The RMPs for which MOs were increased in and adjacent to the Harvest Water recharge area are: RMP_01, RMP_02, RMP_03, RMP_04, RMP_05, RMP_06, RMP_07, and RMP_08.

75% progress; and finally, in 20 years following Plan submission (2042), it is projected that the Basin will meet its long-term Sustainability Goal. Thus, the IMs in 2042 are equal to the MOs.

Importantly, the operational flexibility (difference between MT and MO) varies across sites (**Figures 3-18 and 3-21**). A small or large operational flexibility should not be misinterpreted as overly conservative or potentially damaging, but rather, based on observed groundwater elevation at that site (**Figure 3-4**). Differences in the range of groundwater elevation at a particular site are the result of hydrologic processes and geology (i.e., storage coefficient), and local water use (i.e., pumping, recharge, and other budget terms).

As before with MTs, the MOs and IMs in this Plan are rounded to the nearest integer value to ease interpretation.

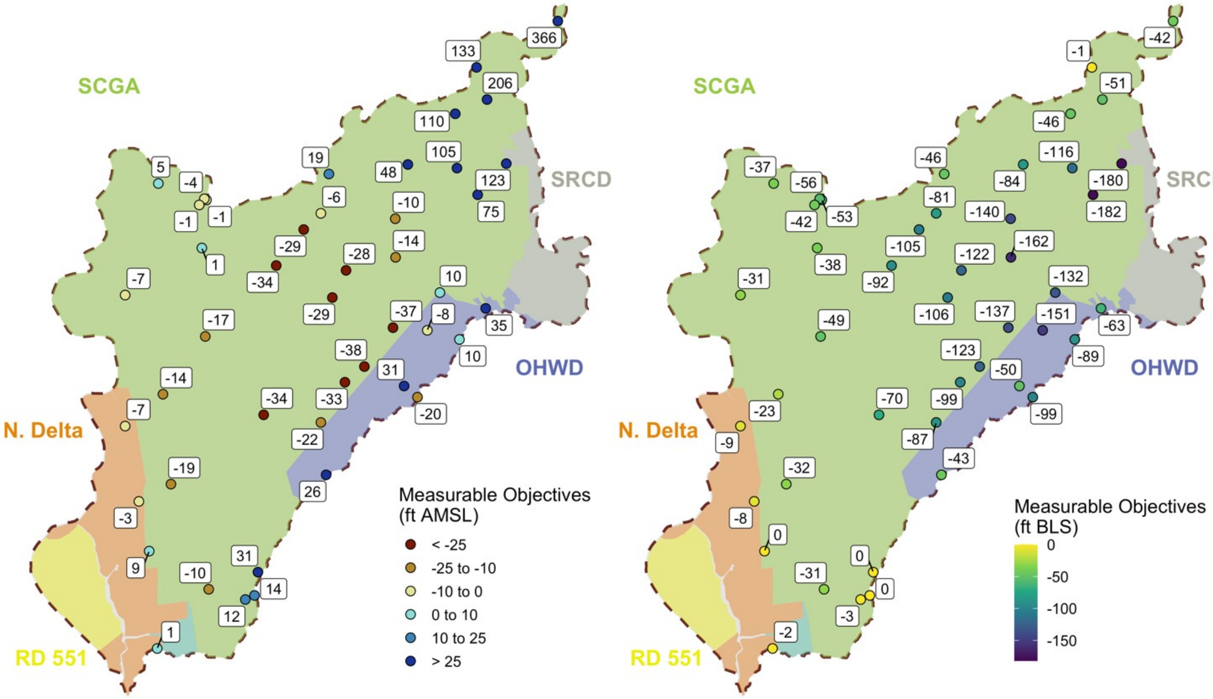


Figure 3-17: Groundwater level and storage measurable objectives at 45 RMPs in the Basin.

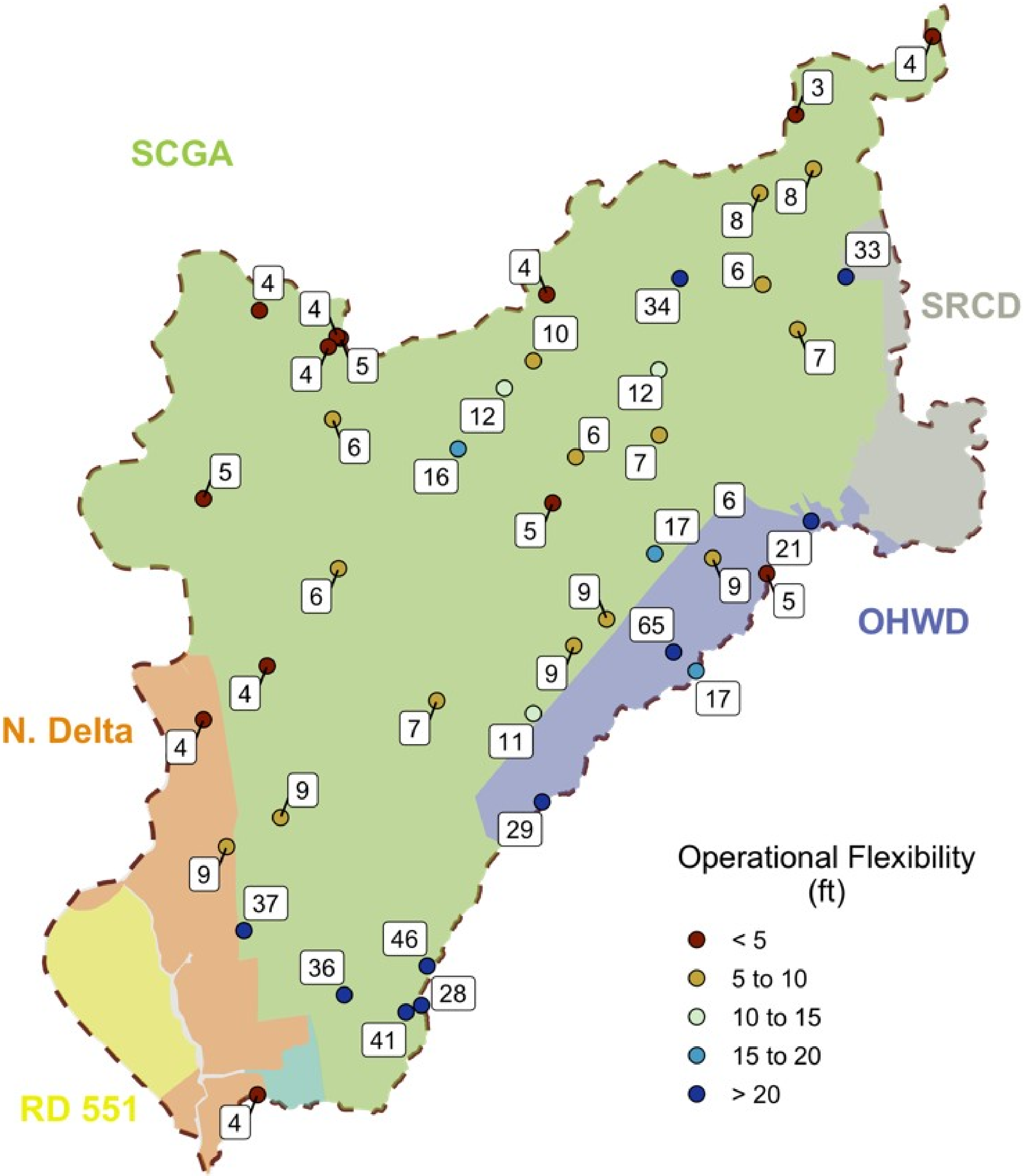


Figure 3-18: **Groundwater level and storage operational flexibility (difference between MT and MO) at 45 RMPs in the Basin.**

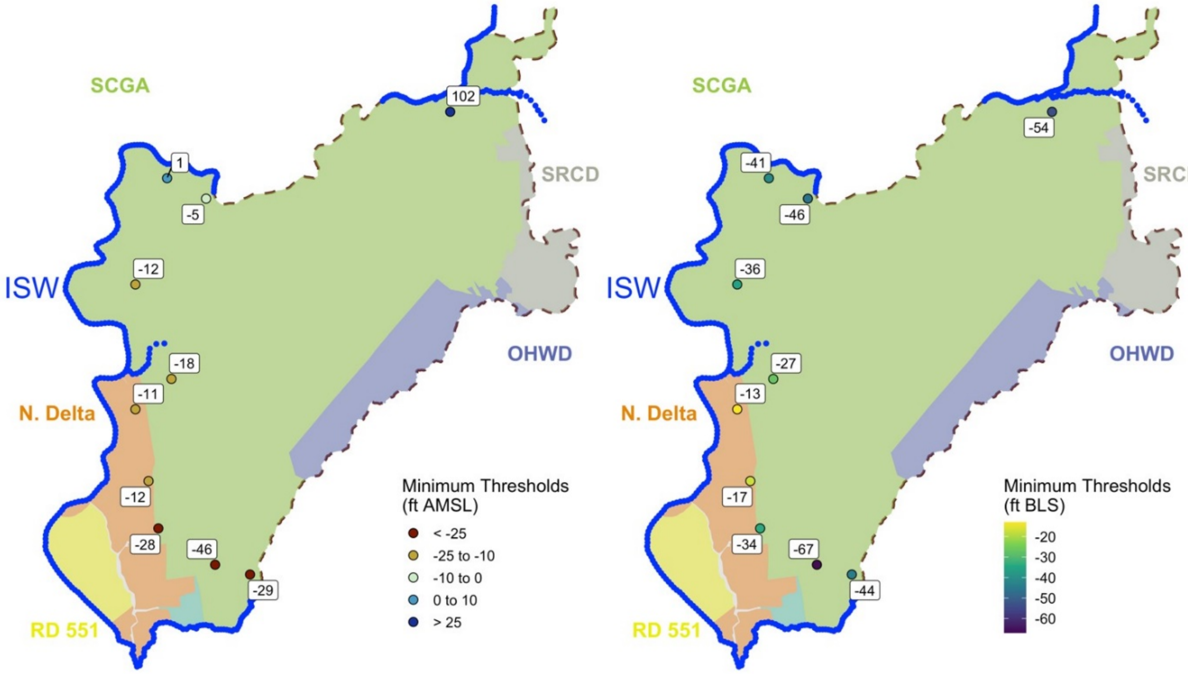


Figure 3-19: Interconnected surface water minimum thresholds at 10 RMPs in the Basin.

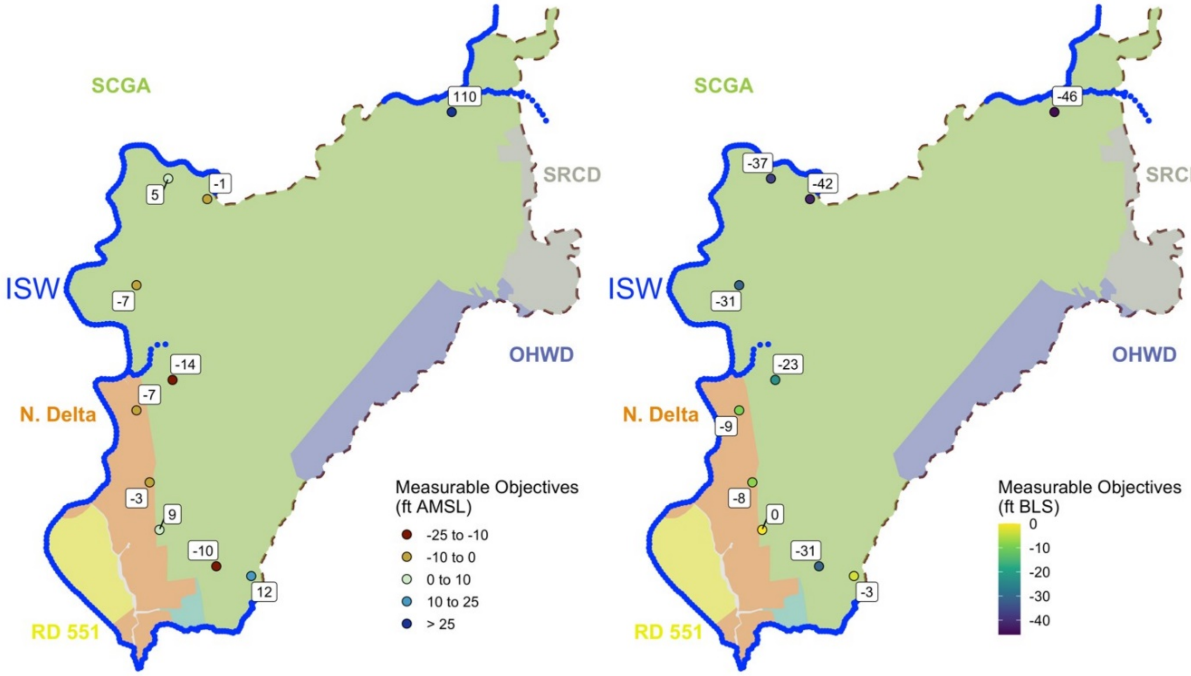


Figure 3-20: Interconnected surface water measurable objectives at 10 RMPs in the Basin.

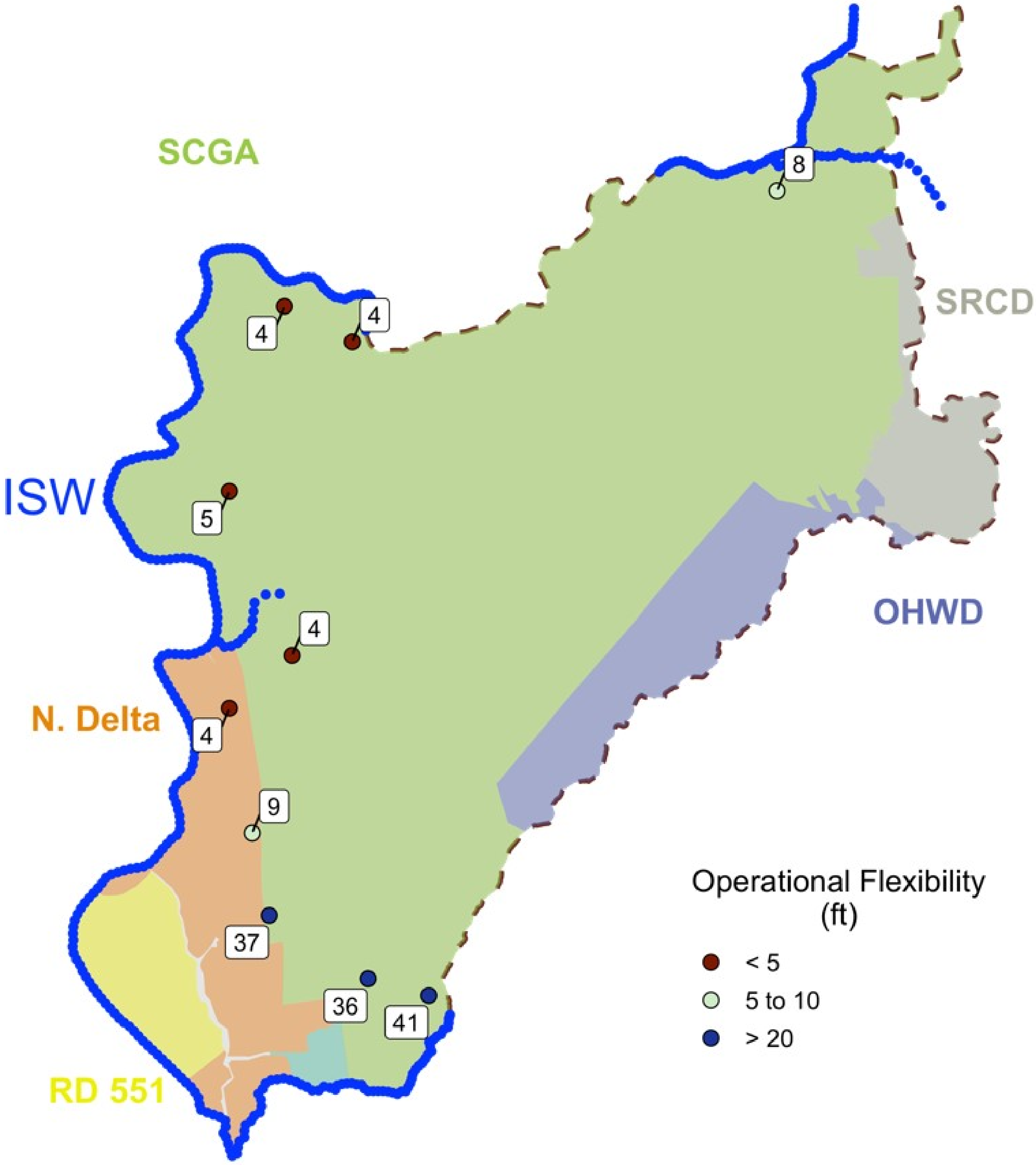


Figure 3-21: **Interconnected surface water operational flexibility (difference between MT and MO) at 10 RMPs in the Basin.**

3.4.2 Measurable Objective and Interim Milestones for Reduction of Groundwater Storage

As before with MTs, chronic lowering of groundwater levels and reduction of groundwater storage are directly correlated, and groundwater level is used as a proxy for groundwater storage (**Section 3.3.2**). Thus, MOs and IMs for reduction of groundwater storage are identical to those set for chronic lowering of groundwater levels (**Table 3-4**), and these values provide reasonable operational flexibility for the Basin.

3.4.3 Measurable Objective and Interim Milestones for Degraded Groundwater Quality

Within the Basin, the measurable objectives for water quality are established to provide an indication of desired water quality at levels that are sufficiently protective of beneficial uses and users. Measurable objectives are defined on a well-specific basis, with consideration of historical water quality data.

Description of Measurable Objectives

The groundwater quality MOs for nitrate and specific conductivity for wells within the SASb monitoring network, where the concentrations of these constituents of concern historically have been below the maximum thresholds for water quality in recent years, is to continue to maintain concentrations at or below the current range, as measured by long-term trends. For wells where the concentrations of constituents of concern have ever historically exceeded or been equal to the maximum thresholds, the measurable objective is 90% of the maximum threshold.

Specifically, for nitrate and specific conductivity, the goal will be to meet MOs in a minimum of nine groundwater quality monitoring wells in each of the aquifer layers (which corresponds to about 90% of wells monitored). In addition, no significant increase in long-term trends should be observed in levels for each of the two constituents of concern in more than one groundwater quality monitoring wells in each of the aquifer layers (i.e., approximately 10% of wells in the monitoring network). The proposed MOs for nitrogen and specific conductivity at the selected wells within the Basin are listed in **Table 3-6**.

Table 3-6: **The proposed measurable objectives for nitrogen and specific conductivity at the selected wells within the Subbasin.**

Well ID	Facility or Water System Name	Aquifer Layer	Measurable Objectives	
			Nitrogen	Specific Conductivity
3400375-001	Slavic Missionary Church Inc	Lower	5	140
3410015-020	Golden State Water Co. - Cordova	Lower	9.0*	160
3410015-022	Golden State Water Co. - Cordova	Lower	1.6	220
3410023-015	Cal Am Fruitridge Vista	Lower	1.13	570
3410029-015	SCWA - Laguna/Vineyard	Lower	0.5	420
3410029-026	SCWA - Laguna/Vineyard	Lower	0.5	190
3410029-027	SCWA - Laguna/Vineyard	Lower	0.5	172
3410704-001	SCWA Mather-Sunrise	Lower	0.5	150
L10007396297-MW-40B	Kiefer Landfill	Lower	1.9	220
S7-SAC-SA10	Unknown	Lower	1.74	272
3410020-009	City of Sacramento Main	Upper	3.77	339
3410029-002	SCWA - Laguna/Vineyard	Upper	3	310
3410029-016	SCWA - Laguna/Vineyard	Upper	1	190
3410029-029	SCWA - Laguna/Vineyard	Upper	2	296
3410033-006	Florin County Water District	Upper	7.23	340
L10005519750-MW-G(S)	Unknown	Upper	9.0*	620
L10008601447-MW-13	Elk Grove Class III Landfill	Upper	4.18	410
3400101-001	Hood Water Maintenance Dist	Upper	0.5	290
3410029-024	SCWA - Laguna/Vineyard	Upper	0.9	396
3410029-025	SCWA - Laguna/Vineyard	Upper	0.5	1060
3901216-001	Unknown	Upper	1.3	1320*

* The maximum historical value has been above the maximum thresholds, i.e., MCL or SMCL. Therefore, the MO has been set equal to 90% of the maximum thresholds.

Path to Achieve Measurable Objectives

The SASb GSAs will support the protection of groundwater quality by monitoring groundwater quality conditions and coordinating with appropriate regulatory agencies with jurisdiction to regulate groundwater quality in the Basin. All future projects and management actions implemented by the GSAs will comply with state and federal water quality standards and Basin Plan water quality objectives, and will be designed to maintain or improve groundwater quality for all uses and users and avoid causing unreasonable groundwater quality degradation. The GSAs will review and analyze groundwater quality monitoring data as part of GSP implementation in order to evaluate any changes in groundwater quality. The need for additional studies on groundwater quality will be assessed through GSP implementation.

Using monitoring data collected as part of project implementation, the GSAs will develop information (e.g., time-series plots of water quality constituents) to demonstrate that projects and management actions are operating to maintain or improve groundwater quality conditions in the Basin and to avoid unreasonable groundwater quality degradation. Should the concentration of a constituent of interest meet or exceed its maximum threshold as the result of GSA project implementation, the GSA will implement measures to address such an occurrence. This process is illustrated in **Figure 3-31**.

Exceedances of the maximum threshold for specific conductivity and nitrate will be referred to the CVRWQCB. Where the cause of an exceedance is unknown, the GSAs may choose to conduct additional or more frequent monitoring.

Interim Milestones

As existing groundwater quality data indicate that groundwater in the Basin generally meets applicable state and federal water quality standards for nitrate and specific conductivity, the objective is to maintain existing groundwater quality. Interim milestones are therefore set to maintain groundwater quality equivalent to the measurable objectives established for nitrate and specific conductivity, with the goal of maintaining water quality within the historical range of values.

3.4.4 Measurable Objective and Interim Milestones for Depletions of Interconnected Surface Water

As before with MTs, chronic lowering of groundwater levels and depletions of ISW are interrelated in that reductions in groundwater elevation in the Basin that increase the hydraulic gradient between ISW bodies and groundwater also lead to increased stream depletion. Arresting groundwater level decline and maintaining groundwater levels above MTs ensures that ISW depletion volumes will not lead to significant and unreasonable outcomes for beneficial users of ISW (**Section 3.2.4**). Wells were carefully chosen to detect gradient changes associated with a potential expanding cone of depression to ISW depletion, and scenario analysis of ISW reach length, streamflow, and seepage at projected groundwater level thresholds was conducted to relate groundwater level conditions to ISW conditions. Groundwater level is thus used as a proxy for ISW depletion and MOs and IMs for reduction of stream depletion are identical to those set for chronic lowering of groundwater levels (**Table 3-4**). These values provide reasonable operational flexibility for the Basin. The MTs, MOs, and IMs for ISW depletion are measured at a subset (10 wells) of the groundwater level and storage monitoring network (**Figure 3-12** to **Figure 3-14**).

3.4.5 Measurable Objective and Interim Milestones for Land Subsidence

Land subsidence is not known to be significant in the SASb. Previous efforts to quantify land subsidence in the Basin have yielded results showing minor amounts of subsidence having occurred in the Basin. Such efforts have mainly been through leveling profiles studied between 1947 and 1966, a 2008 DWR- and the US Bureau of Reclamation-authorized subsidence project throughout the Sacramento Valley using GPS technology (Frame Surveying & Mapping, 2008), and DWR's Sacramento Valley 2017 GPS Survey program, all of which demonstrated that subsidence has been very minimal across the Basin.

Recent InSAR data provided by DWR (TRE Altamira) show no significant or unreasonable subsidence occurring during the period of June 2015 to September 2019 (**Figure 2.3-40**). Small fluctuations observed in these datasets are mainly in two areas: 1.) the Sacramento-San Joaquin Delta area, and 2.) the Elk Grove area. The Delta area of the Basin is likely affiliated with subsurface organic deposit dynamics (CA-DWR, 1995). The Elk Grove area signal is likely connected to small declines of groundwater levels historically present in this area (SCGA, 2016).

The specific geology of the geologically older alluvial aquifer materials comprising the east side of the Basin is not known to contain the thicker clay confining units that typically exhibit inelastic subsidence due to excessive groundwater pumping (i.e., overdraft conditions). While the west side of the Basin contains more fine-grained materials susceptible to inelastic subsidence than the east side, it is more of a cause for awareness than concern for future subsidence impacts to infrastructure in the Basin.

The guiding MO of this GSP for land subsidence in the Basin is the maintenance of current ground surface elevations. This measurable objective avoids significant and unreasonable rates of land subsidence in the Basin, which are those that lead to a permanent subsidence of land surface elevations that impact infrastructure and agricultural production. As this subsidence measurable objective is essentially already met, the specific goal is to maintain this level of land subsidence (i.e., essentially at a similar magnitude to the InSAR data error) throughout the implementation period.

Land subsidence in the Basin is expected to be maintained throughout the implementation period via the sustainable management of groundwater pumping through the groundwater level measurable objectives, minimum thresholds, and interim milestones, as well as the fact that the aquifer geology is not very likely to be susceptible to significant and unreasonable subsidence, even under groundwater overdraft conditions.

The margin of safety for the subsidence MO was established by setting a MO to maintain current surface elevations and opting to monitor subsidence throughout the implementation period, even though there is no historical record of significant and unreasonable subsidence and a major portion of the aquifer is not deemed to be likely to succumb to inelastic subsidence. This is a reasonable margin of safety based on the past and current aquifer conditions and is more reasonable to the alternative action of simply setting the subsidence indicator as 'not applicable' in the Basin due to current and documented historical evidence.

As the current MO is set to maintain the present land surface elevations of the Basin, the interim milestones are set as check-in opportunities to review year-to-year subsidence rates from the previous five-year period to assess whether there are longer-period subsidence trends than what is observed in the annual reviews. The MOs and associated IMs apply to the entire Basin area.

3.5 Monitoring Network

23 CCR § 354.34(d)-(j):

> *(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.*
> *(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.*
> *(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:*
> *(1) Amount of current and projected groundwater use.*
> *(2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.*
> *(3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.*
> *(4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.*
> *(g) Each Plan shall describe the following information about the monitoring network:*
> *(1) Scientific rationale for the monitoring site selection process.*
> *(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.*
> *(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.*
> *(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.*
> *(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.*
> *(j) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.*

3.5.1 Description of Monitoring Network (23 CCR § 354.34)

Monitoring is fundamental to measure progress towards Plan management goals. The GSP monitoring network will characterize groundwater and surface water conditions in the Basin and evaluate hydrologic changes that occur during Plan implementation. This section explains the approach to develop the monitoring network for groundwater, storage, and the interconnection of surface water and groundwater, such that the network provides sufficient temporal frequency and spatial density to evaluate the effectiveness of the Plan.

Monitoring network data is used to evaluate impacts to beneficial uses and users of groundwater, monitor changes in groundwater conditions relative to sustainable management criteria (MOs, MTs, and IMs), and quantify annual changes in water budget components. Data from the network also provides an ongoing record for future assessments of groundwater conditions and informs adaptive management on the path to sustainability, thereby protecting against the Undesirable Results linked to, for example, the decline of groundwater level or the deterioration of groundwater quality. Ongoing monitoring during the plan implementation phase minimizes risk for exceeding maximum water quality thresholds and supports the GSAs in implementing timely projects and management actions.

The scientific rationale for assembling the GSP monitoring network for each sustainability indicator is based on a three-step approach (**Figure 3-22**). First, all existing wells in the Basin were reviewed. Second, a subset of these wells was selected based on selection criteria including well location, monitoring history, and well construction information. “Selected” wells were presented to the working group and subjected to a second set of selection criteria including site access. “Selected” wells with adequate site access are considered “Confirmed” monitoring points. “Confirmed” wells are the representative monitoring points at which SMC are defined (**Table 3-4**). These points are strategically selected to maximize lateral and vertical coverage, ensure historical and present-day data, and secure reliable site access during plan implementation.

Figure 3-22: General framework for monitoring site selection (Section 3.5).
To assess monitoring well suitability, all existing wells were reviewed according to selection criteria. Selected wells were then subjected to a second set of screening criteria including site access considerations. Wells that meet selection criteria and site access considerations are considered “Confirmed” and are present in the GSP monitoring network.

The criteria (well location, monitoring history, well information, well access) used to confirm wells is discussed below:

Well Location

Strategic siting and design of a well network is important to ensure adequate spatial distribution, coverage, and well density. The well network must not only be laterally expansive but also span the vertical dimension and capture different depths of the principal aquifer that require monitoring. Beyond capturing general hydrologic trends, it is especially important to monitor areas within or adjacent to planned GSP projects and management actions at the appropriate temporal frequency, and areas where existing or legacy operations may threaten groundwater quality for beneficial uses and users. Where monitoring wells are not present, statistical methods are used to aid in extrapolating data from existing monitoring sites to the entire Basin.

Monitoring History

Wells with a long historical record provide valuable insight into trends and baseline conditions. Thus, candidate wells with current data, but also a historical record dating prior to 2005 were prioritized as monitoring candidates. Moreover, candidate wells with near present-day measurements were also prioritized.

Well Information

Beyond well location information and reliable site access, well construction information including well depth and depth of screened interval(s) are essential to interpret monitoring results and to ensure adequate vertical monitoring coverage of the principal aquifer. At a minimum, selected wells should have well depth information. Although perforation interval is not present for each well in the “Confirmed” monitoring network, it was essential to include these wells to provide adequate lateral coverage. Data gaps will be addressed in future field work during the GSP implementation period.

Well Access

Most monitoring wells in the Basin are on private land. The ability to access wells to collect data is a limiting factor in a successful monitoring network; thus, local agencies that collect monitoring data were consulted to confirm candidate wells with reliable site access.

3.5.2 Monitoring networks in the Basin

Based on the Basin’s historical and present-day conditions (**Section 2.3**), the groundwater level and storage, groundwater quality, and ISW are the main sustainability indicators to be monitored to evaluate progress towards the Basin’s sustainability goal. Land subsidence and seawater intrusion were not found in the Basin and thus do not have monitoring networks (23 CCR § 354.34(j)).

A general overview of the monitoring network associated with each of these sustainability indicators is discussed below. Additional network details are provided in each sustainability indicator’s subsection.

Groundwater level is used as a proxy for reduction in storage and ISW depletion, thus the monitoring networks for level, storage, and ISW are complimentary; of the 45 wells in the level and storage network, 10 of those wells are in the ISW monitoring network. The water quality monitoring network is separate from the network for groundwater level, storage and ISW depletion. Each monitoring network is described below in greater detail.

Groundwater Elevation Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:*
>
> *(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.*
>
> *(B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.*

The groundwater elevation monitoring network is designed to demonstrate groundwater occurrence, level, flow directions, and hydraulic gradients between the principal aquifer and surface water features.

The initial list of groundwater level monitoring wells included 167 monitoring wells from:

- Department of Water Resources (DWR)
- Omochumne-Hartnell Water District (OHWD)
- University of California Davis (UCD)
- Sacramento State University (CSUS)
- Sacramento County
- Bureau of Reclamation
- Sacramento Central Groundwater Authority (SCGA)
- Historical calibration data in regional hydrologic models (SVSIM and SacIWRM)
- Aerojet

Next, these data were narrowed down by considering the following criteria:

- At least depth or perforated interval are present, preferably both;
- Measured water level data are available at least through 2019 (this criterion was relaxed in locations where spatial coverage is lacking);
- A preference is given to wells with data prior to 2005; and
- The well has at least five historical measurements.

Annual pumping in the Basin exceeds 10,000 acre-feet/year per 100 square miles, and thus, DWR Best Management Practices (CA-DWR, 2017) and Sophocleous (1983) suggest a density of 4 monitoring wells per 100 square miles to collect representative measurements. The surface area of the SASb is 388 square miles, which suggests a need for at least 16 monitoring wells and a lateral coverage of 24.25 square miles per well. The groundwater elevation monitoring network (**Figure 3-23**) uses 45 monitoring wells and covers 92% of the Basin area according to spatial coverage estimates by Sophocleous (1983).

The Basin has one principal aquifer with most groundwater production occurring in the middle Laguna and Mehrten formations (**Section 2-2**). The monitoring network spans these formations (**Figure 3-24**) and provides adequate vertical coverage across unconfined, semiconfined, and confined systems. Importantly, monitoring well density is appropriate to extrapolate seasonal groundwater elevation maps to support the shallow well protection analysis, GDE impact analysis, and to monitor seasonal changes in hydraulic gradients that indicate changes in ISW depletion.

Monitoring frequency (**Figure 3-25**) is important to characterize groundwater and surface water dynamics. All wells will collect at least biannual measurements in spring (mid-March) and fall (mid-October) in line with DWR Best Management Practices (CA-DWR, 2017). Wells in or adjacent to the Harvest Water Recharge management zone will collect monthly measurements. All well IDs with the prefix “ACR”, “MW” and “SS” are within the vicinity of the Cosumnes and Sacramento Rivers and will collect high-frequency 15-minute interval data to improve understanding of stream-aquifer interactions. Specifically, these measurements will be paired with high-frequency 15-minute interval stream gauge data at two locations along the Cosumnes River to improve understanding in this important ecosystem.

Monitoring standards and conventions are consistent with 23 CCR § 352.4, which outline data and reporting standards for groundwater level measurements.

Groundwater Storage Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.*

Groundwater level is used as a proxy for groundwater storage (**Section 3.3.2**), thus the groundwater storage monitoring network is identical to the network for groundwater level. Observations obtained at the groundwater level monitoring network will directly inform integrated surface and groundwater modeling in the Basin as model calibration targets.

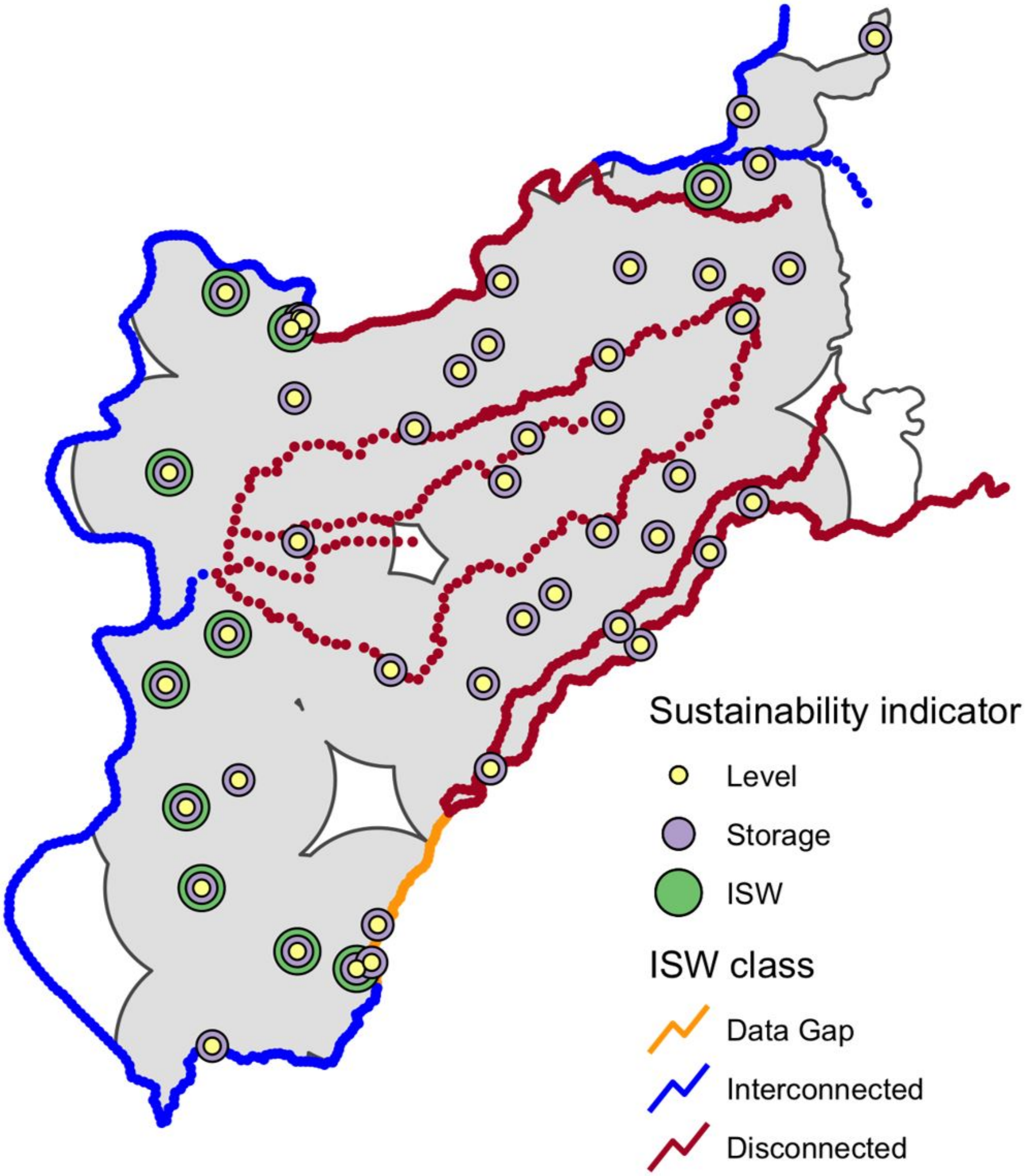
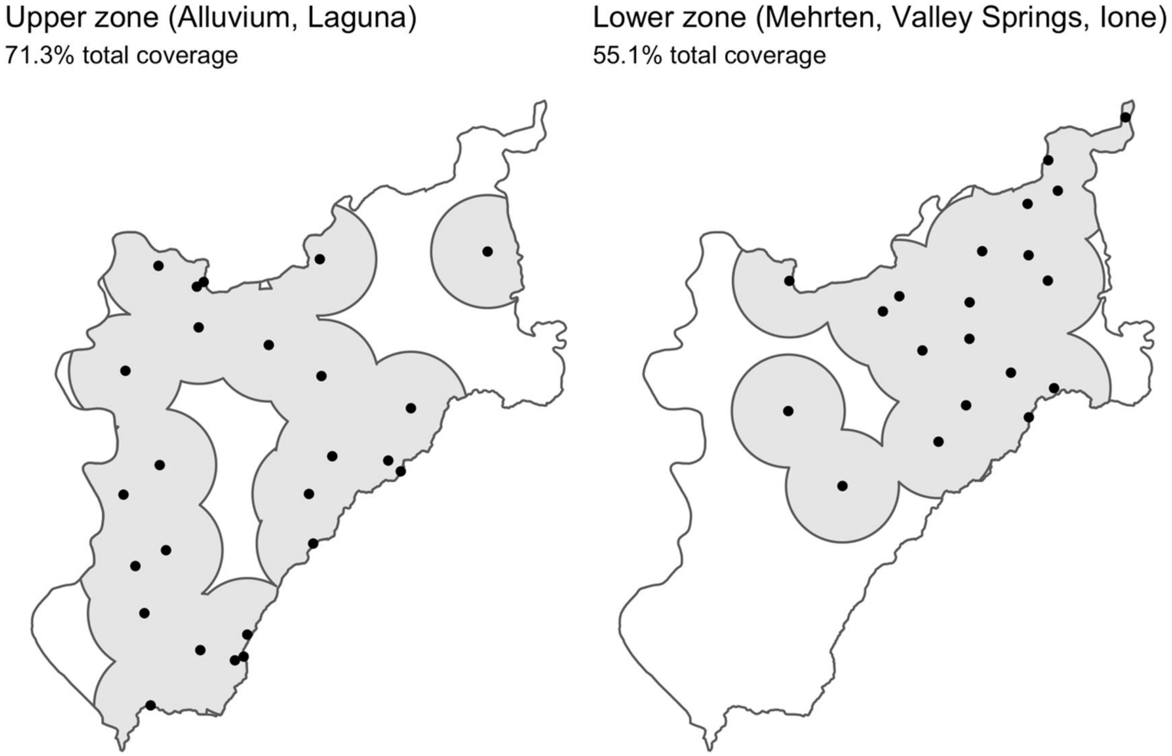


Figure 3-23: Monitoring network for groundwater level, storage, and ISW depletion sustainability indicators.
Network density is depicted with grey, circular 24.25 square mile buffers around each monitoring point that are joined to show the 92% lateral coverage of the network.



Upper zone (Alluvium, Laguna)
71.3% total coverage

Lower zone (Mehrten, Valley Springs, Ione)
55.1% total coverage

Figure 3-24: Density of monitoring locations in the upper and lower zone of the principal aquifer. Depth to groundwater increases in the north and northwest of the Basin, as does density of deeper monitoring wells. Major water bearing production formations are the Laguna and Mehrten. Circular 24.25 square mile buffers are shown in grey around each monitoring point and joined to show the lateral coverage of the network.

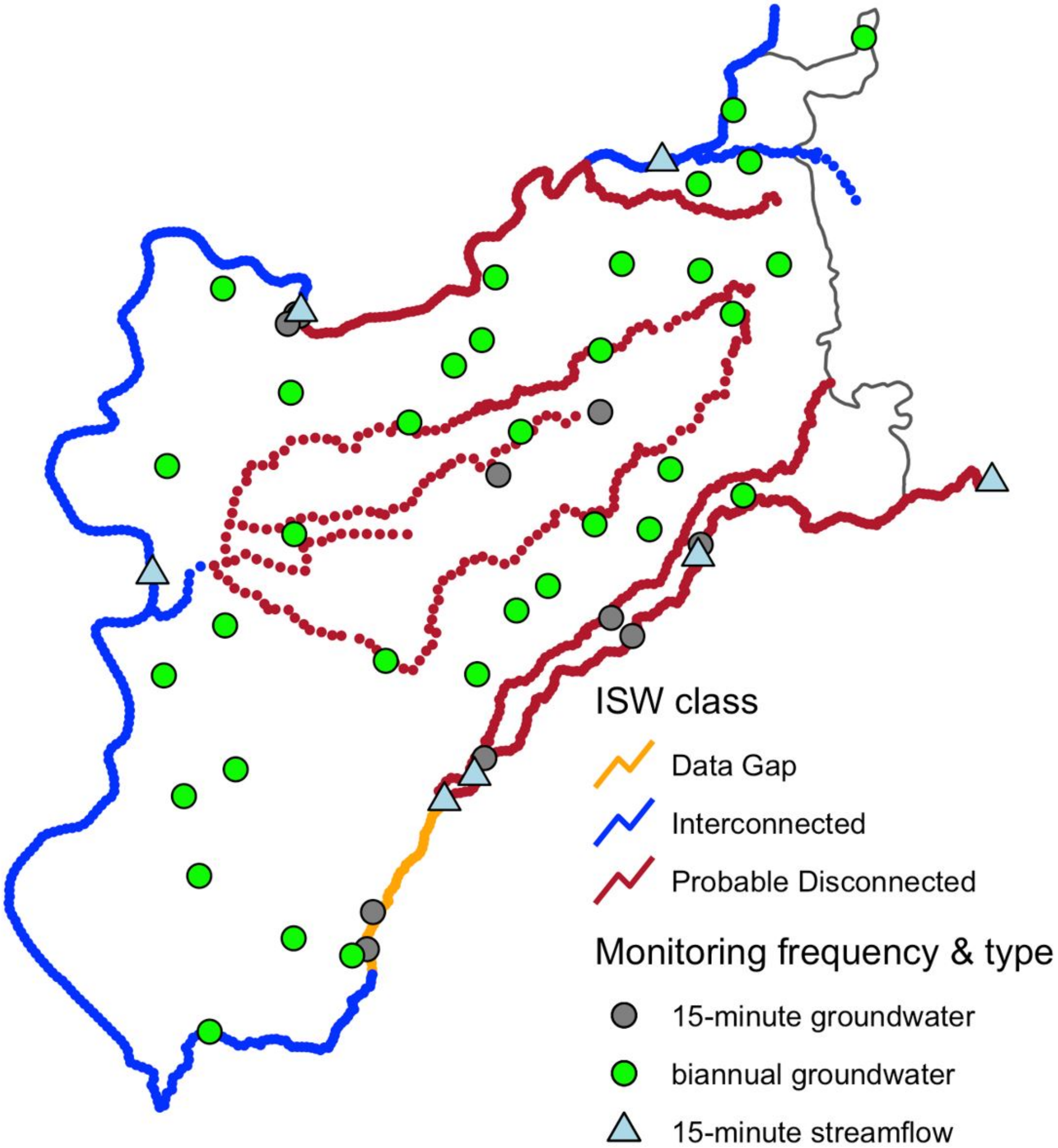


Figure 3-25: **Monitoring frequency for representative monitoring points in the network for level, storage, and ISW depletion.**
Streamflow locations are a combination of USGS (Michigan Bar, Fair Oaks, Freeport), NOAA (H Street, McConnell), and LWA-installed (ACR_181, ACR_189) gauging stations.

Groundwater Quality Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.*

The objective of the groundwater quality monitoring network design is to capture sufficient spatial and temporal detail to understand groundwater quality in the Basin. The data from the network will provide an ongoing water quality record for future assessments of groundwater quality. The spatial and temporal coverage of the groundwater quality monitoring network will be designed to allow the GSAs to take an effective and efficient adaptive management approach in protecting groundwater quality, to minimize the risk for exceeding *maximum* water quality thresholds,[15] to support the GSAs in implementing timely projects and actions, and ultimately, to contribute to compliance with water quality objectives throughout the Basin.

Apart from groundwater quality problems associated with four contamination sites (Aerojet-General Corporation, Mather AFB, Union Pacific, and Inactive Rancho Cordova Test Site), the Basin currently maintains very good groundwater quality, as described in **Section 2.3.4**. Existing wells used for monitoring groundwater quality in the Basin include public water supply wells and monitoring wells at groundwater contamination sites. Coordination will be conducted between existing monitoring programs and the GSA to develop an agreement for data collection responsibilities, monitoring protocols, and data reporting. Wells in existing programs are almost exclusively located within and near the urban areas of the Basin.

Groundwater quality monitoring in the Basin in support of the GSP will rely largely on existing wells used for monitoring groundwater quality in the monitoring network. Groundwater quality samples will be collected and analyzed in accordance with the monitoring protocols outlined in **Section 3.5.3.2**. The monitoring network will use information from existing programs in the Basin that already monitor for specific constituents of concern, and from other programs where these constituents could be added as part of routine monitoring efforts in support of the GSP. New wells will only be incorporated into the network as necessary to obtain information that will fill spatial gaps in data gathered at existing wells.

The existing network will be augmented with additional wells within Regional San's Harvest Water Project (explained in **Section 4**) area that covers agricultural lands in the southern portions of the Basin. These wells will be suitably located to obtain representative spatial coverage and understanding of groundwater quality in the Basin to enable adequate spatial coverage (distribution and density) to characterize groundwater quality conditions at a local and basin-wide scale for all beneficial uses.

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[15] In the context of water quality sustainability indicator, the term "maximum threshold" is used instead of "minimum threshold".

As many of the wells in the Basin are used for public water supply, an extensive record of water quality data is available for most wells. Using the geographic location and screen elevation information of the municipal or monitoring wells with historical groundwater quality records, an initial list of existing wells with groundwater quality measurements was created for inclusion in the monitoring network. Water quality monitoring well locations and depths were intersected with the three-dimensional COSANA texture model (**Section 2.2.1**) to determine the geologic formations monitored by each well. Geologic formations were assigned to each well by aligning the depth ranges occupied by the formation and the screened interval or depth of the monitoring well at each well location. When present, the screened interval of the monitoring well was used to assign geologic formation; otherwise, the depth of the well was used. Two of the wells did not have depth or screened interval information. These data gaps will be addressed by sending cameras down the well casing as part of the GSP implementation activities.

The initial list of groundwater quality monitoring wells was created using data downloaded from the GAMA Groundwater Information System Data Download.[16] Data were downloaded for Sacramento County on May 22, 2020, and includes groundwater quality data from the following sources:

- Department of Pesticide Regulation (DPR)
- Department of Water Resources (DWR)
- Lawrence Livermore National Laboratory
- State and Regional Water Board Regulatory (Electronic Deliverable Format (EDS) and Irrigated Agricultural Land Waiver (AGLAND))
- State Water Board, GAMA Program water quality data (GAMA, USGS)
- State Water Board, Division of Drinking Water public supply well water quality (DOW)
- U.S. Geological Survey (USGS)

Additional data were obtained directly from GEI Consultants, Inc., which developed the Subbasin's 2016 Alternative Plan.

Evaluating these data, the initial list of groundwater quality monitoring wells includes 157 wells with historical data for both nitrogen and total dissolved solids (TDS) measurements screened within either of the aquifer layers. To narrow down the number of wells, the following criteria were considered:

- Both nitrogen and TDS are measured at the same well;

- Measured water quality data are available at least through 2018 (this criterion was relaxed especially in the lower aquifer to provide a better spatial coverage); and

- The well has at least five historical measurements.

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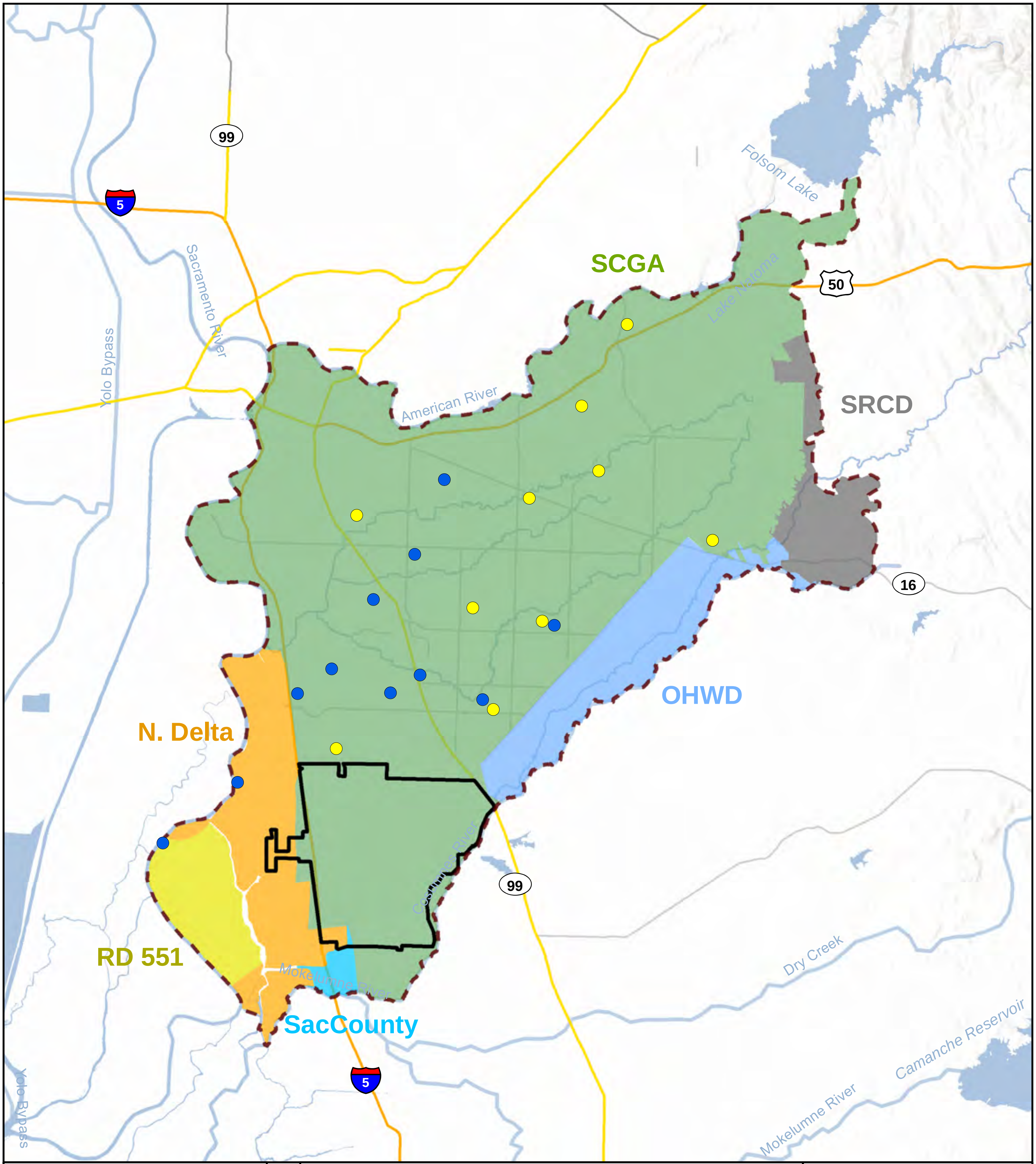
[16] http://geotracker.waterboards.ca.gov/gama/datadownload

A total of 64 wells met these criteria as listed in Table A-1 in **Appendix 3-E** along with the name of their corresponding facility or water system, and the GSA within which the well is located. This list was further narrowed down to avoid inclusion of redundant monitoring wells that are within the proximity of each other. As shown in **Figure 3-26**, the final proposed groundwater monitoring network includes 11 wells screened within the upper aquifer layer (**Table 3-7**) and 10 monitoring wells screened through the lower aquifer layer (**Table 3-8**). The GSA within which each well is located will potentially be responsible for collection and management of the monitoring data during GSP implementation. While there is no definitive rule for the appropriate density of groundwater monitoring points needed in a basin, Hopkins (1984) incorporates a relative well density based on the degree of groundwater use within a given area and suggests that basins pumping more than 10,000 acre-feet per year must have at least four monitoring wells per 100-square miles. This would suggest that each well roughly covers an area occupying 25-square miles. Using this well-density assumption, wells screened within the upper and lower layers of the aquifer would cover approximately 36% (**Figure 3-27**) and 47% (**Figure 3-28**) of the Basin area, respectively. These wells provide a good coverage of mainly central portions of the Basin. As mentioned earlier, coordination will be conducted with Aerojet to add at least one of their wells to the monitoring network. Furthermore, Harvest Water Project, which covers approximately 10% of the Basin area in the southwest, plans to monitor groundwater quality within its project area. The GSA plans to coordinate with the Harvest Water Project to include two additional monitoring wells within their project area. The northwestern portions of the Basin covers urban areas of the City of Sacramento with no issues related to nitrogen or TDS concentrations. Therefore, monitoring concentrations of these constituents within the northern portions of the Basin is not necessary.



South American Subbasin GSP

Proposed Water Quality Monitoring Network

Figure 3-26

Legend

- ● Lower Layer GWQ Monitoring Points
- ● Upper Layer GWQ Monitoring Points
- ▭ Harvest Water
- ▭ South American Subbasin

GSA

- 🟧 N. Delta
- 🟦 OHWD
- 🟨 RD 551
- 🟩 SCGA
- ⬛ SRCD
- 🟦 SacCounty

0 1.25 2.5 5
Miles

N

South American SUBBASIN

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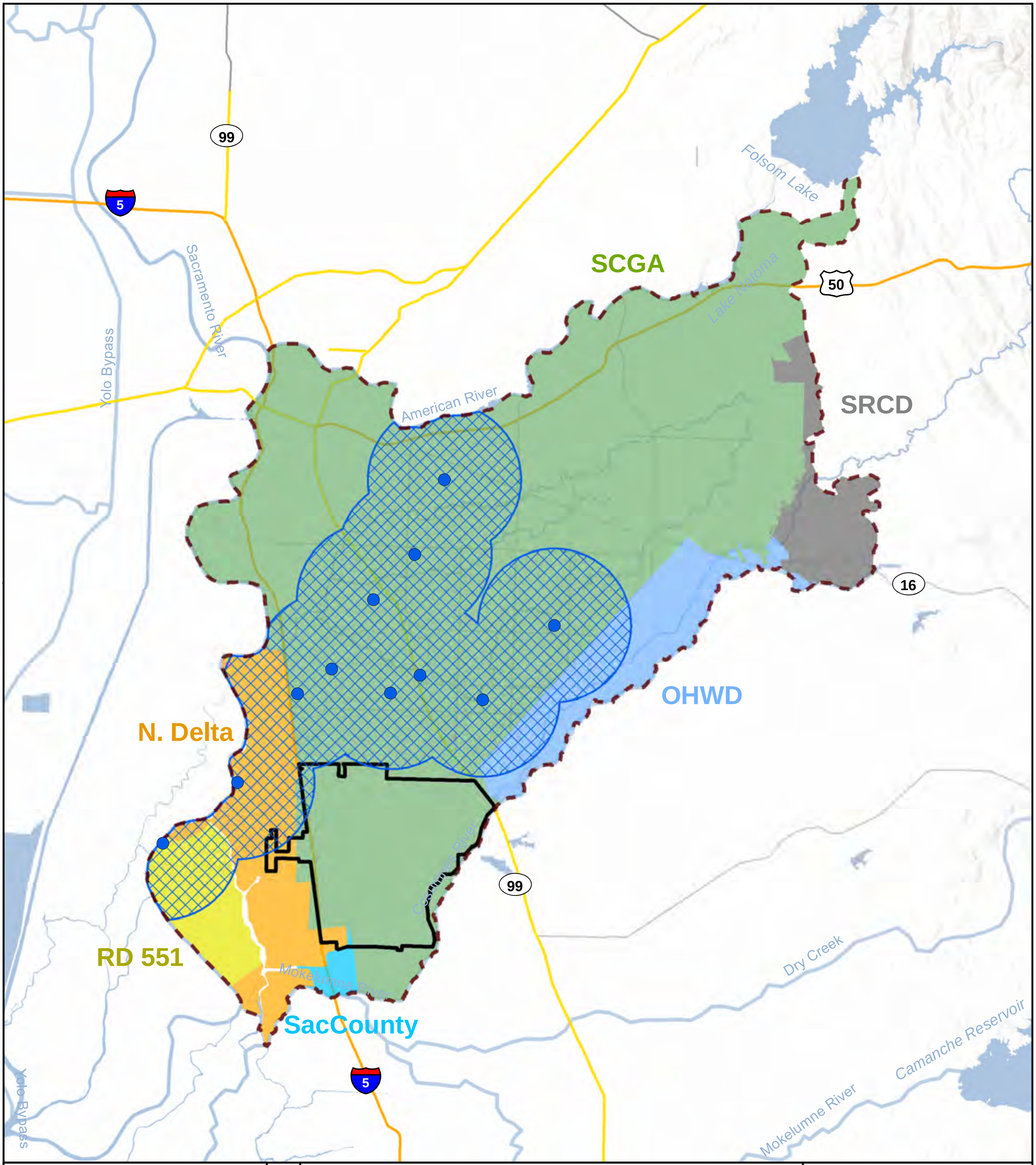

South American Subbasin GSP

Proposed Water Quality Monitoring Network

Figure 3-27

Legend

- ● Upper Layer GWQ Monitoring Points
- ▨ Upper Layer GWQ Wells Buffer
- ▭ Harvest Water
- ▭ South American Subbasin

GSA

- 🟧 N. Delta
- 🟦 OHWD
- 🟨 RD 551
- 🟩 SCGA
- ⬛ SRCD
- 🟦 SacCounty

0 1.25 2.5 5
Miles

N

South American
SUBBASIN

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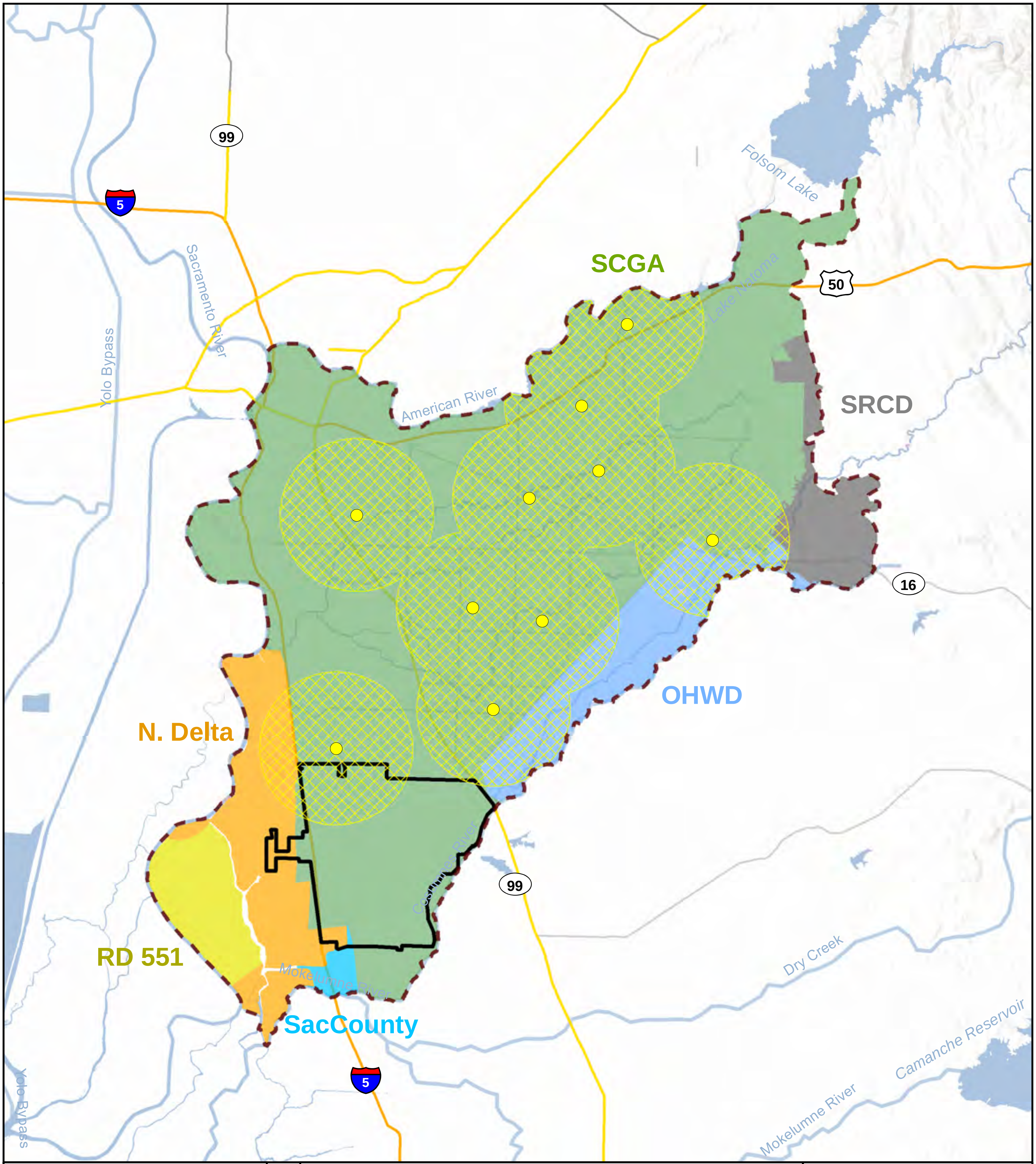

South American Subbasin GSP

Proposed Water Quality Monitoring Network

Figure 3-28

Legend

- ● Lower Layer GWQ Monitoring Points
- ▨ Lower Layer GWQ Wells Buffer
- ▭ Harvest Water
- ▭ South American Subbasin

GSA

- 🟧 N. Delta
- 🟦 OHWD
- 🟨 RD 551
- 🟩 SCGA
- ⬛ SRCD
- 🟦 SacCounty

0 1.25 2.5 5 Miles

N

South American SUBBASIN

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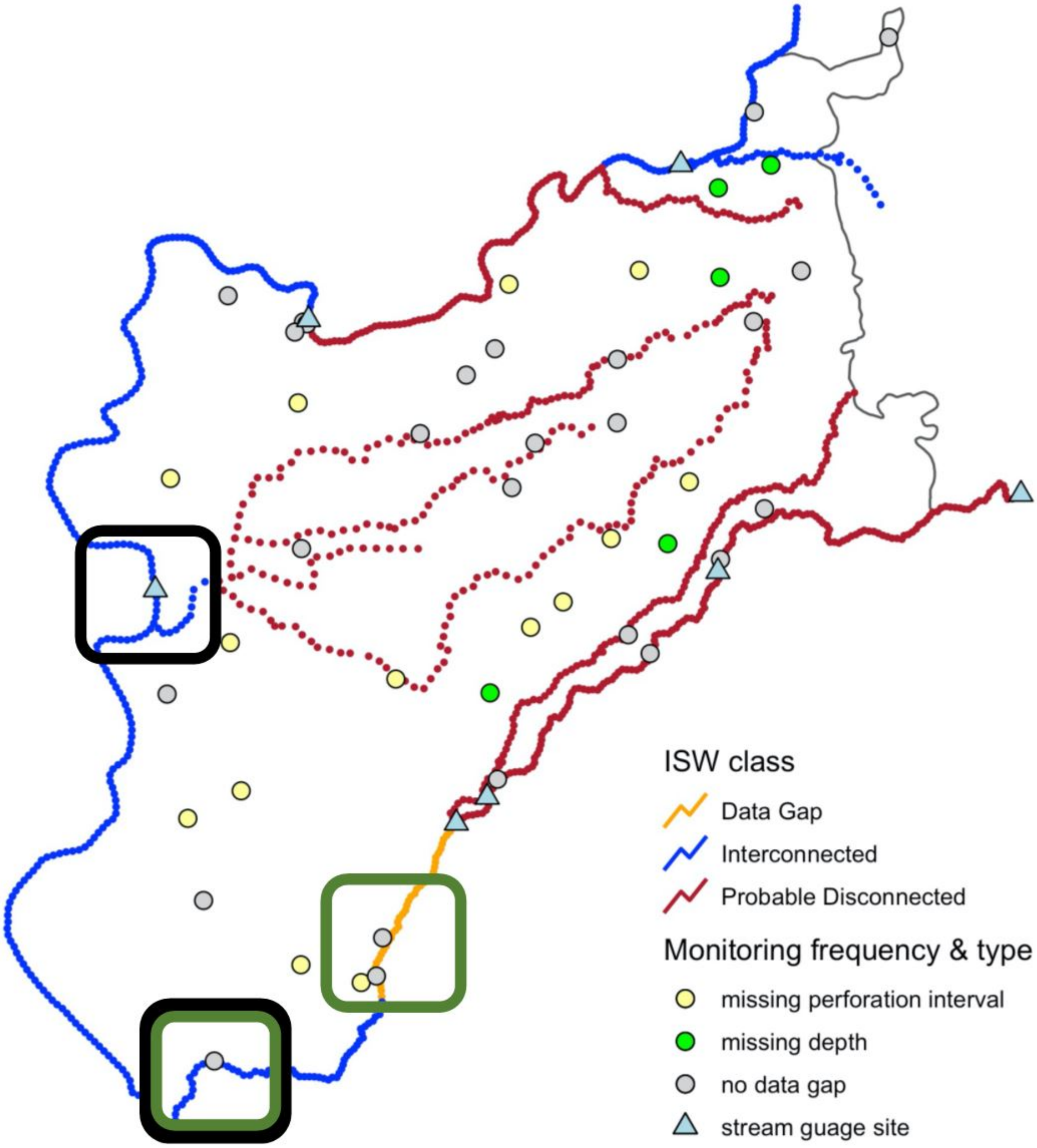


Figure 3-29: **Data gaps to be addressed**
include obtaining depth (light green) and perforation interval (yellow) at groundwater monitoring wells, adding two stream gauges in the lower Cosumnes River (at dark green boxes) and pairing them with 15-minute interval groundwater data, and adding two 15-minute interval groundwater monitoring sites (at black boxes) to pair with 15-minute stream gauge data.

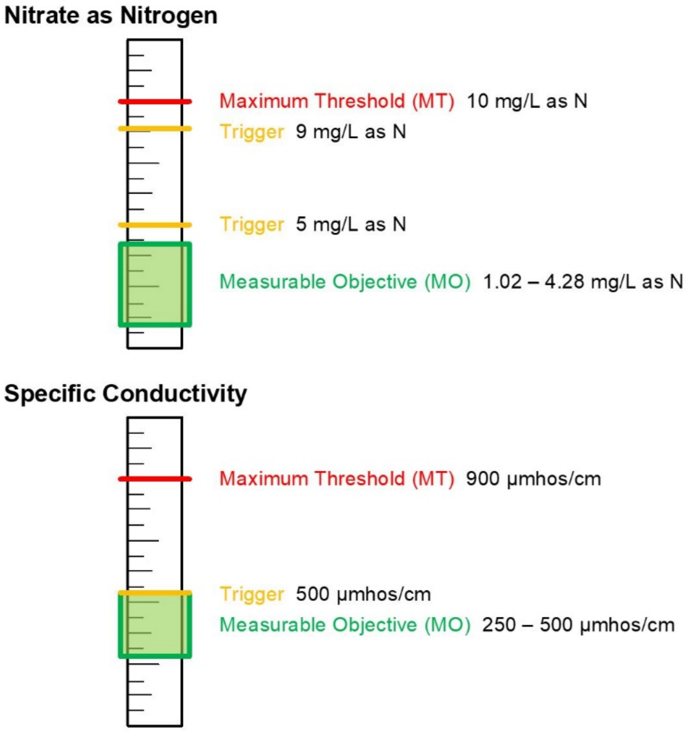
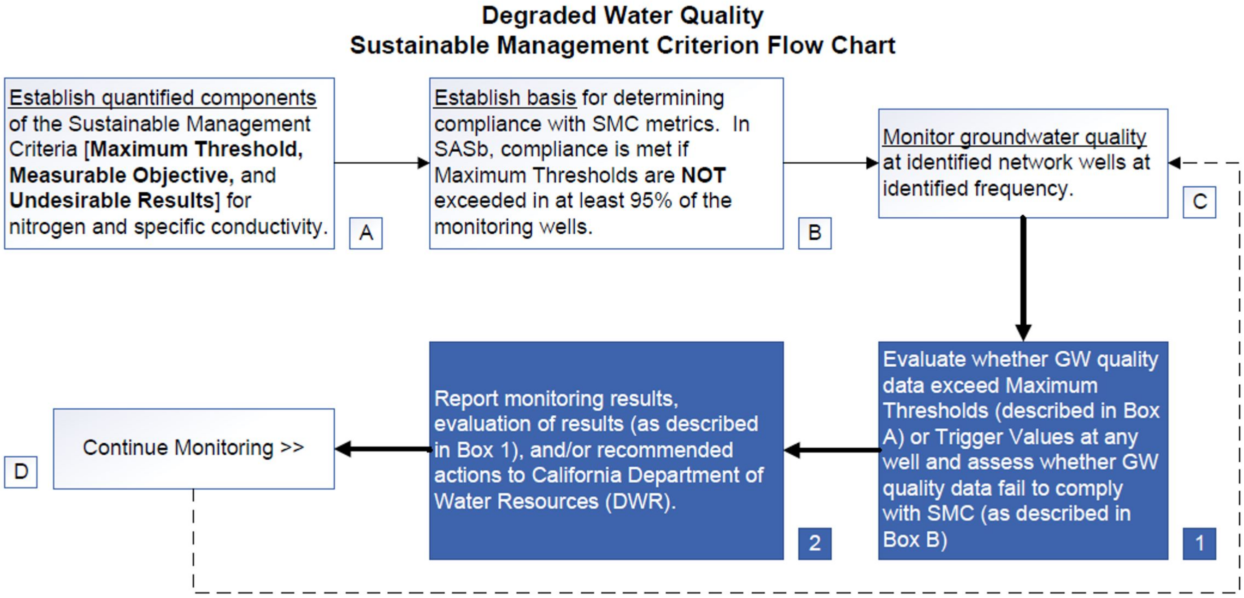


Figure 3-30: **Degraded water quality rulers for the constituents of concern in the South American Subbasin.**



A: Establish quantified components of the Sustainable Management Criteria [**Maximum Threshold, Measurable Objective,** and **Undesirable Results**] for nitrogen and specific conductivity.

B: Establish basis for determining compliance with SMC metrics. In SASb, compliance is met if Maximum Thresholds are **NOT** exceeded in at least 95% of the monitoring wells.

C: Monitor groundwater quality at identified network wells at identified frequency.

1: Evaluate whether GW quality data exceed Maximum Thresholds (described in Box A) or Trigger Values at any well and assess whether GW quality data fail to comply with SMC (as described in Box B)

2: Report monitoring results, evaluation of results (as described in Box 1), and/or recommended actions to California Department of Water Resources (DWR).

D: Continue Monitoring >>

Figure 3-31: **Degraded water quality sustainable management criteria flow chart**
- used to identify probable courses of action when metrics for the sustainability indicator are not met.

Table 3-7: Groundwater Quality Monitoring Wells in the Upper Aquifer Zone

Well ID	Facility or Water System Name	GSA	Nitrogen Measurements			TDS Measurements			Logic for Selection
			From	To	# of records	From	To	# of records	
3410020-009	City of Sacramento Main	SCGA	11/16/1988	2/4/2020	13	11/16/1988	2/4/2020	23	Spatial representation Long monitoring records
3410029-002	SCWA - Laguna/Vineyard	SCGA	2/21/1991	2/13/2020	9	2/21/1991	2/13/2020	26	Spatial representation Long monitoring records for TDS
3410029-016	SCWA - Laguna/Vineyard	SCGA	7/1/1988	2/10/2020	9	7/1/1988	2/10/2020	24	Proximity to GWE monitoring wells Spatial representation Long monitoring records
3410029-029	SCWA - Laguna/Vineyard	SCGA	10/25/2001	2/13/2020	7	10/25/2001	2/13/2020	17	Spatial representation Long monitoring records
3410033-006	Florin County Water District	SCGA	7/13/1990	6/13/2019	10	7/13/1990	3/19/2019	48	Spatial representation Long monitoring records
L10005519750-MW-G(S)	Unknown	SCGA	5/6/2014	12/10/2019	9	5/6/2014	12/10/2019	7	Proximity to GWE monitoring wells Historical exceedance from nitrogen limits
L10008601447-MW-13	Elk Grove Class III Landfill	SCGA	9/25/2014	9/19/2019	12	9/25/2014	9/19/2019	13	Proximity to GWE monitoring wells Relatively high number of measurements
3400101-001	Hood Water Maintenance Dist	Northern Delta	2/19/2008	2/11/2020	3	3/21/2001	11/13/2018	9	Spatial representation
3410029-024	SCWA - Laguna/Vineyard	SCGA	8/26/2002	5/22/2014	5	8/26/2002	5/10/2018	16	Spatial representation
3410029-025	SCWA - Laguna/Vineyard	SCGA	3/21/2001	5/22/2014	6	3/21/2001	5/14/2019	17	Spatial representation
3901216-001	Unknown	Northern Delta	5/22/2002	2/16/2017	4	5/22/2002	2/12/2018	9	Spatial representation Historical exceedance from nitrogen limits

Table 3-8: Groundwater Quality Monitoring Wells in the Lower Aquifer Zone

			Nitrogen Measurements			TDS Measurements			
Well ID	**Facility or Water System Name**	**GSA**	**From**	**To**	**# of records**	**From**	**To**	**# of records**	**Logic for Selection**
3400375-001	Slavic Missionary Church Inc	SCGA	6/8/2012	6/8/2012	1	7/9/2003	3/8/2019	14	Spatial representation
3410015-020	Golden State Water Co. - Cordova	SCGA	5/27/1986	1/14/2014	11	5/27/1986	1/8/2019	32	Proximity to GWE monitoring wells Historical exceedance from TDS limits
3410015-022	Golden State Water Co. - Cordova	SCGA	5/19/1993	5/25/2017	11	5/19/1993	1/15/2019	24	Spatial representation Long monitoring records
3410023-015	Cal Am Fruitridge Vista	SCGA	2/15/1991	1/11/2018	7	2/15/1991	1/19/2017	29	Spatial representation Long monitoring records
3410029-015	SCWA - Laguna/Vineyard	SCGA	7/1/1988	5/23/2018	9	7/1/1988	5/7/2019	22	Spatial representation Long monitoring records for TDS
3410029-026	SCWA - Laguna/Vineyard	SCGA	10/25/2001	5/11/2017	8	10/25/2001	8/15/2019	17	Spatial representation
3410029-027	SCWA - Laguna/Vineyard	SCGA	11/19/2003	2/5/2019	5	11/19/2003	5/22/2018	15	Proximity to GWE monitoring wells Long monitoring records
3410704-001	SCWA Mather-Sunrise	SCGA	8/27/2002	6/4/2014	5	10/25/1999	5/6/2019	18	Spatial representation
L10007396297-MW-40B	Kiefer Landfill	OHWD	9/2/2014	4/24/2019	8	5/7/2014	4/24/2019	5	Proximity to GWE monitoring wells Long monitoring records
S7-SAC-SA10	Unknown	SCGA	11/2/2017	11/2/2017	1	11/2/2017	11/2/2017	1	Spatial representation

An assessment of the monitoring results for both spatial density and monitoring frequency suitability based on the proposed monitoring network will be performed to determine the need for expansion of the network with additional wells. This assessment is planned within the first five years of GSP implementation. Further evaluations of the monitoring network will be conducted on a five-year basis, particularly with regard to the sufficiency of the monitoring network in meeting the GSP's monitoring objectives. The monitoring network may be modified or expanded in the future based on an evaluation of the data collected or changes in land use.

Land Subsidence Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(5) Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.*

The InSAR data provided by DWR (TRE Altamira) have spatial coverage for much of the Basin (considering the point data, while the rasters are interpolated for the entire subbasin area). These data are the only subsidence dataset currently available for the Basin and are consistent with the data and reporting standards outlined in 23 CCR § 352.4. The data have adequate temporal coverage for the Subbasin as well with annual rasters (beginning and ending on each month of the coverage year), cumulative rasters, and monthly time series data for each point data location.

The single CGPS station in the Subbasin (UNAVCO station #P274) is on the very edge of the Basin boundary, as well as near the larger subsidence subareas within the Basin (i.e., Delta and Elk Grove subareas). The InSAR and CGPS data at the location of the CGPS station compare well with one another (see **Figure 2.3-41**) demonstrating that the InSAR data product is an adequate management tool for land subsidence in the Basin. If subsidence was a great future concern, or even a significant one at present, future planned station locations for CGPS could be proposed. However, as this is not the case, no future CGPS stations are proposed for the Basin at this time.

As subsidence is not a significant concern for the Basin at present and likely not into the future, the InSAR data will most likely be sufficient for the monitoring network. If this changes due to anomalies detected in the InSAR data, ground truthing, elevation surveying, and GPS studies might need to be conducted to be understand this unlikely situation in more detail.

The InSAR-based subsidence monitoring network allows sufficient monitoring both spatially and temporally to adequately assess that the measurable objective (which is currently in attainment) is being maintained.

The InSAR data provided by DWR (TRE Altamira) or equivalent InSAR satellite data products are sufficient to adequately resolve land subsidence estimates in the Subbasin spatially and temporally. While CGPS stations offer higher accuracy and frequency, satellite-based InSAR data are available monthly and are less accurate than CGPS data (although it is close enough for the management purposes of this GSP to be equivalent). However, InSAR data points are so many more times more numerous than are even feasible with CGPS stations (1,000s of individual points vs. a few stations) for a given basin that this is the preferable method given funding constraints. InSAR data can also be utilized to determine if and where future CGPS or ground-based elevation surveys should be sited.

Subsidence is not of substantial present or future concern, thus CGPS stations are proposed for the Subbasin at this time.

The InSAR data provided by DWR (TRE Altamira) have adequate spatial coverage for much of the Basin (considering the point data, while the rasters are interpolated for the entire subbasin area). The data have adequate temporal coverage for the Basin as well, consisting of annual rasters (beginning and ending on each month of the coverage year), cumulative rasters for the full time period (2015-2019), and monthly time series data for each point data location. These temporal frequencies are adequate for understanding short-term, seasonal, and long-term trends in land subsidence.

Interconnected Surface Water Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:*
>
> *(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.*
>
> *(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.*
>
> *(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.*
>
> *(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.*

Groundwater level is used as a proxy for ISW depletion (**Section 3.2.4**). Thus, the surface water depletion monitoring network is complimentary with the network for groundwater level. The surface water depletion network consists of a subset of the wells which are strategically sited between ISW and pumping zones and in the upper zone of the principal aquifer (**Appendix 3-A**). Observations obtained at these key locations in the groundwater level monitoring network will directly inform integrated surface and groundwater modeling in the Basin as model calibration targets.

Moreover, through partnerships with GSAs and historical data availability, stream gauges that collect 15-minute interval data (**Table 3-9**) will be paired with 15-minute interval groundwater elevation data at specific locations along the American, Sacramento and Cosumnes Rivers. Paired observations will improve understanding of stream-aquifer exchange (via hydraulic gradient analysis) at a sub-seasonal timescale and inform sustainable and adaptive management of ISW in the Basin.

Table 3-9: Stream Gauge Monitoring Locations in the Basin

ID	Name	Latitude (NAD83)	Longitude (NAD83)
ACR_189	ACR_189	-121.32475	38.371660
ACR_181	ACR_181	-121.20423	38.466710
11335000	Michigan Bar	-121.04417	38.500278
SAMC1	H St	-121.42311	38.569014
11447650	Freeport	-121.50208	38.455775
MCNC1	McConnell	-121.34091	38.360702
11446500	Fair Oaks	-121.22667	38.635556

Data gaps along ISW reaches in the southern Cosumnes River and Sacramento River where 15-minute interval streamflow is available, but 15-minute groundwater elevation is not, will be addressed before the next Plan update by installing high-frequency monitoring sensors at existing biannually measured wells that will be paired with adjacent stream gauges.

3.5.3 Protocols for Data Collection and Monitoring (23 CCR § 352.2)

Establishment of monitoring protocols will ensure that collected data are accurate, representative, reproducible, and contain all required information. All groundwater elevation measurements, groundwater quality sample collection, and testing will follow the established protocols for consistency throughout the Basin and over time as outlined under each sustainability indicator's subsection.

3.5.3.1 Groundwater Level

Groundwater level data collection may be conducted remotely via telemetry equipment, or with an in-person field crew. The following section provides a brief summary of monitoring protocols for groundwater level collection. Establishment of protocols will ensure that data collected for groundwater elevation are accurate, representative, reproducible, and contain all required information. All groundwater level data collection in support of this GSP is required to follow the established protocols for consistency throughout the Basin and over time. These monitoring protocols will be updated as necessary and will be re-evaluated every five years.

All groundwater elevation measurements are referenced to a consistent elevation datum, known as the Reference Point (RP). For monitoring wells, the RP consists of a mark on the top of the well casing. For most production wells, the RP is the top of the well's concrete pedestal. The elevation of the (RP) of each well is surveyed to the National Geodetic Vertical Datum of 1929 (NGVD 29). The elevation of the RP is accurate to at least 0.5 foot.

Groundwater level measurements are taken to the nearest 0.01 foot relative to the RP using procedures appropriate for the measuring device. Equipment is operated and maintained in accordance with manufacturer's instructions, and all measurements are in consistent units of feet, tenths of feet, and hundredths of feet.

Groundwater elevation is calculated using the following equation:

$$GWE = RPE - DTW$$

Where GWE is the groundwater elevation, RPE is the reference point elevation, and DTW is the depth to water.

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

All groundwater level measurements must include a record of the date, well identifier, time (in 24-hour military format), RPE, DTW, GWE, and comments regarding factors which may influence the recorded measurement such as nearby production wells pumping, weather, flooding, or well condition.

Manual Groundwater Level Measurement

Groundwater level data collected by an in-person field crew will follow the following general protocols:

- Prior to sample collection, all sampling equipment and the sampling port must be cleaned. Manual groundwater level measurements are made with electronic sounders or steel tape. Electronic sounders consist of a long, graduated wire equipped with a weighted electric sensor. When the sensor is lowered into water, a circuit is completed and an audible beep is produced, at which point the sampler will record the depth to water. Some production wells may have lubricating oil floating on the top of the water column, in which case electric sounders will be ineffective. In this circumstance steel tape may be used. Steel tape instruments consist of simple graduated lines where the end of the line is chalked so as to indicate depth to water without interference from floating oil.

- All equipment is used following manufacturer specifications for procedure and maintenance.

- Measurements must be taken in wells that have not been subject to recent pumping. At least two hours of recovery must be allowed before a hand sounding is taken.

- For each well, multiple measurements are collected to ensure the well has reached equilibrium such that no significant changes in groundwater level are observed.

- Equipment is sanitized between well locations in order to prevent contamination and maintain the accuracy of concurrent groundwater quality sampling.

Data Logger Groundwater Level Measurement

Telemetry equipment and data loggers can be installed at individual wells to record continuous water level data, which is then remotely collected via cell phone towers to a central database which may be accessed in a web browser in the Stakeholder Data Portal. Installation and use of data loggers must abide by the following protocols:

- Prior to installation the sampler uses an electronic sounder or steel tape to measure and calculate the current groundwater level in order to properly install and calibrate the transducer. This is done following the protocols listed above.
- All data loggers installations follow manufacturer specifications for installation, calibration, data logging intervals, battery life, and anticipated life expectancy.
- Data loggers are set to record only measured groundwater level in order to conserve data capacity; groundwater elevation is calculated from these measurements, and knowledge of the cable length and ground surface elevation.
- In any log or recorded datasheet, site photographs, the well ID, transducer ID, transducer range, transducer accuracy, and cable serial number are all recorded.
- The sampler notes whether the pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are used, data are properly corrected for natural barometric pressure changes.
- All data logger cables are secured to the well head with a well dock or another reliable method. This cable is marked at the elevation of the reference point to allow estimates of future cable slippage.
- Data logger data is periodically checked against hand measured groundwater levels to monitor electronic drift, highlight cable movement, and ensure the data logger is operating correctly. This check occurs at least annually, typically during routine site visits.
- For wells not connected to a supervisory control and data acquisition (SCADA) system, transducer data is downloaded as necessary to ensure no data is overwritten or lost. Data is entered into the data management system as soon as possible. When the transducer data is successfully downloaded and stored, the data is deleted or overwritten to ensure adequate data logger memory. All wells in the Basin on continuous monitoring are on a SCADA system with the exception of Sacramento State wells (ID beginning with “SS”).

3.5.3.2 Groundwater Quality

Sample collection will follow the USGS *National Field Manual for the Collection of Water Quality Data* (USGS 2015) and *Standard Methods for the Examination of Water and Wastewater* (Rice et al., 2012), as applicable, in addition to the general sampling protocols listed below.

The following section provides a brief summary of monitoring protocols for sample collection and analytical testing for evaluation of groundwater quality. Establishment of and adherence to these protocols will ensure that data collected for groundwater quality are accurate, representative, reproducible, and contain all required information. All sample collection and testing for water quality in support of this GSP are required to follow the established protocols for consistency throughout the Subbasin and over time. All testing of groundwater quality samples will be conducted by laboratories with certification under the California Environmental Laboratory Accreditation Program (ELAP). These monitoring protocols will be updated as necessary and will be re-evaluated every five years.

Wells used for sampling are required to have a distinct identifier, which must be located on the well housing or casing. This identifier will also be included on the sample container label to ensure traceability.

Event Preparation

- Before the sampling event, coordination with any laboratory used for sample analysis is required. Pre-sampling event coordination must include the scheduling of the laboratory for sample testing and a review of the applicable sample holding times and preservation requirements that must be observed.

- Sample labels must include the sample ID, well ID, sample date and time, personnel responsible for sample collection, any preservative in the sample container, the analyte to be analyzed, and the analytical method to be used. Sample containers may be labelled prior to or during the sampling event.

Sample Collection and Analysis

- Sample collection must occur at, or close to, the wellhead for wells with dedicated pumps and may not be collected after any treatment, from tanks, or after the water has travelled through long pipes. Prior to sample collection, the sample collector should clean all sampling equipment and the sampling port. The sampling equipment must also be cleaned prior to use at each new sample location or well.

- Sample collection in wells with low-flow or passive sampling equipment must follow protocols outlined in the EPA's *Low-flow (minimal drawdown) ground-water sampling procedures (*Puls and Barcelona, 1996) and USGS Fact Sheet 088-00 (USGS, 2000), respectively. Prior to sample collection in wells without low-flow or passive sampling equipment, at least three well casing volumes should be purged prior to sample collection to make sure ambient water is being tested. The sample collector should use best professional judgement to ensure that the sample is representative of ambient groundwater. If a well goes dry, this should be noted and the well should be allowed to return to at least 90% of the original level before a sample is collected.

- Sample collection should be completed under laminar flow conditions.
- Samples must be collected in accordance with appropriate guidance and standards and should meet specifications for the specific constituent analyzed and associated data quality objectives.
- In addition to sample collection for the target analyte (e.g., nitrate), field parameters, including temperature, pH, and specific conductivity, must be collected at every site during well purging. Field parameters should stabilize before being recorded and before samples are collected. Field instruments must be calibrated daily and checked for drift throughout the day.
- Samples should be chilled and maintained at a temperature of 4^{o} C and maintained at this temperature through delivery to the laboratory responsible for analysis.
- Chain of custody forms are required for all sample collection and must be delivered to the laboratory responsible for analysis of the samples to ensure that samples are tested within applicable holding limits.
- Laboratories must use reporting limits that are equivalent, or less than, applicable data quality objectives.

3.5.3.3 Land Subsidence

The DWR Groundwater Monitoring Protocols, Standards, and Sites BMP does not cite a standard approach for the monitoring of land subsidence but does provide various approaches to making determinations of land subsidence using varying data collection methods. The GSA will monitor all subsidence data annually. If any additional data become available, they will be evaluated and incorporated into the GSP implementation. If the annual subsidence rate is greater than minimum threshold, further study will be needed.

Regarding the technical specifications of the DWR InSAR data (TRE Altamira) used in developing this SMC, the following text is from the California Natural Resources Agency (CNRA) data access webpage (https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence):

> This statewide InSAR subsidence dataset was acquired as part of DWR's SGMA technical assistance to provide important SGMA relevant data to GSAs for GSP development and implementation. The dataset is formatted to support the production of maps and graphs that show the extent, cumulative total, and annual rate of land subsidence.
>
> Interferometric Synthetic Aperture Radar (InSAR) is a satellite-based remote sensing technique that measures vertical ground surface displacement changes at high degrees of measurement resolution and spatial detail. TRE processed Sentinel-1A InSAR data over the study area between January 1, 2015 and September 19, 2019 and calibrating them to data from 232 stations of the regional network of Continuous Global Positioning System (CGPS) stations. TRE provided the resulting time series data of vertical displacement values for point locations on a grid with 100 meter spacing, with values representing averages of vertical displacement measurements within the immediate 100 by 100 meter square areas of each point. Gaps in the spatial coverage of the point data are areas with insufficient data quality. The period of record for the point time series data varies by area, starting as early as January 1, 2015 and as late as June 13, 2015. TRE also provided 2 sets of GIS rasters;

annual vertical displacement and total vertical displacement relative to the common start date of June 13, 2015, both in monthly time steps. An Inverse Distance Weighted (IDW) method with a maximum search radius of 500 meter was used to interpolate the rasters from the point data.

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 160 CGPS stations that were not used for calibrating the InSAR data, as well as 21 CGPS stations that were used for calibrating InSAR data in Northern California. The goal of this study was to ground-truth the InSAR results to best available independent data.

The National Standard for Spatial Data Accuracy (NSSDA), developed by the Federal Geographic Data Committee (Document Number FGDC-STD-007.3-1998), offers a well-defined statistic and testing methodology for positional accuracy of geospatial data derived from various surveying methods including satellite remote sensing. The NSSDA is based on comparison of data from the tested dataset to values from an independent source of higher accuracy. For this study, variation in vertical displacement of California's ground surface over time, as measured from interferometric synthetic aperture radar (InSAR) satellites, was statistically compared to available ground based continuous global positioning systems (CGPS) data.

Tested: 16 mm vertical accuracy at 95% confidence level.

As tested by the processes described, this analysis provides statistical evidence that InSAR data accurately measured vertical displacement in California's ground surface to within 16 mm for the period January 1, 2015 through September 19, 2019. This statement of accuracy is based on the assumptions that the number, distribution, and characteristics of CGPS check point locations provide a representative sample of the entire study area and of the entire InSAR dataset, and that the CGPS data constitutes an independent source of higher accuracy. This statement of accuracy applies to the state-wide dataset and may vary for regional or localized area subsets.

The Department of Water Resources makes no warranties, representations or guarantees, either expressed or implied, as to the accuracy, completeness, correctness, or timeliness of the information in this dataset, nor accepts or assumes any liability arising from use of these data. Neither the Department nor any of the sources of this information shall be responsible for any errors or omissions, or for the use or results obtained from the use of this information. A Groundwater Sustainability Agency is not required to use these data, and their use does not guarantee the adequacy of a Groundwater Sustainability Plan that relies on such data. (CNRA)

3.5.4 Reporting Monitoring Data to the Department (23 CCR § 354.40, § 352.4)

Monitoring data will be stored in the data management system and a copy of the monitoring data will be included in each Annual Report submitted electronically to the DWR. All reporting standards and information shall follow the guidelines outlined in 23 CCR § 352.4.

3.5.5 Assessment and Improvement of the Monitoring Network (23 CCR § 354.38)

The GSP and each five-year assessment report will include an evaluation of the monitoring networks, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin. Evaluation of data gaps must consider whether the spatial and temporal coverage of data is sufficient and whether monitoring sites are providing reliable and representative data. The description of identified data gaps will include the location and basis for determining data gaps in the monitoring network as well as local issues and circumstances that limit or prevent monitoring. These data gaps will be addressed by describing steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

Data gaps to be filled (**Figure 3-26**) before the next Plan update will improve and expand SMC (**Table 3-4**). These data gaps fall into 3 main categories: information improvement, monitoring expansion, and SMC revision.

Information Improvement

Not all monitoring points in the monitoring network contain construction information. After a thorough review of well completion reports and available information in the Basin, 5/45 wells are missing a total completed depth, and 15/45 wells are missing a description of the perforated interval (**Figure 3-26**, red and purple dots). No wells are missing both depth and perforated interval, as selection criteria mandates that at least one of these is present to understand vertical extent covered by the well. These data gaps will be addressed before the five-year Plan update in 2027. During field visitations to the monitoring sites, cameras and measuring tapes will be used to determine total completed depths and screened intervals depths.

Streamflow projections demonstrate significant reductions in all climate change scenarios, especially along the Sacramento and American rivers. More modeling is required to assess the impact of climate change on ISW and will be completed by the next 5 year plan update (2027).

A data gap along the Cosumnes River between Deer Creek and Twin Cities Road will be further investigated in terms of surface and groundwater interaction. Short term, sub-seasonal interaction is observed, but the reach remains disconnected on a seasonal average basis. It is unclear if short term interconnections events play an important role in the maintenance of habitat, species, or other beneficial uses and users. To address these data gaps, additional stream gage and continuous monitoring will be installed in the area, and GSAs will coordinate the Cosumnes subbasin GSAs and other stakeholders and technical experts to assess ISW presence/absence in the area. This data gap will be addressed before the next 5 year plan update (2027).

Streambed elevation is used to determine if a reach interconnects to adjacent groundwater by a comparison of their relative elevations. High resolution elevation mapping of ISW and other surface water bodies that provide ecological and recreational benefits can directly inform improved models and analyses of surface and groundwater interaction. Present day elevation data is likely sufficient to delineate ISW reaches but may be improved in the Cosumnes River.

Monitoring Expansion

The network needs two more stream gauges in the southern reaches of the Cosumnes River both above and below the point where analysis suggests ISW is present (**Figure 3-26**, green boxes). One stream gauge will be installed near an existing 15-minute interval groundwater monitoring site, and the second should be installed along the Mokelumne River upstream of the Sacramento River Confluence.

The network needs two more 15-minute interval monitoring wells (**Figure 3-26**, black boxes), which may be achieved by outfitting existing monitoring wells in the network with sensors and telemetry. These wells will be paired with 15-minute interval stream gauge stations and enable high-resolution monitoring of complex stream-aquifer interactions. Computed hydraulic gradients will improve understanding of sub-seasonal river-aquifer exchange.

GSAs in the Basin will coordinate with the adjacent Cosumnes Subbasin in order to strategically locate these high-frequency flow gauges and monitoring wells.

SMC Revision

Eight (8) representative monitoring points are in critical monitoring locations, but data is only available after 2018. Thus, data gaps in the historical record cause MTs and MOs to be set close to, or at present day, levels because the historical record only contains relatively wet water year types from 2018 onward. MTs, MOs, and IMs for these points (**Table 3-4**) are thus based on the best available information at the time of Plan submission but are expected to change in the five-year Plan update as more information becomes available at these sites. Moreover, 5/8 these sites are high-frequency, 15-minute interval stations what will provide valuable insight into stream-aquifer interactions.

Section 4: Projects and Management Actions

To achieve the sustainability goal for the South American Subbasin (SASb) by 2042, and to avoid undesirable results over the remainder of a 50-year horizon, as required by SGMA regulations, multiple projects and management actions (PMAs) have been identified and considered by the SASb Groundwater Sustainability Agencies (GSAs) in this Groundwater Sustainability Plan (GSP).

4.1 History and Context

The projects and management actions described in this section build upon a long effort that started prior to the adoption of the Sustainable Groundwater Management Act (SGMA). Efforts to manage the SASb groundwater resources started as early as 1972 and became quite intensive in the 1990s. During that decade, a collaborative process involving a wide array of stakeholders resulted in a basin-wide agreement to manage both surface waters and groundwater and set a sustainable yield metric for the Basin. The timeline of these efforts is provided below.

1. Formation of the Sacramento County Water Agency (SCWA) by a special legislative act and creation of countywide groundwater policies – 1952.

2. Adoption of policies by the County of Sacramento recognizing that groundwater should be conserved, managed, and protected – 1972.

3. Voluntary groundwater elevation (spring and fall) monitoring as part of State Well Monitoring Program and development of groundwater elevation contour maps utilized by the State and local agencies to monitor groundwater use – 1974.

4. Partnerships with DWR in Bulletin 118 studies to specifically characterize the region’s aquifer and local groundwater conditions – 1975.

5. Adoption of a master plan, creation of a benefit zone (i.e., Zone 40 of SCWA), establishing a fee structure to implement conjunctive use programs to support all new growth within groundwater impacted areas – 1986.

6. Adoption of county-wide water policies limiting new development’s use of groundwater and requiring that alternative supplies be identified to offset increased water demands – 1990.

7. Development of the Sacramento County Integrated Groundwater and Surface water Model (SacIGSM), which was renamed the Sacramento Integrated Water Resources Model (SacIWRM), along with corresponding analyses of groundwater quality conditions – 1993.

8. Development of current and projected water demands for Water Forum planning models (*The Estimate of Annual Water Demand within the Sacramento Metropolitan Area*) – 1995.

9. Delivery of first increment of surface water as part of the SCWA Zone 40 conjunctive use program – 1995.

10. Quantitative impacts analysis of undesirable effects and groundwater modeling to support Water Forum negotiations – 1995.

11. Establishment of a stakeholder process and significant education to define Sacramento County groundwater management areas and acceptable sustainable yields (Water Forum Process) – 1994-2000.

12. Self-imposed and locally financed consensus-based stakeholder process leading to a quantitative threshold-based groundwater management plan identified as the Central Sacramento County Groundwater Management Plan (GMP) in accordance with the provisions of SB-1938 and a proposed governance structure – 2000-2006.

13. Development of GMP, along with the corresponding hydrologic database management system, which implemented a monitoring program for groundwater levels and groundwater quality with thresholds to manage the basin within the sustainable conditions as set forth by the Water Forum Agreement – 2002-2006.

14. Establishment of a Joint Powers Authority Governance Structure creating the Sacramento Central Groundwater Authority (SCGA) and adoption of the GMP – 2006.

15. Development of the California Statewide Groundwater Elevation Monitoring (CASGEM) program for the SASb, per State requirements – 2009.

16. Voluntary groundwater management activities through SCGA and member agencies and stakeholders who represent all subbasin groundwater use sectors – 2006-Present.

17. Completion of the Freeport Intake and associated pipelines by Freeport Regional Water Authority (SCWA and East Bay Municipal Utility District (EBMUD)) to deliver surface water supplies to users within the SASb - 2007.

18. Completion of the Vineyard Surface Water Treatment Plant by SCWA to produce potable water for the communities of eastern Sacramento County – 2011.

19. Completion of Regional Water Reliability Plan prepared for Regional Water Authority – 2019.

A key output of the pre-SGMA planning efforts was the development of a sustainable yield value of 273,000 AF per year for the SASb. This sustainable yield metric has served as the basis for agreements on land and water use planning in the region and is referenced explicitly in planning documents produced by land use management entities and water purveyors in the SASb, including the 2006 GMP, which serves as the overarching groundwater management document for the SASb.

4.2 Project and Management Actions Under SGMA

For the SGMA process, a description of PMAs that will contribute to the achievement of the sustainability goal in the SASb is provided in accordance with §354.42 and §354.44 of the SGMA regulations. “Projects” generally refer to structural features whereas “management actions” refer to non-structural programs or policies (e.g., designed to incentivize reductions in groundwater pumping or optimize management of the subbasin). PMAs discussed in this section will support the sustainability goal in the context of the measurable objectives and minimum thresholds to avoid undesirable results identified for the Basin in **Section 3: Sustainable Management Criteria**.

At the outset, it is important to distinguish between projects that will be directly funded and implemented by the GSAs in the SASb, as opposed to projects that are currently sponsored and planned and will be implemented by specific entities within the SASb, in coordination with the respective GSAs. This GSP takes such planned projects into account to evaluate whether additional projects will be needed in the future to reach the sustainability goal. An evaluation of the impact of various planned projects on groundwater levels and storage volumes is provided in this Section through the use of scenarios developed with stakeholder input and modeled using the CoSANA model.

It is also important to acknowledge that the basin's beneficial uses and users will receive significant benefits from PMAs that provide multiple benefits and embrace innovation and new technologies. This Plan prioritizes multi-benefit PMAs that stress the utilization of natural infrastructure, including the basin itself for storage and its waterway floodplains as recharge areas. The Plan emphasizes coordination among users and neighboring basins to improve the region's groundwater condition. For example, the multi-benefit Harvest Water program (described in detail later in this section) will provide recycled water, which is treated to the tertiary level, to agricultural water users in the southwestern area of the basin in lieu of groundwater use, resulting in recovery of groundwater levels. The Cosumnes River is expected to gain water by this rise in groundwater levels which will also provide ecosystem benefits in southern parts of the Subbasin. This recycled water is currently discharged to the Sacramento River.

The PMAs identified in this Section will be periodically assessed during the GSP implementation period. The PMAs are in various stages of development so complete information is not uniformly available on construction requirements, operations, costs, permitting requirements, and other details. A conceptual description of the operation of PMAs as part of the overall GSP is provided in this section and in **Section 5: Plan Implementation**.

Each individual project proponent will manage the permitting and other specific implementation oversight for its own projects. Inclusion of PMAs in this GSP does not forego any obligations regarding individual project implementation under local, state, or federal regulatory programs. While the GSAs do have an obligation to oversee progress towards groundwater sustainability, they are not necessarily the primary regulator of land use, water quality, or environmental compliance. It is the responsibility of the implementing agencies of planned projects to ensure compliance with all applicable laws and regulatory requirements. The GSAs will collaborate with project proponents to track progress and support project implementation. The implementation of PMAs will be enhanced by the development of clear policy and guidance by the GSAs that lay out sustainable management criteria for the SASb (as described in **Section 3: Sustainable**

Management Criteria) as well as the monitoring and reporting framework that serve to protect the Subbasin and ensure it achieves and maintains sustainability. The GSP includes a management action to coordinate implementation of each of the key planned projects in such a way that the Subbasin sustainability is achieved in a collaborative environment among the GSAs and the project proponents and sponsors.

The process of identifying, screening and selecting PMAs for detailed consideration in this GSP is illustrated in **Figure 4-1**. Existing and planned projects were first identified from available reports, documents, and websites including:

- American River Basin IRWMP Database
- SCGA Basin Management Plan
- City of Sacramento Urban Water Master Plan (UWMP) and Groundwater Master Plan
- Northern Division Sacramento District UWMP
- Regional Water Authority Regional Water Reliability Plan

New projects were also identified through brainstorming sessions with GSPWG members and other stakeholders, including representatives from the following entities with jurisdictional responsibility in the South American Subbasin:

- Sacramento Central Groundwater Authority
- City of Sacramento
- City of Folsom
- Sacramento County Water Agency
- Sacramento County
- Sloughhouse Resource Conservation District
- Omochumne-Hartnell Water District (OHWD)
- Elk Grove Water District
- Sacramento Regional County Sanitation District
- Golden State Water Company
- California American Water Company
- Northern Delta Groundwater Sustainability Agency
- Sacramento Area Flood Control Agency
- Regional Water Authority
- Cosumnes Coalition
- Environmental Coalition of Sacramento (ECOS)
- The Nature Conservancy

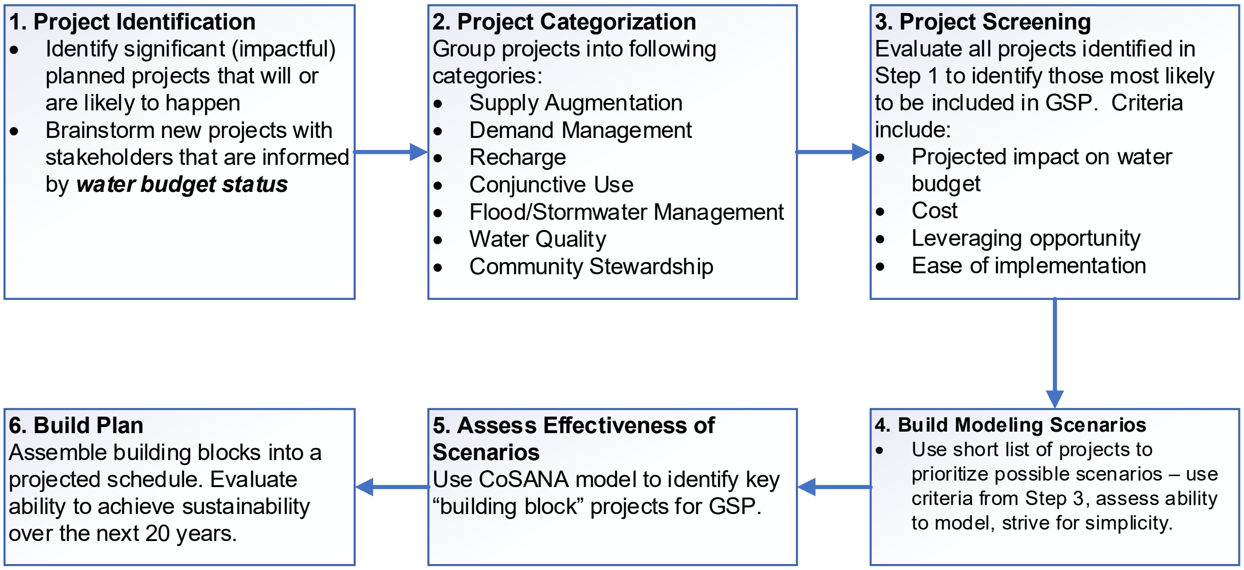


Figure 4-1: The Process of Identifying, Screening, Evaluating and Selecting PMAs

Identified projects are summarized in **Appendix 4-A** and have been grouped into seven categories: Recharge, Flood/Stormwater Management, Water Quality, Supply Augmentation, Demand Management, Community Stewardship, and Conjunctive Use. Projects in each category were evaluated to identify those with the highest potential to impact groundwater conditions and sustainability indicators within the SASb.

The projects identified from the list in **Appendix 4-A** and the stakeholder interviews were then categorized into three groups:

> **Group 1 –** Existing PMAs currently being implemented and expected to continue to be implemented, as needed, to support achievement of the sustainability goal. These PMAs are considered as baseline conditions in the groundwater modeling projections described in this section and in **Section 2: Plan Area and Basin Setting**.
>
> **Group 2 –** PMAs already planned for near-term implementation by individual entities, which may, individually or in aggregate, contribute to achieving sustainability in the SASb over the implementation horizon.
>
> **Group 3 –** Supplemental PMAs that are in conceptual stages which may be implemented in the future and would provide additional benefit in improving groundwater conditions and/or adapting to changes in future conditions.

From this list of projects and management actions, those that had adequate information to allow a modeling evaluation, that were deemed likely to be implemented, and are projected to have a significant impact on groundwater conditions in the SASb were chosen as components for modeling scenarios. Some multi-benefit projects that are described in this Section were not included in the modeling scenarios due to lack of adequate information (e.g., the SAFCA project) but are included herein based on widespread support from GSP Working Group members and local stakeholders. Other projects that have been identified as part of the PMA research effort are listed in **Appendix 4-B**.

Using the CoSANA model, the effectiveness of the different PMA scenarios were assessed to determine the range of impacts of the selected scenarios on sustainability of the Subbasin based on sustainability indicators in the SASb (Groundwater levels, Groundwater storage, and Inter-connected surface water). The projects included in the modeling scenarios and described in detail below fall in Group 2, as described above. These projects would ultimately be implemented by individual entities, in coordination with the GSAs in the SASb, and are therefore not considered as an obligation of the GSAs as part of this GSP. The results of the model scenario runs are provided in **Section 4.7** below.

4.3 Group 1: Existing Projects

In response to the recognized need to diversify water supplies, water management entities in the SASb have historically implemented and continue to implement projects to achieve this goal. Below is a partial list of those actions focusing on the larger efforts that are included in the CoSANA Baseline modeling scenario.

1. The 2005 Zone 40 Water Supply Master Plan recommended the Freeport Regional Water Project as the preferred alternative, which resulted in the collaboration of SCWA and EBMUD to jointly construct the 185 MGD diversion on the Sacramento River, completed in 2007. As part of the recommendation, SCWA also constructed the 50 MGD Vineyard Surface Water Treatment Plant (Vineyard WTP), completed in 2011.

2. Ongoing efforts to increase operational flexibility and capacity for conjunctive use by construction of system interties, treatment plant improvements, and development of groundwater wells. These efforts have been and are being taken by California-American Water, City of Sacramento, SCWA, and the Golden State Water Company.

3. The City of Sacramento Groundwater Master Plan was developed in 2017 to address an extensive well replacement program (as the majority of their wells are near or at the end of their useful life) and to analyze the fiscal implications of well replacement in comparison with surface water treatment expansion. The City has firm water rights on the Sacramento and American Rivers and has historically relied on groundwater from the wells north of the American River. Nevertheless, the City developed a plan to utilize groundwater in both their north and south service areas, as part of the City-wide conjunctive use program to increase water supply reliability for retail and wholesale water supplies in the City. This Groundwater Master Plan includes rehabilitation and/or replacement of wells in the north service area, and installation of new wells in the south service area (i.e., the SASb).

4.4 Group 2: Near-term Planned Projects

Near-term projects are in the planning or design phase and are expected to be operational within the next five (5) years. For these projects, details are provided for implementation, in addition to their expected impact on the groundwater basin.

4.4.1 Harvest Water

4.4.1.1 Project Description

Sponsored by the Sacramento Regional County Sanitation District (Regional San), Harvest Water will provide a safe and reliable supply of disinfected tertiary-treated recycled water for agricultural uses. This project is expected to reduce groundwater pumping, support habitat protection efforts, enhance groundwater dependent ecosystems, and provide near-term benefits to the SASb and the Sacramento-San Joaquin Delta. The project will support efforts at maintaining sustainability indicators for groundwater storage, groundwater levels, and depletions of interconnected surface water in the SASb.

The project will use the upgraded Sacramento Regional Wastewater Treatment Plant (scheduled to be completed in 2023) to deliver up to 50,000 acre-feet per year (AFY) of drought-resistant recycled water to irrigate more than 16,000 acres of permanent agriculture and habitat conservation lands near the Cosumnes River and Stone Lakes Wildlife Refuge (**Figure 4-2**).

The project is in the design phase and is expected to be operational by 2025. After start-up, the project will run continuously.

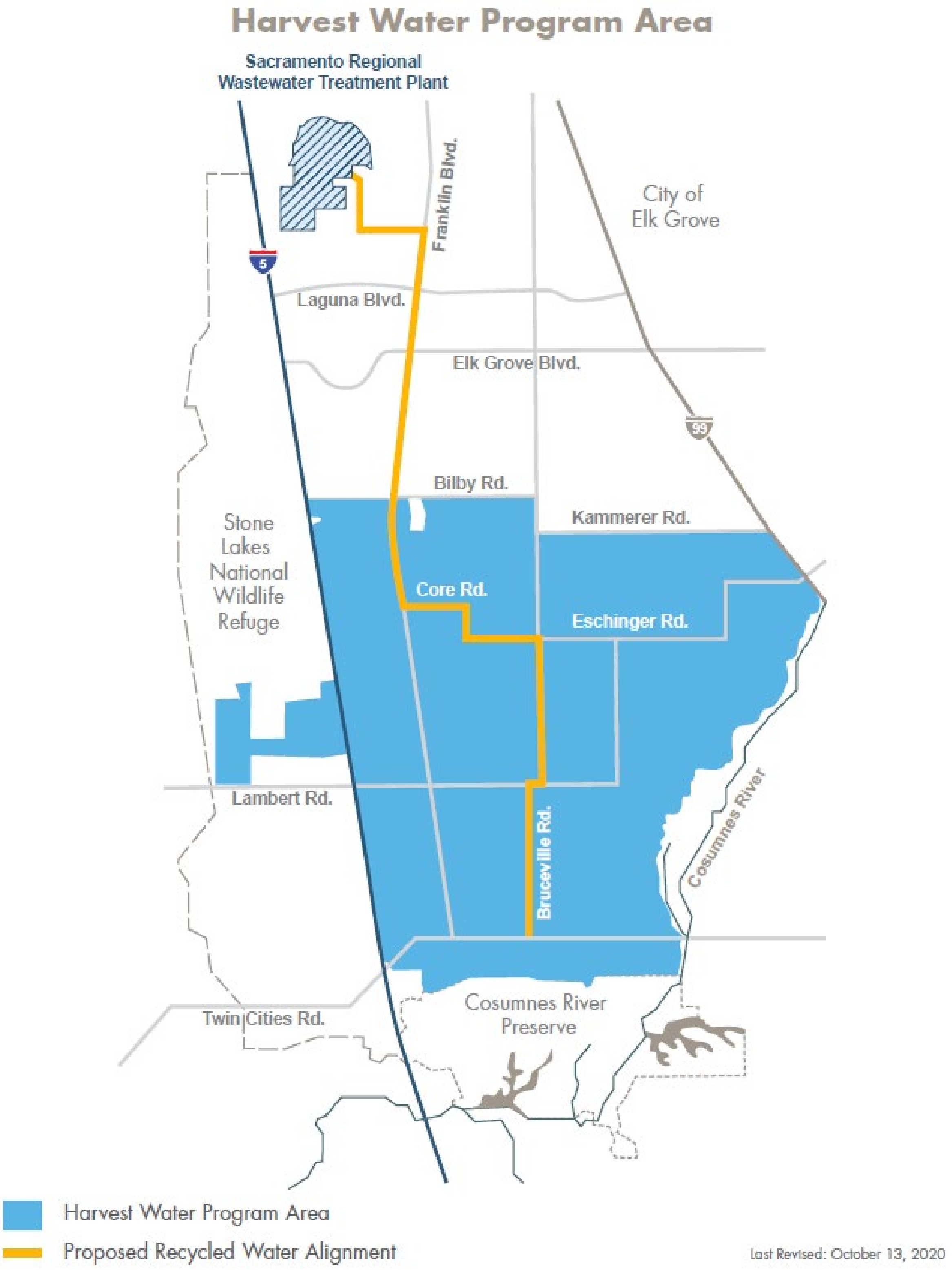


Figure 4-2: Map of Proposed Recycled Water Pipeline Alignment and Program Area

4.4.1.2 Public Noticing

Regional San is in the process of fulfilling public noticing and disclosure requirements under CEQA for Harvest Water and has conducted an extensive public outreach effort and will fulfill all additional public notifications to support implementation of the project.

4.4.1.3 Permitting and Regulatory Process

Regional San is in the process of fulfilling all permitting requirements for the construction and operation of the Harvest Water.

4.4.1.4 Status

This project is currently in the design phase. The project schedule is as follows:

2011 – 2012:	Feasibility Study
2015 – 2023:	Program Planning
2020 – 2021:	Design Reports
2021 – 2023:	Final Design
2022 – 2025:	Construction
2025:	Startup

4.4.1.5 Expected Benefits

- Provides up to 50,000 AFY of recycled water to irrigate more than 16,000 acres of agricultural and habitat lands.
- Increases regional and state water supply reliability through in-lieu groundwater recharge which will increase groundwater in storage via this conjunctive use process.
- Improves water quality by increasing groundwater levels and in-stream flows in the Cosumnes River.
- Restores low groundwater levels up to 35 feet within 15 years and helps advance GSP goals of basin sustainability.
- Increases volume of groundwater in storage by approximately 245,000 AF within 10 years, and approximately 450,000 AF in 40 years.
- Supports and increases riparian and wetland habitat on over 5,000 acres.
- Supports a variety of special status species, such as Swainson’s Hawk, Sandhill Cranes and Giant Garter Snake.
- Increases frequency of Cosumnes River instream flows to support fall-run Chinook Salmon.
- Supports the State and U.S. Bureau of Reclamation goals of increased use of recycled water.
- Provides reliable agricultural water supplies, and drought resiliency.

4.4.1.6 Implementation

The project will be implemented by the Regional San in coordination with the local GSAs and consistent with this GSP.

4.4.1.7 Legal Authority

Regional San is in the process of establishing its legal authority for the project, including obtaining a recycled water permit.

4.4.1.8 Estimated Costs and Funding Plan

The total project cost is expected to be $444.2 million. This total includes:

- $257.4 million for recycled water infrastructure construction
- $76.7 million for ecological program
- $86 million for planning, design, permitting, construction management and other program implementation elements
- $24.1 million for construction and program contingencies

To date, the project has been awarded $287.5 million in grant funds by the California Water Commission from the Water Storage Improvement Program and $4.2 million in grant funds from US Bureau of Reclamation's Water Infrastructure Improvements for the Nation (WIIN) Act. Regional San continues to pursue additional funding opportunities and will finance the balance of capital costs through cash reserves and user rate revenues.

4.4.1.9 Management of Groundwater Extractions and Recharge

The project will provide recycled water from the Sacramento Regional Wastewater Treatment Plant. The recycled water is derived from wastewater originating in the SRWTP service area, which includes the Cities of Sacramento, Rancho Cordova, Folsom, Elk Grove, West Sacramento, Citrus Heights, and unincorporated areas of Sacramento County. During the growing season, this water will be delivered to growers that currently rely on groundwater for irrigation, thereby reducing groundwater pumping in the project service area (**Figure 4-2**). Recycled water is also planned to ultimately be delivered to the Stone Lakes National Wildlife Refuge to further reduce the need for groundwater pumping. Approximately 20 years after recycled water deliveries begin, once the groundwater levels recover and the basin is in sustainable excess, groundwater stored in the basin could be available in the future for potential groundwater accounting partners, such as growers and local municipalities to use in dry years instead of surface water. Through an extensive monitoring well system, Regional San will track progress toward realizing project benefits associated with increased groundwater levels and evaluate conjunctive use operations, as they occur.

4.4.2 Omochumne-Hartnell Water District Groundwater Recharge Project and Groundwater Monitoring

4.4.2.1 Project Description

The Cosumnes River is the last major undammed river draining the western slope of the Sierra Nevada. The river experiences an intermittent and perennial cycle of large peak flows in the winter and low flows in the summer. Historically, the Cosumnes River has had a physical connection to the underlying groundwater basin, which helped improve the flow within the river for fish migration and other beneficial uses. However, the installation of levees in the 1940s which reduced the river flooding that recharged the basin and years of groundwater pumping have lowered groundwater levels and severed the basin’s interconnectivity with surface water in some reaches, reducing the viable times for migration of Chinook salmon and other fish.

In 2011, OHWD received funding to implement a groundwater banking project through a Proposition 84 Integrated Regional Water Management (IRWM) grant submitted by the Regional Water Authority (RWA). That project was re-designed as an off-season irrigation project to enhance recharge to the underlying aquifer in the South American and Cosumnes subbasins. A revised Proposition 84 grant proposal, including detailed scope and budget, was submitted to the Department of Water Resources (DWR); the proposal received project approval by DWR.

The grant funding has been used to construct pipelines and other facilities to divert up to 4,000 AF per year of surface water from the Cosumnes River to a 1,168-acre area between the Cosumnes River and Deer Creek (**Figure 4-3**). In the future, up to 6,000 AFY are planned to be diverted from the Cosumnes River.

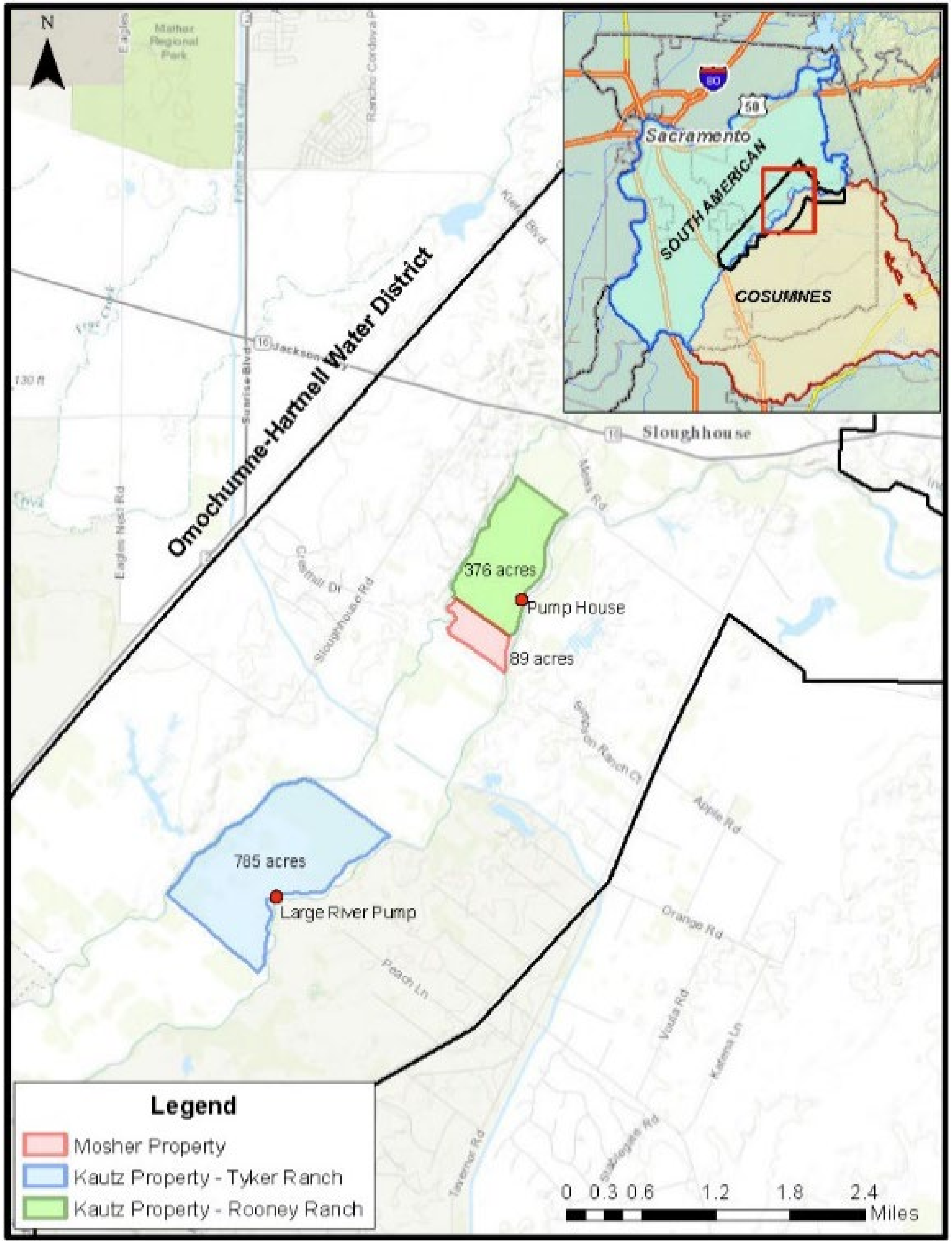


Figure 4-3: Location of Omochumne-Hartnell Water District Groundwater Recharge Project

The project, when fully operational, will help alleviate groundwater overdraft in both the South American and Cosumnes subbasins. The project will also support efforts at maintaining sustainability indicators for water table elevations, and depletion of interconnected surface water.

4.4.2.2 Public Noticing

OHWD satisfied all public noticing and disclosure requirements under CEQA for the existing pilot project. OHWD will fulfill all additional public notifications to support implementation of the final project.

4.4.2.3 Permitting and Regulatory Process

On September 18, 2018, OHWD adopted a final Mitigated Negative Declaration approving the Pilot Project and determining that the Project’s environmental impacts will be less than significant with mitigation.

In Phase 1 of the pilot study, a temporary diversion permit was obtained from the State Water Resources Control Board allowing diversions from the Cosumnes River during periods of high flow from December 1, 2020 to February 15, 2021. This permit allowed for pumping at two locations at a rate of 2000 gallons per minute (gpm) and 5000 gpm, totaling 16 cubic feet per second (cfs).

A second Phase of the pilot study will upgrade the pumping and conveyance systems to allow a maximum diversion rate of 50 cfs and total diversion to underground storage of 6000 AF during wet years. This phase will require a new temporary permit.

Ultimately, the plan is to apply for the right to divert a portion of the peak winter flows in the Cosumnes River to allow permanent implementation of the second phase of the pilot study, i.e., a 6,000-AFY diversion during wet years for groundwater recharge, with extraction of this recharged volume during the next growing season to offset groundwater pumping demands.

OHWD will fulfill all permitting and regulatory requirements prior to implementation of the second Phase of the pilot study and the final project.

4.4.2.4 Status

The project has just completed Phase 1 of the pilot study. Project proponents are currently working to implement Phase 2 and to obtain the necessary permit for diversions during water year 2022. Implementation of the ultimate project is projected to occur after completion of the Phase 2 pilot study.

4.4.2.5 Expected Benefits

- The project will facilitate sustainable groundwater management by increasing recharge, utilizing the available groundwater storage capacity, and thereby increasing the safe yield available to overlying users.

- If OHWD’s efforts are successful in restoring groundwater/surface water connectivity, use of high flow events could allow the watershed to recover and cause longer flows in the Cosumnes River to persist during the dry season as the groundwater levels are incrementally increased through the recharge. To the extent the flow window for the Cosumnes River is extended, the local ecosystem will be enhanced by the project.

Due to the heterogeneity of the local geology, there is some difficulty in predicting the degree to which these benefits will be realized. For that reason, a data collection program has been designed to capture hydrologic data that will assist managers in determining the impact of the project. The data collection program builds on OHWD’s streamflow and temperature monitoring program between Rancho Murieta and State Highway 99 and adds instrumentation for the monitoring of levels and quality in numerous groundwater wells in the floodplain.

4.4.2.6 Implementation

The project has been implemented by OHWD, and Phase 1 is now complete. Phase 2 is scheduled to begin in water year 2022, depending on wet-season flow conditions in the Cosumnes River.

4.4.2.7 Legal Authority

The Omochumne-Hartnell Water District is a California Water District formed under the California Water District Act in 1953; it is located in both the South American and Cosumnes Subbasins. OHWD works to manage surface water flows in the Cosumnes River and groundwater supply in these subbasins to facilitate its landowners’ exercise of their own water rights.

4.4.2.8 Estimated Costs and Funding Plan

Estimated costs for the Phase 2 pilot and the final project are not yet available.

4.4.2.9 Management of Groundwater Extractions and Recharge

An extensive monitoring program has been established to monitor the amount of water recharged and the amount of water extracted. Additionally, some existing wells have been outfitted with instrumentation to monitor groundwater levels in real time to ensure that extraction does not exceed recharge, as indicated by a drop in groundwater levels.

4.4.3 Regional Conjunctive Use Program

4.4.3.1 Project Description

This project is a comprehensive regional conjunctive use program that will increase conjunctive use among both NASb and SASb municipal and industrial (M&I) water purveyors, including California American Water Company, Citrus Heights Water District, City of Lincoln, City of Sacramento, Golden State Water Company, SCWA, and Sacramento Suburban Water District. The project will utilize existing infrastructure and leverage ongoing planning processes to use available surface water through water transfers, groundwater recharge projects, wholesale agreements, or wheeling agreements (**Figure 4-4**). The goal is to provide long-term basin benefits through additional surface water supplies during wet years which would result in reduction of groundwater use. In addition, the program includes groundwater recovery operations by select entities during dry years. It is anticipated that project implementation will be heavily integrated with the Regional Reliability Program (RWA, 2018) and, ultimately, the future Sacramento Regional Water Bank, to track and manage the usage of water.

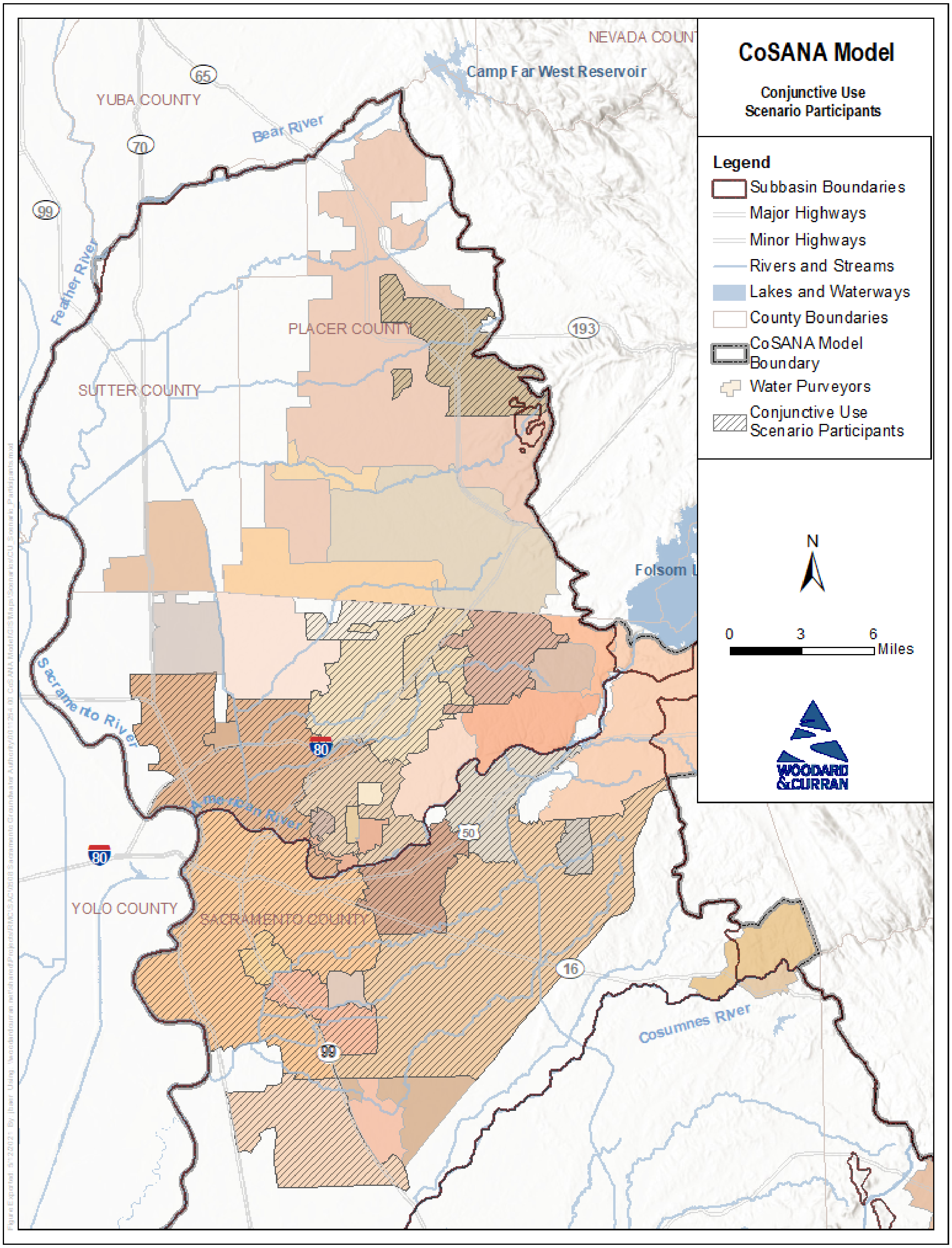


Figure 4-4: Map of Participating Conjunctive Use Program Agencies

The project will allow participating agencies to increase surface water usage during wet years, during short-duration periods such as storm events, or during other year types when surface water is available to be transferred. It is expected that an average of 20,400 AF of surface water would be made available during wet years within the SASb, directly offsetting the use of groundwater. This project is estimated to yield an average annual benefit of about 7,200 AF/year based on CoSANA model output. The program, as currently defined, includes surface water supplies and groundwater pumping reduction as shown in **Table 4-1**.

Table 4-1: Regional Conjunctive Use Program

Entity	Projected Demand	Wet Year Additional SW Supply	Wet Year GW Pumping Reduction	Long-Term (50-Yr) Avg. Annual Pumping Reduction	Dry Year GW Pump Back
California American WC – Parkway	16,604	5,351	5,351	1,819	0
California American WC – Suburban Rosemont	13,227	6,902	6,885	2,341	0
California American WC – Fruitridge Vista	6,609	0	0	0	0
California American WC – Security Park	97	0	0	0	0
Golden State WC – Cordova	19,752	6,177	6,108	2,077	0
City of Sacramento – South	101,306	1,000	1,000	340	0
Sacramento County Water Agency – Laguna Vineyard	72,423	1,000	1,000	612	0
Subtotal SASb	***230,018***	***20,431***	***20,344***	***7,189***	***0***

4.4.3.2 Public Noticing

The agencies sponsoring this project will meet applicable public noticing and CEQA requirements.

4.4.3.3 Permitting and Regulatory Process

The agencies sponsoring this project will obtain necessary permits and meet regulatory requirements.

4.4.3.4 Status

A defined schedule for implementation of this project does not currently exist.

4.4.3.5 Expected Benefits

On a long-term average annual basis, approximately 7,200 AF/year of groundwater would be left in the basin, which would provide both environmental benefits as well as provide long-term water reliability for the water agencies. Benefits include:

- Increased regional and state water supply reliability through groundwater storage and conjunctive use.
- Improved water quality by restoring groundwater levels and increasing in-stream flows in the Cosumnes River.
- Increased reliability of local water supplies, enhanced groundwater storage opportunities, and drought resiliency.

4.4.3.6 Implementation

The project will be implemented through cooperation between the seven agencies listed in **Table 4-1**. The project will require that any direct or in-lieu groundwater recharge precedes groundwater extractions and that a percentage of the recharged volume will be left in the aquifer to account for losses and groundwater storage mitigation.

4.4.3.7 Legal Authority

The entities sponsoring this project have the legal authority to implement this project.

4.4.3.8 Estimated Costs and Funding Plan

The current budget estimate is provided below.

- $0.5 million for interconnection upgrade between Golden State Water Company and California American Water Company
- $0.5 million for interconnection upgrades between Golden State Water Company and Sacramento County Water Agency
- $0.5 million to upgrade the interconnection between Golden State Water Company and the City of Folsom (would upgrade a temporary interconnection into a permanent interconnection)
- Unknown cost for a possible interconnection between the City of Folsom and OHWD at the Folsom South Canal
- Unknown cost for ASR wells for Sacramento County Water Agency
- $663 million for 75 MGD surface water expansion of the City of Sacramento River Water Treatment Plant. Planning has been completed, project in in design phase.

- $30-$40 million for a 36”-54” pipeline along Power Inn Road to move surface water from the City of Sacramento EA Fairbairn surface water treatment plant to southern portions of the American River Place of Use (ARPOU) – Planned

4.4.3.9 Management of Groundwater Extractions and Recharge

The project will require that any direct or in-lieu groundwater recharge precedes groundwater extractions and that a percentage of the recharged volume will be left in the aquifer to account for losses and groundwater storage mitigation.

4.5 Group 3: Supplemental Projects

Supplemental projects are still in the conceptual stage and not expected to be operational within the next 10-15 years, and therefore, have less detailed information related to project implementation. These projects would be beneficial to the attainment of the sustainability goal in the SASb.

4.5.1 SAFCA Flood-MAR

4.5.1.1 Introduction

This project is part of the Sacramento Area Flood Control Agency’s (SAFCA) response to climate driven changes in precipitation patterns and recent advances in meteorological forecasting. Recent research in atmospheric rivers has found that 30-50% of precipitation on the West Coast is due to atmospheric rivers. Using modern forecasting techniques, it is now feasible to more intensively operate flood control reservoirs and structures to capture flood flows and utilize them for various purposes, including groundwater recharge. This project includes modifications to the outlet works of the three largest non-federal dams in the American River Basin so that these facilities can be operated to create reservoir storage space for flood control when extreme atmospheric rivers are forecasted to occur in the American River Basin. In combination with ongoing improvements to Folsom Dam and the downstream levee system, these modifications will allow the flood system to safely contain floods with a 1-in-500 annual probability of occurrence. To secure the broadest level of public support and funding for these improvements, the SAFCA project also includes measures to conserve water for environmental, agricultural, and urban use. These measures include allowance of conditional storage of winter runoff in space normally designated for flood control in Folsom Reservoir; use of the Folsom South Canal and other existing water conveyance facilities to convey this stored water to groundwater infiltration sites for storage in the aquifers underlying the South American and Cosumnes subbasins (**Figure 4-5**); and use of the stored water to improve flow and temperature conditions along the American and Cosumnes rivers, sustain agricultural productivity in South Sacramento County and meet urban water needs during drought conditions.

While not specifically analyzed as a project scenario in this GSP, it is clear that this project, if implemented, will improve groundwater levels and storage volumes in the SASb, and would enhance the attainment of the sustainability goal in the SASb.

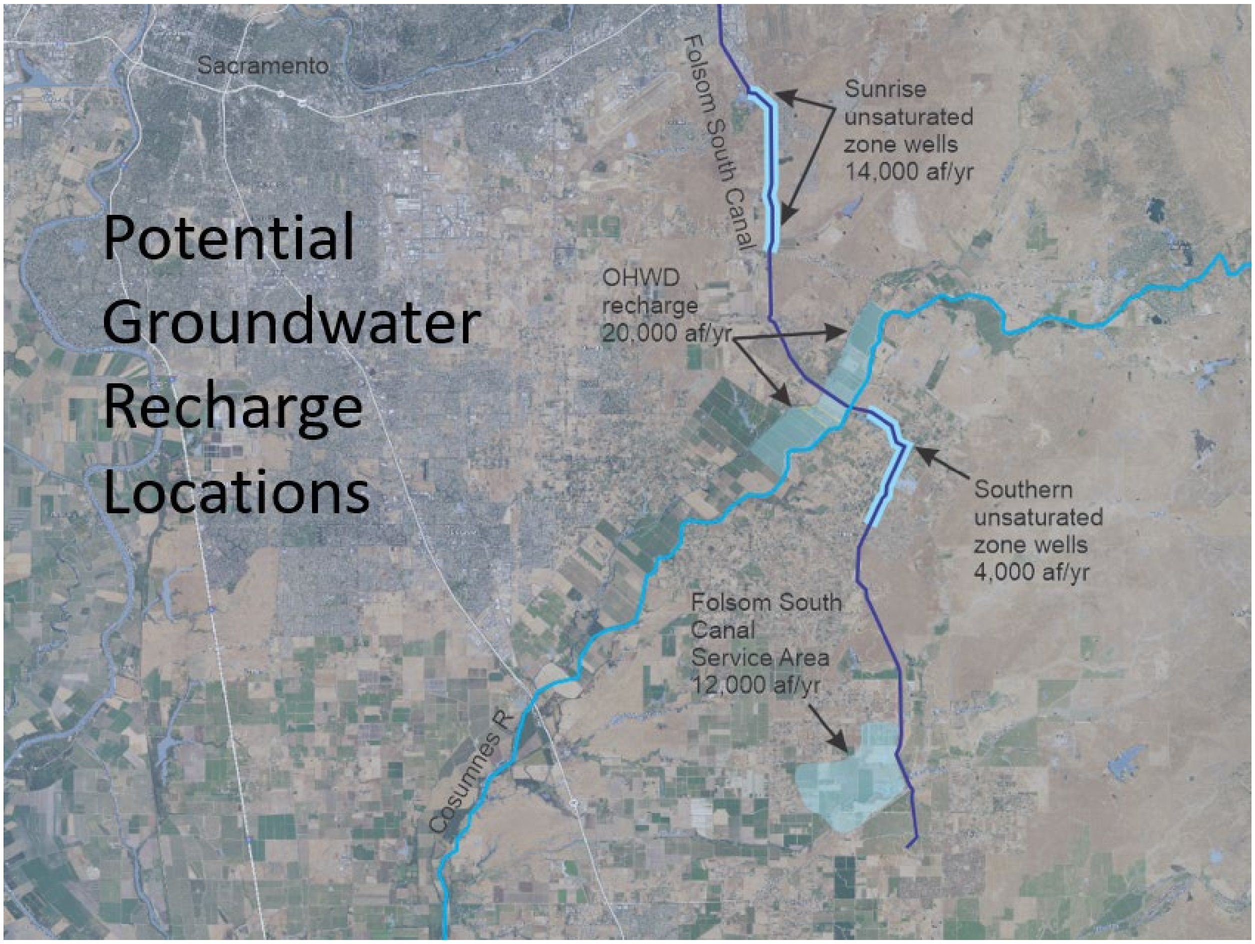


Figure 4-5: Map of Potential Recharge Areas for Water Delivered by the Folsom South Canal

4.5.1.2 Stakeholder Outreach

As project conceptualization continues, the SAFCA leadership team has created a stakeholder outreach and engagement plan. The focal points of this effort are:

- Water Forum Agreement Updates
- South American Subbasin Groundwater Sustainability Plan
- Cosumnes Subbasin Groundwater Sustainability Plan
- Sacramento Regional Water Bank
- American River Basin Study

As this effort proceeds, stakeholder outreach tasks will be addressed and will include:

- Identification of a facilitation team
- Development of a program webinar
- Incorporation of stakeholder technical information
- Creation of a stakeholder partner advisory group

Currently, the expected list of stakeholders include:

- Regional Water Authority
- Sacramento Water Forum
- US Bureau of Reclamation
- Environmental NGOs
- Environmental justice entities
- Water agencies and GSAs
- Landowners and growers
- Resource Conservation Districts
- Native Tribes
- California Department of Water Resources

The stakeholder outreach and engagement plan will be modified as needed in the future as this project develops.

4.5.1.3 Technical Analyses/Pilot Projects

To date, project proponents at SAFCA have articulated an overall vision for the implementation of the project and are now working on specific components. It is projected that the needed institutional and infrastructure improvements will be in place for excess floodwater from the American River to be delivered down the Folsom South Canal by 2027. Recent and ongoing efforts are discussed below:

4.5.1.3.1 Technical analyses

Initial analyses have been completed by MBK Engineers to estimate the volume of available water. That analysis found that surplus flood water will be available in many years and could be used to support an average annual volume of 50,000 AF for managed aquifer recharge. That analysis found that approximately 125,000 AF per year will be available in four out of every ten years.

4.5.1.3.2 Identification of recharge sites

Promising recharge sites have been identified based on proximity to the Folsom South Canal and due to hydrogeologic analyses conducted by UC Davis. The locations are shown in **Figure 4-5**.

4.5.1.3.3 Well demonstration project

In 2021-2022, project proponents are conducting an unsaturated zone well demonstration project in the SASb at locations along the Folsom South Canal where recharge can occur. In

2021, boreholes will be drilled to evaluate the local geology. Concurrently, the necessary permits for CEQA compliance, water transfers, well drilling, and use of the Folsom South Canal will be obtained. In 2022, two wells will be constructed for a demonstration project.

4.5.1.3.4 Farmland recharge demonstration project

In 2021-2022, a farmland recharge demonstration project will be conducted on land in the SASb portion of the OHWD (**Figure 4-5**) using water conveyed in the Folsom South Canal. In 2021, permits will be obtained, and a pipeline will be constructed to the recharge area. In 2022, the recharge demonstration project will be operated.

4.6 Results of Model Scenarios

To evaluate the potential effects of proposed projects and management actions in meeting the sustainability goal of the SASb GSP, the Group 2 (near-term) projects described above have been analyzed using the Cosumnes-South American-North American (CoSANA) model, the fully integrated surface and groundwater flow model that covers the entire South American Subbasin as well as the adjoining North American and Cosumnes Subbasins. The CoSANA model is described in greater detail in the water budget section of this GSP (**Section 2**). The CoSANA model has been used to develop the water budget estimates for historical, current, and projected conditions, as well as basin groundwater levels, streamflows, and inter-connected surface water bodies under baseline and various project conditions.

The analysis below considers the proposed projects using the Projected Conditions Baseline in CoSANA without climate change. The Projected Conditions Baseline applies future land and water use conditions and uses the 50-year hydrologic period of WY 1970-2019 as a planning period for purposes of the GSP. A total of ten scenarios were analyzed, three of which constitute baseline conditions, and seven of which represent additional PMA scenarios (see **Table 4-2** below).

Table 4-2: Projects and Management Actions Analyzed Using CoSANA Model

Scenario	Current Condition Baseline	Projected Condition Baseline	Projected Condition Baseline with Climate Change	Demand Reduction		Harvest Water	OHWD Recharge	Regional Conjunctive Use Program
				5% Ag 10% Urban	10% Ag 10% Urban			
CCBL	✓							
PCBL		✓						
PCBL - CC			✓					
1		✓		✓				
2					✓			
2a			✓		✓			
3		✓				✓	✓	
4		✓						✓
4a			✓					✓
5		✓				✓	✓	✓
5a			✓			✓	✓	✓

Specific assumptions used for the modeling scenarios are included here.

Demand Reduction scenarios:

- Scenario 1 assumes a 5% reduction in agricultural demand and 10% reduction in urban demand (and corresponding reductions in pumping) relative to the Projected Conditions Baseline Scenario

- Scenario 2 assumes a 10% reduction in agricultural demand and 10% reduction in urban demand (and corresponding reductions in pumping) relative to the Projected Conditions Baseline Scenario

Harvest Water:

- Harvest Water is designed to improve groundwater conditions to benefit groundwater conditions, wildlife and ecosystems.

- Harvest Water includes delivery of approximately 41,250 AFY of recycled water from the Sacramento Regional Wastewater Treatment Plant, providing an in-lieu net recharge of approximately 22,500 AFY and winter delivery of approximately 8,750 AFY to enhance wildlife habitat. This water is delivered to farmland within the Harvest Water Project area. Ultimately, Harvest Water is intended to deliver 50,000 AFY to the project area.

- Harvest Water also includes a potential extraction component. The extraction component, if implemented, would not be implemented until certain benefit triggers (e.g., groundwater level increases) have been met, which is expected to take approximately 20 years. The extraction component is conceptualized to allow up to 30% of the recycled water recharge to be extracted, with the remaining 70% of recycled recharge and all winter application assumed not to be extracted. Any extractions, if performed, would be done in a manner to preserve key program benefits to wildlife and ecosystems and to meet SMC and the sustainability goal of this GSP.

- Modeling performed for this GSP has used a net recharge approach that recognizes a future extraction component that has not yet been specified or finalized. Rather than delivering 100% of the recycled recharge water and then extracting 30% of that water, the net recharge approach simulated delivery of 70% of the recycled supply for application in the growing season. This effectively accounts for the extraction of up to 30% of this water without a need to define extraction details that are currently unknown. All winter application is modeled as not being extracted.

OHWD Recharge Project:

- The project assumes a diversion of 6,000 AFY from the Cosumnes River.

- The maximum diversion is assumed to be 50 cfs, which occurs during the period of December 1 through February 28 in any year where adequate peak flows occur in the Cosumnes River.

- Water is applied to 1,168 acres between Cosumnes River and Deer Creek (Rooney Ranch and Teichert Ranch)
- The project is expected to enhance groundwater levels along the Cosumnes River resulting in the river running for longer periods during the spring and summer, with flows beginning earlier in the fall.

Regional Conjunctive Use Program:

- The program is a comprehensive Regional Conjunctive Use Program, with participation by both NASb and SASb urban entities, including California American Water Company, Citrus Heights Water District, City of Lincoln, City of Sacramento, Golden State Water Company, SCWA and Sacramento Suburban Water District.
- Existing infrastructure and planning are assumed to remain in place.
- The program will be integrated with the Regional Water Reliability Program (RWA, 2018).
- Project operations include delivery of wet year surface water supplies to reduce groundwater use and dry year groundwater recovery operations by select entities.

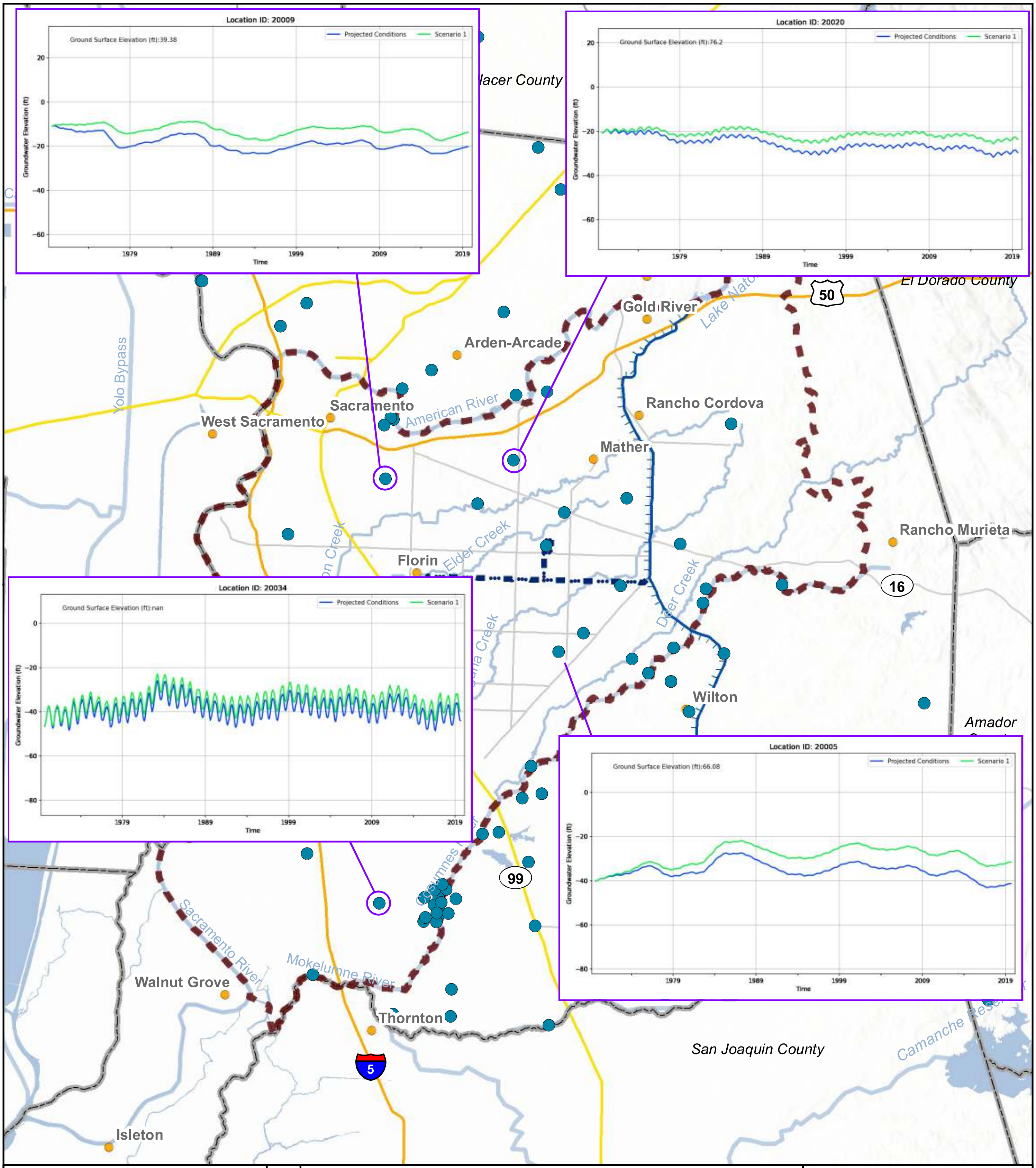
Note that while the SAFCA project was included in the list of supplemental projects above, it was not included in the modeling scenarios for the GSP because of significant uncertainties with respect to the recharge and extraction cycle, including location and fate of extracted water.

The following subsections describe the results of the modeled scenarios.

4.6.1 Results of Demand Reductions Scenarios (Scenarios 1 and 2)

Scenarios 1 and 2 include different potential combinations of reductions in groundwater pumping over the projected 50-year hydrologic period. These scenarios were run to assess the sensitivity of future conditions to potential reductions in demand. Scenario 1 is compared with the Projected Conditions Baseline, and Scenario 2 is compared with the Projected Conditions both without and with Climate Change.

Figure 4-6 and **Figure 4-7** shows groundwater hydrographs that result from Scenarios 1 and 2, respectively, in various locations throughout the subbasin, each compared to the Projected Conditions Baseline without climate change. Both demand reduction scenarios result in higher groundwater levels as compared to the Projected Condition baseline. Scenario 1 results in increases in groundwater levels ranging from 2-10 feet over the 50-year hydrologic period. The increases in groundwater elevations can potentially be greater in the vicinity of the agricultural areas in the southern portions of the subbasin in Scenario 2, with the overall changes ranging from 2-12 feet.



Changes in Groundwater Levels for Scenario 1

South American Subbasin

Figure 4-6

Legend

● Cities and Towns
● Monitoring Wells
Rivers and Creeks
Folsom South Canal
Freeport Pipeline
Counties
South American Subbasin

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: June 2021

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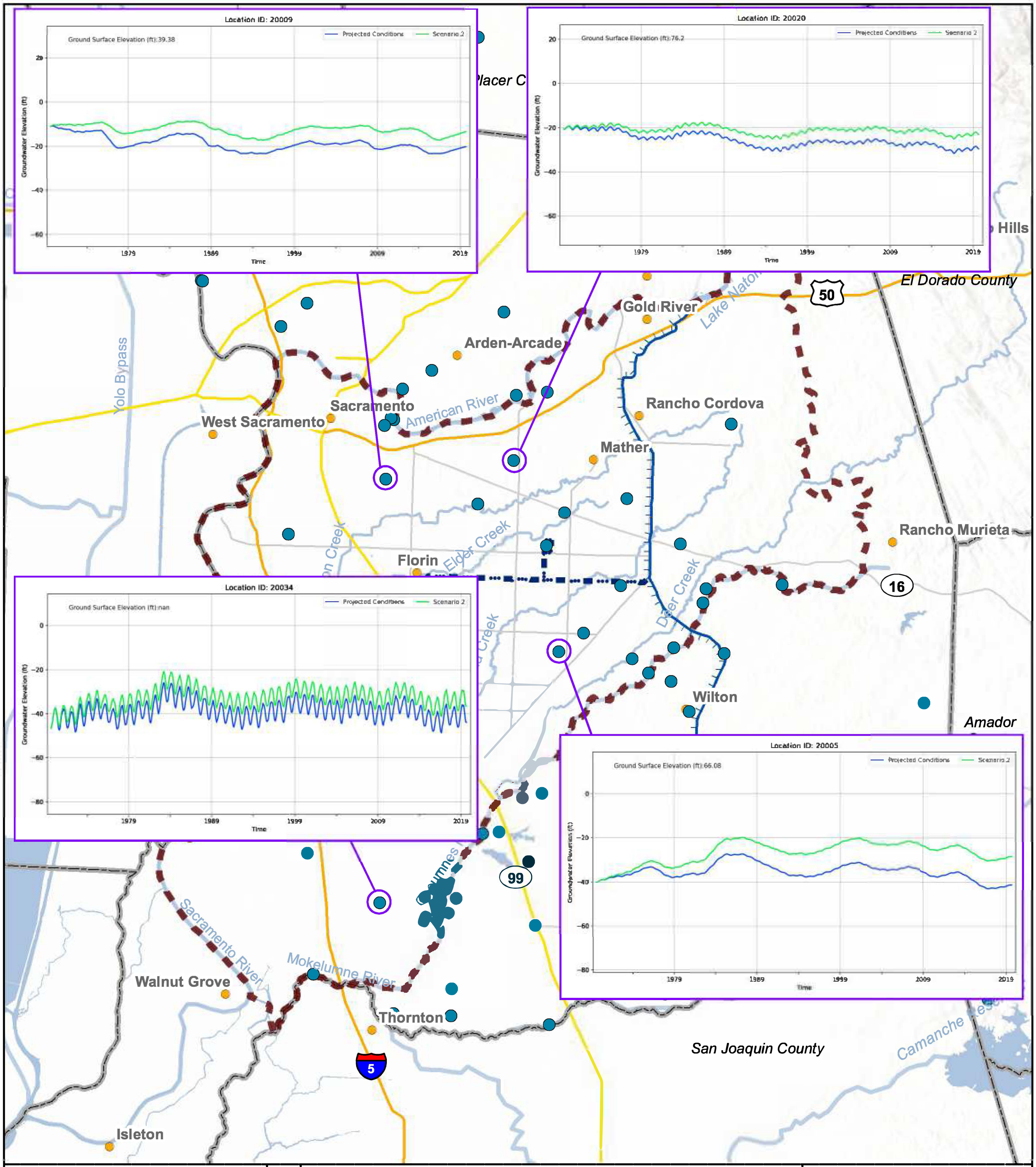

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Changes in Groundwater Levels for Scenario 2

South American Subbasin

Figure 4-7

Legend

● Cities and Towns
● Monitoring Wells
Rivers and Creeks
Folsom South Canal
Freeport Pipeline
Counties
South American Subbasin

0 1.25 2.5 5
Miles

N

South American SUBBASIN

Map Created: June 2021

Figure 4-8 shows the cumulative change in storage in Scenarios 1 and 2 as compared to the respective Projected Conditions Baseline over the 50-year projected hydrologic period. Both scenarios show a similar pattern of increase and decrease in overall storage during various hydrologic conditions over time. However, while the Projected Conditions Baseline indicates an average annual deficit in groundwater storage of about 1,100 AFY, both demand reduction scenarios have a storage surplus over the course of the 50-year hydrologic period. The average annual storage surplus is about 2,000 AFY in Scenario 1 and about 2,800 AFY in Scenario 2. This reflects the effects of reduction in groundwater pumping under each scenario.

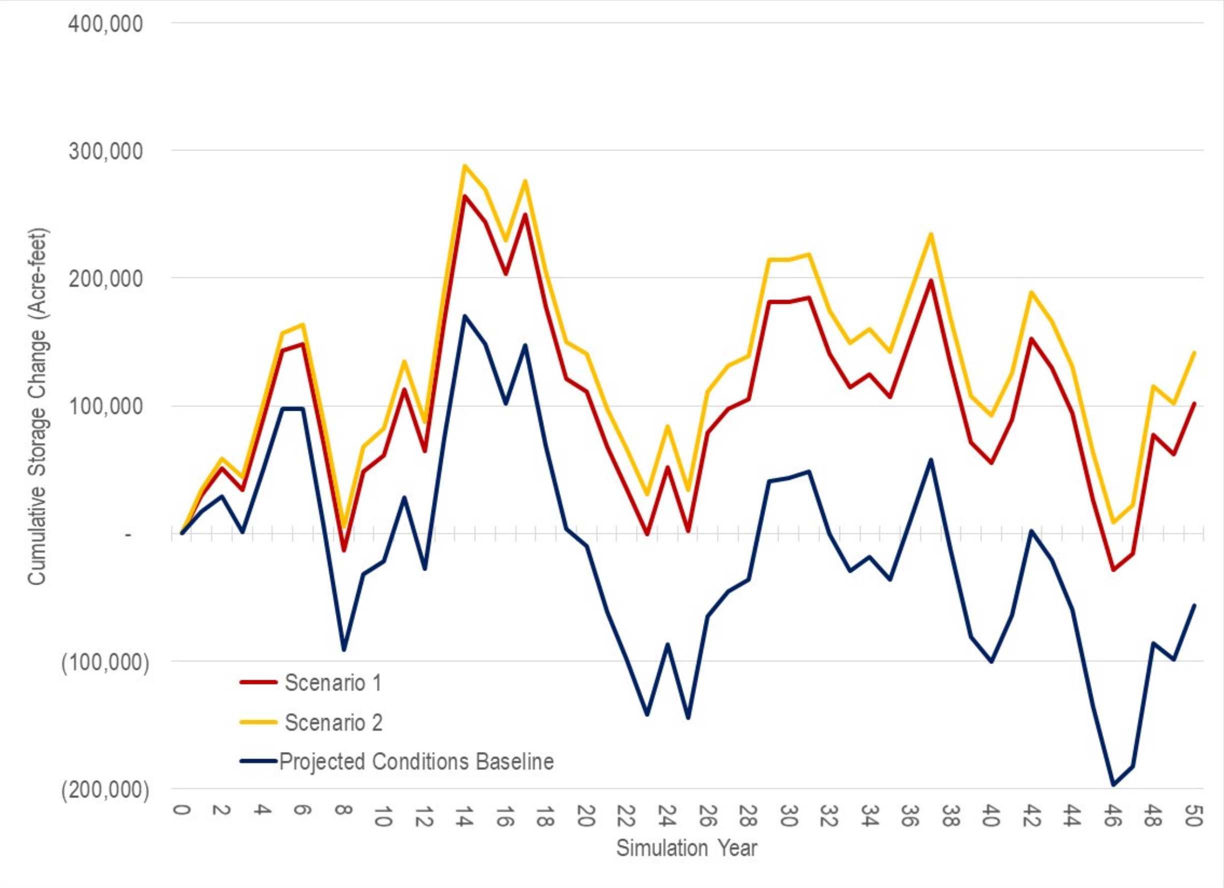


Figure 4-8: Cumulative Storage Change in Scenarios 1 and 2

Additionally, Scenario 2 was simulated using the Projected Conditions with climate change Baseline. **Figure 4-9** shows the cumulative storage change for the Projected Conditions Baseline and Scenario 2 with climate change over the course of the 50-year simulation period. With climate change, the Projected Conditions Baseline has an average annual reduction in storage of about 6,200 AFY. The average annual reduction in storage is about 1,500 AFY in Scenario 2. Therefore, implementation actions resulting in a total basin-wide demand reduction of 10% would be projected to bring the subbasin closer to balance but will not achieve sustainability under climate change.

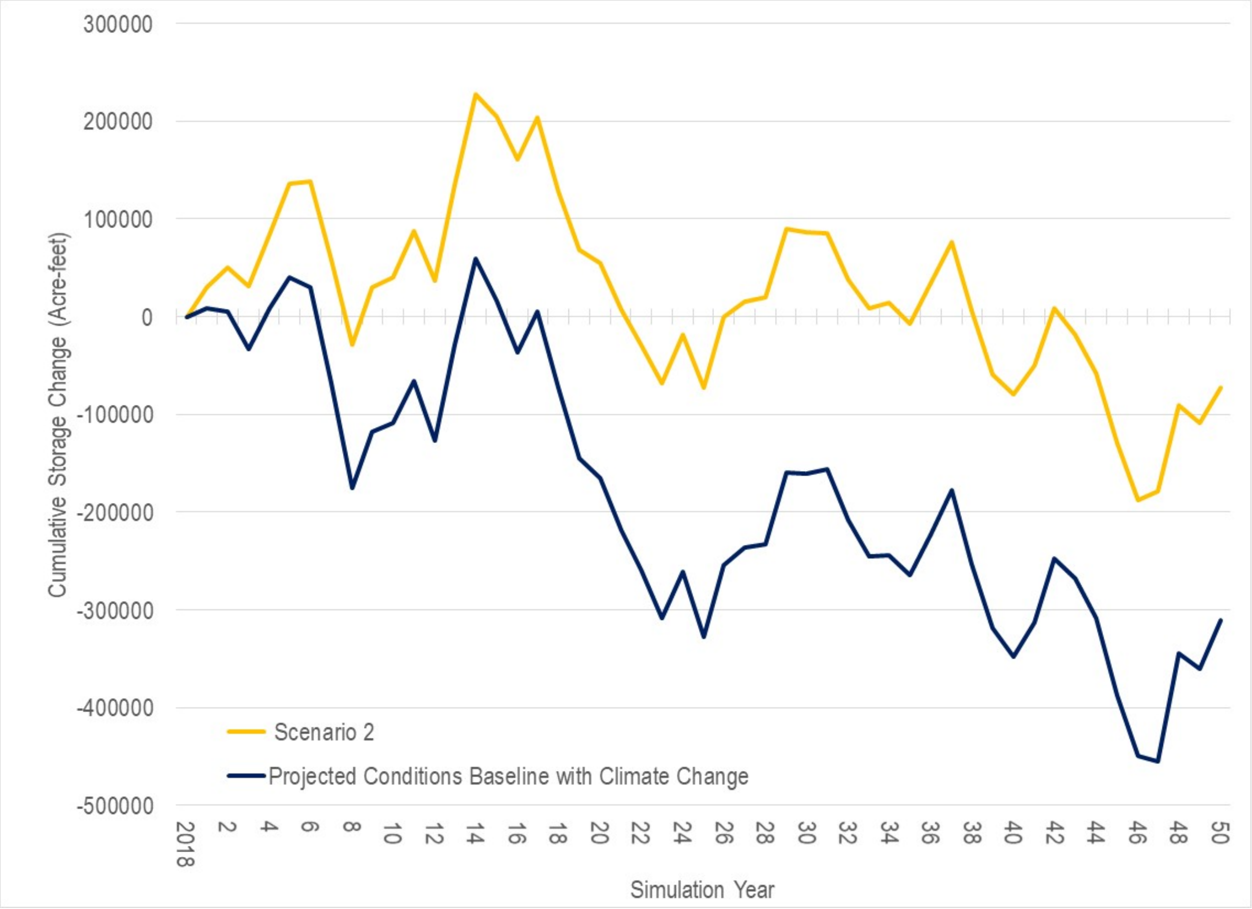


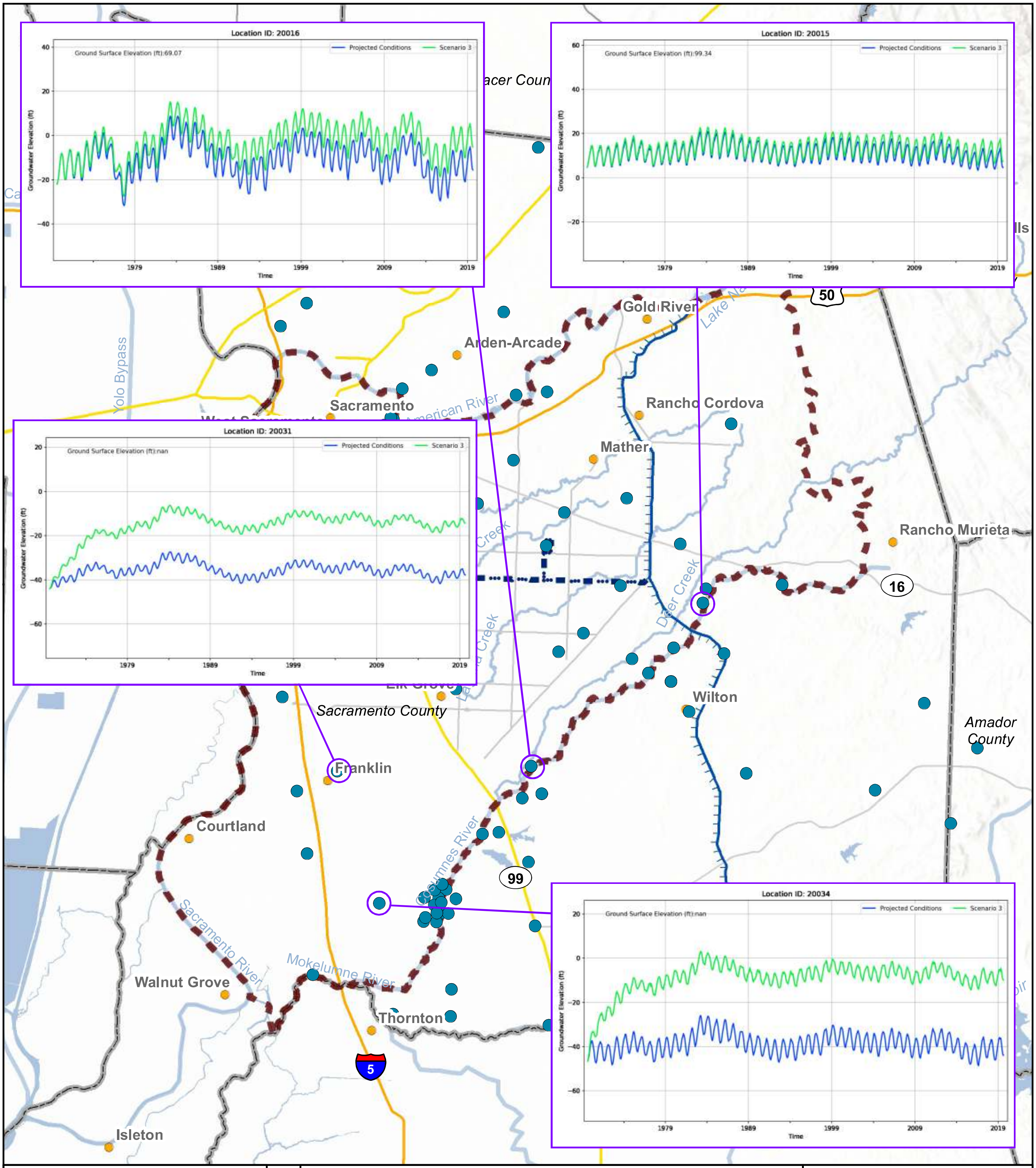
Figure 4-9: Cumulative Storage Change with Climate Change in Scenario 2

4.6.2 Results of Project Implementation Scenario 3

Scenario 3 includes implementation of Harvest Water and the OHWD recharge project over the projected 50-year hydrologic period. Modeling results are compared to the Projected Conditions Baseline without climate change.

Figure 4-10 shows the changes in groundwater hydrographs that result from Scenario 3. In Scenario 3, there is a significant increase in groundwater levels of about 30-40 feet in the vicinity of the Harvest Water project areas in the southwestern portion of the basin in southern Sacramento County. In the OHWD area along the Cosumnes River, there are more moderate increases in groundwater levels of about 10 feet in the southwestern portion of the OHWD GSA and about 5 feet near the intersection of the Folsom South Canal and the Cosumnes River. Note that both the Harvest Water and OHWD projects will provide benefits in the form of increased stream flow in the Cosumnes River and increased subsurface flows to the Cosumnes Subbasin due to the locations of these projects.

Figure 4-11 shows the cumulative change in storage in Scenario 3 as compared to the Projected Conditions Baseline over the 50-year simulation period. There is a similar pattern of increase and decrease in overall storage as the simulation moved through time. However, while the Projected Conditions Baseline has an average annual reduction in storage of about 1,100 AFY, Scenario 3 has a storage surplus of about 3,200 AFY over the course of the 50-year simulation period, reflecting a net benefit to the SASb of about 4,300 AFY. Scenario 3 will provide storage benefits to the Cosumnes Subbasin due to increased subsurface flows to that subbasin.



Changes in Hydrograph Levels for Scenario 3

South American Subbasin

Figure 4-10

Legend

- ● Cities and Towns
- ● Monitoring Wells
- Rivers and Creeks
- Folsom South Canal
- Freeport Pipeline
- Counties
- South American Subbasin

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: June 2021

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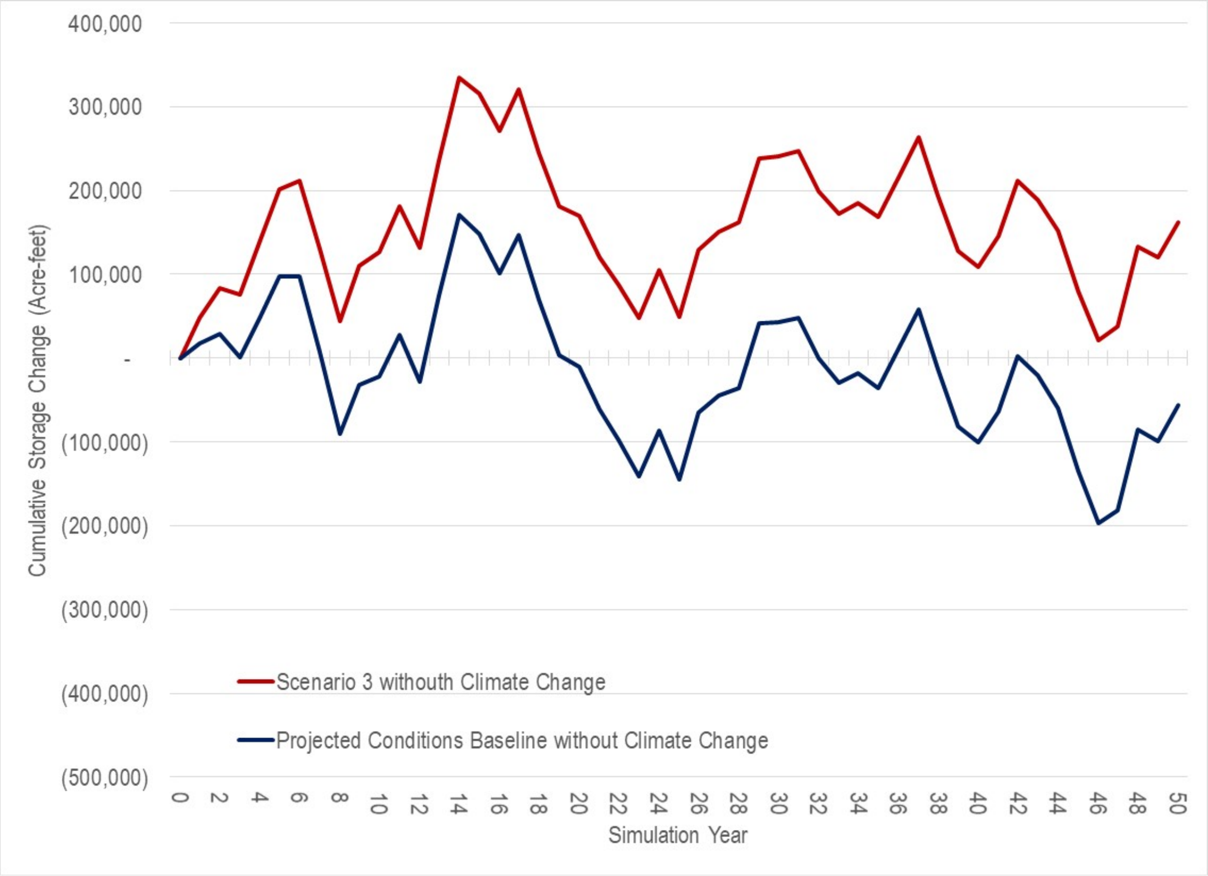


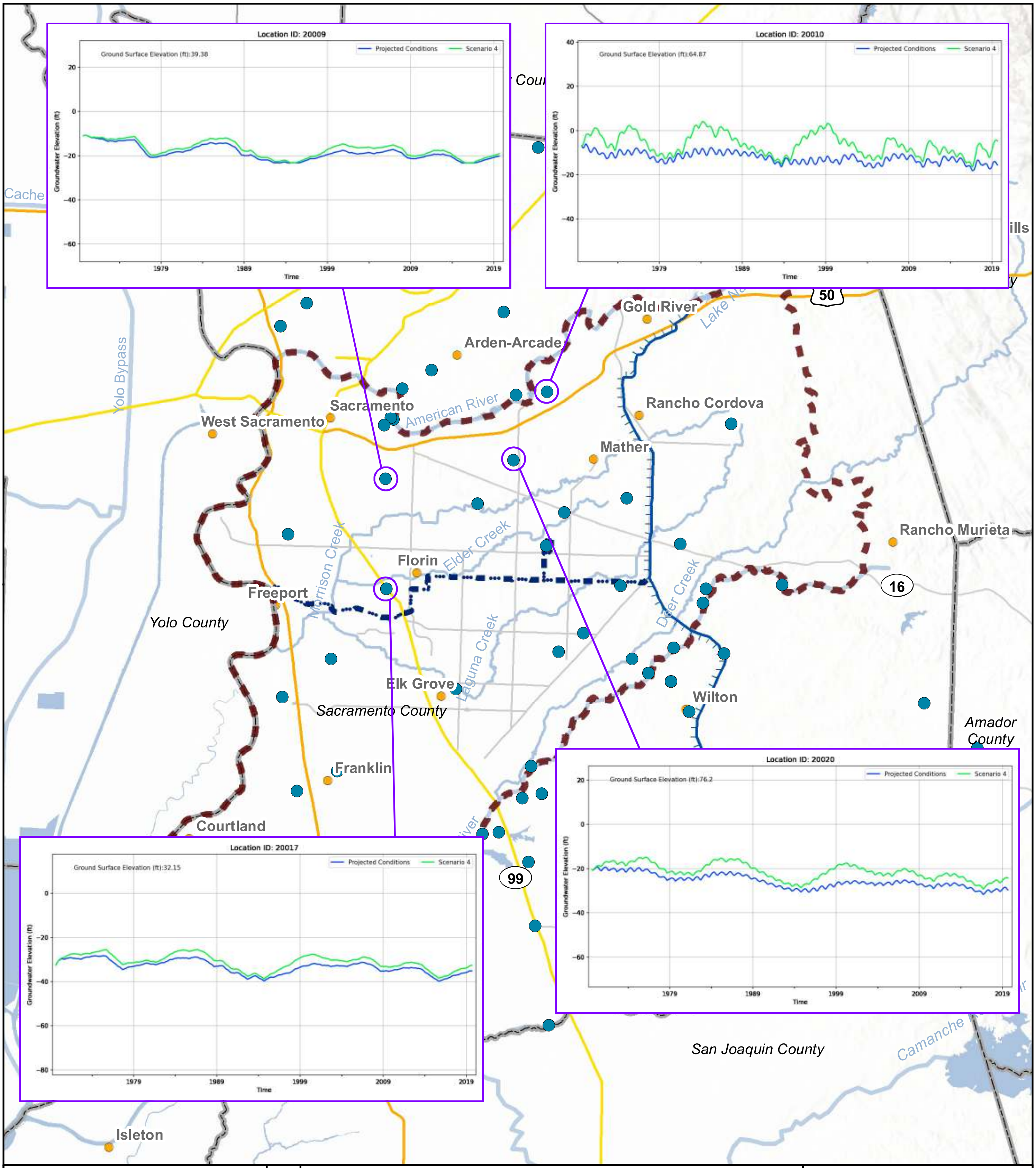
Figure 4-11: **Cumulative Storage Change in Scenario 3**

4.6.3 Results of Project Implementation Scenario 4

Scenario 4 include includes implementation of the M&I entities' regional conjunctive use program. Modeling results are compared to the Projected Conditions Baseline both without and with climate change.

Figure 4-12 shows the changes in groundwater hydrographs that result from Scenario 4 using the Projected Conditions Baseline without climate change. In Scenario 4, there are increases in groundwater levels over the 50-year simulation period ranging from 2-10 feet in the areas of recharge. This includes an increase of about 10 feet in the vicinity of the American River, which results in increased stream flow in the American River and increased subsurface flows to the North American Subbasin.

Figure 4-13 shows the cumulative change in storage in Scenario 4 as compared to the Projected Conditions Baseline both without and with climate change over the 50-year simulation period. While the Projected Conditions Baseline has an average annual reduction in storage of about 1,100 AFY without climate change, in Scenario 4 there is an average annual storage surplus of about 200 AFY. Similarly, while the Projected Conditions Baseline with climate change has an average annual reduction in storage of about 6,200 AFY, the average annual reduction in storage in Scenario 4 is about 4,800 AFY. Therefore, Scenario 4 provides an average annual storage benefit to the subbasin of about 1,300-1,400 AFY, in addition to storage benefits to the North American Subbasin.



Changes in Groundwater Levels for Scenario 4

South American Subbasin

Figure 4-12

Legend

● Cities and Towns

● Monitoring Wells

Rivers and Creeks

Folsom South Canal

Freeport Pipeline

Counties

South American Subbasin

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: June 2021

Figure Exported: 6/3/2021 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\4-12 Model Results with Hydrographs.mxd

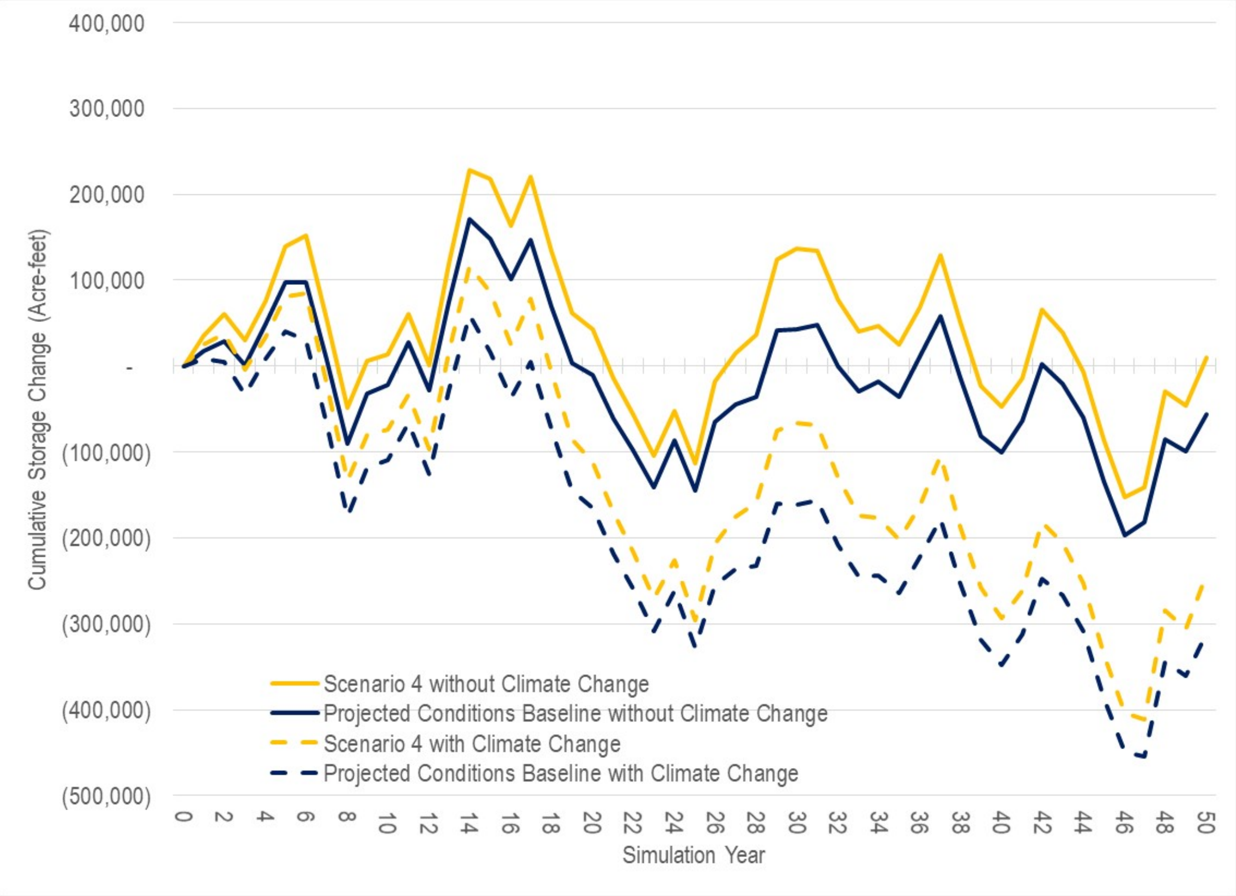


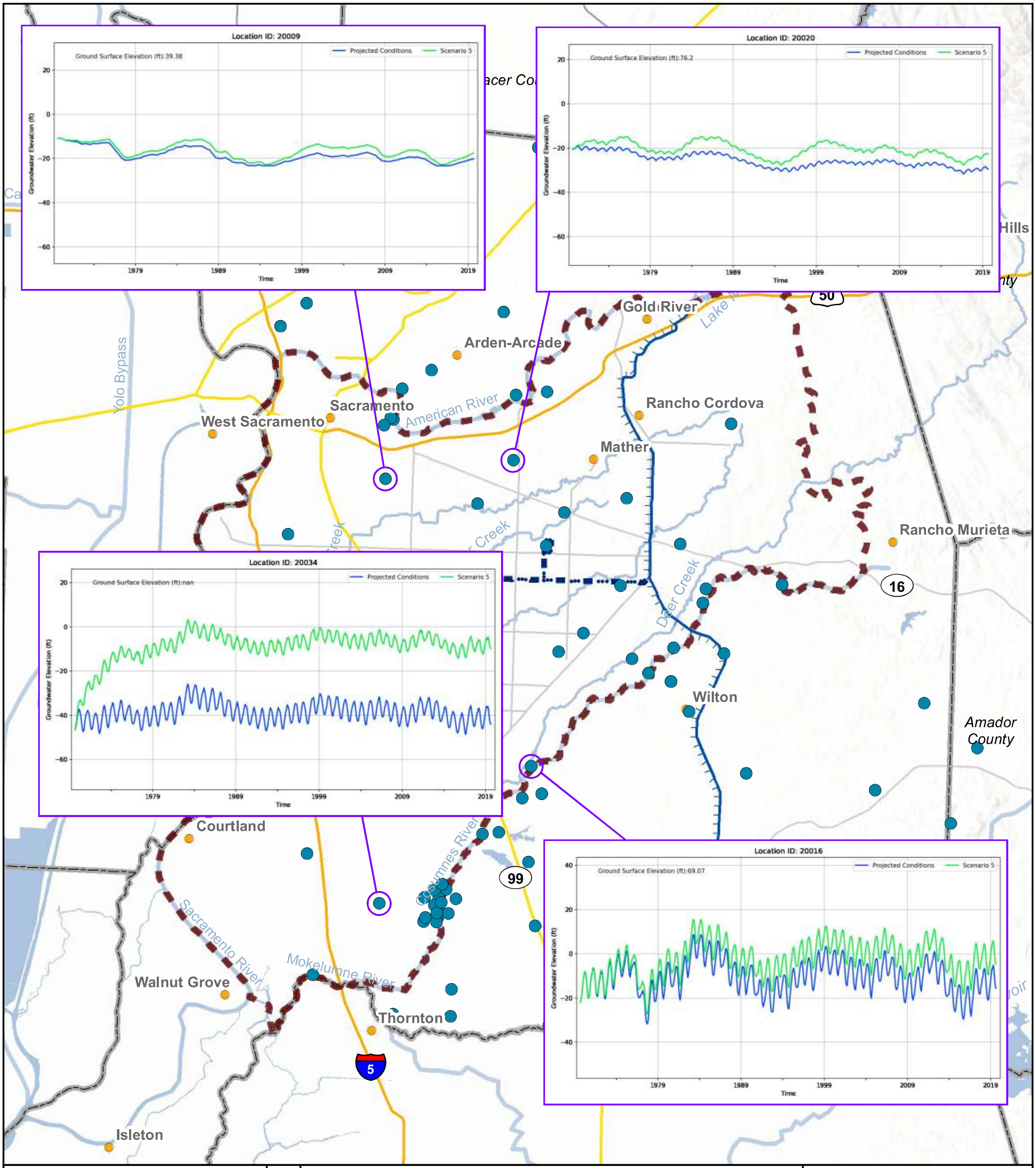
Figure 4-13: **Cumulative Storage Change in Scenario 4**

4.6.4 Results of Project Implementation Scenario 5

Scenario 5 includes all of the projects that were in Scenarios 3 and 4, which include implementation of Harvest Water and the OHWD recharge project, and implementation of the M&I entities' regional conjunctive use program. Modeling results are compared to the Projected Conditions Baseline both without and with climate change.

Figure 4-14 shows the changes in groundwater hydrographs that result from Scenario 5 using the Projected Conditions Baseline without climate change. Similar to Scenario 3, there is a significant increase in groundwater levels of about 30-40 feet in the vicinity of the Harvest Water project area in the southwestern portion of the basin in southern Sacramento County and more moderate increases in groundwater levels of about 10 feet along the Cosumnes River in the vicinity the OHWD GSA. Similar to Scenario 4, there are increases in groundwater levels over the 50-year simulation period ranging from 2-10 feet in the northern portion of the subbasin in the areas of recharge, including increases of about 10 feet in the vicinity of the American River. These relative groundwater level changes provide benefits to the American and Cosumnes Rivers in the form of increased streamflow and to the North American and Cosumnes Subbasins in the form of increased subsurface flows.

Figure 4-15 shows the cumulative change in storage in Scenario 5 as compared to the Projected Conditions Baseline, both without and with climate change over the 50-year simulation period. While the Projected Conditions Baseline has an average annual reduction in storage of about 1,100 AFY without climate change, in Scenario 5 there is an average annual storage surplus of about 4,500 AFY. Similarly, while the Projected Conditions Baseline with climate change has an average annual reduction in storage of about 6,200 AFY, the average annual reduction in storage in Scenario 5 is only about 100 AFY. Therefore, Scenario 5 provides an average annual net benefit to the subbasin in the range of 5,600 to 6,100 AFY, in addition to storage benefits provided to the North American and Cosumnes Subbasins. It is anticipated that planned demand management (as considered in either Scenario 1 or 2) resulting from implementation of future conservation measures (e.g., as described in 2020 Urban Water Management Plans) would offset the small storage deficit of 100 AFY predicted for Scenario 5 with climate change.



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Changes in Groundwater Levels for Scenario 5

South American Subbasin

Figure 4-14

Legend

● Cities and Towns
● Monitoring Wells
— Rivers and Creeks
┬┬┬ Folsom South Canal
••■•• Freeport Pipeline
▭ Counties
▨ South American Subbasin

0 1.25 2.5 5
Miles

N

South American SUBBASIN

Map Created: June 2021

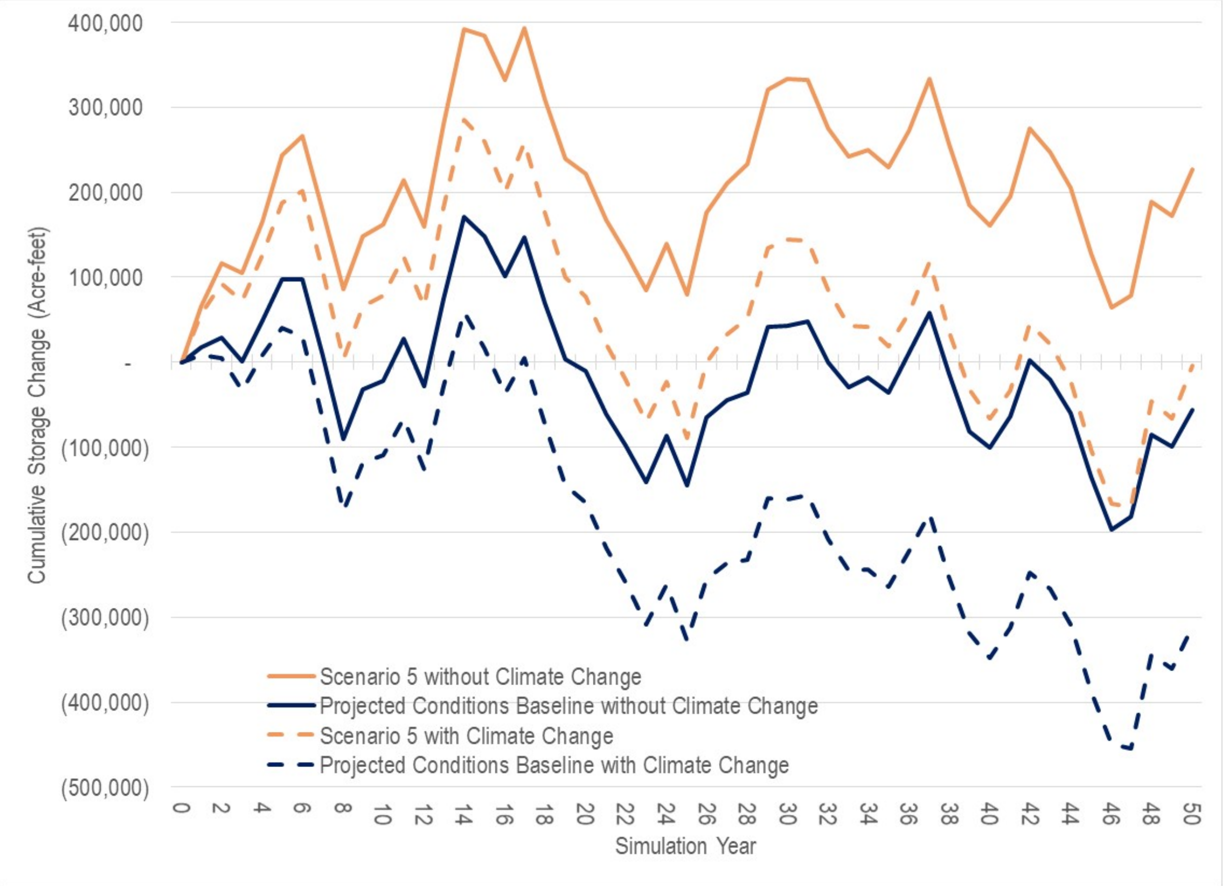

Figure 4-15: Cumulative Storage Change in Scenario 5

4.6.5 Summary of Project Management Scenario Results

The results of the project management scenarios are summarized for scenarios simulated without consideration of climate change in **Table 4-3** below and for the scenarios simulated with consideration of climate change in **Table 4-4** below. Both without and with climate change, all scenarios result in lower average annual groundwater pumping and an improvement in groundwater storage. Note that Scenarios 1 and 2 (Demand Reduction) were run separately from Scenarios 3, 4 and 5 (Projects) to assess the isolated benefit of either expected urban demand reductions or potential agricultural demand reductions. Therefore, estimated storage benefits resulting from Scenarios 1 and 2, which fall in the Group 1 category, are additive to the outcomes from the other scenarios, which are comprised of Group 2 projects. Long-term groundwater basin sustainability can be achieved under any of the projected management scenarios if projected conditions without climate change were to occur. If, as anticipated, the projects that were included in Scenario 5 all occur as planned, and accounting for an expected planned reduction in demand, long-term groundwater basin sustainability will occur under the climate change conditions that have been modeled.

Table 4-3: Summary of Project Management Action Modeling Scenarios Without Consideration for Climate Change

CoSANA Model Scenarios	Description	Average Annual Groundwater Pumping (AFY)	Average Annual Groundwater Storage Condition (Inflows minus Outflows) (AFY)
PCBL	Projected Condition Baseline	234,000	-1,100
Scenario 1	Demand reduction (5% Ag; 10% Urban)	216,500	+2,000
Scenario 2	Demand reduction (10% Ag; 10% Urban)	210,900	+2,800
Scenario 3	Harvest Water & OHWD Recharge	211,800	+3,200
Scenario 4	Regional Conjunctive Use	227,400	+200
Scenario 5	Harvest Water, OHWD Recharge & Regional Conjunctive Use	205,200	+4,500

Table 4-4: Summary of Project Management Action Modeling Scenarios With Consideration of Climate Change

CoSANA Model Scenarios	Description	Average Annual Groundwater Pumping (AFY)	Average Annual Groundwater Storage Condition (Inflows minus Outflows) (AFY)
PCBL CC	Projected Condition Baseline with Climate Change	245,800	-6,200
Scenario 2	Demand reduction (10% Ag; 10% Urban)	220,400	-1,800
Scenario 4	Regional Conjunctive Use	239,100	-4,800
Scenario 5	Harvest Water, OHWD Recharge & Regional Conjunctive Use	216,600	-100

4.7 Management Actions

In this subsection, proposed management actions to be taken by SASb GSAs as an element of GSP implementation are identified and described.

4.7.1 Shallow/Vulnerable Well Protection Program

The concept of a shallow/vulnerable well protection program has been discussed at numerous GSPWG meetings and public meetings. The purpose of the program would be to provide relief to users of shallow wells in the SASb impacted by declines in groundwater levels in the vicinity of their wells due to groundwater management activities associated with the GSP. Based on best available information, an analysis has been performed (**Appendix 3-C: Shallow Well Protection Technical Memorandum**) which indicates that the incidence of such impacts is projected to be low over the GSP planning horizon. However, uncertainty in measured and modeled groundwater elevations, the number of shallow/vulnerable wells in the SASb, well completion data, and age of active wells requires additional coordination, monitoring, and data collection to ensure ongoing protection of shallow and vulnerable wells. The creation of a shallow well protection program is intended to address the cases where such impacts may occur.

The development, implementation and funding of a shallow/vulnerable well protection program would be consistent with historical action in the SASb; a well protection program was previously considered by SCGA, as part of the Zone 40 Water Supply Master Plan and SCWA developed and implemented the North Vineyard Well Protection Program in the Sunrise-Douglas area within the City of Rancho Cordova. The new program would be developed with knowledge of the details of these previous efforts.

The Sacramento County Environmental Management Department Wells Program (Wells Program) is the entity with responsibility for oversight of well construction, modification, repair, inactivation, or destruction of wells in Sacramento County. Any water supply or monitoring well that is constructed in Sacramento County must first obtain a permit from the Wells Program. Therefore, the development of a shallow well protection program will be done in close coordination with the Wells Program.

An incremental approach to a well protection program is favored by the GSAs, with early emphasis on information gathering, outreach, program development and engagement. This includes formation of a shallow well advisory group (SWAG) comprised of local well owners and agency representatives, increased coordination, improved risk assessment based on additional data collection through a volunteer well monitoring network to assess groundwater depths, revision of well completion data, and early contributions to a well mitigation fund to address rehabilitation or replacement needs. After the first two (2) years (Phase I), an assessment will be made regarding future direction of the program (Phase II).

The SASb well protection program is organized around three core tasks: (1) stakeholder engagement and outreach, (2) coordination with and analysis of data from a volunteer well monitoring program, and (3) a well impact mitigation fund. Tasks 1 and 2 aim to acquire and integrate new information into well protection planning over time, and Task 3 provides a set-aside for reasonable financial protection to wells that may be impacted by drops in groundwater levels.

Task 1 – Stakeholder coordination and outreach:

The SASb GSAs will assist in the formation of a “shallow well advisory group” (SWAG) with representatives from the GSAs and local community members. The SWAG will meet bi-annually to coordinate community outreach, engage with stakeholders on well construction standards (e.g., Sacramento County EMD Wells Program), support the volunteer monitoring effort (task 2 below), and support further development of the well protection program. A critical objective of the SWAG is to assist in the definition of the scope and administrative details of the mitigation element of the well protection program.

Task 2 – Volunteer Monitoring Program (VMP):

Interest exists within the SASb agricultural-residential community to develop and participate in a volunteer well monitoring program (VMP). Data properly collected at individual wellheads is valuable information for identifying vulnerable wells and ascertaining if wells may be impacted by declining groundwater levels. In addition to groundwater levels, samples at selected wells may be used to assess water quality constituents of interest (e.g., nitrates, EC, arsenic, iron, manganese). Monitoring hundreds of wells in a single GSP is infeasible for the GSP[1];but, by involving many residents in a volunteer monitoring process, the VMP can improve the spatial and temporal resolution of groundwater level information, well completion data and water quality data. These improved data will in turn improve the accuracy of future well impact analysis, inform preventative rehabilitation (e.g., lowering pumps before wells are impacted), and empower local well owners to better understand the status of local groundwater conditions.

- Administration of the VMP includes outreach, communication, and training. It is assumed that activities will be coordinated by community representatives that also participate in the SWAG (task 1 above).

- Instrumentation (e.g., sensors) and administration (e.g., program support and training) needs will be assessed by the SWAG.

- Groundwater level and (in a subset of wells) groundwater quality data collection will take place at the scale of the individual participants. It is assumed that data interpretation will occur at the group level.

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[1] For scale and reference, the CA-DWR monitors around two thousand wells per year across the entire state as part of their ambient groundwater level monitoring.

- Solutions to automatically collect, transform, visualize, and report data collected by the VMP may be explored by the GSP working group during the first two (2) years of GSP implementation (i.e., Phase I – see next section).
- Using the DWR OSWCR database as a starting point, a well inventory for the basin will be developed. Processes will be developed by which residents can refine their well's location in the well inventory, and input key information.

Task 3 – Well impact mitigation fund:

In addition to increased monitoring, data collection, and coordination, modeled well impact estimates will be used to assess the risk to shallow/vulnerable wells in the SASb and to assess the need for a mitigation fund – built up over time – to rehabilitate or replace wells directly impacted by declining groundwater levels. The need and amount of the fund will be informed by the best available estimates of the number of wells that may be impacted if MTs are reached, and the value attributable to those wells. Importantly, if a well is impacted, data collected by the VMP will help determine the likely cause. Eligibility conditions that define the well impacts that are covered by the fund will be scoped by the GSAs, in coordination with the DWAG, and may include factors such as well age, construction status, and the nature of the problem with the well. Throughout implementation, the size of the fund will be adjusted in accordance with the best available information on well vulnerability.

Timing

The timing of Tasks 1, 2 and 3 in GSP implementation will proceed in two phases:

Phase I: For the first two (2) years of GSP implementation (2022-2023), additional effort will be placed on establishing agency-community relationships, building a volunteer monitoring network, and improving well completion data (Tasks 1 and 2). A well rehabilitation fund will be progressively built, commensurate in amount to current estimates of vulnerable wells. Data collected in this phase will inform the need, scope and structure of a rehabilitation fund (Task 3).

Phase II: By the third year of GSP implementation (2024), the GSP will re-assess and adjust startup efforts to focus on program maintenance and will determine the appropriate scope of a rehabilitation fund (Task 3). These activities will continue as appropriate throughout the implementation period.

Details of Program that are to be Developed

The administrative details to be resolved in the development of a Shallow Well Protection Program during the Phase I period may include the following. Note that this list of questions is provided only as an example of possible considerations and does not represent the content of the eventual Shallow Well Protection Program for the SASb.

1) Who should be covered by a Shallow Well Protection Program?
    - Domestic well owners
    - Agricultural irrigation well owners
    - Other private wells (industrial, commercial, institutional)

2) What area should be covered?
    - Only outside the boundaries of municipal water suppliers
    - Outside the distribution system of municipal water suppliers
    - Within water supplier service areas

3) What services should be covered?
    - Emergency water supply (bottled water, water truck)
    - Pump lowering
    - Pump replacement
    - Well deepening
    - Drilling of a replacement well

4) Would the full cost of services be covered?

5) What conditions in the groundwater basin are covered?
    - Regional decline in water levels
    - Local decline in water levels, i.e., influenced by a neighboring well

6) Is a Water Well Drillers Report necessary to cover a well in the program?

7) Should well owners be required to register in advance and provide information on their well to be a candidate for assistance under the program?

8) Should the program be proactive , i.e., identify wells at greatest risk and take early actions, reactive, or both?

9) How should the program be funded and administered?

It is intended that the GSAs will work in concert with the SWAG and other stakeholders to develop the administrative and policy details of the Shallow Well Protection Program for the SASb during the Phase 1 period, as described above. This management action is the commitment to develop and fund the phased program described above in the first several years of GSP implementation.

4.7.2 Well Permit Coordination

A second management action under this GSP is the development and implementation of a process for SASb GSAs to coordinate with the EMD Wells Program. The GSAs will work with EMD and the Sacramento County Board of Supervisors to modify well construction ordinances or take other measures to establish:

- Minimum screen depth requirements to limit high-capacity wells from impacting the shallow zone of the SASb aquifer and users on that shallow zone (i.e., shallow domestic and agricultural wells, groundwater-dependent ecosystems, inter-connected surface waters)

- Well spacing requirements for high-capacity wells to limit impacts on existing wells
- Consultation/coordination between EMD Wells Program and SASb GSAs to ensure new wells do not impact the performance or quality of information derived from wells in the GSP Monitoring Network.

4.7.3 Coordination Activities

A third management action under this GSP is a commitment to provide resources for ongoing coordination with various entities on various topics to support GSP implementation. Each of the proposed coordination activities are consistent with effective management of groundwater resources in the SASb and are also consistent with the requirements of SGMA for GSP development and implementation.

The specific activities included in this management action include:

a. Coordination with GSAs on overarching groundwater management issues consistent with the GSP (through a governance structure that is provided as a companion document to this GSP).

b. Coordination with agencies with local land use authority in the SASb to ensure that future land use plans consider the information generated through GSP implementation, including monitoring data and specific modeling results. The GSP has been developed using available information from existing land use plans. Identify and evaluate significant changes in those land use plans that may significantly impact the future groundwater conditions in the SASb. Proactively work with land use agencies to ensure future development is compatible with GSP goals, attainment of SMC and implementation actions by GSAs through information sharing and annual meetings with those agencies.

c. Coordination with entities sponsoring beneficial projects identified in this GSP to provide support and otherwise facilitate implementation of these projects, including support for grant funding opportunities, as appropriate

d. Coordination with water supply agencies to support their implementation of water use efficiency measures. For agencies responsible for the development of urban water management plans, it is anticipated that the 2020 versions of those plans will lead to increased water conservation practices. This coordination activity will encourage implementation of the urban demand management scenarios that were modeled with CoSANA. Coordination with RWA, Water Forum, and local agencies regarding regional water supply planning and water resources management.

e. Coordination with GSAs in adjacent basins, including consideration and/or development of formal agreements to support ongoing information sharing during GSP implementation (e.g., groundwater levels, boundary fluxes, outreach messages). Coordination with the Cosumnes Subbasin to address data gaps along the middle reach of the Cosumnes River to address uncertainties regarding interconnectedness between surface water and groundwater. Coordination with NASb and Water Forum to ensure Lower American River Flow standards are addressed appropriately, and that the subsurface flow conditions and movement of regional contamination plumes are properly controlled within the context of regional contamination cleanup efforts.

f. Coordination with Regional Water Authority and other regional partners to support development of a groundwater banking and accounting framework to enable effective implementation of future conjunctive use projects and other water resource management actions, consistent with attainment of the sustainability goal in the SASb. The Sacramento Regional Water Bank is envisioned as an institutional and legal framework for operating a sustainable storage and recovery program in the NASb and SASb. Participation in the Regional Water Bank will be voluntary, with incentives in place to expand conjunctive use operations. The primary goal will be to manage the subbasins sustainably and to enhance climate change resiliency, while protecting all beneficial uses and users. Fundamental principles of the Regional Water Bank are that water must be stored before it can be recovered, that losses must be taken into account, and that the net effect of its operations are to enhance groundwater conditions in the subbasins, in the form of increasing groundwater levels and storage. Operation of the Regional Water Bank will require monitoring, modeling and mitigation to ensure the protection of all users and beneficial uses. Planning for the Regional Water Bank, led by the RWA, is projected to proceed over the next several years, with active participation by the GSAs and other entities in the NASb and SASb.

g. Coordination with Regional Water Authority and other regional partners in the development of a refined climate change assessment for use in the 5-year update of the SASb GSP.

4.7.4 Address Data Gaps

A fourth management action under this GSP to be implemented by the GSAs is the collection of information to fill data gaps that are identified in the GSP. Specifically, this includes the following:

a. Collection of well depth and screened interval information for specific wells in the Monitoring Network as described in **Section 3**.

b. Collection of groundwater and surface water information in the stretch of the Cosumnes River between Deer Creek and Twin Cities Road which has been identified in **Section 3** as an area where the interconnectedness of surface and groundwater is uncertain.

c. Analysis of water quality samples collected by shallow well owners under the Shallow Well Protection Program Voluntary Monitoring Network. The number of samples and the water quality constituents to be analyzed will be determined by the GSAs in coordination with the Shallow Wells Advisory Group described in **Section 4.7.1** above.

The GSAs will develop a plan, schedule and budget estimate for actions to address the data gaps identified above within the first year of GSP implementation.

Section 5: Plan Implementation

Groundwater management has been ongoing in the South American Subbasin (SASb) and the neighboring North American Subbasin (NASb) and Cosumnes Subbasin for decades. As described in prior sections, a variety of projects and management actions (PMAs) have been implemented in recent years which have largely stabilized current groundwater conditions in terms of groundwater levels, storage volume and interconnected surface waters. As planned changes in land use occur, a small annual decline in storage volume is likely to occur and will increase under potential future climate change conditions. Additional projects are currently planned and being implemented by local entities which will contribute to the maintenance of sustainable conditions in the SASb over the implementation horizon of this Groundwater Sustainability Plan (GSP). PMAs described in **Section 4** will improve groundwater conditions in the SASb and enable the continued and effective use of groundwater with sufficient flexibility to ensure a sustainable groundwater system into the future. These projects include recycled water use, winter recharge in years with adequate peak stream flows, and regional conjunctive use projects; management actions include well protection actions, GSA coordination activities, and information gathering that will benefit all uses and users in the SASb.

In this section, the elements of GSP implementation are identified and described. Those elements include:

- GSA management, administration, legal and day-to-day operations
- Implementation of the GSP monitoring program activities described in **Section 3**
- Technical support, including model updates and other technical analysis
- Coordination and partnership activities among GSAs within SASb and with other entities
- Reporting, including preparation of annual reports and 5-year evaluations and updates
- Projects and Management Actions (PMAs) as described in **Section 4**
- Ongoing outreach activities to local, regional, state and federal stakeholders
- Actions in response to Undesirable Results

Cost estimates and elements of a plan for funding GSP implementation are also presented in this section.

It should be noted that an effort has been performed to develop an agreement and governance structure for the implementation of the SASb GSP by the GSAs responsible for this GSP. This agreement (which is submitted as a companion document to this GSP) will establish the framework for joint activities by the GSAs that are described in this Section.

5.1 Description of GSP Implementation Elements

The following tasks and functions will be required for implementation of this GSP:

5.1.1 GSA Management, Administration, Legal and Day-to-Day Operations

GSA functions associated with the management and administration of the GSP implementation activities are covered under this category, which includes administrative, technical and finance staff support and related expenses; office supplies; insurance; and grant writing to support funding for specific projects and/or management actions. GSA staff and/or contractors will provide work products, administrative support, staff leadership, and management for the GSAs.

As the GSP implementation begins in 2022, staffing support and ongoing administrative and management needs will be further evaluated so that necessary budget refinements can be incorporated. Staffing needs will be reevaluated annually during the early years of GSP implementation to gain a better understanding of the support required. Staffing needs during out-years will be assessed on an as-needed basis.

Each of the GSAs in the SASb are administered independently. These agencies run their own meetings and oversee individual GSA projects and programs. GSA administration activities include coordination meetings within each GSA; coordination with other GSAs on projects or studies; coordination meetings of a GSP Implementation Ad-hoc Committee; email communications for updating GSA members about on-going activities; administration of projects implemented by the GSA; public outreach; and general oversight. Coordination meetings between the GSAs are anticipated to occur quarterly. Other coordination, oversight and administrative activities will occur on an as-needed basis.

Each GSA is responsible for and authorized to take appropriate action to achieve sustainable management of groundwater within their portion of the Subbasin based on the authority granted under Section 6 of the California Water Code. As such, GSAs may retain legal counsel to assist in these actions.

5.1.2 Implementation of the Monitoring Program Activities

This category covers the functions associated with monitoring activities, including logistics and coordination with entities performing monitoring of wells in the GSP Monitoring Network, and associated management of monitoring data. The GSP Monitoring Networks for groundwater level and groundwater quality, including the agencies performing that monitoring, are explained in **Section 3**.

To address data gaps that are identified during GSP implementation, improvements to or expansion of the GSP Monitoring Network may be necessary. In that event, coordination with existing well owners will be explored as a first step in expanding the monitoring network. This work may include data acquisition at additional monitoring wells; drilling new dedicated monitoring wells; monitoring well instrumentation; sampling and in-situ measurements; sample analysis; and maintenance and upkeep of associated data management system and data analysis and reporting. Costs for those facilities and activities are uncertain at this time but will be developed as the need arises during GSP implementation.

Areas of particular interest for additional data collection include information regarding well depth and screened intervals for specific wells in the GSP Monitoring Network and groundwater monitoring wells and stream gages along the middle reach of the Cosumnes River. These activities are included in the GSP as a management action and are described in **Section 4**.

Annual monitoring and data-related activities include:

- Groundwater Elevation Monitoring
- Groundwater Quality Monitoring
- Groundwater Extraction Monitoring/Modeling
- Stream flow Monitoring
- Obtaining and utilizing available satellite imagery and/or vegetation data to monitor GDEs as described in **Section 3**
- Monitoring Data Management (including data management system [DMS] maintenance), data validation (QA/QC), data entry and security, and data sharing

5.1.3 Technical Support, Including CoSANA Model Updates, Sustainable Management Criteria (SMC) Tracking, Other Data Analysis and Technical Support

CoSANA Model updates – Management activities and ongoing performance evaluation of the SMC are informed by CoSANA model output, which will require periodic updates and refinements as additional data and new information become available. Model updates and refinements will improve the model functionality and its capabilities in providing representative and defensible model output. These activities will include incorporation of new modeling tools and features; data input and model parameter updates; calibration updates as additional data from the monitoring network and stream gages are obtained; use of CoSANA to update water budgets, assess water usage, and assess the status of the SASb-wide groundwater storage volume; and related work to support ongoing analysis of implementation of PMAs, including conjunctive use, recharge and water banking projects.

SMC tracking – Synthesis of data will be performed to analyze and track the status of compliance with SMC at the representative monitoring point (RMP) wells in the SASb Monitoring Network. This synthesis will provide essential information for inclusion in the annual reports and 5-year GSP updates and will also provide information to trigger action by GSAs in the event problems in achieving SMC are detected.

Database Management System (DMS) – As data on groundwater conditions become available, the DMS will be updated and refined to support the annual reporting requirements, as well as supporting model refinements and updates. This data includes, but is not limited to, annual land use and cropping patterns, water demands by urban water purveyors and agricultural entities, groundwater levels, groundwater use, surface supply use, and hydrologic conditions data, including precipitation and streamflow. Additionally, new groundwater quality data will be added to the DMS.

Data analysis and other technical support – Data analysis will be needed for the annual reporting and 5-year GSP update and to support outreach activities. The GSAs may require support to integrate new information into the GSP as ongoing work proceeds to fill identified data gaps. In addition, as-needed data analysis and other technical support needs may arise to support the GSAs in implementation of the GSP.

5.1.4 Coordination Activities with Other GSAs and Entities

As identified in **Section 4**, GSAs in the SASb will need to budget for ongoing coordination during GSP implementation to meet SGMA requirements and to enable/promote sustainability of the SASb. Coordination will be required with the following entities on the following topical areas as a management action under the GSP:

- With other GSAs in SASb on GSP implementation measures, including, but not limited to, joint management actions, regional water bank/accounting, and grant applications supporting recharge projects.
- With agencies in SASb with land use jurisdiction to identify activities that may impact SASb groundwater sustainability.
- With GSAs in adjacent subbasins to coordinate possible future agreements, information exchange, monitoring network augmentation, and to resolve any issues regarding SMC along their common boundary. Additionally, as the CoSANA model is a common analysis tool among the NASb, SASb, and COSb, coordination is needed among various GSAs in these subbasins regarding data collection, model upgrades, calibration updates, and application.
- With water supply agencies to obtain updated information on monthly water use volumes, implementation of water use efficiency programs, and information regarding the impacts of those programs on water demands.
- With entities sponsoring projects in the SASb that will provide benefits to attainment of sustainability goals and objectives, including support for grant funding.
- With other regional entities to work on regional water bank development and implementation and to continue to refine climate change studies to develop the projections that can be used in preparing the 5-year update to the GSP.

To achieve this coordination, the SASb GSAs will need to develop governance and communication processes to support these activities efficiently and effectively.

5.1.5 Reporting, Including Preparation of Annual Reports and 5-year Evaluations and Updates

As part of GSP implementation, the GSAs must, either singly or jointly, prepare and submit annual reports and 5-year assessments to the California Department of Water Resources (DWR). Annual reports will be submitted to DWR by April 1st of each year for the previous water year (WY), and an initial 5-year GSP assessment and update will be due to DWR by April 2027. Requirements for each of these reports are explained below.

5.1.5.1 Annual Reporting

Per Water Code Sections 10727.2, 10728, and 10733.2, SGMA regulations require the GSAs to submit an annual report on the implementation of the GSP to the DWR. Each annual report will be submitted to DWR by April 1st for the previous WY (October 1st to September 30th). Development of each annual report will begin during October of each calendar year. Therefore, the first Annual Report will cover WY 2021 and will be submitted by the GSAs to DWR no later than April 1, 2022. (Note that WYs 2015 through 2020 will be included in the first annual report, as required by SGMA, because groundwater conditions have not been reported for those WYs.) The annual reports will be completed in a format consistent with Section 356.2 of the SGMA regulations and include the following three key sections:

5.1.5.1.1 General Information

General information will include a map of the Subbasin and an executive summary that includes a description of the sustainability goal, ongoing PMAs in the subbasin, jointly funded PMAs and their progress, as well as an updated implementation schedule.

5.1.5.1.2 Basin Conditions

This section will describe the current groundwater conditions and monitoring results used to evaluate how groundwater conditions have changed in the Subbasin since the previous WY. SGMA regulations require the following key components to be included in this section:

- Groundwater elevation data from monitoring wells in comparison to SMC and will include (1) groundwater elevation contour maps for the principal aquifer depicting seasonal high and low groundwater conditions, and (2) hydrographs of historical-to-current-reporting-year data showing groundwater elevations and WY type.

- Groundwater extractions during the WY summarized by water use sector, including a map showing the general location and volume of groundwater extractions, as well as the method of measurement (direct or estimate) and accuracy of measurements.

- Surface water supply for groundwater recharge or in-lieu use, including the annual volume and sources for the WY.

- Total water uses by water use sector and water source type, including the method of measurement (direct or estimate) and accuracy of measurements.

- Maps of changes in groundwater storage for the principal aquifer and a graph depicting historical-to-current-reporting-year WY type, groundwater use, annual change in groundwater in storage, and the cumulative change in groundwater storage for the Subbasin.

This information may change over time to incorporate potentially revised GSA priorities and to reflect new Subbasin conditions and applicable SGMA requirements.

5.1.5.1.3 Plan Implementation Progress

The progress made toward achieving interim milestones, as well as implementation of PMAs, will be explained in this section, along with a summary of plan implementation progress and sustainability progress.

5.1.5.2 Periodic Evaluations Every 5 Years

Per Water Code Sections 10727.2, 10728, 10728.2, 10733.2, and 10733.8, SGMA regulations require the GSAs to provide a written assessment of GSP implementation and progress towards meeting the sustainability goal at least every 5 years. A similar evaluation must also be submitted whenever the GSP is amended. The 5-year assessment reports will be completed in a format consistent with Section 356.4 of the SGMA regulations and include the following elements:

5.1.5.2.1 Sustainability Evaluation

The overall Subbasin sustainability and current groundwater conditions for each applicable sustainability indicator will be described, including progress toward achieving interim milestones and measurable objectives, and an evaluation of groundwater elevations at each of the RMPs in relation to minimum thresholds. The report shall describe any observed or anticipated problems in attaining SMC and actions taken by GSAs to either prevent or respond to such problems.

5.1.5.2.2 Plan Implementation Progress

This section will describe the current implementation status of PMAs, along with the effect on groundwater conditions resulting from their implementation, if applicable.

5.1.5.2.3 Reconsideration of GSP Elements

Elements of the GSP may require revision due to one or more of the following: collection of additional monitoring data during GSP implementation; collection of information to fill identified data gaps; exchange of information with adjacent subbasins; implementation of PMAs; significant changes in groundwater uses or supplies and/or land uses. Such new information may require revision to the following GSP elements: Subbasin setting, water budgets, monitoring network, SMC, PMAs, GSP implementation, and/or inter-basin coordination.

5.1.5.2.4 Monitoring Network Description

This section will provide an assessment of the monitoring network’s function, an analysis of data collected to date, a discussion of data gaps and the steps taken to address them, and identification of areas within the Subbasin that are not monitored in a manner commensurate with the requirements of Sections 352.4 and 354.34(c) of the SGMA regulations.

5.1.5.2.5 Consideration of New Information for Basin Setting and SMC

New information made available after GSP adoption will be described and evaluated. If new information would warrant a change to the GSP, including a re-evaluation of the Subbasin setting and SMC, then corresponding revised descriptions will be included in the 5-year evaluation report.

5.1.5.2.6 Regulations or Ordinances

If DWR adopts new regulations that impacts GSP implementation, the update will also identify and address those requirements that may require updates to the GSP.

5.1.5.2.7 Legal or Enforcement Actions

Any enforcement or legal actions taken by the GSAs or their member agencies to contribute to attainment of the sustainability goal for the Basin will be summarized.

5.1.5.2.8 Plan Amendments

Each 5-year assessment report will include a description of amendments to the GSP, including adopted amendments, amendments that are underway during development of the report, and recommended amendments for future adoption.

5.1.5.2.9 Coordination

A summary of coordination activities will be provided in the 5-year assessment report, including activities between SASb GSAs, with GSAs in neighboring subbasins, and with agencies with jurisdiction over land use, water supply and well construction within the Subbasin.

The 5-year assessments will also include any other information deemed appropriate by the GSAs to support DWR in its periodic review of GSP implementation as required by Water Code Section 10733.

5.1.6 Projects and Management Actions

Section 4 of this GSP identifies three different groups of projects in the SASb, plus several management actions, as follows:

1. **Group 1** – Projects that are currently in place and will continue to be implemented by specific participating agencies within the SASb to support groundwater management and GSP implementation.

2. **Group 2** – Projects that are currently planned and will be implemented by specific participating agencies within the SASb in the near future which will contribute to attainment of SMC and the attainment of the SASb sustainability goal, and will otherwise support GSP implementation.

3. **Group 3** – Projects which have been identified which may occur in the SASb in the future, would provide benefits in contributing to the attainment of the sustainability goal and SMC, and would otherwise support GSP implementation.

4. Management actions that will be undertaken jointly by the SASb GSAs to provide assurance that beneficial uses and users of groundwater will be protected and maintained.

As described in **Section 4** and based on the results of CoSANA model scenario analyses, the projects in Groups 1 and 2 will be sufficient to ensure sustainability of the SASb and to avoid the occurrence of undesirable results. The Group 1 and 2 projects will be separately sponsored and funded by individual entities and will therefore not require funding by the GSAs. The supplemental multi-benefit projects in Group 3 would provide opportunity for improvement of groundwater conditions in the SASb and to support adaptive management in the event future conditions or outcomes are different than projected.

The management actions that will be undertaken by the GSAs in the SASb, either jointly or singly, include the following, which are described in greater detail in **Section 4**:

- Development and implementation of a Shallow/vulnerable well protection program in coordination with local well owners.
- Coordination with Sacramento County Environmental Management Wells Program to revise Well Construction requirements to protect existing wells and promote consistency with the GSP.
- Actions to fill identified data gaps in **Section 3**.
- A variety of coordination activities, including:
  - Coordination with GSAs in the SASb.
  - Coordination with agencies with local land use authority to enable appropriate consideration of GSP provisions in land use decisions and to establish regular communications between GSAs and those agencies.
  - Coordination with entities sponsoring the planned projects described in **Section 4** that will be beneficial to attainment of the goals of the GSP.
  - Coordination with water supply agencies to support water use efficiency measures and coordination with Regional Water Authority (RWA), Water Forum and local agencies regarding regional water supply planning and water resources management, including development of refined climate change projections.
  - Coordination with GSAs in adjacent basins to share information (e.g., groundwater levels and boundary fluxes) and to coordinate outreach activities and messages, as appropriate.
  - Coordination with RWA and others to support the development, formation and operation of the Sacramento Regional Water Bank and associated accounting framework in the SASb.

Table 5-1 presents management actions, responsible entity, and proposed means for generating revenues to support these actions.

Table 5-1: Proposed Responsible Entities and Proposed Funding Mechanisms for Proposed Management Actions

Management Actions	Proposed Responsible Entity	Proposed Funding Mechanism
Shallow Well Protection Program	GSAs under MOU	Combination of fees and property tax, potentially supplemented by grant funds
Well Construction coordination – Proposed Ordinance revisions	GSAs under MOU	Combination of fees and property tax
Actions to fill identified data gaps	GSAs under MOU	Combination of fees and property tax
Coordination activities with various entities	GSAs under MOU	Combination of fees and property tax

5.1.7 Outreach/Engagement with Stakeholders

Activities under this element of the GSP implementation plan include continuation of education, outreach, and engagement with stakeholders, building off the framework and activities established in the GSP Working Group meetings that led to the development of the GSP and further described in the Communication and Engagement Plan, as described in **Section 2.** Such activities performed during GSP implementation include maintaining the SASb website and the online/social media presence of member agencies, convening regular community meetings, workshops, and public events. The formation of a stakeholder advisory group has been suggested by engaged stakeholders and should be considered by the GSAs, given the benefit derived from stakeholder input during GSP development and the basic premise of SGMA to promote such engagement. These activities may also include electronic newsletters, informational surveys, coordination with entities conducting outreach to diverse and/or disadvantaged communities in the Subbasin, coordination with tribal representatives, and development of brochures and print materials. Decisions regarding the nature and extent of these outreach activities will be made by the GSAs, acting either singly or jointly.

5.1.8 Actions in response to Undesirable Results

In the event Undesirable Results are either anticipated or observed based on the information derived from the monitoring and reporting functions described above, the GSAs will take the following actions:

- Clearly identify the information pointing to either anticipated or observed Undesirable Results, e.g. failure to meet SMC at specific Monitoring Network wells at problematic frequency or duration, failure to meet criteria for protection of GDE or ISW, unanticipated failures of shallow wells

- Commence an investigation to determine the cause of the anticipated or observed problem

- Develop and implement a plan and schedule for resolution of the problem, including allocation of resources.

- Track progress in resolution of the problem
- Report the above in the annual report to DWR.

It should be noted that the technical work supporting the development of this GSP does not project the occurrence of Undesirable Results in the SASb, based on best available information. The above process is described to address unanticipated future events.

5.2 Estimate of GSP Implementation Costs

The implementation costs for the SASb GSP will include funding for functions associated with the GSP implementation elements described above, including GSA management and administration, monitoring, technical support, data management, coordination, reporting, GSP management actions, and outreach. GSP implementation costs will also cover the building of sufficient fiscal reserves to address other potential costs for the near-term GSP planning horizon.

Implementation of the SASb GSP over the 20-year implementation horizon by the SASb GSAs is projected to cost $860,000 per year, to be shared among the GSAs, and does not include the cost of new wells or equipment. The estimated costs for management and administration of each GSA are separate and could range from $120,000 to $460,000 per year, depending on the specific GSA and its activities.

Table 5-2 summarizes the estimated costs by implementation element; the table includes a range of GSA-specific management and administrative costs in addition to the estimate of shared costs. These costs are based on the best available estimates at the time of Plan development and may vary during the period of Plan implementation. Grant awards may offset some costs. If the GSAs develop additional projects or management actions during the GSP implementation period, the cost estimates will be refined and reported to DWR through annual reports and the 5--year periodic assessments.

Development of this GSP was funded through a Proposition 1 Groundwater Grant Program and Proposition 68 Grant, with additional local share contributions. The GSAs may pursue additional grant funding for GSP implementation, if it is available. The GSAs will identify other sources of funding to cover GSP implementation costs, which may include parcel fees, groundwater extraction fees, increased water rates, other grants, and low interest loans. The exact funding mechanisms will vary by GSA and will depend on the legal authority of each GSA.

Table 5-2: Summary of Estimated GSP Implementation Costs

GSP Implementation Tasks	Annual Cost Range (varies by GSA)	Annual Costs (Shared Among GSAs)
GSA Management, Administration, Legal and Day-to-Day Operations		
Administrative Staff Support /Accounting	$50,000 – $190,000	
GSA management and staff support	$50,000 – $190,000	
Legal support	$10,000 – $40,000	
Implementation of the GSP Monitoring Program Activities		
Monitoring data collection, Coordination with monitoring entities, Data Validation		$80,000
Data management		$35,000
New monitoring wells, equipment (not including costs for Management Action 4)		To be determined (TBD)
Technical Support, including Model Updates and other Technical Analysis		
CoSANA Model updates		$70,000
Special data analysis needs		$20,000
SMC Tracking		$40,000
GSP Reporting		
Annual Reports		$60,000
5-Year GSP Assessments (annual contribution to fund $1.0 million reserve for 5-year update to GSP)		$200,000
GSP Management Actions		
Management Action 1 – Shallow/Vulnerable Well Protection Program		$100,000
Management Action 2 – Well construction requirement revisions		$20,000
Management Action 3 – Coordination activities		$100,000
Management Action 4 – Address Data Gaps		$30,000
Ongoing Outreach Activities to Stakeholders		
Outreach & Education		$25,000
Contingency		
Contingency (~10%)	$10,000-40,000	$80,000
Total [not including new monitoring wells]	**$120,000-460,000**	**$860,000**

5.2.1 Financial Reserves and Contingencies

To mitigate financial risks associated with expense overruns due to unanticipated expenditures and actual expenses exceeding estimated costs, the GSAs may carry a general reserve with no restrictions on the types of expenses for which it can be used. Adoption of a financial reserves policy is authorized by SGMA Sections 10730(a) and 10730.2(a)(1). A reserve for operations usually targets a specific percentage of annual operating costs and may consider factors such as billing frequency and the recurrence of expenses to address cash flow constraints.

5.2.2 GSP Implementation Costs Through 2042

Implementation of this GSP is estimated to have a total annual cost as described in **Table 5-2**. The estimated annual costs include an approximate 10% contingency amount which would be used for unanticipated expenditures.

5.3 Schedule for Implementation

The schedule for agency administration, management and coordination activities, GSP reporting, and community outreach and education is provided in **Table 5-3**. While most activities are continuous during GSP implementation, annual reports will be submitted to DWR by April 1st of each year and periodic 5-year assessment reports will be submitted to DWR by April 1st every five years after the initiation of Plan implementation in 2022 (i.e., assessment report submittal in 2027, 2032, 2037, and 2042).

Table 5-3: GSP Implementation Schedule

Description	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
GSP Development & Adoption	▨																					
GSP Submittal to DWR																						
Agency Administration & Operations	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Management & Coordination																						
Monitoring: Groundwater	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Monitoring: Streamflow	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Data Collection	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Data Management	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
GSP Reporting																						
Annual Reports		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Five-year Assessment Report							▨					▨					▨					▨
Outreach & Education	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

5.4 GSP Implementation Funding Approach

The SGMA regulations require various financial information for the implementation of a GSP. The requirements state that a GSP must include:

1. An estimate of the cost of implementation of the GSP and a description of how the GSA(s) will meet those costs.

2. Cost estimates for each project and management action that the GSA(s) will implement that will help the basin achieve sustainability and a description of how the GSA(s) will meet those costs.

A summary of the costs related to implementation of the GSP (**Table 5-2**), was provided previously in this Section. In Section 4, the project and management actions (PMAs) identified to meet the requirements of SGMA and meet the sustainability requirements for the SASb are described. Given this information, the following sub-sections outline the funding approach for the identified activities, management actions, and projects.

5.4.1 Legal and Financial Resources

As noted in this report, the SASb contains six separate GSAs. Five of the six GSAs entered into an MOU (**Appendix 1-B**) to establish the GSPWG. RD 551, the sixth GSA, subsequently entered into an agreement with the NDGSA to be represented on the GSPWG. Each GSA is a slightly different type of public agency, but all are local agencies that were approved by DWR as meeting the requirements to serve as a GSA for their portion of the subbasin. As a GSA, the local agencies have the legal authority to:

> "…impose **fees**, including, but not limited to, permit fees and fees on groundwater extraction or other regulated activity, to fund the costs of a groundwater sustainability program, including, but not limited to, preparation, adoption, and amendment of a groundwater sustainability plan, and investigations, inspections, compliance assistance, enforcement, and program administration, including a prudent reserve." (Water Code Section 10730)

The following sections present a summary of the GSAs, their legal authority and financial means to fund the implementation of the GSP and associated management actions. More background information about each GSA is presented in Section 1.4.1. The GSAs will execute an MOU to address governance and cost sharing for GSP implementation.

5.4.1.1 Sacramento Central Groundwater Authority GSA

The Sacramento Central Groundwater Authority (SCGA) is a Joint Powers Authority of five entities in the South American Subbasin: the cities of Sacramento, Folsom, Rancho Cordova, and Elk Grove, and the County of Sacramento. These five agencies are the signatories of the JPA. The governing board of the SCGA is made up of sixteen members that include representation from nine public agencies, two private water purveyors, one representative of agricultural interests, one representative of agriculture-residential groundwater users, one representative of commercial/industrial self-supplied groundwater users, one representative of conservation landowners, and one representative of public agencies that are self-supplied groundwater users.

SCGA recently completed a fee study outlining the level of annual fees necessary to support SCGA and the costs associated with implementing the GSP and funding for PMAs. A copy of the fee study can be found at https://scgah2o.saccounty.net/Pages/SCGA-Groundwater-Fee.aspx. The fee study outlined a funding methodology based on a "hybrid" approach. The "hybrid" component of this study is that the urban water purveyors will be billed directly and pay

SCGA based on the number of parcels and groundwater usage by the purveyor within their service area and located within the SCGA GSA. All other parcels, i.e., those outside the service areas of the urban water purveyors, will be billed through the property tax rolls and those revenues generated will be distributed to SCGA. Under this approach, all parcels within the SCGA GSA will be contributing to the funding of SCGA through a parcel fee and, if using groundwater, a groundwater usage fee.

The SCGA Board held several public meetings discussing the fee study approach, methodology, and charges. As part of the fee study approach, the fee program was implemented through a Proposition 218 process. In April 2021, SCGA mailed out a customer notification outlining the proposed fee to the affected parcels. On June 22, 2021, SCGA held a public hearing to receive customer comments and determine if a majority protest existed. A majority protest did not occur and subsequently the SCGA Board adopted the fee program.

5.4.1.2 Sacramento County GSA

Sacramento County GSA is an approximately 1,500-acre area of the South American Subbasin primarily overlying Cosumnes River Preserve lands. Sacramento County GSA has entered into a Memorandum of Understanding with SCGA to include this 1,500-acre area in its GSA and fee study. As a result, this area was included in the SCGA fee study and the County's share of costs could be funded using the methodology described under the SCGA GSA. Imposing this fee would require County action.

5.4.1.3 Sloughhouse Resource Conservation District GSA

SRCD is a resource conservation district (RCD) formed in 1956. RCDs are special districts of the State of California, set up to be locally governed agencies with their own locally appointed or elected, independent boards of directors. California RCDs implement projects on public and private lands, and educate landowners and the public about resource conservation. SRCD is governed by a five-member Board of Directors. SRCD is engaged in the discussions of a multi-GSA MOU to identify the cost sharing approach and estimated costs associated with GSP implementation and completion of PMAs. SRCD will develop its own fee structure to fund its portion of the SASb GSP implementation based on the estimated cost share as developed in the MOU.

5.4.1.4 Omochumne-Hartnell Water District GSA

OHWD is a California Water District formed 1953 and it has the authority to exercise powers related to groundwater management and rural irrigation services. OHWD is also engaged in discussions for an MOU to fund its share of the GSP implementation and completion of PMAs. OHWD recently completed a fee study that included the cost sharing assumptions as outlined in the MOU for those parcels within the South American Subbasin. The OHWD fee program is based on irrigable agriculture acreage as outlined by the California DWR Statewide Crop Mapping data. OHWD held a public meeting and adopted the fee study for the projected costs associated with the South American Subbasin GSP based on the MOU and cost sharing estimate.

5.4.1.5 Northern Delta GSA

The Northern Delta GSA (NDGSA) initially formed as a Joint Powers Agency by 17 local agencies, each with water management responsibilities. The individual agencies were formed to manage water for flood, irrigation, and drainage within their local area, typically an area encompassing a single island in the Sacramento-San Joaquin.

NDGSA Board of Directors has proposed to impose a fee to generate revenue sufficient to fund both annual Agency operations costs and expenses associated with the implementation of the GSP. Because the NDGSA overlies multiple groundwater basins, the income from fees will be maintained and accounted separately by basin. Any activities undertaken by the NDGSA that benefit all of the Agency's service area, such as administrative actions, will be funded by drawing down the separate funds proportionally by geographic area; any activities that only provide services and benefits to one groundwater basin will be financed with funds collected from property within that same basin. This accounting practice will ensure that each geographic area pays only its share of the costs.

The proposed fee schedule will apply to all assessable parcels within the Agency's boundaries as the NDGSA's administrative and GSP-development services are provided to all parcels. Some parcels may not be assessable due to public ownership. The actual fee will be set annually by the NDGSA Board, based on the budget needs, but not to exceed the proposed rate. If activities are proposed to attain the sustainability criteria established in the GSP that would require supplemental funding and fees greater than the fees recommended in this report, the NDGSA would need to adopt a new fee schedule to fund these costs, and if necessary, will comply with the requirements in Article XIIID of the California Constitution, commonly referred to as Proposition 218 requirements.

5.4.2 Implementation Costs Split

The estimated annual costs to be shared amount the GSAs are described in **Table 5-2**. The GSAs are currently developing an MOU to identify how these costs will be shared among the GSAs. Each of the GSAs is able to meet its commitments to the GSP Implementation, including management actions, from their individual adopted fee processes. Any additional funding needs may be made up through other grants, bonds, or cost-sharing opportunities, which will be determined as they are needed.

5.5 Funding Sources and Mechanisms

SGMA authorizes GSAs to charge fees, such as pumping and permitting fees, to fund the costs of groundwater management and sustainability programs. A portion of the funding for GSP implementation will be obtained from the annual contributions made by the GSA member agencies. This cost allocation may change as the GSA's understanding of GSP implementation evolves over time through data collection and the assessment of the beneficial impacts of PMAs on groundwater sustainability. The total and individual agency contributions will be evaluated and may be refined, as needed.

The GSAs may pursue funding from state and federal sources for GSP implementation. The GSAs will further evaluate funding mechanisms and fee criteria and may perform a cost-benefit analysis of fee collection to support consideration of potential refinements. **Table 5-4** presents examples of potential financing options.

Table 5-4: Potential Funding Sources for GSP Implementation

Funding Source	Certainty
Ratepayers	High – User rates pay for operation and maintenance (O&M) of a utility's system. Depends upon rate structure adopted by the project proponent and the Proposition 218 rate approval process. Can be used for project implementation as well as project O&M.
General Funds or Capital Improvement Funds (of Project Proponents)	High – General or capital improvement funds are set aside by agencies to fund general operations and construction of facility improvements. Depends upon agency approval.
Special taxes, assessments, and user fees (within Project Proponent service area or area of project benefit)	High – Monthly user fees, special taxes, and assessments can be assessed by some agencies when new facilities directly benefit existing customers. Depends upon the rate structure adopted by the project proponent and the Proposition 218 rate approval process.
Bonds	Low – Revenue bonds can be issued to pay for capital costs of projects allowing for repayment of debt service over 20- to 30-year timeframe. Depends on the bond market and the existing debt of project proponents. Not anticipated in SASb.
Integrated Regional Water Management (IRWM) implementation grants administered by the California Department of Water Resources (DWR)	Medium – Proposition 1, IRWM implementation grants.
Proposition 68 grant programs administered by various state agencies	Medium – Grant programs funded through Proposition 68 (passed by California voters in June 2018 and administered by various state agencies) are expected to be applicable to fund GSP implementation activities. These grant programs are expected to be competitive, where $74 million has been set aside for Groundwater Sustainability statewide.
Disadvantaged Community (DAC) Involvement Program	Medium – DWR DAC Involvement Program This program is not guaranteed to be funded in the future.

Section 6: References and Technical Studies

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Appendix 1-A

Central Sacramento County Groundwater Management Plan
(February 2006)

CENTRAL SACRAMENTO COUNTY

GROUNDWATER MANAGEMENT PLAN

FEBRUARY 2006

MWH

WATER FORUM

SACRAMENTO COUNTY WATER AGENCY

Members of the Central Sacramento County Groundwater Management Plan Task Force

The following participants are thanked for generously giving their time and effort in the oversight and preparation of the Central Sacramento County Groundwater Management Plan:

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Larry Rodriguez (*Omochumne-Hartnell Water District)*

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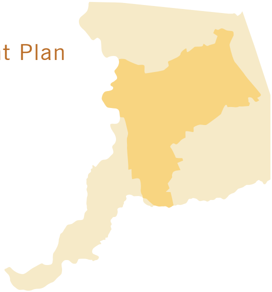
Executive Summary



Executive Summary

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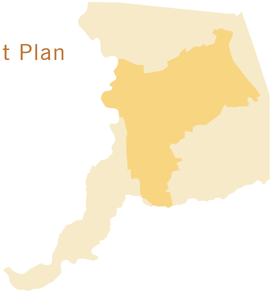


Executive Summary

FOREWORD

The Central Sacramento County Groundwater Basin stakeholders, in coordination with the Sacramento County Water Agency and the Water Forum Successor Effort have developed the Central Sacramento County Groundwater Management Plan (CSCGMP). The CSCGMP represents a critical step in establishing a framework for maintaining a sustainable groundwater resource for the various users overlying the basin in Sacramento County between the American and Cosumnes Rivers. It includes specific goals, objectives, and an action plan to provide a "road map" for the governance body as the steps necessary to manage the basin are taken in coordination with the various stakeholders. This Executive Summary is an outreach component of the CSCGMP that brings forth the essence of the CSCGMP in a similar format but in a condensed manner that still allows a basic level of understanding. The reader is encouraged to refer to the larger CSCGMP document if additional detail is needed.

INTRODUCTION

The CSCGMP is the result of over a decade of negotiations and agreements between stakeholders in the region. In 2000, the Water Forum Agreement (WFA) was signed by regional stakeholders, and the Water Forum Successor Effort (Successor Effort) was formed to continue forward in regional water supply planning.

The WFA laid the foundation for the Successor Effort. One of the responsibilities of the Successor Effort was to facilitate negotiations among stakeholders in the Central Sacramento County Groundwater Basin (Central Basin) that would lead to the creation of a groundwater basin governance body. This governance body would be responsible for the protection, health and long-term viability of the underlying groundwater as a sustainable resource for both current and future users. **Figure ES-1** shows the locations of the groundwater basins within Sacramento County.

Under the aegis of the Successor Effort, the Central Sacramento County Groundwater Forum (CSCGF) was formed in February 2002 to provide recommendations on a basin governance body to the Successor Effort. Following concurrence by the Successor Effort, this recommendation would be adopted by the appropriate agencies.

The CSCGF stakeholder interest groups included representatives in the following areas:

- Agricultural
- Agricultural Residential Groundwater Users
- Business Interests
- Environmental/Community Organizations
- Local Government/Public Agencies
- Water Purveyors

The total number of stakeholder representatives was approximately 40 people. These representatives met monthly for approximately three years at which time a decision was made to create an Advisory Committee, composed of CSCGF stakeholders, to develop a groundwater management plan for the Central Basin. The Advisory Committee spent approximately one year in developing the CSCGMP for adoption by the full CSCGF.

PURPOSE OF GMP

A Groundwater Management Plan (GMP) is a planning tool that assists overlying water providers in maintaining a safe, sustainable and high quality groundwater resource within a given groundwater basin. This CSCGMP is intended to be adaptive to changing conditions within the groundwater basin and will be updated and refined over time to reflect progress made in achieving the CSCGMP's objectives.

What is required in a GMP?

The GMP is a tool used to help ensure a long-term reliable water supply for rural domestic, agricultural, urban, business/industrial, environmental, and development uses in the region. The California Water Code (CWC) requires that a GMP contain numerous technical provisions which are briefly summarized as follows:

- An inventory of water supplies and a description of water uses within a given region. This information is summarized in a water balance showing overall water demands and available water supplies.
- Basin Management Objectives (BMOs) that are designed to protect and enhance the groundwater basin.
- Monitoring and management programs that ensure the BMOs are being met.
- Description of stakeholder involvement and public information plan and programs for the groundwater basin.

How does a GMP benefit the basin stakeholders?

The CSCGMP provides information related to planning activities currently taking place in the Central Basin. This information serves the following purposes:

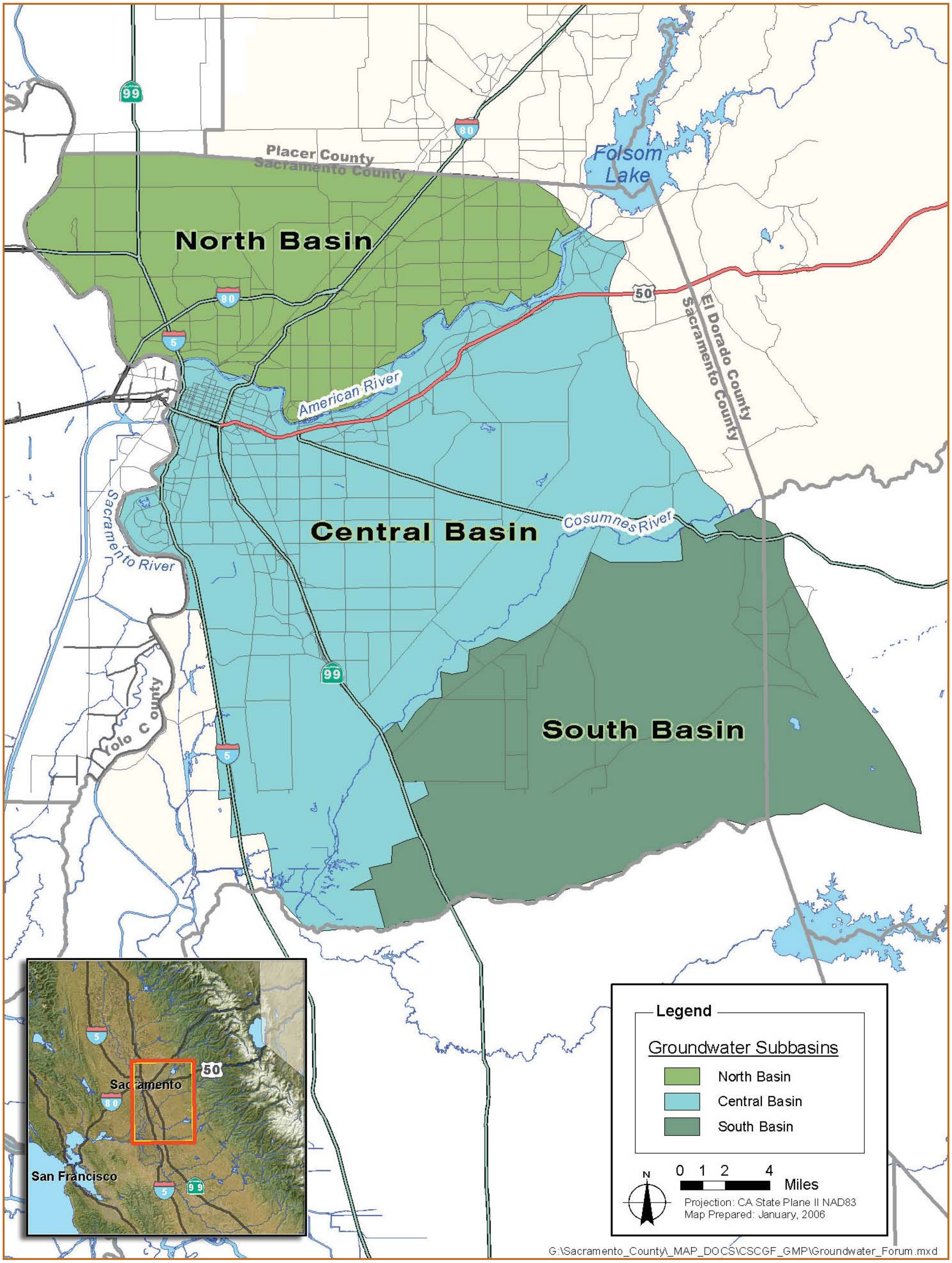
- It provides a management plan for the protection and preservation of groundwater resources.
- It underscores stakeholder interests and objectives.
- It ensures protection of groundwater quantity and quality.
- It assists in monitoring and maintaining groundwater elevations.

WATER RESOURCES SETTING

Physical Setting

Unique to Sacramento County are three major rivers each acting as a major source of recharge for the groundwater basin underlying the county. In some instances, the recharge process creates natural dividing lines along the rivers that can be used to delineate

Figure ES-1. Sacramento County Groundwater Basins



the individual sub-basins (i.e., North, Central, and South Basin as shown in **Figure ES-1**). Groundwater underlying the North Basin is currently managed by the Sacramento Groundwater Authority. Efforts are underway in the South Basin, led by the Southeast Sacramento County Agricultural Water Authority, to develop a groundwater management plan in accordance with the CWC and the provisions of the WFA.

The Central Basin

The Central Basin is made up of a variety of groundwater users (i.e., agriculture, agricultural residential, urban, and environmental). The Central Basin boundary was defined by the Sacramento County groundwater model that was used in the Water Forum process and took into account the hydrogeologic boundaries and the political boundaries of organized water purveyors/districts, cities (where they retail water within their boundaries), and the County of Sacramento.

In October 2004, the Sacramento County Water Agency (SCWA) adopted a GMP for the portion of the Central Basin that is served water through Zone 40 of the SCWA. The Zone 40 GMP was done to measure the effectiveness of the conjunctive use program outlined in the Zone 40 Water Supply Master Plan and for the purpose of seeking state grant funding to help finance large infrastructure projects that would benefit groundwater underlying the Central Basin. At the time of its adoption, the Zone 40 GMP recognized that a Central Basin GMP was necessary to meet the needs and interests of all the stakeholders in the Central Basin.

Groundwater underlying the Central Basin is contained within a shallow aquifer (Modesto Formation) and in a deep aquifer (Mehrten Formation). Groundwater is located from 20 to 100 feet below the ground surface depending on when and where the measurement is taken. The shallow aquifer is typically used for private domestic wells and typically requires no treatment. The deep aquifer is separated from the shallow aquifer by a discontinuous clay layer that serves as a semi-confining layer. The deep aquifer typically requires treatment for iron and manganese, which may cause mineral deposits and affect the taste of water. **Figure ES-2** contains a conceptual diagram of the aquifer.

Intensive use of groundwater over the past 60 years has resulted in a general lowering of groundwater elevations. Over time isolated groundwater depressions have grown and coalesced into a single cone of depression that is centered in the southwestern portion of the Central Basin (see **Figure ES-3** for Sacramento County Groundwater Elevations).

How does the CSCGMP address groundwater contamination problems in the Central Basin?

There are several sources of groundwater contamination within the Central Basin. These sources include: Mather Field, Aerojet, Boeing, the former Sacramento Army Depot, the Union Pacific railyards, and present and former landfills. The known extent of groundwater contamination and landfill sites are shown on **Figure ES-4**. The CSCGMP addresses the concerns well owners have regarding the potential for groundwater contamination threatening their wells.

Supply and Demand

The CSCGMP identifies available water supplies to meet the water demands of users within the basin. Water supplies include surface water, groundwater, recycled water, and remediated groundwater. Water demand is a result of rural, agricultural, private industrial, environmental, and urban activities. Demand reduction is being accomplished through water conservation measures identified in the WFA.

How much water supply does the Central Basin have?

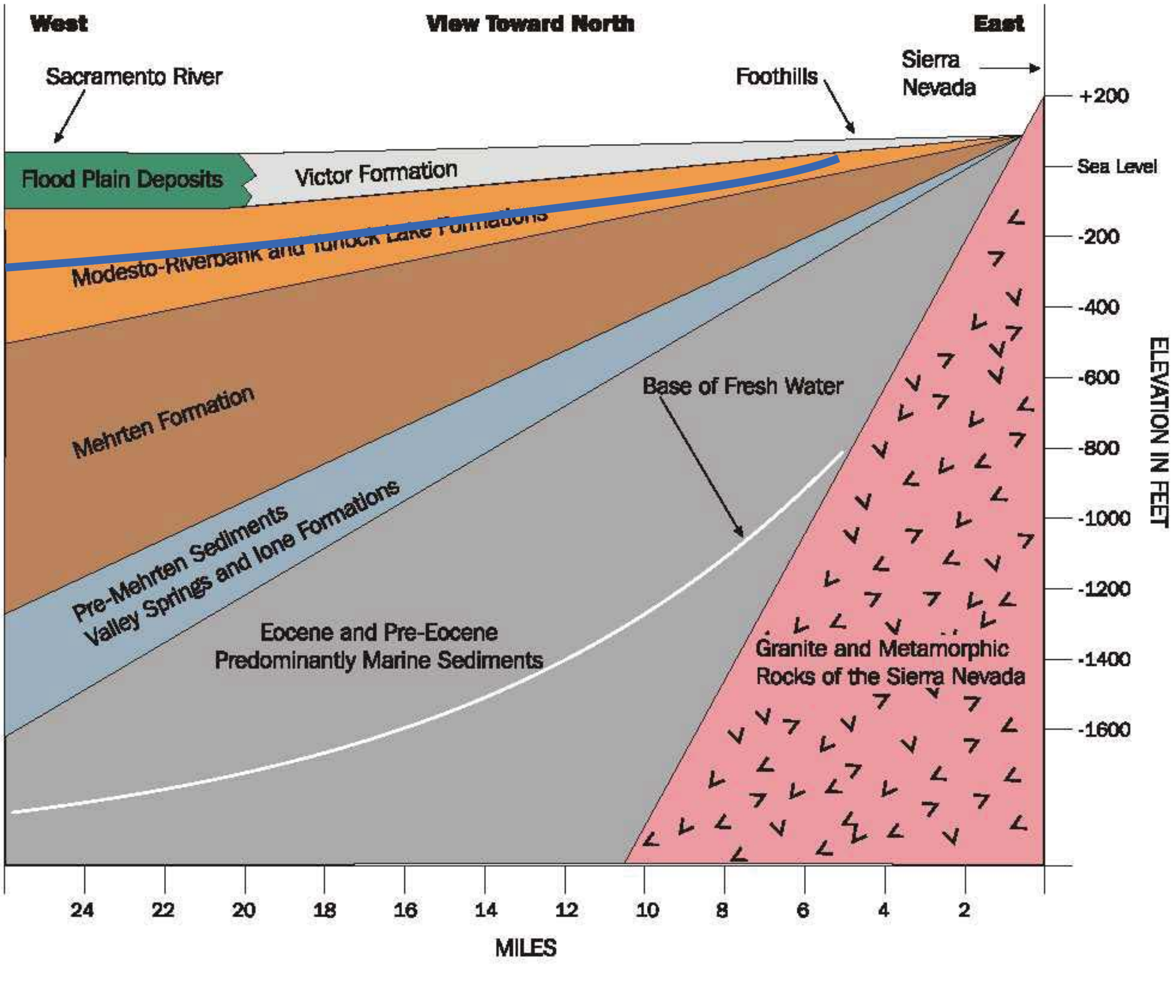
Water supplies have been quantified in some detail in the CSCGMP. Availability and reliability of surface water is dependent on the particular contract or water right and the hydrologic year type (e.g., wet or dry years). **Figure ES-5** summarizes surface water supplies available to each of the surface water purveyors and identifies the river source from which they originate. Based on existing and projected contract and water right entitlements, the total surface water supply available to the Central Basin is approximately 350,000 AF/year.

In addition to surface water supplies, the Water Forum determined the estimated long term average annual sustainable yield of groundwater from the Central Basin to be 273,000 acre-feet per year (AF/year). Currently, groundwater extractions are estimated to be 250,000 AF/year.

Recycled water use in the Central Basin is planned for up to 4,400 AF/year by 2030. The Sacramento Regional County Sanitation District is currently developing a Recycled Water Master Plan that will evaluate the feasibility of increased recycled water use in the County.

Water that is extracted for purposes of groundwater contamination clean-up activities is included in the overall sustainable yield of the Central Basin aquifer. In-basin use of remediated groundwater is an objective of the CSCGMP. This issue is addressed more fully in the Groundwater Contamination Monitoring and Collaboration Program summarized in the Plan Implementation section.

Figure ES-2. Hydrogeologic Cross Section



Modified from DWR Bulletin 118-6, 1978

Figure ES-3. Spring 2004 Sacramento County Groundwater Elevation Contour Map

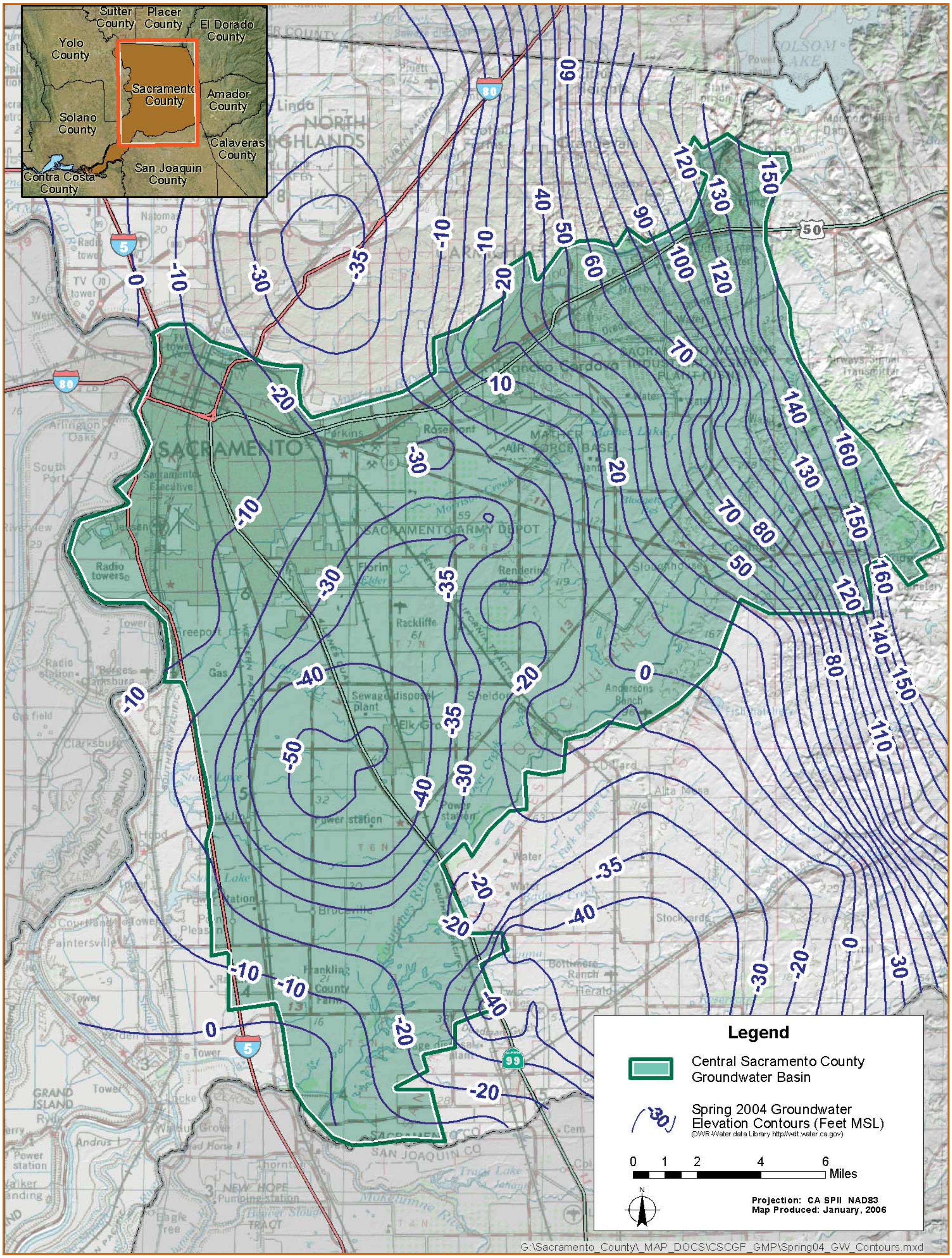
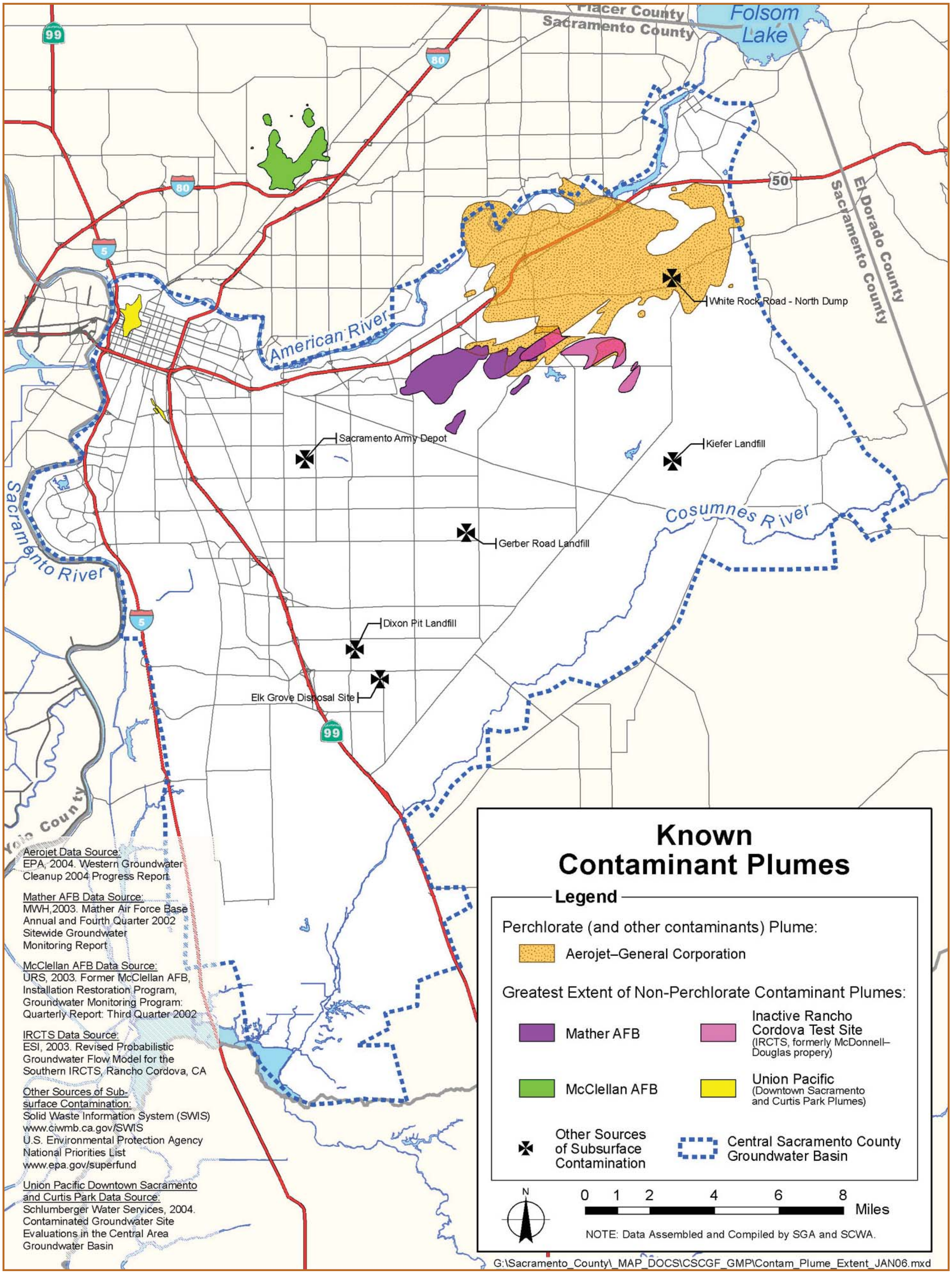


Figure ES-4. Known Extent of Contamination



Aerojet Data Source:
EPA, 2004. Western Groundwater Cleanup 2004 Progress Report

Mather AFB Data Source:
MWH,2003. Mather Air Force Base Annual and Fourth Quarter 2002 Sitewide Groundwater Monitoring Report

McClellan AFB Data Source:
URS, 2003. Former McClellan AFB, Installation Restoration Program, Groundwater Monitoring Program: Quarterly Report: Third Quarter 2002

IRCTS Data Source:
ESI, 2003. Revised Probabilistic Groundwater Flow Model for the Southern IRCTS, Rancho Cordova, CA

Other Sources of Subsurface Contamination:
Solid Waste Information System (SWIS)
www.ciwmb.ca.gov/SWIS
U.S. Environmental Protection Agency National Priorities List
www.epa.gov/superfund

Union Pacific Downtown Sacramento and Curtis Park Data Source:
Schlumberger Water Services, 2004. Contaminated Groundwater Site Evaluations in the Central Area Groundwater Basin

NOTE: Data Assembled and Compiled by SGA and SCWA.

G:\Sacramento_County_MAP_DOCS\CSCGF_GMP\Contam_Plume_Extent_JAN06.mxd

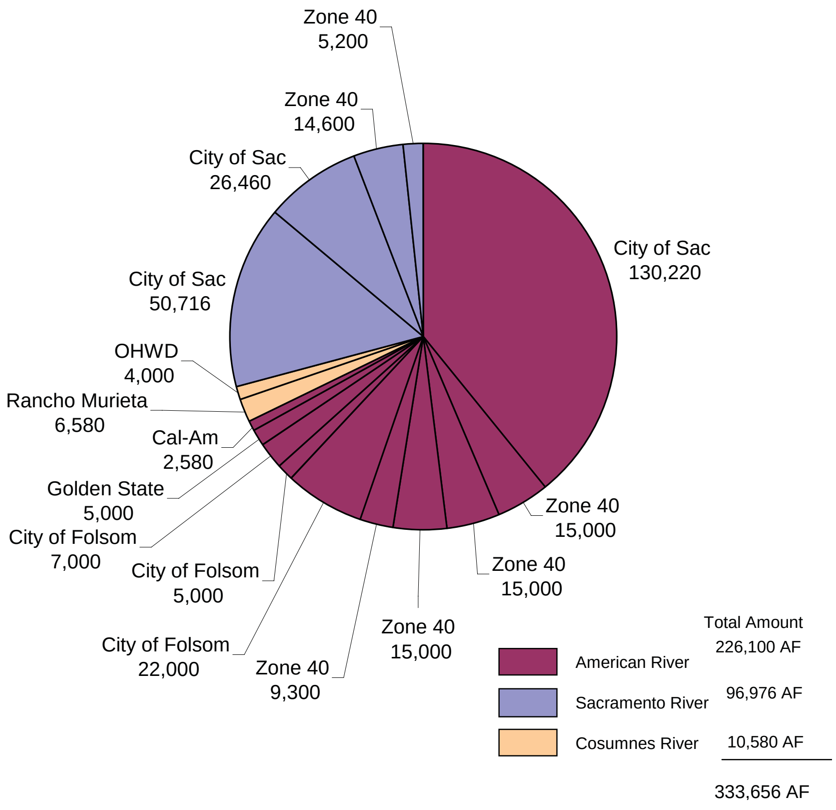
How are water demands calculated?

Water demands are determined using various methods based on identified uses of water. For instance, agricultural demands can vary significantly based on crop type. For agricultural-residential water users, demands are based on indoor usage, the amount of landscaped area around the home, and the amount of irrigated pasture for parcels that maintain livestock or other farm animals. Urban water demands are typically based on land use and zoning. Private industry and park district water demands are specific to the type of activity taking place at each site. Existing and future average annual water supply and demand is summarized in **Figure ES-6a and ES-6b** below. The graphs indicate that supplies meet demands and fluctuate depending on dry and wet hydrologic conditions, reflecting the conjunctive use of groundwater and surface water over the Central Basin by the various water purveyors and urban demand reductions during dry years. (In **Figure ES-6b**, conditions in 2030 demonstrate more clearly the results of existing and planned conjunctive use programs in full effect at that time). These demands also reflect the implementation of Best Management Practices (BMPs) for water conservation that are described in the WFA.

MANAGEMENT PLAN ELEMENTS

A goal of the CSCGMP is to ensure a viable groundwater resource for beneficial uses including water for purveyors, agricultural, agricultural residential, industrial, and municipal supplies that support the WFA's coequal objectives of providing a reliable and safe water supply and preserving the fishery, wildlife, recreational, and aesthetic values of the lower American River. In addition, the CSCGMP recognizes the need to maintain and enhance flows in the Cosumnes River because of its ecological significance.

Figure ES-5. Summary of Surface Water Rights and Contracts



Basin Management Objectives

Basin Management Objectives (BMOs) are used to help achieve groundwater basin goals. Five BMOs provide the foundation for the CSCGMP:

1) Maintain a long-term average groundwater extraction rate of 273,000 AF/year.
2) Establish specific minimum groundwater elevations within all areas of the basin consistent with the Water Forum "Solution."
3) Protect against any potential inelastic land surface subsidence.
4) Protect against any adverse impacts to surface water flows.
5) Develop specific water quality objectives for several constituents of concern.

Each of these objectives is fully described in **Section 3** of the CSCGMP.

Program Component Action Items

The Program Components listed below provide specific action items that will be implemented to help achieve the Basin Management Objectives.

Stakeholder involvement - several means of achieving broad stakeholder participation in the management of the Central Basin will be used, including: 1) involving the public, 2) involving other agencies within and adjacent to the Central Basin, 3) using advisory committees, 4) developing relationships with state and federal agencies, and 5) pursuing a variety of partnership opportunities.

Monitoring program - a good monitoring program is capable of assessing the current status of the basin and predicting responses in the basin as a result of future management actions. The CSCGMP includes actions related to monitoring of groundwater elevations, groundwater quality, the potential for land surface subsidence resulting from groundwater extraction, and developing a better understanding of the relationship between surface water and groundwater along the American, Cosumnes, and Sacramento Rivers.

Groundwater quality protection - groundwater quality protection is critical to ensuring a sustainable groundwater resource. Groundwater quality protection includes: 1) the prevention of contamination from entering the groundwater basin, and 2) the remediation of existing contamination.

Groundwater sustainability - the CSCGMP seeks to maintain or increase the amount of groundwater stored in the basin over the long-term. The WFA's groundwater management element provides a framework by which the groundwater resource in the Sacramento County-wide basin can be protected and used in a sustainable manner.

Planning integration - it is important to integrate water management planning on a regional scale (i.e., the development of an Integrated Regional Water Management Plan). The WFA provides a regional conjunctive use framework with commitments from individual purveyors concerning groundwater and surface water operations, including limitations on surface water diversions from the lower American River during dry years.

Figure ES-6a. 2005 Annual Average Water Balance

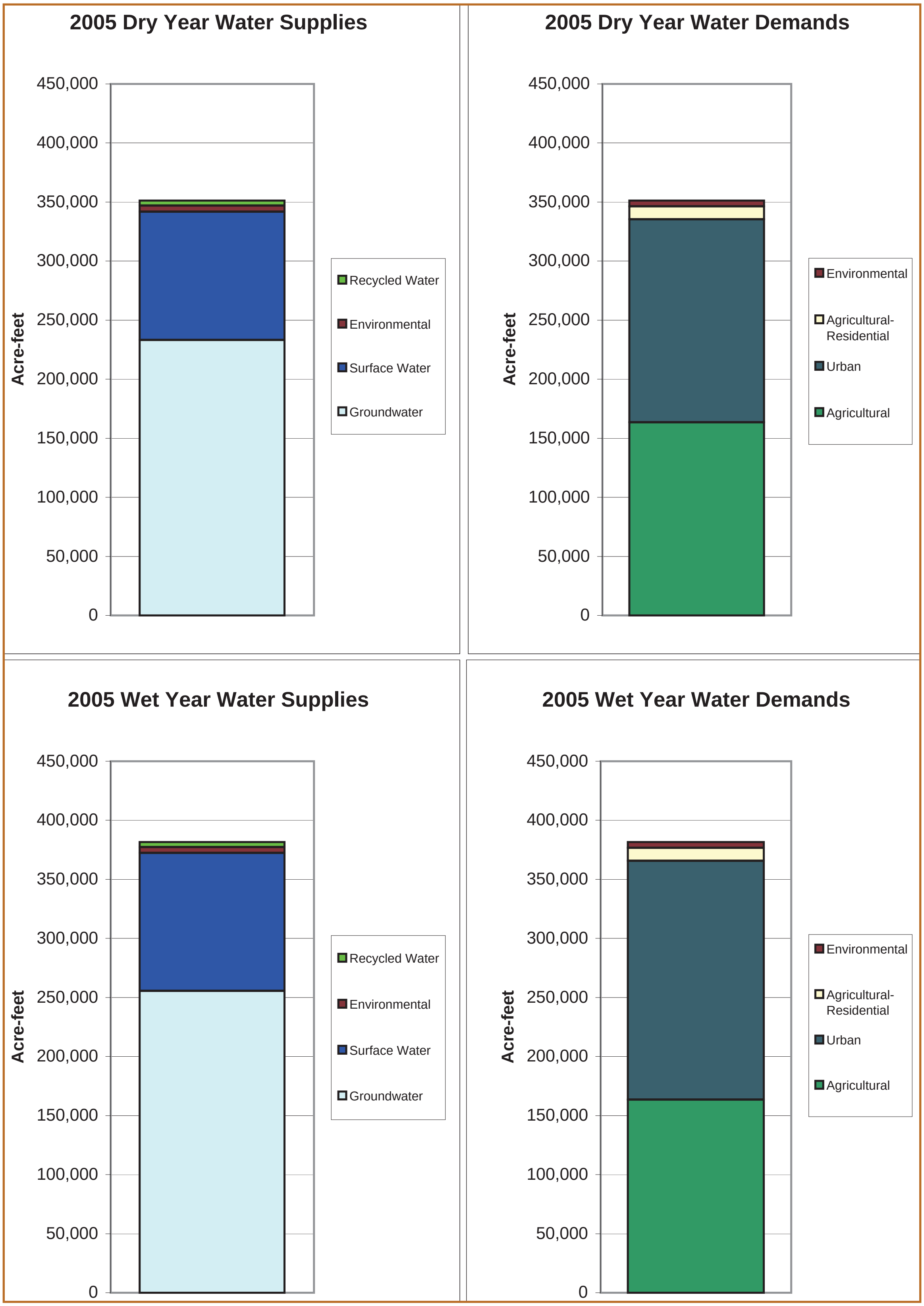
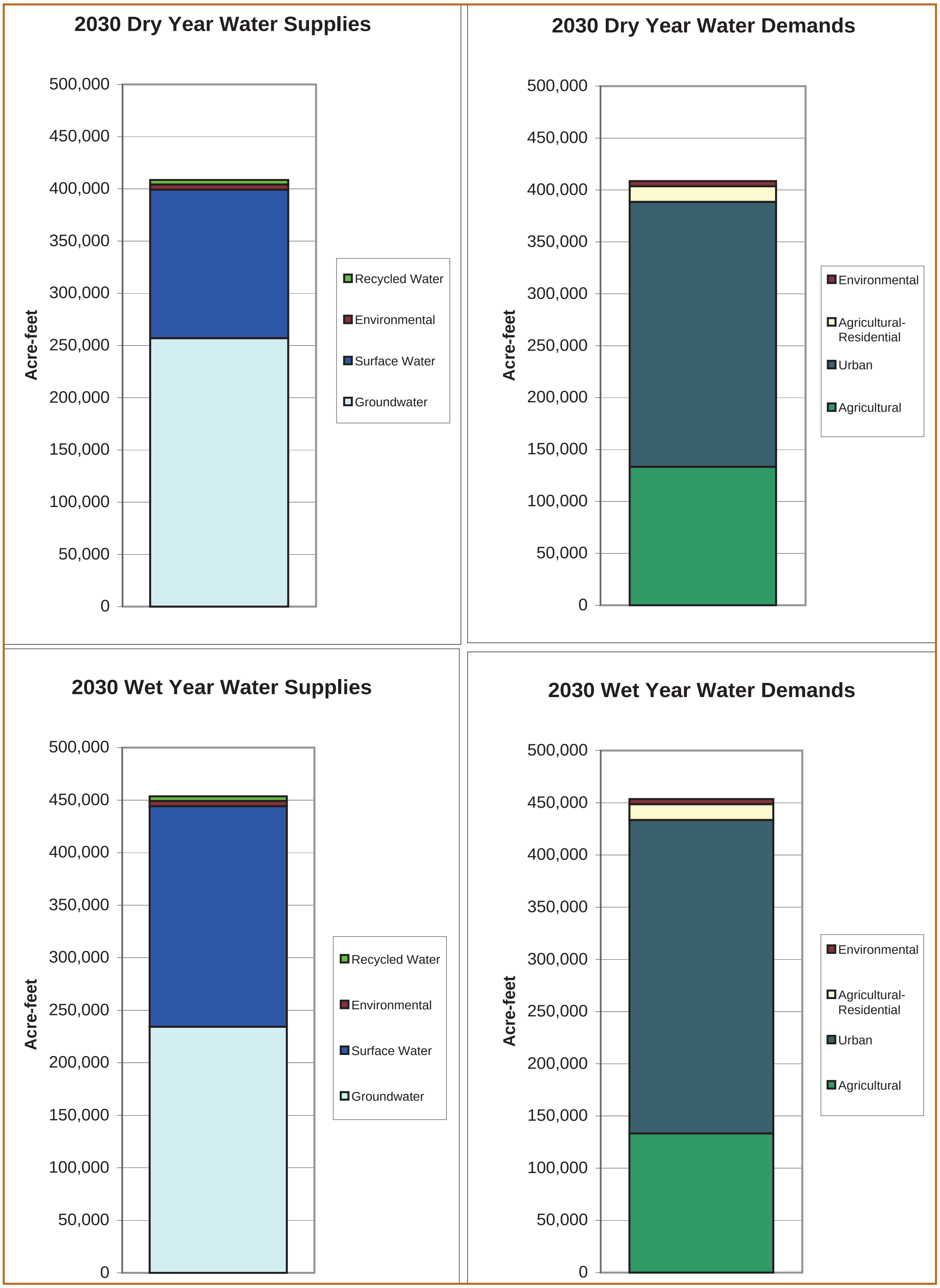


Figure ES-6b. 2030 Annual Average Water Balance



PLAN IMPLEMENTATION

An important element of a GMP is the establishment of trigger points and remedies necessary to fully implement the BMOs. Many of the remedies set forth in this GMP involve coordination with other local, state, and federal agencies. This coordination will begin upon adoption of the CSCGMP by the governance body.

BMO Trigger Point Activities

Trigger Point activities involve monitoring and assessing trends in the basin to determine the adequacy of the monitoring network for meeting the goals and objectives of the CSCGMP. These assessments will be made as new monitoring data become available for review by the basin governance body and results documented in an annual State of the Basin report. As mentioned in the introduction, this GMP is adaptive and relies on monitoring data, evaluation of remedies based on monitoring data and input from basin stakeholders. It requires that the basin be managed in a manner that makes the most practical sense in light of on-going collection and analysis of data.

Protection of Privately Owned Wells

The CSCGMP includes two programs that were negotiated by the stakeholders in the Central Sacramento County Groundwater Forum: the Well Protection Program and the Groundwater Contamination Monitoring and Collaboration Program.

How is an existing private well protected?

The Well Protection Program grew out of discussions that took place in the CSCGF and stems from the need to protect domestic and agricultural irrigation wells. Protection of existing privately owned wells is of fundamental importance to the stakeholders of the CSCGF. As part of this program, a trust fund will be put in place to cover costs of deepening or replacing any existing well that provides water for agricultural or domestic use that may be impacted by future development. The trust fund revenue will be generated from a fee assessed on every new building permit and permit to drill a new well. In 2005, the fee is estimated to be less than $100 per equivalent dwelling unit (e.g. single family home) within the basin.

How is the private well owner kept notified of groundwater contamination clean-up efforts?

The Groundwater Contamination Monitoring and Collaboration Program is focused on maintaining a clear line of communication between the designated Responsible Parties for groundwater contamination clean-up activities and private well owners. The program encourages the use of remediated groundwater in urbanized areas to keep the groundwater in the basin. This program also envisions the Regional Water Quality Control Board requiring designated Responsible Parties to survey private wells within 2,000 feet of any identified contamination plume. Assistance will also come from the Sacramento County Environmental Management Department (EMD). EMD is encouraged to exercise the strictest vigilance to ensure that all permitting

requirements are enforced and that, if requirements are not met, EMD will undertake whatever rigorous enforcement actions are effective.

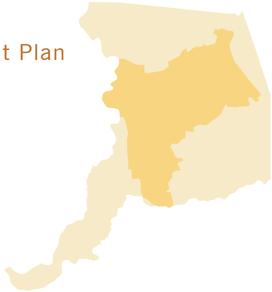
Basin Governance Body

The governance body is responsible for implementing the actions contained within this CSCGMP. The governance body will initiate the trust fund of the Well Protection Program, take over its administration, and provide annual reporting on the program. In addition, it will pursue any grant opportunities available to the Central Basin and participate in the Integrated Regional Water Management Plan that is currently underway. This is a regional planning document that is a prerequisite if a region is to pursue Proposition 50 implementation grant monies. Lastly, the governance body will collect, evaluate, and report on all of the data and management activities that have been taken in the Central Basin once a year in a State-of-the-Basin Report.

Plan Implementation Costs

First year program startup costs are estimated at $280,000. This is essentially 1.2 full-time people working throughout the year on setting up monitoring programs, taking measurements, compiling data, and reporting data. Future program costs will be evaluated on an annual basis by the basin governance body.

GROUNDWATER MANAGEMENT PLAN



Foreword

The genesis of the Central Sacramento County Groundwater Management Plan (CSCGMP) stems from events that began in the early 1990s and continues to the present day. Foremost among these was the formation of the Sacramento Area Water Forum (Water Forum). At the culmination of the Water Forum process (1993 to 2000), a Water Forum Agreement (WFA) was signed by participating agencies (described in more detail in **Section 1**). After signing the WFA the Water Forum Successor Effort (Successor Effort) was formed to carry forward the work outlined in the WFA.

One of the objectives of the Successor Effort was the formation of a basin governance body for the Central Sacramento County Groundwater Basin (Central Basin). See **Figure 1-1** for the geographic location of the Central Basin and **Figure 1-2** for the location of existing organized water purveyors in the Central Basin. As a result, the Central Sacramento County Groundwater Forum (CSCGF) was established; each member or stakeholder of the CSCGF has an interest in the groundwater underlying the Central Basin (details of CSCGF membership are described further below). The stakeholders are listed as follows:

1. Local Government/Public Agencies Interests
2. Business Interests
3. Agricultural Interests
4. Agricultural/Residential Interests
5. Environmental/Community Organizations Interests
6. Water Purveyor Interests

In order to assist in the development of the basin governance body a recommendation was made to the CSCGF to first develop a groundwater management plan for the Central Basin. The stakeholders recognized that development of a groundwater management plan would help them focus on an appropriate structure for the basin governance body once they had an understanding of the responsibilities and requirements for implementing a groundwater management program. The CSCGF agreed by consensus to act on this recommendation and formed a smaller group of CSCGF stakeholders (GMP Task Force) that were tasked with developing the CSCGMP.

The CSCGMP is a tool that is designed to ensure a long-term reliable groundwater supply for beneficial use within the Central Basin. It should be noted that the CSCGMP is not a land use policy tool. However, it is understood that a groundwater management plan may effect land use decisions simply through its influence on water use in a groundwater basin.

The structure of the CSCGMP is described below:

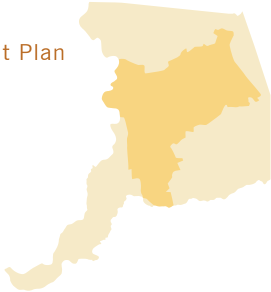
Section 1. Introduction. Describes the political and geographic setting and the activities taking place by water purveyors and interested stakeholders in the Central Basin.

Section 2. Water Resources Setting. Prior to managing a basin available water supplies have to be identified and quantified. In this section information is presented to assist the reader in understanding the availability of different water supplies and how they can be used within the Central Basin. This section provides a primer on the unique hydrogeology and setting within the Central Basin, it also provides an understanding of water quality issues and the groundwater and surface water infrastructure that is currently in-place. The relationship between water demands, water supplies, and land use are considered in the development of a water balance that examines current and future (2030) water supply needs.

Section 3. Components of the Groundwater Basin Management Plan. This section identifies the six components that constitute a groundwater management plan as described in the California Groundwater Management Guidelines (Groundwater Resources Association of California, Second Edition 2005). An important aspect of this section is the identification of Basin Management Objectives (BMOs) and the elements necessary for their implementation.

Section 4. Plan Implementation. Using the BMOs a set of threshold criteria (trigger points) have been developed to assist in reviewing and analyzing monitoring actions throughout the year. Once a trigger point is exceeded a recommended action takes place. Because the CSCGMP is based on adaptive management, trigger points and recommended actions can be changed by the basin management body. The section also includes a Well Protection Program that provides for the protection of domestic and agricultural and a Groundwater Contamination Collaboration Program to assist private well owners in understanding the risk of groundwater contamination to their wells.

Section 5. References. This section provides a compilation of references used in the development of the CSCGMP.



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ABBREVIATIONS AND ACRONYMS

μg/L	micrograms per liter
AB	Assembly Bill
Aerojet	Aerojet-General Corporation
AF	acre-feet
AF/year	acre-feet per year
AFB	Air Force Base
AFRPA	Air Force Real Property Agency
ag/res	agricultural/residential
Agency Act	State of California Sacramento County Water Agency Act
ARWRI	American River Water Resources Investigation
ASR	aquifer storage and recovery
bgs	below ground surface
BMO	Basin Management Objective
BMP	best management practice
BVID	Brown's Valley Irrigation District
Cal-Am	California-American Water Company
CALFED	CALFED Bay-Delta Program
CCR	California Code of Regulations
Central Basin	Central Sacramento County Groundwater Basin
CEQA	California Environmental Quality Act
cfs	cubic feet per second
City	City of Sacramento
CMP	Sacramento Coordinated Water Quality Monitoring Program
COC	contaminant of concern
Cooperating Agencies	American River Basin Cooperating Agencies
CSCGF	Central Sacramento County Groundwater Forum
CSCGMP	Central Sacramento County Groundwater Management Plan
CSD	Community Service District
CSUS	California State University, Sacramento
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWC	California Water Code
DAU	Data Analysis Unit
Delta	Sacramento/San Joaquin Delta
DHS	California Department of Health Services
DMS	Data Management System
DTSC	State of California Department of Toxic Substance Control

DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection Program
EBMUD	East Bay Municipal Utility District
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EMD	Sacramento County Environmental Management Department
EPA	United States Environmental Protection Agency
FMS	Flow Management Standard
Folsom	City of Folsom
FRCD/EGWS	Florin Resource Conservation District/Elk Grove Water Service
GMP	Groundwater Management Plan
gpm	gallons per minute
GSWC	Golden State Water Company
GWNT	Groundwater Negotiation Team
ID	irrigation district
IGSM	Integrated Groundwater and Surface Water Model
InSAR	Interferometric Synthetic Aperture Radar
IRTCS	Inactive Rancho Cordova Test Site
JPA	Joint Powers Authority
LSCE	Luhdorff & Scalmanini Consulting Engineers
LUFT	leaking underground fuel tank
LUST	leaking underground storage tank
M&I	municipal and industrial
Mather AFB	Mather Air Force Base
McClellan AFB	McClellan Air Force Base
MCL	maximum contaminant level
MFP	Middle Fork Project
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
msl	mean sea level
NAWQA	National Water Quality Assessment
NCMWC	Natomas Central Mutual Water Company
NDMA	n-nitrosodimethylamine
NEPA	National Environmental Policy Act
NGS	National Geodetic Survey
NPDES	National Pollutant Discharge Elimination System
PBE	physical barrier effectiveness
PCA	potentially contaminating activities
PCE	tetrachloroethene

PCWA	Placer County Water Agency
PL	Public Law
PMT	Project Management Team
POU	Place of Use
PSA	Purveyor-Specific Agreement
Reclamation	United States Department of the Interior, Bureau of Reclamation
RWA	Regional Water Authority
RWQCB	Regional Water Quality Control Board
SACOG	Sacramento Area Council of Governments
SCWA	Sacramento County Water Agency
SCWC	Southern California Water Company
SGA	Sacramento Groundwater Authority
SMUD	Sacramento Municipal Utility District
SMWA	Sacramento Metropolitan Water Authority
SOP	standard operating procedure
SRCSD	Sacramento Regional County Sanitation District
SSCAWA	Southeast Sacramento County Agricultural Water Authority
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TDS	total dissolved solids
Title 22	California Code of Regulations, Title 22
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
Water Forum	Sacramento Area Water Forum
WD	water district
WEP	Water Efficiency Program
WFA	Water Forum Agreement
WPP	Well Protection Program
WSMP	Water Supply Master Plan
WTP	water treatment plant
WWTP	wastewater treatment plant
Zone 40	area within the Central Basin that includes Laguna, Vineyard, Elk Grove, and Rancho Cordova